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THE AMBIGUOUS ROLE OF METHODS IN DESIGN EDUCATION: INITIAL FINDINGS FROM THE DELFT METHOD STUDY

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1. Introduction

A design method is often portrayed as something a designer can follow—like a *road*—to reach a predetermined outcome. While not necessarily reflecting the reality of method usage in practice, as pointed out by Jensen and Andreasen [Jensen and Andreasen 2010], the *road metaphor* suggests that methods, when followed carefully and systematically in a step-by-step procedure, will more or less guarantee designers a good end result. Further, this view on design often raises the expectation that *any* designer is able to successfully apply a particular method in the intended way (and favours to do so), regardless of the problem or challenge at hand. Put differently, the dominant view on methods in design as expressed in the road metaphor, produces an image of methods as fixed procedures—with instructions to follow in a certain order, promising certain results. However, do methods really represent paved roads to success in design? Or, is the road to success maybe bumpier and more personal than we currently acknowledge?

Much research in design has focused on the development of systematic methods which are assumed to be applicable to any type of design problem, in any situation, and by any designer. An example is the systematic approach to engineering design of Pahl and Beitz [Pahl and Beitz 1986]. Although the usefulness of systematic methods in the hands of *skillful designers* is not questioned, the idealized expectations that emerge from many methods have led to much debate (see for example the discussion between [Eder 1998], and [Frost 1999]). On the one hand, as exemplified above, systematic methods are portrayed as universal instructions, Pahl and Beitz [Pahl and Beitz 1986] for instance argue that while intuition may, in rare cases, produce good results in engineering design, the application of a systematic method will raise the chances of success significantly. On the other hand, the usefulness of specific methods is seen as emerging from the process of design. For example, Jensen and Andreasen [Jensen and Andreasen 2010] argue that methods typically are the result of a collaborative design process, rather than the premises of it. Consequently, methods should be viewed as means to aid for example communication, coordination and justification in social settings, rather than mere instructions for how to go about when designing. Moreover, Andreasen [Andreasen 2003] points to the fact that a 'proper' (effective) method execution typically requires a 'proper' mindset from the individual designer. Reports from practice also indicate that the use of systematic methods is anything but widespread and that few methods are universally adopted (see e.g., [Araujo et al. 1996]). Eder [Eder 2009] points to design methods' role in developing expertise and their use in non-routine operations. Nevertheless, a comprehensive understanding of the role methods play in design is lacking, leading to confusion about their potential benefits and consequences among practitioners, students and educators. Still, method teaching often holds a prominent place in engineering and product design education. Methods are used to guide students in carrying out specific design activities. They are also used as a frame of reference when teaching students how design is organized in practice, that is, they make up an important part of the 'arranged practice' in design education [Andreasen 2011]. To this end, systematic methods do not only provide step-by-step procedures but also suggest a general mindset for how to go about when designing. However, despite their educational value, systematic methods do not always sit well with the unruly reality of design for a number of reasons. Dorst [Dorst 2008] points out three important aspects in designing that usually are left out when developing a method or tool. First, few systematic methods account for how the objective of a design activity (e.g., the problem, the solution, the challenge, etc.) can be (so) vastly different and, therefore, may need to be approached differently also. Second, methods seldom prescribe how to account for the fact that the context of a design activity (e.g., the organization in which it happens, the resources available, etc.) can take many forms and therefore may also require special attention. Third, and perhaps most fundamentally, few methods take into consideration that the actors undertaking a design activity (e.g., the designer, the design team, etc.) can be vastly different in terms of educational background, expertise, mindset, motivation, and so forth.

Given the above, it is not surprising that certain promises inherent to the *road metaphor* (i.e., methods as a paved road to success) often clash with first-hand experiences of both design students and design educators. In the design literature, a number of explanations are also offered for why method usage is a complex issue in design (e.g., see [Frost 1999]). However, few studies have empirically tried to understand the role that methods play in shaping the work practices of designers. For example, why they function as paths to success for some designers whereas as paths to failure for others. Noteworthy exceptions are found in the transdisciplinary German research efforts on design where psychologists and engineers together studied design in practice (for an overview of this research effort see [Pahl et al. 1999]). As a part of this research effort, Günther and Ehrlenspiel [Günther and Ehrlenspiel 1993] compared the behavior and performance of six designers with formal methodological training to two designers without formal methodological training. The results showed marked differences between the designers in terms of the work practices (strategies) they used for problem clarification, conceptual design and embodiment design. However, restricted to a small sample of designers, Günther and Ehrlenspiel recognized a need to study the use of methods with larger samples to acquire a greater understanding of the work practices of designers. In doing so, they also noted that a key area for future study pertains to the more experiential aspects of method usage (e.g., the tendency to give up, ways of coping with failure, etc.).

In the present study, we analyze method usage in an educational setting. Specifically, we study the method usage of 213 students taking part in a design exercise in which they had to come up with a concept for a tangible product: a 'key-manager' to help elderly in daily life. We focus our study on method usage during synthesis. Synthesis methods play an important role in engineering design and industrial design, both in education and practice. They typically aid designers in combining information to form something new. The road metaphor might be less accurate for analysis methods. Owing to their more algorithmic nature, it seems problematic in situations when a designer is required to make creative leaps and synthesize (often incomplete) information. Our results provide a detailed account of the intricacies involved in dealing with method usage in design. First, we report on significant differences in the design process experiences and performance assessment between students instructed to follow a systematic approach and students instructed to follow rules of thumb (heuristics). Second, we extend these findings by pointing to individual differences in the way the design process was experienced. In doing so, we derive four distinct design process experience profiles in terms of the way the students perceived time pressure, self-confidence, motivation, conscientiousness and effort. Analyzing the potential origin of these profiles, we once again find differences between pursuing a systematic or heuristic approach. However, we also find that past design experience and assessment of the design brief seem to play an important role in shaping the design process experience of students. We therefore propose that individual differences in method usage should not be underestimated in understanding the role methods play in design.

In advancing this argument, we organize the remainder of the paper as follows. We begin by describing the theoretical foundation for our study, highlighting known intricacies underlying and shaping method usage in design. Next, we describe the specific conditions under which our study was performed and describe the research approach taken. Subsequently, we present the results of our study.

In seeking to open up the discussion on what it means to use (and teach) methods, we end the paper by discussing potential interpretations of our findings as well as their implications for method development and design education.

2. Method usage in design

We adopt Andreasen's definition of a design method as "a goal oriented rationalisation of *designers'* work in the form of a standardised work description." [1] Following this definition, a method can range from being a systematic step-by-step instruction (or systematic guideline) to a rule of thumb reflecting/capturing a specific design activity. A method can also vary in terms of the amount of information-processing that it requires from the designer; ranging from striving to include complete information which is a characteristic of systematic methods (such as morphological analysis) to ignoring/excluding information which is a characteristic of rules of thumb or heuristics (such as iteration and satisficing). In both cases, a method is a rationalization of a certain design activity or work practice of designers.

Using methods does not only have implications for the outcome of the design process but also for the way designers experience the design process. Further, in evaluating design performance, it is not only the outcome of the design activity (i.e., the object of design) that is of interest but also the process followed to reach that outcome [O'Donnel and Duffy 2007]. As such, next to the outcome of a method, how designers experience the design process represents a central concern for method development in design. However, few design methods explicitly address the way designers experience the design process, or how individual differences may exist in how designers use and benefit from a specific method. Similarly, relatively few empirical studies have specifically targeted designers' needs for methodological support or the role methods play for individual designers.

In a series of studies on cooperative design processes in engineering design, Badke-Schaub and Frankenberger [Badke-Schaub and Frankenberger 1997] uncover a broad set of interrelated factors that influence both the process and outcome of design activities. Specifically, the studies show that the use of design methods did not guarantee success but that factors such as conflict handling often were equally (and sometimes more) important. As a result, they conclude that designers should be trained to "[…] be capable of modifying inadequate strategies and strengthening successful strategies. For example, to recognise the conditions which allow the application of specific design and problem solving methods […]" (p. 311-312). In other words, designers should not be led to believe that applying the same method, in the same way, in different situations, will produce the same or even similar results. Instead, Badke-Schaub and Frankenberger argue that designers should be encouraged to develop the competency and tendency to adapt their work practices according to the situation at hand.

In developing such a competence (or tendency) of adaptive method usage, understanding the role methods play in design in general, but also for individual designers, is topical. In particular, with respect to developing a mindset on design, understanding how methods shape the design process experience of designers seems to be of key relevance for educators in adapting their teaching practices. An important reason for this is that design process experience in most cases constitutes a more direct measure for performance than the (tangible) outcome of a method, which typically is assessed much later. Therefore, from an educational perspective, we study how methods affect the work practices of designers. The following research questions guide our inquiry:

1. How does method usage affect the design process experience (and performance assessment) of designers?
2. And, how do individual differences in dealing with methods shape the design process experiences of designers?

3. Research method

In answering our research questions, we studied how design students' experienced different methods during a design exercise. The students were all enrolled in a master-level course on design theory and

[1] Personal communication, 11th April, 2011

methodology. The design exercise constituted a mandatory assignment and was carried out electronically. From an educational perspective, the purpose of the assignment was to stimulate discussion on the role of methods in design and to help the students to critically reflect on their own method usage. In targeting these learning objectives, we devised the design exercise in a way so that the students could compare their own process experiences with the different types of methods. The exercise was divided in three parts. In each part the students were given a different design brief and a different set of method instructions. Students were instructed to respond to the brief by developing their ideas into a tangible product concept.

Design brief

In developing the three briefs, we sought briefs that were comparable in complexity, clarity and stimulated interest. To achieve that, we incorporated the advice of academic colleagues who commented on the relative complexity, clarity and feasibility of the briefs. We also performed two rounds of pre-tests with students who assessed the briefs in terms of complexity, raised interest and feasibility on seven-point scales (1: Low to 7: High)[2]. The final three briefs scored low in terms of the complexity of the briefs (M = 2.34) and moderately to high in terms of complexity of the task (M = 4.46), triggered interest (M = 5.07) and feasibility (M = 4.47).

All the briefs asked for the design of a tangible device (a product concept) and suggested a user-centered approach. As such, they represented a common problem for the students. In order to stimulate the students' interest in the exercise, the briefs asked of the students to empathize with a specific user group and to develop a product specifically for the needs of this group. They were also asked to imagine themselves being a designer while working for a small national company. The three briefs asked for the design of: (1) a key manager for elderly, (2) a glucose measurement device for children and (3) a bag lifter for pregnant women. In this paper, we focus on the students' design process experiences with respect to the first brief.

Method instructions

In designing a product concept for each brief, the students were instructed to follow one out of three design approaches (conditions): (1) required to follow a systematic method approach, (2) required to follow a heuristic (method) approach or (3) required to follow the approach they normally would follow when designing. In all conditions, the focus was on providing instructions for how to go about in developing their ideas into a tangible product concept. In this paper, we focus on the design process experiences with respect to the first brief following either a systematic (N = 118) or heuristic approach (N = 95).[3]

In the literature on design methodology, methods are often described as being heuristic in nature in a specific sense: methods can enhance success but do not guarantee it [Roozenburg and Eekels 1995]. In this sense, all design methods are heuristics. However, in aiming to account for differences between types of methods (and for different designers), we focused on the amount of information processing that different types of methods prescribe. Building on the work of Gigerenzer [Gigerenzer 2010] on the use of heuristics in decision making, this distinction places methods on a continuum ranging from 'processing as much information as possible' to 'ignoring most information'. The more a design method resembles the former, the more it can be considered to be systematic in nature; the more a method resembles the latter, the more it can be considered to be heuristic in nature. In other words, we make a distinction between (1) methods that require designers to for example 'generate as many solutions principles as possible' and (2) methods that require a designer for example to 'pick the most salient sub-problem intuitively'.

With respect to the systematic approach, the students were asked to follow a highly systematic method by designing according to the principles of morphological analysis. Morphological analysis was originally introduced as a broadly applicable method for studying the interrelations between objects,

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[2] Participants indicated their agreements/disagreement with several statements for each of the constructs. For ease of reporting, the extent of their agreement/disagreement is expressed in terms of „low" vs. „high".

[3] From an educational perspective, the third design approach was incorporated as a comparison for the students.

phenomena and concepts [Zwicky 1967], and receives sustained interest in the field of engineering design. The underlying idea of a method is to refrain from 'prejudice' and 'pre-evaluations' in order to overcome some of the limitations of the human mind with respect to problem-solving. When applied to design, the method prescribes that a design problem is formulated which can be decomposed into sub-functions. For each sub-function, alternative solutions are generated from which different concepts are created to solve the original design problem. In short, the goal of this decomposition (and composition) is to acquire as much information as possible within a given problem/solution space before combining the different sub-solutions to overall concepts from which to make an informed choice.

With respect to the heuristic approach, the students were instructed to deliberately avoid/neglect information by adhering to four common rules of thumb (heuristic) in design. The first rule of thumb was the 'primary generator' [Darke 1979]. This heuristic advises to take the most salient (prominent) sub-problem as a starting point for the design activity. The second rule of thumb was 'conjecture-analysis' [Hilier et al. 1972]. This heuristic suggests reducing the solution space by the proposition of an initial solution that comes to mind (one that is worthwhile exploring). The third rule of thumb was 'iteration'. This common rule of thumb in design suggests developing an initial idea and adapting it continuously until it fulfills the design objectives. Last, the fourth rule of thumb was 'satisficing' [Simon 1969]. This heuristic suggests to stop designing as soon as the design objectives are met by a solution in order to avoid unnecessary optimization.

Data collection

Data was collected at three occasions. One week before the exercise, a web-questionnaire was distributed among the students regarding their preconceptions and experiences with methods in design. In the questionnaire, the students were asked to describe their past design experience in terms of prior exposure and general preference for systematic and heuristic methods. They did so by indicating their agreement/disagreement to a number of statements on seven-point scales. The statements (items) were devised to capture different facets of the students' prior exposure and general preference to systematic and heuristic methods. In developing the statements, we began by compiling a larger list of items for each area of interest. We then had academic experts and students review the different statements in terms of clarity and accuracy. Next, based on the comments of the experts and the students, we selected several statements for each area of interest in order to improve the reliability of our scales. The students' prior exposure to systematic and heuristic methods was conceptualized to cover three sub-areas: (1) their past training in systematic and heuristic methods, (2) past experience in using systematic and heuristic methods and (3) their frequency of using systematic and heuristic methods when designing. Exploratory factor analyses were conducted separately for both systematic and heuristic methods and each area of interest. In each of those areas only one component was extracted based on Kaiser's criterion of Eigenvalues > 1. All scales showed very high reliability with Cronbach's alphas exceeding .89. We therefore derived separate index scores for prior exposure to systematic and heuristic methods and general preference for systematic and heuristic methods by averaging across the items for each scale (area of interest).

Before engaging in the design exercise (i.e., prior to having received the method instructions), the students were asked to assess the briefs. As in the pre-test, the students rated the briefs with respect to several statements (items) covering (1) the complexity of the design brief, (2) the complexity of the design task, (3) the interest triggered and (4) feasibility to solve the brief within a two hour time limit. Exploratory factor analyses were conducted separately for each area (construct). Factor analyses again led to the extraction of reliable one component solutions for each construct.4 We therefore derived separate index scores (scales) by averaging across the items for each construct.

Directly after completing the design exercise, the students were asked to reflect on it by indicating their agreement/disagreement to a number of statements on seven-point scales. To acquire a broad understanding of their experiences, they were asked to assess their design process experience in

[4] With respect to the complexity of the brief and the complexity of the design task and based on the results of the factor analyses, we excluded a few single items (statements) in order to improve the reliability of the scales.

several areas. The areas covered (1) how pressed for time they had felt, (2) how self-confident they had felt, (3) how motivated they had been, (4) how conscientious they had been, and (5) the effort they had placed in doing the exercise. In acquiring an overall performance assessment regarding the work, they were asked to provide (1) an overall evaluation of their final design concept and (2) an assessment of the effectiveness of the taken approach. We also asked them to indicate their experience with the specific approach taken. As was the case for earlier areas of interest, each area (construct) was covered by multiple statements (items). Again, we also performed exploratory factor analyses prior to averaging the scores to produce separate index scores for each construct.[5]

4. Results

We analysed our data in two phases. In response to our first research question, we begin by comparing the design process experience scores between the students that were instructed to follow a systematic method approach to the students that were instructed to follow a heuristic method approach. With respect to how pressed for time they had been in doing the exercise, the students that followed the systematic approach scored significantly higher in terms of time pressure ($M = 4.03$, $SD = 1.33$) than the students that followed a heuristic approach ($M = 3.23$, $SD = 1.40$), $t(211) = 4.27$, $p < .001$. The effect size ($d = .59$) exceeded Cohen's (1988) convention for a medium effect ($d = .50$). With respect to how motivated they had been, the students that followed the systematic approach reported significantly lower motivation ($M = 4.43$, $SD = 1.03$) than the students that followed the heuristic approach ($M = 4.73$, $SD = 1.02$), $t(211) = –2.14$, $p < .05$. The effect size (d = .29) exceeded Cohen's convention for a small effect ($d = .20$). With respect to how much effort they felt they had placed, the students that followed the systematic approach reported significantly higher effort ($M = 4.77$, $SD = 0.97$) than the students that followed the heuristic approach ($M = 4.49$, SD = 0.99), $t(211) = 2.07$, $p < .05$. The effect size ($d = .29$) indicated a small effect size. With respect to how confident they had felt and how conscientious they had been in doing the exercise, the results show no significant difference.
Next, we compared the performance assessment between the two groups of students. The results show no significant difference between the students with respect to the overall evaluation of their final design. However, the students that followed the heuristic approach reported significantly higher effectiveness of the approach taken ($M = 5.09$, $SD = 0.72$) than the students that followed the systematic approach ($M = 4.44$, $SD = 1.03$), $t(211) = –5.23$, $p < .001$. The effect size for this analysis ($d = .72$) indicated a medium to large effect.[6]

Beyond methods alone: Mapping individual differences in design process experience

The results above show that the choice between promoting systematic or heuristic method usage in design is not straightforward. Following a systematic approach produced more time pressure and somewhat lowered motivation. It was also deemed as less effective than following a heuristic approach. However, the students also indicated that they placed somewhat greater effort in doing the exercise in the case of a systematic approach. Further, there was no significant difference between the two groups in terms of confidence, conscientiousness or overall evaluation of the final design. To this end, our results underscore the complexity surrounding method usage in design where the choice for or against systematic or heuristic methods often emerge as ambiguous.
Therefore, in response to our second research question, we take a more holistic view on design process experience—one that does not depend on whether or not the students followed a systematic or heuristic approach, one that rather focuses on the individual experiences of the students. The goal of the analysis is to explore how individual differences potentially interact with method usage in shaping the design process experience of designers. In doing so, we set out to provide designers and educators

[5] Again, based on the results of the factor analyses, we excluded single items (statements) in order to improve the reliability of the scales.
[6] We controlled for past design experience between the two groups. The results show no significant difference between the two groups in terms of their prior exposure or preference for systematic and heuristic methods in general or with respect to the specific approach taken. We also compared the assessment of the briefs between the two groups. The results show no significant differences.

with a more in-depth understanding about the role of methods in design—an understanding that might help to potentially adapt their (educational) practices.

We began by subjecting the design process experiences scores to cluster analysis to reduce the 213 students' assessments of their design process to a manageable set of individual process experience types. Before subjecting the scores to cluster analysis, the design process experience scores were standardized. We used a SPSS based K-means clustering procedure to group the process experience scores in terms of time pressure, self-confidence, motivation, conscientiousness and effort. K-means clustering does not provide any information on the number of potential cluster solutions. Therefore, following the recommendations by Burns and Burns (2008), we first used a hierarchical clustering procedure to determine the number of clusters to explore with the K-means procedure. A hierarchical cluster analysis using Ward's Method and Squared Euclidean Distance suggested four meaningful main clusters within the students' process experience scores. As shown in Table 1, the four clusters produced by the K-means procedure consisted of 31 (14.55%), 70 (32.86%), 64 (30.04%) and 48 (22.54%) students, respectively. In assessing the relevance of the different clusters, we compared the performance of the students in each cluster. Further, in understanding the potential origin of the mapped design process experience profiles, we compared the past design experience and design brief assessment of the students in the different cluster. The results suggest that different types of process experiences relate to different types of performance, and that some types are more common for certain types of methods. However, they also suggest that factors such as past design experience with a specific method, motivation, and self-confidence, play a role in the way students deal with methods. We elaborate on these results below per cluster.

Cluster 1: 'On top of things'

Students in this cluster are generally ambitious. They are highly motivated, highly conscientious and putting high effort into the exercise (design task) while feeling little time pressure and generally self-confident. The very positive overall process experience suggests that this group of students feels 'on top of things'—well equipped for the task and eager to do well. They also show the highest scores of all in assessing their own performance, for both their evaluation of their final design and the effectiveness in the design process. The positive process experience seems to shape their performance assessment. Fitting well into the overall picture, students in this cluster rated the design brief low in complexity and expected the task itself to be both rather feasible and interesting, and not too complex. In terms of past design experience, students reported a relatively bigger exposure to systematic methods, also preferring them slightly to heuristic methods. Within this cluster, a slight majority of people had been following the heuristic approach in the design exercise.

Cluster 2: 'Swamped, yet striving'

Students in this cluster can be described as ambitious. They put considerable amount of effort into the exercise (design task) and work conscientiously. At the same time however, they experience high time pressure and low self-confidence.. This seems to come at the expense of motivation: students in this cluster do feel motivated but considerably less than students in cluster 1. Yet, they are much more motivated than students in clusters 3 and 4. This mixed overall process experience suggests that this group of students feels 'swamped' (high time pressure, low self-confidence) and in doubt about their own performance. Yet they continue to 'strive' to master the design challenge at hand (still motivated and conscientious). Further, in assessing their own performance, they show much lower evaluations of their final design and the effectiveness of the design process compared to cluster 1, probably owing to the high uncertainty experienced in the process. Fitting well into the overall picture, students in this cluster rated the design brief low in complexity, however, in relative terms higher than in all the other clusters. They further expected the task itself to be feasible, showing slightly above average interest in it. The task was judged to be of average complexity, considerably more complex than clusters 1 and 3. In terms of past design experience, students reported a relatively bigger exposure to systematic methods, yet, without showing any preference for either systematic or heuristic methods. Within this cluster, a majority of people had been following the systematic approach in the design exercise.

Table 1. Cluster solutions

	Overall N = 213	Cluster 1 ' On top of things' N = 31 (14.55%)	Cluster 2 ´Swamped, yet striving´ N = 70 (32.86%)	Cluster 3 ´Indifferent and Disconnected´ N = 64 (30.04%)	Cluster 4 ´Lost faith´ N = 48 (22.54%)
Design process experience (Z-scores)					
Time pressure	0.00	– 0.83	0.93	– 0.71	0.12
Self-confidence	0.00	0.66	– 0.56	0.62	– 0.44
Motivation	0.00	1.25	0.33	– 0.17	– 1.06
Conscientiousness	0.00	0.78	0.46	– 0.59	– 0.40
Effort	0.00	1.03	0.54	– 0.33	– 1.01
Performance assessment (1:Low to 7:High)					
Overall evaluation of the final design**	4.93 (0.91)	5.73 (0.80)	4.85 (0.86)	5.15 (0.66)	4.25 (0.86)
Effectiveness of the taken approach**	4.73 (0.96)	5.23 (0.96)	4.57 (0.94)	5.02 (0.82)	4.24 (0.90)
Design brief assessment (1:Low to 7:High)					
Complexity of design brief (comprehension)	2.08 (0.98)	1.91 (0.89)	2.29 (1.06)	1.95 (0.90)	2.06 (0.99)
Complexity of design task**	3.35 (1.06)	3.32 (1.22)	3.78 (0.99)	3.18 (1.00)	3.77 (0.99)
Interest**	4.30 (1.31)	5.06 (1.33)	4.37 (1.30)	4.16 (1.22)	3.88 (1.27)
Feasibility**	5.12 (0.95)	5.52 (0.79)	4.94 (1.00)	5.31 (0.93)	4.86 (0.89)
Past design experience (1: Low to 7:High)					
Prior exposure to systematic methods	4.43 (1.22)	4.64 (1.27)	4.21 (1.36)	4.45 (1.13)	4.58 (1.06)
General preference for systematic methods	5.17 (0.91)	5.20 (1.23)	5.12 (0.91)	5.16 (0.87)	5.27 (0.70)
Prior exposure to heuristic methods	4.02 (1.32)	4.32 (1.50)	4.00 (1.34)	3.99 (1.26)	3.87 (1.26)
General preference for heuristic methods	5.03 (1.02)	5.08 (1.09)	5.18 (1.00)	4.95 (1.02)	4.88 (1.00)
Experience with specific method (approach)*	3.73 (1.50)	4.34 (1.70)	3.45 (1.64)	3.67 (1.32)	3.82 (1.28)
Preference for specific method (approach)*	4.88 (1.18)	5.27 (1.39)	5.05 (0.92)	4.82 (1.22)	4.47 (1.20)
Design approach (Condition)					
Instructed to follow a systematic method	118	13	46	28	31
Instructed to follow a heuristic method	95	18	24	36	17

* Separate one-way ANOVA test on the average scores over the four clusters were significant at $p < 0.05$
** Separate one-way ANOVA test on the average score over the four clusters was significant at $p < 0.01$

Cluster 3: ´Indifferent and disconnected´

Students in this cluster can be described as rather unambitious. They score low on conscientiousness and on the effort they put into the exercise (design task). This in turn might also explain why they feel little time pressure and generally self-confident (with scores comparable to those of cluster 1). In terms of motivation they seem indifferent to the task, as supported by a slightly below average score in motivation. Interestingly, in assessing their own performance, they score high on the evaluation of their final design and the effectiveness of the design process (only slightly below that of cluster 1). The fact that they give themselves high values in performance, despite their modest investments in the design task, might be best summarized as being 'indifferent and disconnected'. Put more bluntly, students in this cluster can be characterized as underachievers with an unrealistic expectation of their performance. Fitting well into the overall picture, students in this cluster rated the design brief low in complexity, comparable to that of cluster 1. They expected the task to be rather feasible (considerably more so than students in clusters 2 and 4), while showing average interest in it. The complexity of the task was judged below average (less complex), the lowest of all clusters. In terms of past design experience, students reported a considerably bigger relative exposure to systematic methods, also preferring them to heuristic methods. Within this cluster, a slight majority of people had been following the heuristic approach in the design exercise.

Cluster 4: ´Lost faith´

Students in this cluster are generally unambitious. They show very low scores in motivation and effort, and fairly low scores in conscientiousness and self-confidence. The students in this group might have started out in an ambitious manner, but seem to have been 'caught up' by the reality of doing the exercise (design task) according to the instructions given. Together with the low scores in assessing their own performance, both in the evaluation of their final design and the effectiveness of the design process, this group of students can best summarized as ‘having lost faith’. In other words, they do not (sufficiently) believe in themselves anymore to master the design task. In comparison, more students in this group were asked to use a systematic approach. Fitting well into the overall picture, students in this cluster rated the design brief low in complexity. They further expected the task itself to be feasible, yet, in relative terms the least feasible of all clusters. They also showed slightly below average interest in it, again the lowest of all clusters. The task was judged to be of average complexity, considerably more complex than clusters 1 and 3. In terms of past design experience, students reported a considerably bigger relative exposure to systematic methods, also preferring them to heuristic methods. Within this cluster, a majority of people had been following the systematic approach in the design exercise.

5. Discussion

Design methods are an important part of design. This is shown by the tradition to develop methods as part of research practice in the academic community. It is also shown by their frequent use in education and practice. Still, evidence on the role methods play in design is, at best, inconclusive. Drawing on the results of an empirical study with 213 design students, we have investigated the role of methods in shaping the design process experience of designers in developing their ideas into tangible product concepts. The results suggest that the role of (synthesis) methods in design is rather ambiguous. The design process experience of the students has shown to be influenced by the type of method (systematic vs. heuristic), their mindset (past design experience and own method preferences) and their self-perception during the design process (time pressure, self-confidence, motivation, conscientiousness and effort).

Our empirical study consisted of two parts. In the first part we compared the way the students experienced their design process depending on the method followed in a design exercise. One group of students was instructed to use a systematic method (‘morphological analysis’) and one group was instructed to use four heuristic rules of thumb (e.g., ‘satisficing’, ‘iteration’, …). The students following the systematic method reported significantly more time pressure than the students instructed to follow the heuristic method. They were also less motivated and described their design process as less effective. However, they also indicated that they placed significantly more effort in doing the exercise than the other students. To this end, our results show the value of using both systematic and heuristic methods in design.

In understanding how individual differences in dealing with methods potentially shape the design process experiences of designers, we probed the students’ individual design process experience further in the second part of the study. By means of a cluster analysis we were able to acquire a more in-depth view on the role of methods in design, going beyond merely the type of method used. Based on this analysis, four different profiles (clusters) were derived, accounting for the differences in the way the students experienced their design process. In these profiles, we distinguish students that felt “on top of things”, “swamped, yet striving”, “indifferent and disconnected”, and students that seemed to have “lost faith” during the design exercise. The type of method used did not seem to be the sole origin of these profiles. In fact, the method used only to partially explained the students´ process experiences.

Overall, the profiles underscore and extend past claims in the literature. From an educational perspective, our findings underscore earlier calls for a more adaptive method usage in design [Badke-Schaub and Frankenberger 1997]. We also extend them by identifying a need for design educators to acknowledge individual differences in method usage and provide a structure for doing so. Method usage undoubtedly influences the design process experience of students. In this regard, it is not surprising that educators promote the use of different methods in forming a specific mindset for designing; a mindset that might prove valuable for students in the future. However, as recognized in both theory and practice, method usage does not occur in isolation; hence, whether or not a method will lead to a good end-result depends on the greater context, in which the individual designer plays a key role. As a result, putting more emphasis on individual differences in method usage should represent a prime concern for educators.

In accounting for individual differences in design, the different profiles serve as a learning tool to stimulate a dialogue between teachers and students on method usage. Specifically, in an educational setting, they can facilitate reflection on the relevance of method usage in design. They can also function as meaningful indicators to help students and educators to interpret and evaluate individual process experiences and method usage. Hence, we hope that our initial findings will contribute to more research on method usage in design and help in putting the individual designer more into the spotlight.

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