



TEACHING DESIGN METHODS WITH THE INTERACTIVE 'METHODOS' PORTAL

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1. Introduction

Nowadays, engineers have to face more and more challenges caused by reduced product life cycle times which also shorten the development time for new products. As a result of the strong competition at the global markets, companies are forced to innovate, e.g. inventive products or new product service systems. To cope with these challenges, solving engineering tasks is based on the use of design methods and a methodical approach [Gausemeier 2001], [Ponn and Lindemann 2011]. Graner [2013] could show that an integrated method use can strongly support the new product development. In more than 400 development projects, the intensive method use was correlated to the success of the new product. Especially the intensive and continuous application of methods in early development phases was identified as an important factor, e.g. Total Cost of Ownership or Design for Manufacturing/Assembly. However, in most cases design methods are not applied constantly and intensively in industry as proposed. There are various deficits of design methods like their complexity as well as often their high level of abstraction [Birkhofer et al. 2005], [Jänsch 2007]. Another problem of the application in practice is the time needed for implementing design methods in existing processes [Wallace 2011]. In some cases, the starting effort is not worth the benefits of the method use afterwards. Furthermore, many engineers complain about the missing possibility of adapting methods to their situation. In general, the engineers themselves and their competencies as well as experiences play an important role when selecting or using a method [Birkhofer et al. 2002], [Badke-Schaub et al. 2011].

The aim of this paper is to introduce a newly developed interactive method portal which targets at students, the future engineers. The idea is to improve the design method education within their studies, as this is an easier starting point for innovative ways. The future engineers carry their knowledge into the companies which benefit from it in the long term. Section 2 motivates this approach more detailed and gives an overview of existing ways to teach methods with the focus on web-based solutions.

The following section, section 3, describes the new portal which provides some interactive features that permit sharing experiences between the users. On the one hand, this means an interaction among students, but on the other hand an interaction between students and teachers. The last-mentioned way allows the teacher to adapt the content of teaching to the users' (students') needs. An evaluation presented in section 3.3 demonstrates first results concerning the new portal and its introduction into an exemplary design engineering course. The limitations indicated by these results and future work to do like the transfer to the industry will be spotlighted in section 4. Section 5 concludes the paper.

2. Different media in method education

The first question to answer is: why did we start with design education to introduce methods and why

did we not start with industry? The reason is as follows: the results of the empirical study 'MuPro-KMU' (methodical support for small and medium-sized enterprises) [Bavendiek et al. 2014] conducted by the TU Braunschweig in the region of Lower Saxony signalise that engineers in the industry mainly use methods they know from their education, respectively from their studies. Therefore, we identified the education, e.g. at a university, as the principal source of design methods knowledge. Thus, in the following we will mainly focus on making available design methods for engineering students as the future engineers in practice.

But what does teaching of design methods actually look like? For the purpose of answering this questions, one can find the results of a German survey named 'acatech Studie', which was performed among 46 professors from 41 different German universities and 5 universities of applied sciences in 2011 [Albers et al. 2012]. The results show that the main format in design education in Germany consists of lectures (40 %) and according to 74 % of the professors this will be unchanged in the future. It can be expected that this is also transferable to the design methods teaching in particular, so the lecture format plays a relevant role subsequently. Assumed to be quite important and useful are team projects with the task to solve a design problem (currently 29 %) [Albers et al. 2012]. Within those projects, the method use can also be practiced; thus, they seem to be an adequate way for design method teaching. At the ETH Zurich, there is a 'Design and Technology Lab Zurich' where students of Mechanical Engineering can work in an interdisciplinary collaboration with industrial design students [Product Development Group Zurich]. In a smaller setting, we realise a similar project named 'design²' at our institute each year, in which students of industrial design and engineering work together on automotive tasks [Sanchez Ruelas et al. 2012]. There are some disadvantages of those projects, though. It is extensive and costly to perform such projects, and the target groups are relatively small. To make it effortable it is necessary to limitate the number of students, as a result our program is only available for a small group of students. So, as a traditional alternative, there is a lot of literature dealing with design methods, e.g. [Pahl et al. 2007], [Lindemann 2009]. Literature is often recommended to students, but focusing on the exams, those books are rarely used. A similar medium are lecture notes or slides like they are provided at almost every university. Here, you will find some examples with free access to the public via internet: Stanford (teaching purpose) [Breiter], [dschool] or Hanover (mainly for industry) [IPH]. As a further step towards the web-based learning and coupled with the technological progress, various portals with design methods were developed at the beginning of the 21st century. Some of them are mainly designed for the purpose of teaching, like 'CiDaD' [Ponn et al. 2005] or 'PinnGate' [Weiss 2006], some are not for teaching in the university context in particular, e.g. 'Wipro' [RWTH Aachen], 'MEPORT' [GfU Gesellschaft für Unternehmenslogistik mbH], 'GINA - Methodos' [Franke et al. 2003], 'MAP-Tool' [RPK - Universität Karlsruhe 2001] or 'Design Methoden Finder' [Nagel et al. 2010]. Most of those portals describe design methods in a structured way: the purpose, the proceeding to apply the method, strengths and weaknesses as well as further literature and tools to support the method use. WiPro also offers a modern layout and detailed selection options such as the size of the applying company, the expenditure of time or the demand to exchange information with outside persons or companies (open innovation). Portals like GINA - Methodos and MEPORT focus on the purpose to find an adequate method for the requested operation by using special basic operations. An application for mobile devices is also a new way to supply users with the information about methods that is required. The 'InnoFox' is such an application which was tested by students and proved to be good to support the method acquirement and method selection [Albers et al. 2014, 2015]. Another possibility to describe methods is the usage of short videos that explain the idea and the application of a method. The project 'dms - design is making sense' [dms ServiceDesign] provides an example in which eight videos were produced for methods used mainly in service design processes.

Figure 1 shows an extract of a table that lists several web-based and paper-based method collections such as the above-named, e.g. CiDaD or MEPORT. We rated the proposed method portals, books or further media (that grant free access or the access was allowed to us) regarding various criteria. We distinguished between formalities, e.g. the provided selection options and additional support, and content of the descriptions themselves. Due to the medium, the paper-based collections show weaknesses concerning the filter and search options. The possibility to exchange experiences via a chat or with the aid of comments or ratings is only realised by a few portals like WiPro. Using video tutorials

is not common within the method portals except for the above-mentioned project dms; but dms provides no further descriptions beside the video tutorials. So, we identified some deficits of the existing portals which we will address in the following section 3.

	Formalities			Content of method description										
	Filter criteria	Chat or forum	Search options	Strengths and Weaknesses	Similar methods	Pictures	Advices about realisation	Comments and rating	Literature	General description	Practical examples	Step by step procedure	Overview of tools	Video tutorials
paper-based method description and selection														
Name or Author														
IPH-methods	○	○	◐	●	○	◐	●	○	●	◐	◐	●	◐	○
Breiter (Stanford)	○	○	◐	○	○	◐	◐	○	○	◐	◐	◐	◐	○
Lindemann	○	○	○	◐	○	◐	●	○	●	◐	◐	●	●	○
web-based method description and selection														
Name or Author														
GINA - Methodos	◐	○	●	●	◐	○	●	○	●	●	●	●	○	○
CiDaD	◐	○	●	○	○	○	○	◐	◐	●	○	●	●	○
MEPORT	◐	○	●	●	◐	●	●	○	●	◐	◐	●	●	○
WiPro	●	◐	●	●	●	○	◐	◐	●	●	○	◐	○	○

Explanation:

- not considered
- ◐ little considered
- ◑ partly considered
- ◒ mostly considered
- completely considered

Figure 1. Extract of a rating table regarding various criteria of method descriptions and selections (references and the entire table can be requested from the authors)

Now, we found various ways to teach and to learn design methods and possible gaps to close. But how do students want to learn methods? During two team projects, we asked eight male undergraduate mechanical engineering students about their rating of the relevance of different requirements. We separated the requirements into four groups: the availability of method descriptions, their degree of complexity and their extent as well as the custom-designed flexibility or adaptability respectively (as presented in [Bavendiek et al. 2014]). The results were similar to those conducted with engineers in practice. The availability is the most important requirement, whereas the adaptability is least important to the students, which differs clearly from the practitioners' opinion. Within the requirement group availability of method descriptions, we found that the students favour the web-based access over the paper based access, but also over the access via a mobile application. As the engineers reflected this view as well, we decided to develop a web-based method database as a refresh and an extension of the existing GINA - Methodos database [Franke et al. 2003].

The deficits of the existing web-based portals that shall be addressed by the new one are the missing interactivity and the lack of focus on the method user and their team. The last-mentioned aspect is often pointed out, e.g. [Badke-Schaub et al. 2011]. The interactivity means sharing experiences and the possibility to discuss methods and their results. These aspects are often missing, so the learners cannot participate directly.

3. Methodos - An interactive method portal

In the following, the concept of the newly developed method database will be presented. When doing this, we will, on the one hand, focus on the methods' description with references to team aspects and competencies. On the other hand, we are going to demonstrate the different method selection options. The second part of this section will state the introduction process of the developed Methodos portal into one of our engineering design courses which is followed by the third part concerning an evaluation of both, the portal itself and the introduction process.

3.1 Concept

The Methodos portal is based on the existing GINA - Methodos database [Franke et al. 2003]. The idea was to add new functionalities which were found to be interesting for engineers in practice, but also for

students. Amongst others, these new functionalities are video tutorials and pictures as well as the possibility to comment on the methods and to rate them. The name Methodos was adopted from the old database to mark the continuance. The target group of the new Methodos primarily consists of students, though. That is because the results of the MuPro-KMU study reflected studies or education, respectively, as the first source of methods' knowledge. The idea is to present the portal from the beginning up to the end of studies. Apart from the usage within various engineering design courses, the aim is the application in team projects and other practical works by the students. In this way, the students are supposed to learn self-directedly, which might increase their motivation. As another attraction, we utilise several kinds of media and interactive features like a rating and comment function. These functions are well known from social networks and they support the exchange of experiences and the use of the portal in student groups. Additionally, the students can participate not only by commenting, but also by contributing their own examples and by discussing them with others, including the teacher [Bavendiek et al. 2014]. In the long-term, the students might use the Methodos portal also when already working as an engineer in practice.

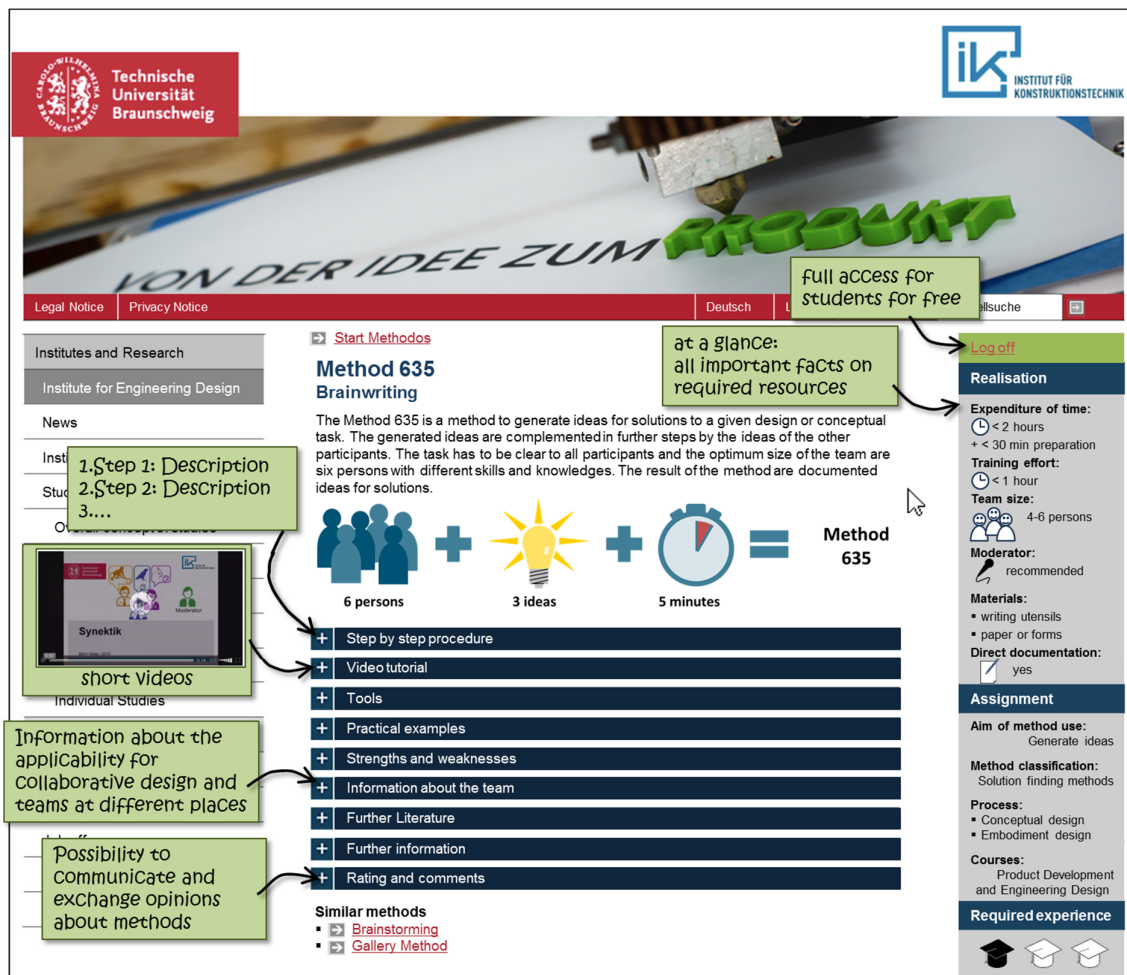


Figure 2. GUI of an exemplary method description when logged in as a student of the TU Braunschweig

Figure 2 presents the GUI of a typical method description. Firstly, the corporate design of the TU Braunschweig was chosen to demonstrate the membership. The portal's website is located at the institute's website under the category of 'Studies'. So, Methodos is easy to find for students even if they had not known about the portal before. As a student of the TU Braunschweig, the access is free and feasible with the normal web identification number of the TU Braunschweig.

Each method description starts with a short introduction or portrait that represents the idea and the goal of the method. Generally, this short text is completed by an image illustrating the procedure, the aim or a result of the method use. Below in the content area, various sections are arranged. The first of them is a step by step procedure which is presented as a numbered text for each single step. Optionally, we attached selected methods with a flow chart. Herein, the same or similar steps are illustrated in the same way to achieve a recognition value. The section 'video tutorial' provides short videos that explain the methods' application by using examples. The durations range from 3 to 7 minutes, depending on the method's degree of difficulty. The videos can be seen as additional material to illustrate a method. They are kept simple and usually, most information available within the method description is repeated in some form or another. We used some of the videos during lectures as well to introduce the corresponding method to the students.

Another part of the tools are forms or other templates to assist the method use, e.g. a template for the requirement list as an Excel sheet or as a pdf document. We also developed short instruction manuals for single methods which can be imagined like a step by step guidance. Generally, there are different tools provided, adapted to each method and its aim.

The next section consists of practical examples. These examples are, on the one hand, results or extracts from industry projects. On the other hand, students are able to contribute their own examples that were e.g. elaborated during a student project. In combination with the rating and commenting functionality, this is the main part of the interactivity of the Methodos portal. Students have the possibility to give feedback, so the teaching staff can adjust and continuously improve the content of teaching.

As one of the innovations, special information about team aspects is provided. The information helps to find adequate methods, e.g. if the team consists of interdisciplinary persons or the team members are located at different places. In addition to that, the suitability for heterogeneous teams is part of the information available. In this connection, heterogeneity firstly means different professional expertise and, secondly, hierarchic discrepancy. Finally, the experience required is also indicated with the three gradations: beginner, advanced and expert (Figure 2, bottom right corner) [Braun 2005]. Although we estimate this information less important to students – as they usually have the same background (mechanical engineering studies, similar age) – we wanted to test the details concerning the relevance and content of the given information.

On the right hand side of the method description, all important facts on the required resources are shown at a glance. With the aid of these, one can easily decide whether a method is suitable for the current situation or not. The section on the right, called assignments, indicates the aim of the method use, the method classification as well as the affiliation to a process phase within the product development process. Finally, the assignment to the engineering design courses is quoted.

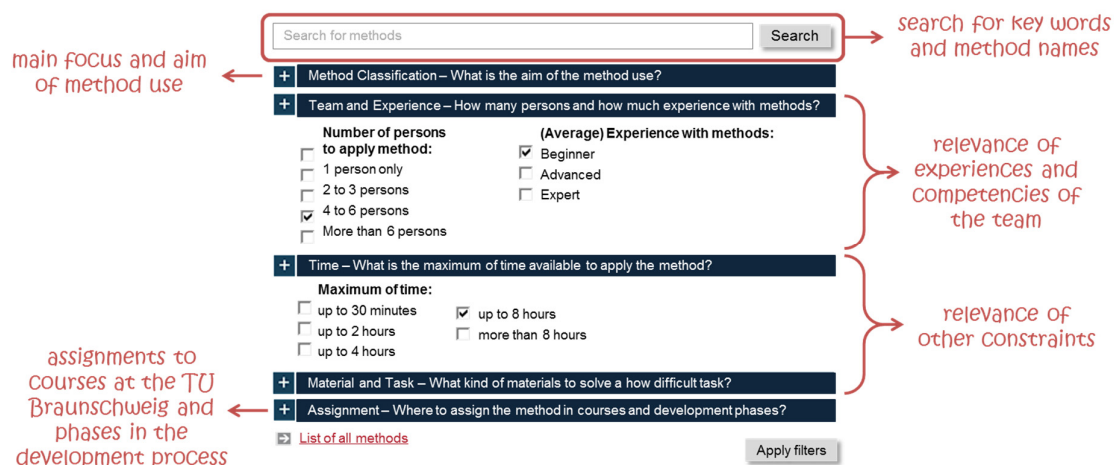


Figure 3. Different options to search for methods in Methodos

The last-mentioned description details can also be used to select a method. The different selection options are represented in Figure 3. At the top, the search for keywords is placed. Below, one can find

the mentioned aim of the method use, and at the bottom the phases in the development process and courses. In the middle of Figure 3, the options for the team and time restrictions can be seen. These options correspond to the information and scales indicated in the method description. The benefit of the criterion experience is that beginners will not receive difficult methods as a result that require a lot of experience. The idea not to ask for the favoured degree of difficulty of a method was chosen deliberately, because it seems obvious that easier methods are often more attractive in practice.

At last, the alphabetical list of all methods grants facilities when a general overview is requested.

3.2 Introduction

The above-described Methodos portal was introduced in one of the engineering design courses at the TU Braunschweig ('Product Development and Engineering Design') in the winter semester 2015/2016. The course is part of the bachelor studies Mechanical Engineering during the fifth semester and deals with product development and its process in general. Connected to the different phases of this process, various methods are introduced, e.g. Method 635 and the Gallery Method. Attached to the normal lectures, we propose a small team project and several exercise classes. We decided to utilise this course as the starting point to apply the described portal. The first reason was the comparatively high number of methods dealt within this course, the second reason was the manageable amount of students participating. Our intention was to test the usability of the portal, get feedback and, later on, integrate it to optimise the functionalities, the handling as well as the layout. Therefore, we needed a relatively small group at the beginning of the engineering studies.

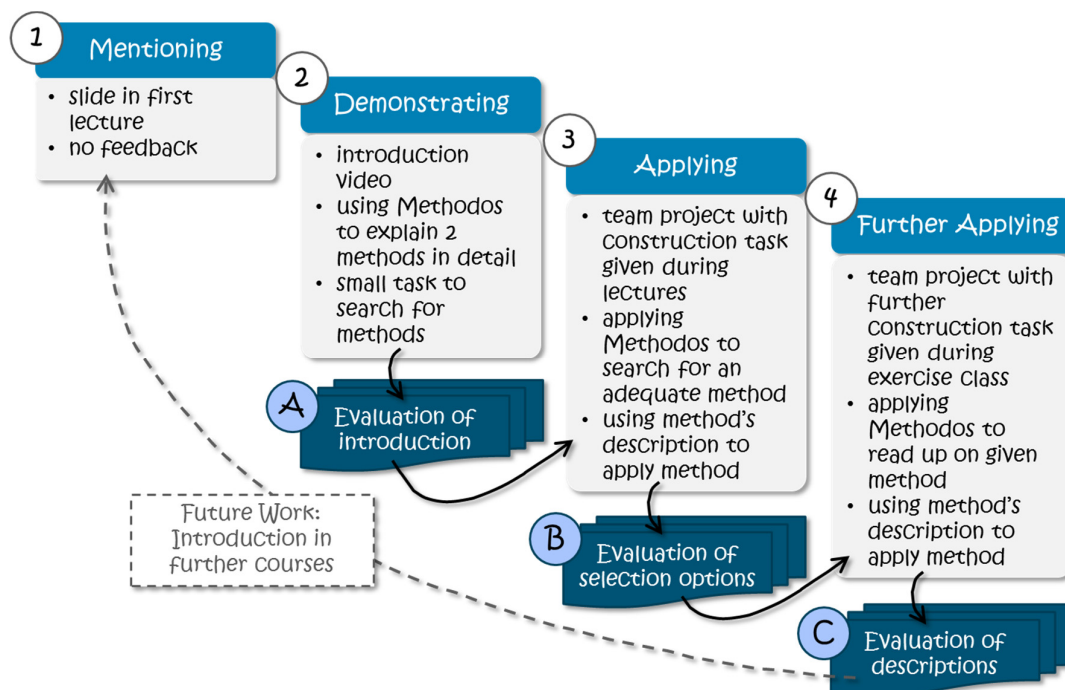


Figure 4. Four steps to introduce Methodos into an engineering design course

While planning the introduction, we established a four step approach starting with the first lecture of the course, see Figure 4. Within this lecture, the portal should be just mentioned on a slide and the teacher should tell the audience a little about it. The next step was demonstrating the functionalities of Methodos during a lecture. For this purpose, we produced a short, four-minute introduction video. The video showed the screen only, and during the lecture, the teacher explained what could be seen. The selection options and the description of single methods were the main focus of the video. Still, two methods (Gallery Method and Method 635) were presented via the Methodos portal as teaching content of this particular lecture instead of using the usual slides. Another method was taught with the aid of a short video which can be found on the portal in the section video tutorial. At the end of the lecture, a small

task was given to the students to select an adequate method for a given situation (number of team members, available time and rough description of the design task). The answers were requested via 'EduVote', an application to conduct short surveys during lectures. To evaluate the introduction as well as the portal itself, we used a questionnaire with sixteen questions and six categories (evaluation A). The answers were mostly a four-point scale (yes, rather yes, rather no, no), so it was easy for the students to recognise the scheme and to answer the questions quickly. This kind of evaluation was used after each of the following steps (step 2 - evaluation A, step 3 - evaluation B and step 4 - evaluation C), even though the number of questions varied as well as the type of questions.

The third step of the introduction process is the application of the database ('Applying'). In this step, the Methodos portal was used by the students within a team project during a lecture session. The students were given a simple design task which they were supposed to solve in a team of four to six persons in a time period of 40 minutes. Before they started, the teams were asked to search for an adequate method using the portal. Various kinds of material were available, such as flipcharts, big papers, markers, moderation cards etc. The teams chose different methods, e.g. Method 635 or Synectics, which they knew from the lectures. At the end of the lecture, the solutions were presented to the whole group and the evaluation B was handed out as described before.

The last step is a further application ('Further Applying'). This time, the students had to solve another design task in the framework of an exercise class. The method (Gallery Method) was prescribed and the focus was to read up on it in the Methodos portal. Besides the description and the step by step procedure, a video tutorial as well as information about the team and its competencies is available. The aim was to find out the important information for the students when learning a new method. Finally, another questionnaire was used to rate the important details of the method (evaluation C).

As shown in Figure 4, a possible next step in the future might be the introduction of Methodos in further courses of design education.

3.3 Evaluation

In the following, we will present the results of the evaluations conducted after each lecture as described above. Please note that we introduced the Methodos portal in only one of our design education courses in a beta stadium. The aim is to identify strengths and weaknesses to improve the usability of the portal subsequently.

Evaluation A: The results of our first evaluation show quite clearly that the 'Mentioning' during the first lecture was not successful. Only 19 % of the 42 attending students could remember the Methodos portal before passing through the second step, the 'Demonstrating'. As the number of participating students normally decreases from the first lectures to the following, we can assume that almost all students present in the second step of the introduction process had also attended the first one. Furthermore, about 93 % of the students rated demonstrating the Methodos portal during the lecture as helpful or rather helpful. 69 % of the respondents stated that, all in all, they found the introduction comprehensible and clear, about 28 % rated it as rather comprehensible and clear and only one person rated it negatively. Although 97 % thought they got all relevant information about the portal and its application, still one quarter estimated they did not know the whole of functionalities of the Methodos portal. Concerning the different media used to introduce the portal, the short video was rated best, since all students except one indicated it as a good overview. Showing two methods with the aid of the Methodos portal was evaluated to be helpful with a percentage of 90 % of the answering students, whereas 44 % did not appreciate the small task to search for a method. We assume that the task was not clear to the audience, or maybe the level of difficulty was too high. One person mentioned the first reason assumed as a problem. As a conclusion of the first evaluation, 23 % of the students would use Methodos for further projects (57 % probably), and all but one would recommend the portal to others.

Evaluation B: The focus of the second evaluation after the third, introducing step ('Applying') lay on the options to select a method. Primarily, we asked whether all information to apply the portal had been given before. Figure 5 shows, on the basis of the pattern of the bars, that mainly all information was available before. Additionally, we found the use of Methodos to solve the given task in the context of the team project to be rather helpful. The relation between the two results mentioned can be observed in Figure 5.

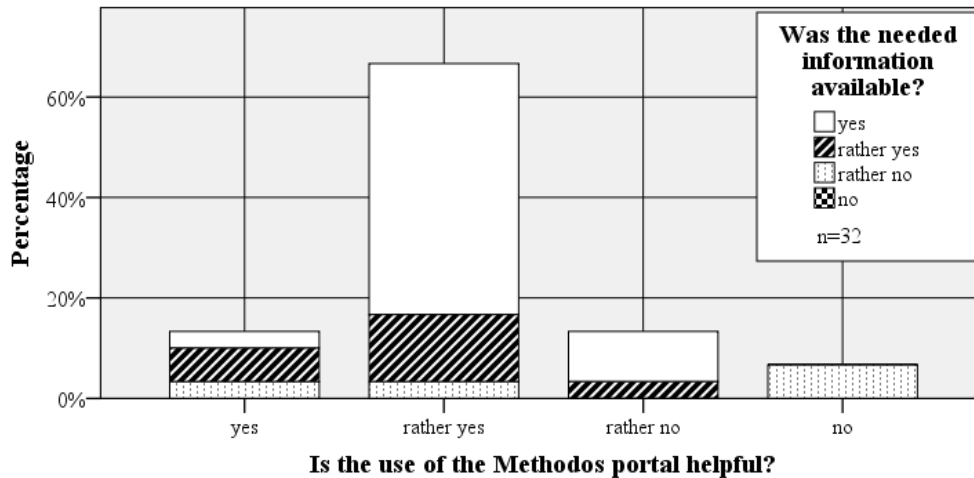


Figure 5. Results of step 3 during the introducing process: students (n=32) were asked if the Methodos portal is helpful to solve the given task (abscissa) and if any information needed was available before (pattern of bars)

Concerning the method selection options, 28 % of the 32 participating students stated they found the handling of these options easy, 56 % rather easy. The missing 16 % (5 students) referred to the handling of the buttons and bars as confusing, since you cannot see the query in total because of the closing question groups. However, the criteria themselves to filter the methods were mainly rated as understandable or rather understandable. Furthermore, we gave the participating students a query with different filter criteria to which they should name their expectations on the result of the query. We mainly found out that the students' expectations matched the search algorithm that was developed except for one filter criterion, namely the difficulty of the task. Here, the students were not sure about the graduations and their meanings, we suppose.

Finally, we asked them to rate the Methodos portal in total, using a grade from 1 (very good) to 6 (failed), referring to the German 6-point grading scale from school. Methodos received an average grade of 1.9 which can be assumed to be good.

Evaluation C: The third and last evaluation within the beta test stadium focused on the rating of the method's descriptions. We divided the method description into different parts, like the short introduction and the picture or the important facts of the realisation at the right marge. For each part, we asked the students to give a grade between 1 (very good) and 6 (failed) (again referring to the German 6-point grading scale from school). This time to rate the three criteria: relevance, layout and comprehensibility. We calculated an average grade for each criterion and also a total average grade for each part of the description. Generally, the description was graded as good. The best part scored 1.65 the worst 2.33 which is still categorised 'good'. The students liked best the step by step procedure and the important facts of the realisation at a glance. The relevance and comprehensibility were both rated very good (1.4 to 1.5), the layout good (1.9). As assumed before, the information about the team was not estimated very relevant (2.4) by the students compared to the other parts. The videos and the required experience were also identified as less relevant, but the layout and comprehensibility suited most of the students. The layout of the video was even rated with 1.6. The other parts (e.g. strengths and weaknesses or similar methods) achieved grades between 1.7 and 2.1. In total there are no further remarkable results to be mentioned.

Altogether, we found the results satisfying and appropriate. We got some useful hints and we will improve the Methodos portal according to these results as a future work.

4. Limitations and future work

However, we face some limitations with our web-based method portal Methodos. First of all, the portal currently only runs in a beta stadium and is open to students of the TU Braunschweig. It was introduced in only one of the engineering design courses with about 50 participants. So, the sample is quite small

but shall be increased by introducing the Methodos portal in further courses starting in spring 2016. Before doing so, however, the feedback and suggestions have to be proved and subsequently implemented. As another limitation, we can cite the way of collecting data. We used questionnaires which had to be filled after using the portal and applying the method to gain reasonable results. The problem is the time gap between working with the portal and answering the questions. We cannot ensure that the students chose the same options as they would have done directly in the interface of Methodos. To improve the way of data collection, we will log the query and the chosen selection options without reference to the user himself. Thus, we will be able to evaluate whether a selection criterion is helpful and, hence, used frequently. Like this, we want to further improve and optimise the Methodos portal. With the experiences gained from the test phases, we want to introduce the Methodos portal into all of our courses concerning methods step by step; this means to extend the content of methods from 19 nowadays to a great number of methods. In this way, the students notice the benefit, learn to use Methodos during their whole studies and get used to it. By applying methods also in the framework of their practical projects, the students can achieve various experiences which they can utilise in practice as well. This leads us to another possible extension of the Methodos portal, the inclusion of industrial design practice. The application in industry is not the primary focus, but should be considered in further research as students are future engineers or designers. Particularly for small and medium-sized enterprises, the portal and its interactive features could be a worthwhile support for engineering tasks. A further step towards an interdisciplinary learning is to transfer the portal to another discipline like computer science or the field of industrial design. Both provide various methods that can be described via the Methodos portal. In this way, the Mechanical Engineering students could learn methods outside of the subject area, as well as the students of computer science or industrial design. Especially in interdisciplinary teams, this extension seems to be very helpful.

5. Conclusion

The Methodos portal as a web-based method database with various selection options for single methods was introduced in a beta stadium into one of the engineering design courses at the TU Braunschweig. The primary target group are students, and one of the innovative aspects is the interactivity which permits the students to share experiences and to give feedback to the teachers. The results of the three evaluations that were done during the introduction process mainly reflect satisfaction and acceptance by the students. Though, the deduced positive effects on the students' learning have to be proven subsequently. Thus, a question to answer remains: Does Methodos improve the students' durable and successful learning process? As future work, we try to answer this question performing further empirical studies. In addition, the Methodos portal will be optimised and introduced in further courses.

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