DISCURSIVE VS. INTUITIVE - AN EXPERIMENTAL STUDY TO FACILITATE THE USE OF DESIGN CATALOGUES

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Abstract

Though shown to be of support to the designer, design method acceptance is still an issue to the design society today. Requirements and concepts in general derived from fundamental learning principles have been developed to enhance learning. This study is an experimental study to collect impressions about design method acceptance based on predefined criteria for facilitated use of design catalogues. Two workshops in sequence were conducted with students of advanced integrated product development courses to teach and train them in design catalogues. The control group applied twice a discursive solution finding process with design catalogues whereas the test group first worked intuitively with the brainstorming method and just in the second stage with a discursive solution finding process. Results have shown differences in the perception of both groups and revealed an improved method acceptance for groups who worked discursively twice. The groups working intuitively first and then discursively claimed that the design catalogues rather restricted their creativity but were considered useful as an additional tool. Implications for enhancing the learning experience could be deduced.

Keywords: Design learning, Education, Integrated product development, Human behaviour in design, Training

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Please cite this paper as:
Surnames, Initials: *Title of paper*. In: Proceedings of the 21st International Conference on Engineering Design (ICED17), Vol. 9: Design Education, Vancouver, Canada, 21.-25.08.2017.

1 INTRODUCTION

The effectiveness of design methods has been demonstrated in case studies (Eilmus et al., 2012). Although data illustrate that financial savings can be made (Eilmus et al., 2012) and that the savings can be extended to other resources, like time, proving that the use of design methods leads to improved performance is challenging (Badke-Schaub et al., 2011). Research has demonstrated a "missing link" in the transfer of design methods from academia to industry (Wallace, 2011). Reasons for this gap include organisational issues, such as design methods lacking adaptation to organisational structures (Geis et al., 2008), and educational challenges, such as inadequate training (Jänsch et al., 2004). These lead to barriers in design method acceptance and therefore their use.

Even though various methods have been developed (Gebhardt et al., 2016; Beckmann et al., 2016) to motivate and facilitate the active implementation of design methods, how to facilitate or quicken the process of learning specific product development design methods is still of interest to design science. The underlying idea is to develop practical guidelines to increase acceptance and foster efficient use of design methods.

Although there are several indicators of design method acceptance, this study considers the fundamental learning process as the key to formally enabling designers to use a method.

This study illustrates two approaches to introducing design catalogues (Figure 1) to product development students in an experimental study as future designers and method transporters. According to VDI 2222 (1982), design catalogues are systematically organised information stores. Different types exist, such as object and solution catalogues. They include solutions to the realisation of functions and thus support the designer in the solution finding process. Graphic illustrations, such as sketches, are included and further enriched by formulas and examples.

Lecturers of the course Advanced Product Development at the research institute were interviewed about student learning about engineering design catalogues, produced by Roth (2001). The interviews revealed that the degree of abstraction of the catalogues is perceived to be too high, the volume of information too great (especially for a short time period), and the visual depictions are not exciting enough. This experiment is considered to be helpful for a situation in industry as similar conditions exist, such as introduction of a new, abstract design method into existing daily routines with a lot of information and accompanied changes to be learned in a short amount of time, though learning motivation levels may vary between engineers in industry and university students.

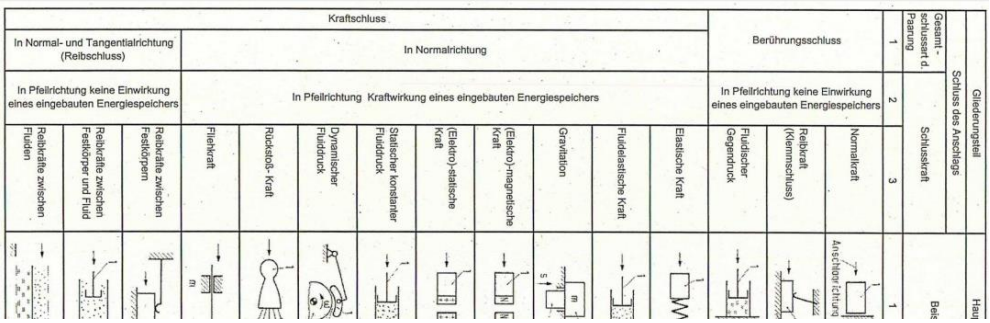


Figure 1. Excerpt from engineering design catalogues, from Roth (1994)

This experiment is conducted using two groups and two solution finding approaches: intuitive solution finding, resulting from spontaneous ideas; and a discursive approach based on a systematic procedure to finding solutions using a step-by-step process (Pahl, Beitz 1996). Through a two-stage process, the control group was given the task of solving two engineering design problems using the discursive approach and design catalogues in both stages; the other group was asked to solve the first engineering task using an intuitive solution finding approach then in the second stage using only the discursive approach. The effects on student perception and attitudes are analysed to get a more precise understanding of the term acceptance.

There are various parameters affecting the acceptance of design methods. Several approaches have been developed to enhance learning, such as supporting the designer in the process of solution finding with recommendations on the actions possible and argumentations (Jänsch et al., 2006). This study has primarily focused on the facilitation and speeding up of the learning process. The findings of this study

help to foster understanding of the conditions under which the learning process, using design catalogues, is facilitated. The study began with the hypothesis that there are significant variables in knowledge acquisition that increase acceptance of design methods. A key initial assumption about the control group was that acceptance will rise through better understanding of the design catalogues which will occur through repeated application of the method. The second assumption was that students who worked intuitively first would need to find solutions and would therefore accept design catalogues in their second stage after experiencing a lack. Challenges were identified and synthesized from the literature then enriched with the industry interviews of Beckmann et al. (2014) to illustrate the term acceptance. Requirements and shortcomings include lack of adaptability to the designer and the organisation, abstract representation of the design method, and the huge effort required to understand and apply the method. More specifically, the study of Beckmann et al. (2014) revealed among others that:

1. The development of a solution needs to be efficient and therefore support the designer well
2. Cognitive overload occurs due to the perceived complexity of the method and its application
3. Efficient method use is influenced by simplicity and intuitiveness of use
4. Methods are not relevant to daily routines
5. Descriptions of methods are poor.

These challenges are turned into the following associated learning goals:

1. The presented method supported me well while developing a solution
2. The methodical approach was easy to understand
3. The methodical approach was easy to apply
4. The methodical/intuitive approach is easy to remember/repeat
5. The material provided supported me well during application of the method.

Items 1-3 can be directly inferred from the challenges. Item 4 was formulated to respond to the two dimensions of lacking relevance to daily routines: working conditions allow application only under limited conditions or the method itself is not flexible enough; and the method user is not familiar enough with the method to recognise opportunities for its use immediately. Therefore, the associated goal focuses on remembering and being able to repeat the application. This innovative and original study aims to contribute to experimental evaluation of methods in the context of method validation.

2 RESEARCH METHOD

2.1 Study objectives and preparations

The main goal of this study was to find perceptual differences to enhance understanding of design methods and ease initial negative impressions of working out solutions via different approaches. Conditions for an improved learning experience will be deduced. The need to keep all conditions the same, manipulating just one variable for causal analysis, required an experimental study that qualitatively explores the boundary conditions required for improved method transfer during training. Besides literature research, an experimental study was developed, based on the fundamental theories illustrated by Field and Hole (2011) and enriched by the collection and evaluation of feedback. A control group and an experimental group were created. These groups were treated differently in a two-phase experiment, which included continuous and timely collection of relevant feedback. The control group used a discursive method in both exercise phases while the experimental group used an intuitive approach in the first phase and a discursive one in the second. Students undertaking a Masters of Product Development who attend the Advanced Product Development course were asked to participate in this study. These students were chosen based on their homogenous background knowledge of design methods. Though some students have more experience due to thesis work with the topics, the experience was considered as having only a minor influence on the results. General background information on the participants can be found in Table 1.

Table 1. Characteristics of the experiment participants

Prior knowledge on design catalogues		Sources of prior knowledge on design catalogues	Average age	Gender	
Yes	No			Female	Male
36,7 %	63,3%	• Lectures and projects at university • Internship	24,5 years	10 %	90 %

The Advanced Product Development course aims to strengthen student skills and deepen their knowledge in various fields of modern product development. General concepts for group mediation, project management and requirements analysis are presented and complemented by specific technical methods, such as design for variety and the development of modular product families, risk management and probabilistic approaches.
Two researchers accompanied the study and three tutors were responsible for giving instructions, mediating the group and collecting data during the experimental group exercises. Using a special sheet, data were collected on the group (e.g. size and problem solving method, i.e. intuitive or discursive), the groups performances as teams, and their procedure used to solve the task.
For each of the groups and the two exercise sessions, surveys were prepared for written evaluation of first impressions, reflections about good and challenging aspects of the solution finding process, and biographical data. The survey allowed for evaluation on a Likert scale and open answers. Questions for oral feedback were also prepared and focused on the challenges experienced and helpful elements during the solution process.

2.2 Study design and intervention

Several changes were made to the classic approach used to teach students design catalogues for years. The changes were particularly focussed on the exercise. Instead of only one exercise with engineering design catalogues after a short lecture on the topic, two exercise stages were carried out. In the classic approach, after the group exercise phase, including a presentation and discussion of solutions, students are introduced to how a design catalogue can be developed. In the classic approach, students then try to develop one in a team.
The new experimental study design (Figure 2) contained various elements of active participation and evaluation. Students were asked at the beginning and end of the experiment to show their level of knowledge of design catalogues and their ability to use them in a 2D diagram. As in the classic approach, the experiment started with a lecture on solution finding methods (conventional, intuitive and discursive, as in Feldhusen et al. (2013)). Students were then asked to think about requirements for information storage. Different forms of engineering catalogues, object catalogues, operation catalogues, solution catalogues and solution collections according to VDI 2222 (1982) were introduced to the students. This was followed by workshop I, during which students were asked sketch the functionality of a nail gun, according to requirements such as nail speed and ergonomics. Students worked in groups of average 5 for approximately 30 minutes, were provided the lecture slides, the task description, and, depending on whether they worked intuitively or discursively in the first stage, provided with several engineering design catalogues and the general procedure for working with design catalogues according to Roth (2001). Presentation of their solution to the class and discussion was required. Researchers and tutors were available for questions and commented on the solutions presented. In workshop I, 3 groups accomplished this task using the discursive approach and engineering design catalogues (Group A); the other 3 groups worked on the same task using the intuitive approach (Group B).
The second workshop task was to design a kiteboard with requirements changing operating modes. Students worked in the same groups as in workshop I. The groups working with the discursive method in workshop I used it again. Group B, using the intuitive approach in workshop I, were now provided with design catalogues to solve the task using a discursive approach. A within-subject design was chosen to enable comparison of the two approaches. After 30 minutes of group work, the teams presented their solutions to others and received feedback. Finally, a short summary was given on how to develop a design catalogue.

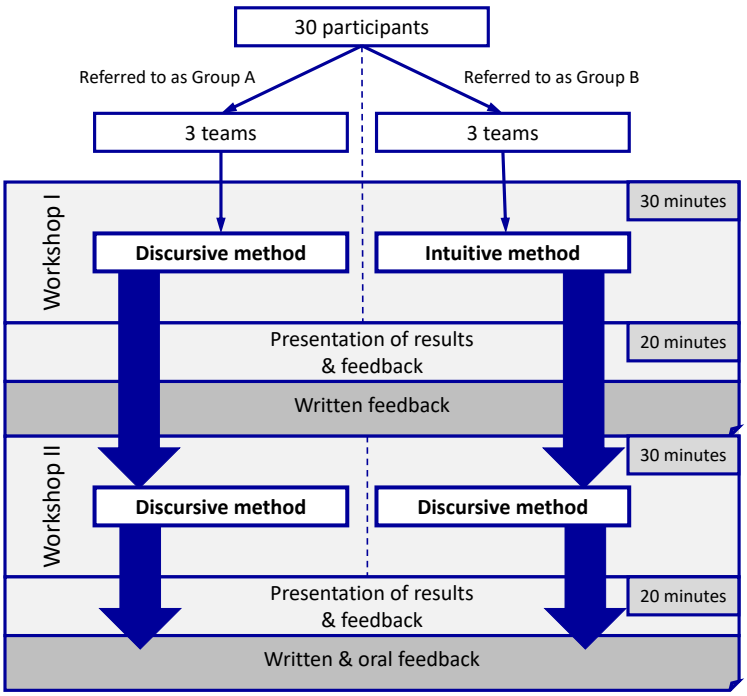


Figure 2. Study design and data collection

2.3 Data collection

Quantitative and qualitative data were collected with the help of different resources. The first pillar on which the study results are based is student feedback, as they were a crucial stakeholder in the study. Written feedback was collected from students three times and enriched with their oral feedback. The scope of interest varied slightly from group to group in the written feedback, which referred to the solution finding processes. Oral feedback questions and general evaluation of the lecture were the same for all students. The first survey was distributed after workshop I to assess the perceptions and attitudes of students after their first group exercise. The second survey was provided to students to assess their experiences in the second stage after workshop II. Oral feedback was collected at the end of workshop II to complement the written feedback. A final survey was distributed to evaluate the lecture overall.
The second pillar for data collection is the tutors who had observed and documented the group processes and who gave oral feedback to the researcher at the end of the tutorial. This was elaborated with oral feedback from the second researcher involved in the course. In total, 30 students participated in the experiment, some of which had to leave the course before the end due to clashes in their timetable which led to minor fluctuations in the team size.
Collected data were analysed by hand and using excel sheets. Qualitative data collected, as in Table 1, were weighted, summarised, and the average was taken and normalised to the number of participants. The items in Table 2 are defined as influencing acceptance and therefore analysed. Answers to open questions were categorised manually on the basis of existing schemes in literature, such as inappropriate representation (Badke-Schaub et al., 2011), and were extended and detailed where necessary. All statistical analyses described above were performed using Microsoft Excel.

2.4 Outcomes

The basic structure of the surveys on workshops I and II were as follows. A description of the study was given. Informed consent was required and to retain anonymity, students were asked to develop a code. This code was used to map the opinions and attitude changes of students from stage one in workshop I to stage two in workshop II. Students were asked about their prior knowledge of engineering design catalogues. They ranked several elements of the course using to a Likert scale. The lecture, quality of the solution, ease of understanding of the method, and confidence levels during application of the method were evaluated. Feedback on difficulties and helpful elements was collected; see Table 2 for examples. Questions on how to improve the lecture, the method used, and the conditions of the group process were asked. The questionnaire ended with biographical data.

The tutors responsible for collecting data were trained and supervised by the principal investigator on possible difficulties of students during the group exercise and how to document the group processes during the workshops. The documentation sheet for the group exercises was necessary to note what the group was doing (e.g. how the team proceeds, which material they are using, when problems occur, and what help is given by tutors or researchers), the prevailing working atmosphere (e.g. group dynamics), and work phases (e.g. discussion phase, idea generation phase), as well as special incidents (e.g. disturbances). Input required, expressed in terms of questions to the supervisors and respective answers, was also noted.

Table 2. Example of collected data

	1: Completely agree (5)	2: Agree to a great deal (4)	3: Moderately agree (3)	4: Hardly agree (2)	5: Disagree completely (1)	0: I do not know or not applicable (0)
The presented method supported me well while developing a solution. (1)	☐	☐	☐	☐	☐	☐
The design catalogues and the methodical approach/intuitive approach were/was easy to understand. (2)	☐	☐	☐	☐	☐	☐
The design catalogues and the methodical approach/intuitive approach were/was easy to apply. (3)	☐	☐	☐	☐	☐	☐
The design catalogues and the methodical approach/intuitive approach are/is easy to remember/repeat. (4)	☐	☐	☐	☐	☐	☐
The material provided supported me well during the application of the method. (5)	☐	☐	☐	☐	☐	☐

3 RESULTS

The main finding is that the sequence of teaching students engineering design catalogues (discursive-discursive and intuitive-discursive) makes a difference to perception. Students who repeatedly worked with design catalogues in the first stage confirmed that they experienced easier use in the second stage. The groups who first worked intuitively and then discursively revealed different opinions. While some found the catalogues useful, other students felt that their thinking processes were limited in the second stage as all solutions are presented in the engineering design catalogue. The approaches to familiarising students with design catalogues suggest that there are differences in design method acceptance according to the sequence and type of methods used during the learning process.

3.1 Qualitative findings from feedback on the first stage

Feedback revealed that the two groups had different needs. Data collected in the first stage of the experiment from Group A illustrate difficulties in getting an overview, finding the right catalogue and matching ideas to working principles. The students found it difficult to match partial solutions and know that the solution sought was definitely in the catalogue. This situation and having many solutions at hand (which was seen as an incentive to take any offered solution) was perceived to restrict creativity. Lacking exercise contributes to the feeling of being overwhelmed by the amount and abstract form of solutions presented. The amount of solutions was also considered positively, as they helped inspire and do not force the designer to come up with solutions when they cannot think of any. In this case, the catalogues were said to save time. The comparison of principles in the catalogues, personal experience, and the group discussions were also considered supportive while solving the task.
The students mentioned that getting familiar with the catalogue was time-consuming. Due to this and the fact that an intuitive approach was helpful and faster, an intuitive approach was followed by all teams

in Group A, though they were instructed to work discursively. The design catalogues were not used consistently.
Group A required step-by-step instructions on how to use the catalogues to find solutions, more examples and explanations of their application. The state-of-the-art technical solution and a digital tool to show solutions that met designer needs were demanded. Gaining practice through more applications was considered to be helpful to facilitate use of design catalogues. Students said they would favour the use of design catalogues for more complex and abstract tasks, tasks in which the design catalogues are indispensible, and when implementing a structured procedure to work towards a solution within the group. Design catalogues were said to be a useful additional help in cases where an overview of other solutions is required, insight to a specific principle is needed, existing ideas need improving, or time is limited. Otherwise, getting into the subject matter requires too much time and effort, and puts limitations on creative thinking processes.
Group B started with the intuitive solution finding process and mentioned difficulties in finding unusual concepts, keeping track of all requirements, organising their teamwork, and structuring their thoughts and technical solutions. More time, clear goal setting, a group leader, a known team with diverse technical backgrounds, and clear procedural instructions were demanded to improve solution finding. Getting lost in details was also mentioned as contributing to making the process more difficult. A clearer method to get more quickly to solutions was demanded. The catalogue was considered to be helpful for graphics and giving examples. For more thorough solutions, there would be a higher need to use the design catalogues, but for quick and easy solutions, the intuitive approach is preferred. More practice was demanded. Some students also mentioned that they felt a lack of design catalogues, special templates and information storage. Insecurity about the quality of the solutions also existed. Freedom in the working process and background knowledge were said to be useful when solving the task.

3.2 Qualitative findings from feedback on the second stage

Feedback from Group A after the second stage of workshop II demonstrates that teamwork and discussion helped to develop a solution. The principles in the catalogue were considered to support the process. Nevertheless, students experienced problems, such as a lack of an overview, the degree of complexity of the design catalogues, and matching what is needed for the task to the given solutions. Students were motivated to use the catalogues for specific functions and claimed that the catalogues were too simple and general. Several Group A students said that they did not use the catalogues consistently as intuitive solution finding also works and it works faster. Students mentioned that they found what they were looking for more quickly than in the first round and felt more confident in using them. Design catalogues are useful in conditions of not being able to find what is needed or more solutions than those at hand are required. It was considered to be an additional tool for support and provided the safety that all possibilities are considered.
Feedback on the second stage from Group B revealed that teamwork, discussions and the design catalogue graphics were helpful. Students demanded more exercises to become familiar with the catalogues. Lacking overview was mentioned by several students as making the catalogues demanding to handle. Challenges also occurred during the transfer of general solutions from the catalogue to their specific problem. Matching requirements to working principles and creating complete solutions from single principles were perceived as difficult. Problems during group decision-making were mentioned to be demanding, too. Students said that a procedure for how to work with engineering design catalogues is missing. The fact that there are more solutions in the catalogue than found during brainstorming was overwhelming, requiring a better introduction; more examples of method use and for the procedural use of the design catalogues were perceived to be helpful at the same time.
In comparison to their first session, students claimed that the process from having found an idea to developing the idea was facilitated. The strategic procedure and the fact that solutions existed saved time by looking at the principles and choosing were mentioned. Students also mentioned that the design catalogues narrowed and restricted their free ideas that had been generated in brainstorming. Hints for lay out were also proposed by students, referring to having more pictures and less text, making the pictures more intuitive and graphically aesthetic. Support for choosing, like a decision tree, was demanded. Another requirement to enhance design catalogue use was the need for a routine by working more with them. The conditions under which the use of design catalogues would be favoured were complex tasks, and that the designer is trained and has experience using them. Intuitive solution finding was considered to generate a quick solution. It is important to mention that in the first workshop, groups

who were advised to work discursively performed an intuitive search first. Groups who performed intuitive solution finding in accordance with their task were observed to find solutions on their own first and then share them with the group.

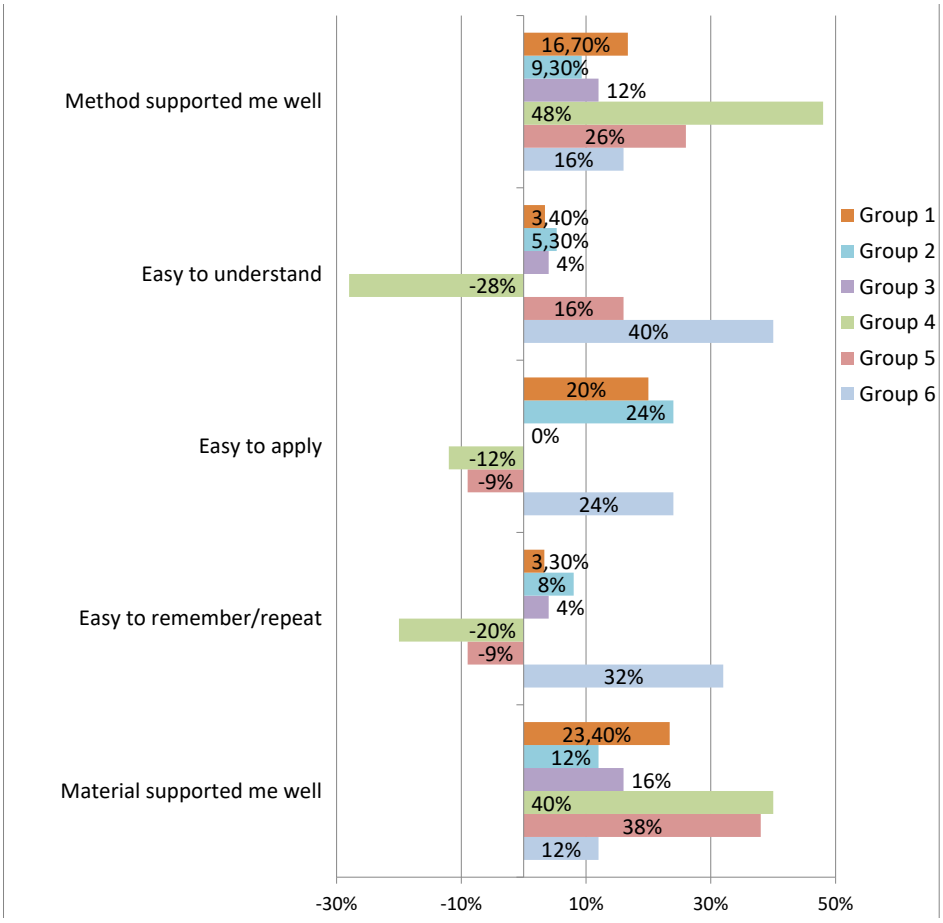
3.3 Summarised quantitative data

Quantitative data can be taken from Tables 3 and 4, which contain feedback after workshops I (WSI) and II (WSII) and the respective changes. The items are stated in a detailed way in Table 2. Weights from 5 (I completely agree; equal to 100%) to 0 (I do not know or not applicable; equal to 0 %) were taken and normalised for each item.

Table 3. Weighted average percentages out of 100% for items presented in Table 2

	Groups with discursive workshop first						Groups with intuitive workshop first					
	1		2		3		4		5		6	
	WSI	WSII	WSI	WSII	WSI	WSII	WSI	WSII	WSI	WSII	WSI	WSII
Method supported me well (1)	43.3%	60%	64%	73.3%	44%	56%	12%	60%	44%	70%	32%	48%
Easy to understand (2)	56.6%	60%	68%	73.3%	68%	72%	84%	56%	64%	80%	28%	68%
Easy to apply (3)	43.3%	63.3%	56%	80%	64%	64%	68%	56%	84%	75%	40%	64%
Easy to remember/ repeat (4)	53.3%	56.6%	72%	80%	60%	64%	80%	60%	84%	75%	36%	68%
Material supported me well (5)	46.6%	70%	68%	80%	40%	56%	16%	56%	32%	70%	40%	52%

Table 4. Changes from workshop I to workshop II for each team



3.4 Student self-evaluation

The experiment finished with self-evaluation, which was also carried out prior to the experiment (Figure 3). At the beginning of the lecture, the students were asked to evaluate their knowledge of engineering design catalogues (the vertical axis). The horizontal axis required self-assessment of their level of use. The second evaluation after both workshops was carried out with different colours to contrast the ones in the beginning (red) and the group (A, B) perceptions after different treatments in the first workshop (Group A, green; Group B, yellow). The picture illustrates that Group A assesses themselves higher in knowledge and use than Group B. Overall, the change from red dots to green and yellow dots can be interpreted as a positive increase in both axes.

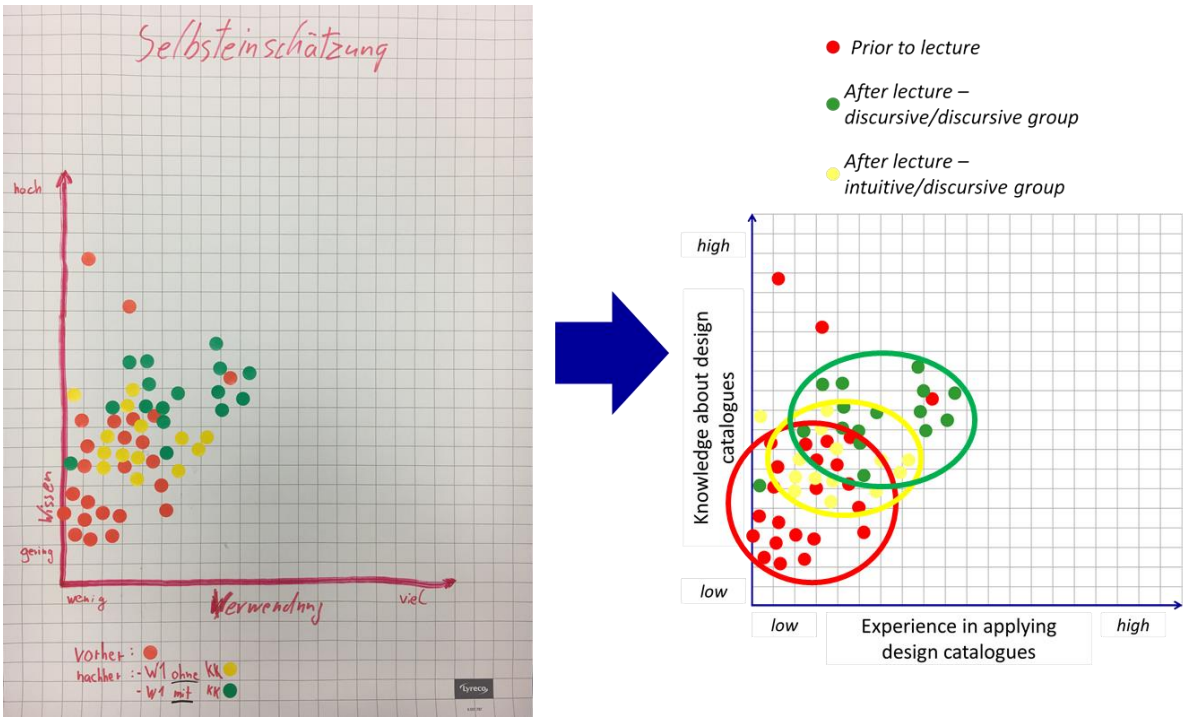


Figure 3. Self-evaluation of students prior to (red) and after the workshop (Group A, green; Group B, yellow)

4 DISCUSSION

This study has revealed the intricacies of reactions by students to different sequences of solution finding in teaching design catalogues. Regarding the initial assumption (see introduction), the control group turned out to have increased facilitation, thus acceptance, of design catalogues when they used them a second time to solve a similar task. This is mainly because more practice was gained and the time required to get an overview has already been spent in the first experiment stage. The assumption that students who work intuitively first, experience a lack of design catalogues, and therefore would accept design catalogues, could not be generally supported in this study. Students considered the catalogues as an additional tool or support, with the constraint that they can restrict creativity in finding solutions. The conditions named for facilitated use were that design catalogues would be preferred for more complex tasks and the intuitive approach was favoured for quick solutions.

After the second workshop, all groups perception that the method supports the designer improved, as well as their understanding of the subject matter and supporting material. The ease of application and repetition of the method decreased for two intuitive teams and stayed the same for one discursive team in workshop I; ease of understanding decreased in one intuitive team. Therefore, the sequence in which students are familiarised with a design method influences their perceptions and acceptance, depending on the above criteria. Students could experience the same method twice to develop a routine or they could experience different methods to assess their benefits, shortcomings and the conditions under which they would prefer one or the other, thus strengthening their methodical decision competences. Awareness of the goal of sequential intervention is therefore recommended to determine which one should be first. Taking into account the required level and structure of guidance is also recommended.

Whereas groups working with discursive methods seemed to be more schematic in their approach, the groups that performed the intuitive approach first mentioned that structuring the team (through a leader for instance) and technical contents would help. Though groups demanded support on the procedure, it was observed that they did not use the procedural steps of VDI 2222 (1982) at any point in time. It is also worth mentioning that both Groups experienced similar problems with the discursive approach. The difference lies in the reflections of the students, such as being constrained in creativity. For general purposes, trying the intuitive approach first then proceeding with a discursive approach is recommended. In this study, the intuitive approach used was brainstorming and the discursive approach was the use of design catalogues, but there are many more to test for future research.

The limitations of this study are technical and organisational. One technical limitation is that the findings are based on this one study and can only be generalised to highly similar contexts. The findings are relevant to learning situations of similar contexts, with limited amounts of time, methods with high degree of abstractness, and teamwork. An organisational limitation is the minor fluctuations during group work that resulted from students leaving the course due to other obligations. These fluctuations were considered to be negligible in the evaluation of feedback. There was a misunderstanding about the task in workshop I that took a while to discover and convey the correct information. The comments referring to this were taken into account and filtered for their relevance to basic assumptions. Time lost was mitigated by allowing additional time to work on the task.

Future work should focus on how to facilitate the intuitive method and deduct training recommendations. It is important to realise that the sequence and frequency of how often a method is used plays an important role in design method acceptance. Based on these findings, important projects can benefit from teams who have higher acceptance of design methods.

REFERENCES

Badke-Schaub P, Daalhuizen J, Roozenburg N. (2011), "Towards a Designer Centred Methodology: Descriptive Considerations and Prescriptive Reflections", In: Birkhofer H (Ed.), *The Future of Design Methodology,* Springer-Verlag London Limited; pp. 181-197.

Beckmann G, Gebhardt N, Bahns T, Krause D. (2016), "Approach to transfer methods for developing modular product families into practice", *International Design Conference,* Design 2016, Dubrovnik 2016. pp. 1185-1194.

Beckmann G, Gebhardt N, Krause D. (2014), "*Transfer of Methods for Modular Product Families into Practice - An Interview Study*", International Design Conference, Design 2014, Dubrovnik 2014, pp. 121-130.

Eilmus S, Gebhardt N, Rettberg R, Krause D., (2012), "Evaluating a methodical approach for developing modular product families in industrial case studies", *International Design Conference*, Design 2012, Dubrovnik 2012, pp. 837-846.

Feldhusen, J, Grote, K.-H. (Ed.) (2013), *Pahl/Beitz Konstruktionslehre. Methoden und Anwendung erfolgreicher Produktentwicklung*, Springer Verlag

Field, A., Hole, Graham (2011), *How to Design and Report Experiments*, Sage, London.

Gebhardt, N, Krause, D. (2016), "A method for designing visualisations as product development tools", *International Design Conference,* Design 2016, Dubrovnik 2016.

Geis C, Bierhals R, Schuster I, Badke-Schaub P, Birkhofer H. (2008), "Methods in practice – a study on requirements for development and transfer of design methods". *International Design Conference,* Design 2008, Dubrovnik 2008.

Jänsch J, Weiss S, Birkhofer H. (2006), "*Towards a design method-suitable, computer-supported learning environment*", International Design Conference, Design 2006, Dubrovnik 2006.

Jänsch, J., Birkhofer, H. (2004), "The gap between learning and applying design methods", *International Design Conference,* Design 2004, Dubrovnik 2004.

Roth, K. (2001), *Konstruieren mit Konstruktionskatalogen, Band II Konstruktionskataloge*, Springer Verlag.

Roth, K. (1994), *Konstruieren mit Konstruktionskatalogen, Band II Konstruktionskataloge*, Springer Verlag.

Pahl G, Beitz W (1996), *Engineering Design. A Systematic Approach,* Springer-Verlag, London.

VDI-Richtlinie (1982), *VDI 2222 Blatt 2. Konstruktionsmethodik; Erstellung und Anwendung von Konstruktionskatalogen,* Beuth Verlag, Berlin and Cologne.

Wallace K. (2011), "Transferring Design Methods into Practice", In: Birkhofer (Ed.), *The Future of Design Methodology*, Springer-Verlag, London; pp. 239-248.