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HOW CAN WE EXTRACT EXPERIENCE FROM STUDENT DESIGN PROJECTS AND TRANSFER IT TO NEW PROJECTS?

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ABSTRACT

In this paper we present an approach dealing with the analysis of student design projects and the extraction of relevant contents. Due to the standardized way of describing project contents, an analysis of the data on several levels is possible and a comparison of projects concerning applied procedures and methods, created artifacts and obtained experience is facilitated. The overall goal is to use the extracted knowledge for first, improving design education contents and second, supporting student designers in their projects. In order to enable the transfer of these contents to new design situations, the following approach is proposed: project "stories" are stored in a web-based repository and several access mechanisms are provided. Importance is placed on creating a systematic access to relevant contents, the relevance depending on the situation of persons looking for information. The experience with a first prototype of the system is subjected to a critical discussion, showing potential for further development.

Keywords: student design projects, product development methods, best practice, knowledge transfer, web-based system

1 INTRODUCTION

The Institute for Product Development at the Technische Universität München (TUM) offers various lectures in its curriculum, where students are taught methods for product development and conceptual design. The contents are trained in tutorials and students have also the possibility to apply these procedures and methods in the course of semester projects. No project is the same, there are variations e.g. with respect to the motivation for the project, the number of students involved, the type of the product and the type of the task (see figure 1).

attribute	specifications, variations			
motivation (project origin)	industrial (company)	academic (institute)	personal (student)	
number of students involved	1 (single designer)	2-3 (small team)	4-8 (larger team)	
product type, branch	sports equipment	household appliance	automotive	…
type of task	new product development	…	product redesign	
overall project goals	innovation (functionality etc.)	…	optimization (cost, weight etc.)	
student method experience	novice (3rd year)	…	expert (5th year)	
…	…	…	…	

Figure 1. Characteristics of student design projects

Considering the large variety of project types, also differences in applied procedures and methods as well as achieved results can be noticed. The results typically include the description of one or several solutions to the technical task in the form of conceptual drawings, CAD models and/or hardware prototypes. In addition, some sort of validation or proof of concept is carried out, in the form of prototype tests or ratings, where the generated solution is e.g. compared to existing products.

The project documentation, which students create when working on the project in the course of a semester thesis or diploma thesis, typically contains details on goals, procedures, methods, results and evaluation. An important part is also the reflection on the process, the method application and the results, the derivation of lessons learned, potential for improvement of the methodology etc. Thus, the semester projects represent an application of procedures and methods that are taught in lectures and tutorials. Furthermore, this application experience is documented and available for further use. Important research questions for this paper are: How can we make use of the experience made in student design projects? How can we extract relevant contents efficiently from the available documentation? And how can we transfer them to new design projects?

2 RELATED WORK

In this section, different approaches towards capturing and reusing design process contents are presented. Moreover, the suitability of these methods with respect to the design projects described above are discussed.

A framework for capturing and indexing design information is depicted by Eris et al. [1]. Here, design information consisting of video records and predominantly text-based design documents are stored in two information systems. The data is indexed and can therefore be retrieved e.g. by keyword search. The possibilities for producing video protocols are, however, limited in design projects that are not studio based, that span over a larger period of time (e.g. 6 months) and that involve several actors working in distributed environments. Text-based design documents are referred to as traditional means of documenting design information, as formal accounts of what has taken place and been learned during a project and therefore resemble the type of student project documentation in focus of this paper. Eris et al. [1] underline the usefulness of text-based design documents for informing future projects and their strategic importance in establishing a knowledge base that can facilitate organizational learning.

Another type of text-based design document that is more informal, but widely used in industry is the engineer’s logbook. Hicks et al. [2] state that it represents a significant amount of design information and knowledge that could be of considerable benefit for supporting both current and future design activities. A detailed study of the information content of engineers’ logbooks was carried out, e.g. resulting in the identification of key classes of information associated with logbooks. The analysis is seen as a prerequisite for the development of tools and strategies for improving the management of this important information resource. The documentation in consideration within this paper tends towards a more formal type of information. Contents are usually well elaborated, structured and reflected, because ultimately they are going to be reviewed and evaluated by the institute staff. This also leads to the fact that the design process is not captured “live” and in its entirety. The real process is just represented to a certain degree, sometimes the difference is huge. The report may communicate a systematic, well-planned proceeding according to the textbook, although the real project consisted of heavy iterations and short-term actions. Important details about a design process, which can tell a lot about how the results were developed, may potentially “get lost”.

On the other hand, the critical reflection of the real process and the construction of a "story" present rich opportunities for assimilating experiences from design education and design practice and to deepen the understanding of the design process. McDonnell et al. derived such conclusions from work carried out with small teams of students in Video Assisted Learning in Design (VALiD) workshops [3], where short video stories of the design process were constructed. The scope of the design processes regarded in this paper is a different one (period of observation: weeks to months). The constructed stories of the design process are text-based and contain different information compared to detailed video documents telling the story of a short design task. Therefore, they are potentially suitable for a different kind of design knowledge transfer.

Wodehouse et al. [4] describe the groupware product TikiWiki, which is used in student design projects as a digital repository and collaborative tool. The system has meanwhile been further developed, its name has been changed to LauLima in order to distinguish it from the original system [5]. Wiki pages represent a digital project logbook for students, utilized as a means of documentation of project contents. In addition, they enable the communication of relevant information between different teams. The retrieval is facilitated by linking the pages with each other, thus enabling a browsing of contents in addition to a keyword search. However, there is a tendency towards uncontrolled growth of contents with varying quality due to a multitude of different users entering information. The complex network of single pages connected by hyperlinks enables the browsing for information, but also causes intransparency.

Vroom et al. address the problem of coping with the enormous volume of information, tools and knowledge available (e.g. on the internet). They are aiming at facilitating the search for relevant aspects by providing a system called C-DET (conceptual design engineering toolbox) [6]. An important topic they are dealing with is to structure the knowledge and information adequately in order to suit the designer's search actions, which is also an aspect that was considered in the work presented in this paper.

3 PROCEDURE

The approach followed here (towards extracting design process contents from student projects and making them available for further use in new projects) has generally been described in [7]. The procedure for putting the developed approach into practice consists of several steps that are displayed in figure 2 and shall be explained briefly (see [8] for a more detailed description and discussion of the procedure).

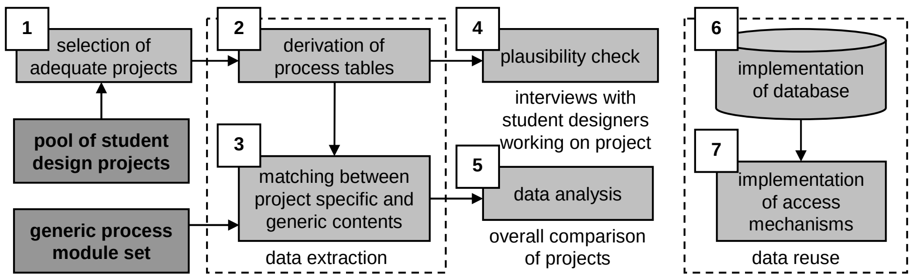

Figure 2. Procedure for extraction and analysis of contents and preparation for reuse

As a first step, adequate projects were selected. Projects had to meet some requirements in order to be suitable (concerning e.g. the level of concretization of the solutions, the quality of the documentation etc.). A process table was then generated for each project

(step 2). The process tables contain individual process steps, the input and output artifacts of each process, applied methods and tools, and obtained insights. The standardized format of the process tables and the included contents allow for an analysis and comparison of the generated data and also facilitate the reuse.
In a third step, the process steps from the process tables were matched with the contents of a generic set of process modules, i.e. each process step from the project was classified and assigned to a process module from the set (provided that a suitable process module was found). The set contains about 30 process modules, organized in seven categories, according to the elements of the Munich Procedural Model (MPM): plan goal, analyze goal, structure task, generate solutions, assess properties, make decision, ensure goals achieved. A more detailed description is given in [7]. The extraction and analysis of the data was carried out by the main author of this paper, assisted by students that had not been involved in the projects. Therefore, interviews with the student designers who had been working on the projects were carried out as a plausibility check, to guarantee that the results of the analysis were valid (step 4).
The data obtained from the previous steps was then analyzed in MS Excel® (step 5). This data analysis allows a view on the projects on three different levels of detail: (1) concerning the overall procedure that was chosen by the students, (2) concerning individual tasks and the methods selected for these tasks and (3) concerning the details of how the methods were applied. More information on the results of a preliminary analysis of four projects is given in [8]. This paper primarily focuses on steps 6 and 7: the implementation of a database as well as adequate mechanisms to access the contents in order to enable the reuse of the deposited design knowledge and information.

4 RESULTS

In the remaining part of the paper we will describe, how general design contents (process modules, methods etc.) along with project “stories” are stored within the database, how these contents are linked to each other and how a targeted access to specific contents, which are relevant in a given design situation, is provided.

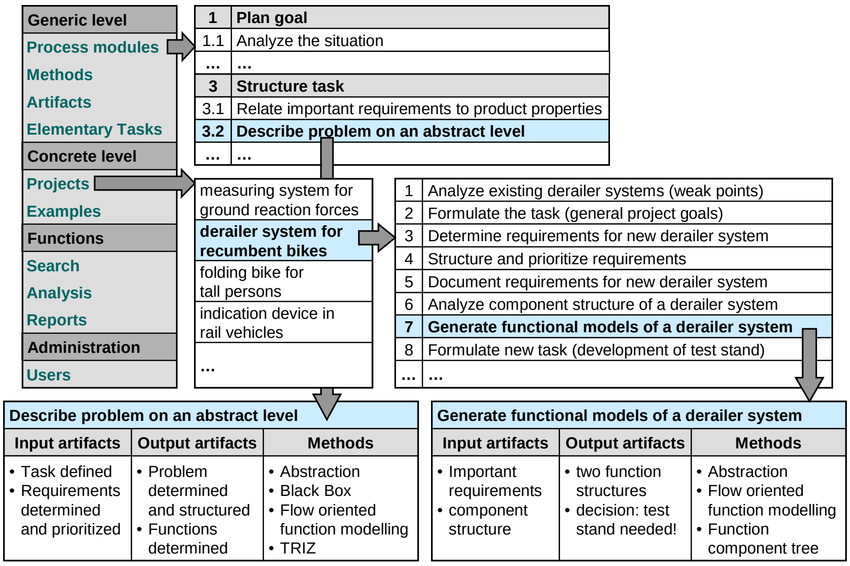

Figure 3. Overview of structure and example contents of the database

In the database, generic contents as well as concrete contents are deposited (see figure 3). On the generic level, the process modules (forming the process module set) can be accessed. Furthermore, a list of methods, artifacts and elementary tasks is provided. To each of the process modules, corresponding input and output artifacts as well as suitable methods were assigned. An example is given in figure 3 (process module 3.2: “Describe problem on an abstract level”). The methods included in the process module set represent a selection, which the Institute for Product Development focuses on in lectures and tutorials (around 80 methods at the moment). Artifacts are described by objects (situation, requirements, problem, solution characteristics, solution properties etc.) and their states (unknown, abstract, incomplete, determined, structured, documented, consistent, prioritized, selected, confirmed etc.). The development of an adequate definition and categorization of artifacts is the aim of ongoing research.
On the concrete level, process specific contents extracted from each of the analyzed projects were deposited. The exemplary project list in figure 3 gives a glimpse over the variety of projects that have been considered so far. An excerpt of the process table originating from the project “development of a derailer system for recumbent bikes” is also displayed. The details of each process step are deposited showing the same structure as the process modules. Hereby, a comparison of generic process modules and concrete process steps is possible. Figure 4 shows the complete process of the bike derailer project. Process step 7 represents a key point in the project, because here work on the derailer system was interrupted to develop and build a test stand.

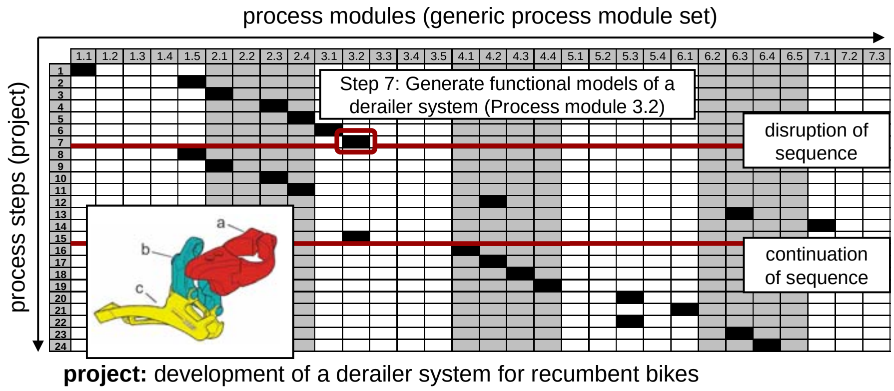

Figure 4. Matching between concrete process steps and generic process modules

The access to the contents of the database is enabled by several mechanisms: browsing through the structure, search by categories and keyword search. The browsing can start on the generic or the concrete level, depending on the preferences of the user and the given search situation. Bidirectional links between process modules, process steps, methods and artifacts have been implemented. The search by categories allows the selection of product type and subsystem type. As a result, a list of projects is delivered that corresponds to the selection made. The same mechanism works on the level of individual process steps. Here particular process modules, methods and artifacts can be selected and a list of process steps is delivered that corresponds to the query. In addition to the brief standardized summary of each process step (input, output, methods), a PDF document containing the relevant section of the project documentation was made available in order to enable a more detailed view on each process step.

5 DISCUSSION AND CONCLUSIONS

The focus of this paper lies on supporting the practice of design in an academic environment (student design projects). The presented approach lays the foundation for a reuse of project specific information in new design projects. Potential positive effects are seen in the promotion of a problem-based learning. Students shall be encouraged to reflect on their own design situation, to compare it to available “stories” of design situations in a digital repository and to transfer relevant contents to their own situation in order to enhance the quality of their design process and the design outcomes. Whether the approach shows the anticipated effects, still remains to be evaluated.

However, work on the first prototype of the database lead to a number of insights and the definition of future activities on the topic. Two major points of interest concern first, the feasible extraction of suitable project “stories” and second, the generation of adequate access mechanisms to relevant contents. At present, the data extraction (derivation of process tables, matching with process modules) represents a considerable effort. It also requires a certain level of expertise and is often a matter of subjective interpretation. It is planned to develop precise guidelines for that task. By letting the student designers create the process tables themselves parallel to working on their project, a better relation of benefit and effort is expected. With respect to offering an adequate access, investigations focus on the type of information needs of student designers and ways of matching these needs with available contents.

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