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FORMING A MINDSET: DESIGN STUDENTS' PRECONCEPTIONS ABOUT THE USEFULNESS OF SYSTEMATIC METHODS

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ABSTRACT

Teaching students to use systematic design methods effectively is not straightforward. While method teaching often focuses on the procedural aspects of method usage (e.g., what steps to take and in what order), effectively using a systematic method entails more than following its 'instructions'. As noted by Andreasen [1], students need to be equipped with a proper method mindset in order to use methods effectively. A mindset represents a mental framework that supports designers in using methods. To this end, Andreasen recognizes that a mindset encompasses at least knowledge about a method and its use. Yet, learning to use a new method requires more than just prior knowledge about it. In order to use it effectively, students also need to develop a preference for working with a method (or certain type of methods). In this paper, we investigate how *knowledge* and *preference* affect method usage. Drawing on a survey among 305 industrial design engineering students, we study how prior knowledge and preference for systematic methods affect their use in five different basic design activities. For four of the activities, we show that preference mediated the effect of knowledge on method usage. For one activity (analysis), we unveil a complementary mediation effect for the knowledge–usage relationship. Our results support Andreasen's proposition of a method mindset. They also extend Andreasen's initial ideas about the underlying elements of a method mindset by underscoring the role preference holds in facilitating method usage.

Keywords: design methods, mindset, design education

1 INTRODUCTION

Method teaching fulfills an important role in engineering and product design education. Methods are used to provide guidelines for carrying out specific design activities. They are also used to describe how design is organized in practice, that is, they make up an important part of the 'arranged practice' in design education [2]. To this end, methods are used as a frame of reference for how to go about in designing. In this light, students' ability to use a variety of methods is seen as a virtue. However, teaching students to use design methods effectively is not straightforward. The reason for this is that effectively using a method when designing entails more than following its 'instructions' (e.g., its prescribed steps). In fact, Andreasen [1] argues that in order to use methods effectively, designers need to possess a proper *mindset*. Acquiring adequate knowledge about a method and its use forms an important part of this mindset. Subsequently, this mindset, which should be sufficiently present in the mind of the designer, determines the extent to which the designer is able to use a method in a way that benefits the design task at hand. Put differently, a proper mindset positively influences the designer's ability to use a method, as it allows him or her to more effectively address the problem or challenge at hand when designing.

While knowledge seems to be an important prerequisite for using a method, we are quick to note that adequate knowledge about a method alone does not seem to be sufficient for good method usage. Any investment in a method's application depends on the designer's willingness and preference to use the method at hand. Furthermore, a proper mindset also entails that the designer deems a method appropriate given the situation at hand. In other words, whether the designer will actually take

advantage of a method is determined by both possessing adequate knowledge about the method (and its use), a general preference for working with it and its fit with the situation in which it is used. In this paper, we investigate the possibility of this proposition. Specifically, we focus on systematic method usage in the basic design cycle [3] and compare the reported usage of systematic methods of students for five activities: (1) analysis, (2) synthesis, (3) simulation, (4) evaluation, and (5) decision-making. We also study how prior *knowledge* (about systematic methods and their usage) and *preference* (for using systematic methods) affect the reported usage of systematic methods in those activities.

2 METHOD MINDSET

According to Andreasen [1], a method mindset is “an important part of a mental framework leading to the execution of a method”. Andreasen recognizes that a method mindset encompasses at the very least knowledge about a certain method and its use. In forming a method mindset, he distinguishes four interrelated elements: (1) understanding of the task and context, (2) understanding the theory behind the method, (3) mastering and proper use of the method and (4) the ability to assess the proper use of the method and its outcomes. Overall, these elements encompass knowledge about understanding the prerequisites for using a method (know-what) as well as the skills and ability needed to use it effectively (know-how).

However, from an educational perspective, prior (theoretical) knowledge about the use of a method and the (practical) skills needed to execute it are not sufficient. Learning to use a new method typically requires students to develop an appreciation and ultimately preference to work with a method or certain types of methods. From practice, it is also a well-known fact that designers favor to work in idiosyncratic ways. Most educators would therefore agree that motivation and interest, as captured in the designer’s general preference for a method, are key factors in determining whether he or she will use a certain method to their benefit. We propose that in (methodological) design education, developing a general preference for using a (certain type of) method becomes as important as developing the knowledge needed to use the method.

That said, acquiring knowledge certainly remains an integral part in the formation of a method mindset. But, by using a method extensively, students not only start to understand how a method works, they also learn to appreciate it. Once a general preference for a specific method has been developed, students will be more prone to use it. We summarize this argumentation in the conceptual model below (Figure 1). In this model, following Andreasen, knowledge about the use of a method has a direct influence on how likely someone is to use a method (path c’). In addition, knowledge also has an indirect influence on how likely someone is to use a method through his or her preference for a method (path a and b).

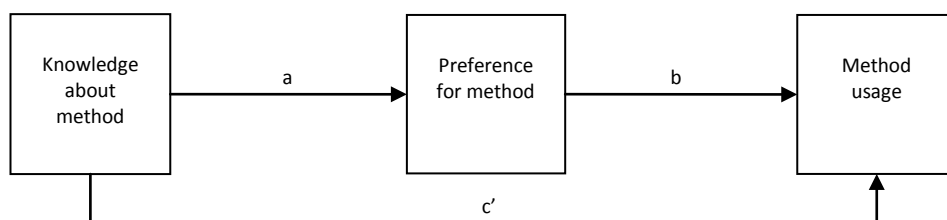


Figure 1. Conceptual model

3 RESEARCH METHOD

For testing our conceptual model, we analyzed data on students’ reported method usage from the Delft Method Study. The Delft Method Study is a research initiative hosted by the Department of Product Innovation Management at the Faculty of Industrial Design Engineering, Delft University of Technology. One of the main motivations behind this research initiative is to contribute to the better understanding of the role of methods in design by drawing on empirical data. In 2011, we studied how design students’ experienced using different methods during a series of design exercises. The students were all enrolled in a master-level course on design theory and 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 experiences with different types of methods. For a more detailed description of the Delft Method Study see Daalhuizen, Person and Gattol [4].

One week prior to performing the exercise, a web-questionnaire was distributed among the students in the course. In the questionnaire the students were asked to report on their prior experiences with methods in design. 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' experiences. In developing the statements, we compiled larger lists of items for each area of interest and asked academic experts in design to review them in terms of clarity and appropriateness. The final selection of statements was based on comments of the design experts. Several statements were selected for each area of interest, which is known to further improve the reliability of scales for a questionnaire. In total, we collected 305 questionnaires. All data originated from this questionnaire. For the analyses in this paper we focus only on a subset of the data, namely the students' preconceptions and experiences with systematic methods in design.

The students' knowledge about systematic methods was operationalized in terms of (1) their prior training in using systematic methods (i.e., the amount of training they had received in using systematic methods) and (2) their prior experience in using systematic methods (i.e., how skilled they felt in using systematic methods). Prior training and experience was measured by three items each. Their general preference for systematic methods was assessed in four items. The students' use of systematic methods when designing was assessed over the basic design cycle, as conceptualized by Roozenburg and Eekels [3]. The activities in the basic design cycle are (1) analysis, (2) synthesis, (3) simulation, (4) evaluation, and (5) decision making in design. The degree to which they used systematic methods for the different activities was measured with multiple items for each activity.

4. RESULTS

In testing our conceptual model, we began by comparing the reported usage of systematic methods for the different activities in the basic design cycle. Prior to comparing the mean scores for the different activities, we conducted exploratory factor analyses to assess the reliability of the scales of each activity. For each activity, only one component was extracted based on Kaiser's criterion of Eigenvalues > 1 . All scales showed high reliability with Cronbach's alpha exceeding .74. We therefore derived separate index scores for their self-reports on the use of systematic methods for each basic design cycle activity by averaging across the items for each scale (see Table 1).

We then compared the mean scores for the different activities in order to assess the perceived usefulness of systematic methods across the basic design cycle. A repeated-measures ANOVA (with a Greenhouse-Geisser correction) showed a main effect of the within-subjects factor *basic design cycle activity*, indicating that the reported systematic method usage in the five design cycle activities differed statistically, $F(3.015, 916.652) = 39.545, p < .001, \eta_p^2 = .115$. Post-hoc pairwise comparisons (with Bonferroni correction) revealed that students reported higher usage for activities related to analysis than to synthesis and simulation, higher usage for activities related to evaluation than to synthesis and simulation, and higher usage for activities related to decision-making than to synthesis and simulation.

	Mean (SD)	
A. Analysis ($\alpha_S = 0.838$)	4.84 (1.129)	A > B, C*
B. Synthesis ($\alpha_S = 0.803$)	4.39 (1.311)	B < A, D, E*
C. Simulation ($\alpha_S = 0.742$)	4.39 (1.124)	C < A, D, E*
D. Evaluation ($\alpha_S = 0.791$)	5.01 (1.137)	D > B, C*
E. Decision-making ($\alpha_S = 0.796$)	5.00 (1.124)	E > B, C*

* Pair-wise comparisons (alpha-levels adjusted using Bonferroni) were significant at $p < .001$

Table 1. Reported systematic method usage over the basic design cycle, $N = 305$

Next, in understanding the formation of a method mindset, we studied the effects of knowledge and preference on the reported use of systematic methods across the basic design cycle. We performed five separate mediation analyses incorporating the students' reported knowledge and preference for systematic methods as well as their reported usage of systematic methods in each of the five activities in the basic design cycle. Prior to performing the mediation analyses, we conducted exploratory factor analyses to assess the reliability of the scales for systematic method knowledge and preference. For both systematic method knowledge and preference only one component was extracted based on Kaiser's criterion of Eigenvalues > 1 . Both scales showed very high reliability with Cronbach's alpha exceeding .93 for knowledge and .85 for preference. We therefore derived separate index scores for systematic method knowledge and preference by averaging across the items for each scale.

For all our analyses we used the SPSS macro developed by Preacher and Hayes [5]. Significance tests for each of the mediated effects were bootstrapped estimates for the upper and lower boundaries of Confidence Intervals ($z = 1,000$). Separate regression analyses showed a direct effect of preference on method usage across all activities in the basic design cycle ($\beta > 0.43, p < .001$). The direct and mediated effects of knowledge on method usage differed over the basic design cycle.

For *analysis*, results from bootstrapping yielded a significant indirect effect of systematic method knowledge on systematic method usage of $\beta = 0.20$ (S.E. = 0.034) with a 95%-confidence interval from 0.13 to 0.27. Preference mediated the effect of knowledge on systematic method usage for activities related to analysis—however not exclusively, as both knowledge ($\beta = 0.10, p = .03$) and preference ($\beta = 0.51, p < .001$) significantly predicted changes in method usage when regressed simultaneously. This type of mediation can be classified as 'complementary'.

For *synthesis*, results yielded a significant indirect effect of systematic method knowledge on systematic method usage of $\beta = 0.17$ (S.E. = 0.041) with a 95%-confidence interval from 0.09 to 0.25. Preference mediated the effect of knowledge on systematic method usage for activities related to synthesis, as knowledge did not display a significant direct effect on usage ($\beta = .09, p = .16$) when controlled for preference. Preference displayed a significant direct effect on usage ($\beta = 0.43, p < .001$) when method usage was regressed both on knowledge and preference simultaneously. This type of mediation can be classified as 'indirect-only'.

For *simulation*, results yielded a significant indirect effect of systematic method knowledge on systematic method usage of $\beta = 0.20$ (S.E. = 0.035) with a 95%-confidence interval from 0.13 to 0.27. Preference mediated the effect of knowledge on systematic method usage for activities related to simulation, as knowledge did not display a significant direct effect on usage ($\beta = .08, p = .09$) when controlled for preference. Preference displayed a significant direct effect on usage ($\beta = 0.51, p < .001$) when method usage was regressed both on knowledge and preference simultaneously. Again, this type of mediation can be classified as 'indirect-only'.

For *evaluation*, results yielded a significant indirect effect of systematic method knowledge on systematic method usage of $\beta = 0.23$ (S.E. = 0.039) with a 95%-confidence interval from 0.16 to 0.31. Preference mediated the effect of knowledge on systematic method usage for activities related to evaluation, as knowledge did not display a significant direct effect on usage ($\beta = .06, p = .20$) when controlled for preference. Preference displayed a significant direct effect on usage ($\beta = 0.60, p < .001$) when method usage was regressed both on knowledge and preference simultaneously. Again, this type of mediation can be classified as 'indirect-only'.

For *decision-making*, results yielded a significant indirect effect of systematic method knowledge on systematic method usage of $\beta = 0.23$ (S.E. = 0.038) with a 95%-confidence interval from 0.16 to 0.31. Preference mediated the effect of knowledge on systematic method usage for activities related to decision-making, as knowledge did not display a significant direct effect on usage ($\beta = .07, p = .13$) when controlled for preference. Preference displayed a significant direct effect on usage ($\beta = 0.60, p < .001$) when method usage was regressed both on knowledge and preference simultaneously. Again, this type of mediation can be classified as 'indirect-only'. In sum, for all activities, preference shows a significant effect on method usage; in all but one activity (analysis), knowledge does not show a direct effect on method usage. However, our analysis shows that knowledge indirectly induces an effect on method usage. For four out of five activities in the basic design cycle, preference mediates the effect of knowledge on method usage. For one activity (analysis), we find a complementary mediation effect for the knowledge-usage relationship.

5. DISCUSSION

Teaching students to use systematic design methods effectively is not straightforward. While method teaching often focuses on the procedural aspects of method usage (e.g., what steps to take and in what order), effectively using a systematic method entails more than following its 'instructions'. As proposed by Andreasen (2003), a proper method mindset is a prerequisite to be able to use methods effectively. In this paper, we empirically studied Andreasen's [1] proposition for the usage of systematic methods in the basic design cycle. Our results support Andreasen's proposition of a method mindset. The reported usage of systematic methods differed over the basic design cycle. The students reported highest usage of systematic methods for analysis, evaluation and decision-making. Moreover, we also found that their method mindset influenced their use of systematic methods for different design activities. Our results also extend Andreasen's initial ideas about the underlying elements of a method mindset. With respect to forming a method mindset, Andreasen recognized practical and theoretical knowledge as prerequisites to use a method effectively. The mediation analyses showed that preference for systematic methods mediates the effect of knowledge on method usage for all but one activity in the basic design cycle.

From an educational perspective, our results point to new areas of interest for method teaching. Given that a student's method mindset greatly affects his or her method usage when designing, design education needs to go beyond the procedural aspects of method usage. It also needs to embrace how to develop a deeper understanding and appreciation for specific methods if design educators wish to promote specific work practices among their students. In doing so, the didactic dimension of asking students to 'follow' or 'use' a specific method only partly determines students' knowledge and preference about a method and its usefulness. In facilitating the formation of a method mindset, design educators also need to support design students in reflecting on their use of and preference for different methods. Such reflections do not occur by following a method once or twice but through multiple encounters where students are provided the opportunity to reflect and compare both the benefits and limitations different methods bring to design. We therefore hope to see more studies on the role of methods in design, and the role of design educators in promoting specific work practices for design.

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