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CIDAD – A METHOD PORTAL FOR PRODUCT DEVELOPMENT

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1. Introduction

The knowledge transfer in science and industry, in particular in the domain of product development, is enhanced by a growing number of knowledge bases available on the internet. Student designers, and design engineers in industry benefit from a huge variety of technical information and knowledge, that is hereby provided. In addition, the choice of systematic procedures and the application of product development methods is an important factor for successful product development processes. Various web-based portals are dedicated to providing access to procedural and method knowledge. However, the use of these portals amongst practitioners in academia and industry is still poor. This leads to the question: What requirements does such a system have to meet in order to be attractive for potential users?
This paper investigates the motivation and various requirements concerning a web-based method portal for product development. Furthermore, the characteristics of the CiDaD method portal (http://www.cidad.de/), developed by the Institute of Product Development at the Technische Universität München (TUM), are presented and discussed. CiDaD is the abbreviation for "Competence in Design and Development". The purpose of the system is to enhance the transfer of product development method knowledge in science, industry and design education. In chapter 2 origin and current status of the CiDaD project are briefly described. Chapter 3 deals with the system's structure and contents. Details concerning the technical realization are given in chapter 4. In chapter 5, ways of working with CiDaD are described and illustrated by two examples. Chapter 6 contains a discussion and an outlook on future work. Chapter 7 concludes the paper.

2. The CiDaD project – motivation, goals and related work

In times of an increasing connection of the parts of the world, there is a rising need for collaboration and exchange of knowledge and information. Concerning the knowledge transfer in science and industry the internet has been gaining in importance over the past years. Numerous knowledge bases for specific, application-oriented access to technical information have emerged. With the expanding amount of available information, there also rises the need to a context-related access and a fast retrieval of relevant contents. This paper focuses on the domain of product development. If a company wants to meet market demands, to cope with time and cost pressure, and to provide customers with high quality products, the involved actors' technical knowledge is an important success factor. Moreover, procedural and method knowledge is required: the choice of systematic procedures in given situations during design projects as well as the appropriate application of product development methods help to increase the efficiency of development processes and to create better solutions.

In the recent years, various internet portals were developed, making available information and knowledge about methods of product development and addressing different types of users and topics (e.g. [RPK 2006], [DRM Associates 2006]). These internet portals represent a considerable potential for the impersonal transfer of method knowledge to users, in particular to engineers in industry. Of course, personal means of transferring know-how, such as individual coachings by professional consultants, are in many ways superior and can never be fully replaced. Method databases however can serve as a valuable supplement. However, the use of method databases in industry is still poor. The Institute of Product Development at the TUM has learned in numerous industrial projects that two aspects are of vital importance: the consideration of the designer's individual characteristics and a systematic support aiming at the specific design situation. Therefore, method databases have to exceed the pure service as reference book and provide individual and situational assistance. For presenting the contents of a method database, certain requirements have to be met depending on the type of user and the type of situation (see also [Berger et al. 2003]).
The motivation for the CiDaD project originates from a collaborative initiative between several institutes from universities in the German-speaking area dedicated to product development (*"thekey to innovation"* [Birkhofer et al. 2001]). The project's objective was to develop a knowledge base containing product development contents in a structered and modularized form. Based on the mutual work, the participating institutes put their focus on specific solutions. At the Centre of Product Design of the ETH Zurich, the education and knowledge domain "product innov@tion" was developed [Elspass et al. 2003]. At the Department of Product Development and Machine Elements (pmd) at the Darmstadt University of Technology, the teaching, learning and training system "pinngate" was created [Berger et al. 2003].
The Institute of Product Development at the TUM concentrated on the fundamental revision of the contents and the treatment of linkage mechanisms. These measures base on the Institute's experience from teaching activities as well as research and industry projects, which have shown that users evaluate the quality of such portals by considering two aspects: the quality of the offered contents and the possibilities to quickly access relevant contents. Wiki pages (e.g. [Wodehouse et al. 2004]) are a similar approach towards making product development contents available online. 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.
In cooperation with CRM InformationSystems GmbH, the CiDaD knowledge portal was conceptualized and implemented. At present, the web-based learning and working environment is in operation in its second version. The system's aim is to facilitate the access to method knowledge and to guide people involved in product development throughout the course of design processes. The contents of CiDaD are addressed to two primary target groups: firstly, students dedicated to acquiring knowledge in the area of product development and applying it in university projects; secondly, designers in industry engaged in solving design problems on a daily basis with boundary conditions such as time pressure, cost targets etc. The next two chapters deal with structure and contents of the system as well as the technical realization.

3. The CiDaD system – structure and contents

Currently available contents in CiDaD focus on method knowledge in product development based on the lecture "Working Methods for Product Development" at the Institute of Product Development. These contents represent the state-of-the-art of the Institute's research [Lindemann 2005]. A new flexible view on product development processes and methods is developed with the intention of increasing the application of methods to a considerable degree and improving their effects. Hereby, mechanisms for the selection of methods and their adaptation to the specific development context play a decisive role. The CiDaD database is structured into two different environments, which support various ways of accessing method knowledge and which are described in detail in the following: the course environment and the method environment (see figure 1).

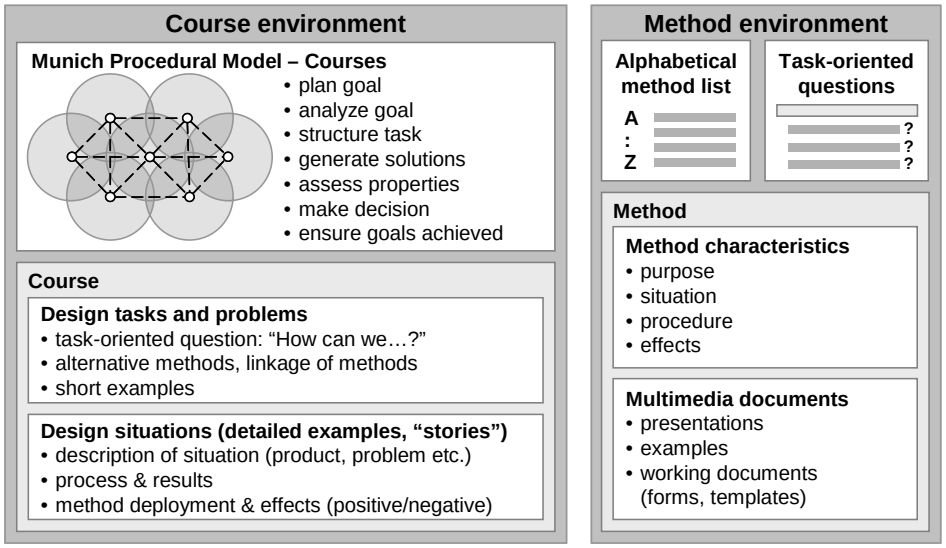

Figure 1. Structure and contents of the CiDaD method database

3.1 The CiDaD course environment

The course environment contains the description of methods in the context of design processes, tasks and situations. The structure of the courses corresponds to the Munich Procedural Model (MPM), which contains seven general process steps for problem solving as elements [Lindemann 2005]. The model represents the network character of product development processes, a fact that has been taken into account when creating the model's graphical illustration. The MPM serves for the planning of future processes, the orientation in current processes and the reflexion of past processes. For every element of the procedural model, there exists a course containing chapters on general design tasks and problems as well as chapters describing examples of specific design situations ("stories").

Design tasks are expressed in the form of questions, such as "How can we create ideas for new solutions?" Barriers that inhibit the execution of the task and other potential problems for the designer are mentioned (e.g. a lack of creativity or fixation on existing solutions in the case of the task "generation of ideas for new solutions"). Also, alternative methods that offer support and their characteristics are presented and their suitability within the context of the task is discussed. Moreover, possible adaptations of methods to specific boundary conditions are characterized, e.g. the possible combination of methods. The contents are supplemented by a number of small examples in order to enhance their comprehensibility.

More detailed examples of design situations are included in every course as "stories", showing the exemplary deployment of methods in selected development scenarios. In a story, a specific procedure is described which was chosen according to the characteristics of the situation (company, product, problems, requirements, boundary conditions etc.). The application of particular methods and the corresponding effects and side-effects are depicted. It is demonstrated how inappropriate method application causes failures (negative example) and how an appropriate method deployment (i.e. selection, adaptation and application) leads to advantages (positive example).

3.2 The CiDaD method environment

The method environment contains information on around 80 methods of product development at present. The structure of the method descriptions is standardized, which guarantees an easy comparison of methods. The decision whether a method is suitable or not in a specific situation is therefore facilitated. Characteristics (or attributes) that are part of the method description are: purpose, situation, procedure and effects.

The general **purpose** of a method indicates tasks and activities that are supported. The purpose of a list of requirements is e.g. to document product and process requirements in a structured way. The structuring and clear visualization of a certain number of elements can also be achieved by Mind Mapping®. Therefore, the purpose of a method is related to the task-oriented questions, but from the "point of view of the method". Criteria of **situations**, in which the method application promises to be of use, include typical problems, requirements concerning the user or resources, necessary input information etc. These criteria may serve as indicators for the selection of a method. The **procedure** contains the individual steps necessary to put the method into practice and therefore serves as a guideline for method application. Finally, **effects** and side effects of the method are explained in order to demonstrate, which results the developer can expect. Sometimes the side effects of a method can be more useful than the actual main effects. The anticipated effects of a brainstorming are ususally a number of innovative solutions to a given problem. The side effect of an improved team atmosphere after a successful brainstorming session could be equally valuable.
Furthermore, the CiDaD database provides multimedia documents to the user as a supplement to the method descriptions. These documents are for instance concrete examples of method implementation and adaptation to enable a better understanding of a method's working principle. Also, working documents are availabe in MS Office® format (such as MS Excel®, MS Word® or MS Powerpoint®), which can be downloaded and used right away within design processes. This includes forms and templates, checklists, lists of requirements, evaluation matrices etc. Finally, glossary entries, abbreviations and bibliographical references are linked to courses and method descriptions.

4. The CiDaD system – technical realization

The technical implementation of the entire system is based on freeware. For the realization of the CiDaD portal, a conventional internet client-server-architecture was used. Any internet browser capable of javascript may serve as client. On the server side the LAMP configuration (Linux, Apache, MySQL, PHP) was implemented. The contents within the database are stored in a modularized form, the so-called container-element-architecture. In order to represent information in a well structured way, contents are unitized into modules that are filed into the data base as separate elements. Elements are merged in containers that can again be assembled in higher-ranking containers. Therefore, the author has the possibility of creating contents, e.g. courses, in a flexible way and if necessary for different purposes. A structured cross reference list is always available on the left hand side of the browser window, a context dependent and dynamic actualization of crosslinks and references is provided. Therefore, a "manual" definition of crosslinks is not necessary.

5. Working with CiDaD – individual and situational support

In chapter 2 the important requirement of giving individual and situational assistance in the search for product development method knowledge was pointed out. In the following, different types of users and situations, which have to be supported accordingly, are described. Three basic ways of accessing method knowledge are distinguished and their implementation in the CiDaD system are described.

5.1 Supporting different users

Depending on the user's level of method expertise, different contents of the system and different ways of accessing these contents are relevant. **Method novices** typically need more guidance and background information. Students following the lecture "Working Methods for Product Development" can be associated with this category. They are enabled to an easy and uncomplicated access to design education contents, they can delve into specific topics at any time in addition to getting presented the contents in lectures and tutorials. Since the CiDaD courses show exactly the same structure as the lecture, the familiarity of the contents during the navigation in the system is guaranteed. Students are also assisted in working out own design experiences, for example in the context of a student research project. Here, the basic pattern of the Munich Procedural Model with a standard path through the model provides guidance in the course of the project, which is valuable for unexperienced design novices and also student designers, who already possess some basic method background and a certain

degree of method competence. **Method experts** rather require a "toolbox" that allows the quick access to the right tools at the right time. In the method environment of the CiDaD system, users are assisted in the selection and application of methods, when no theoretical background is needed. From an alphabetical list they can directly chose methods they are acquainted with or know at least their names. The method descriptions serve for refreshing their knowledge on these methods and giving them directions for their application. The list of task-oriented questions is a pragmatic way of being guided to adequate methods. Here, the design tasks are detached from the procedural model, which might be more convenient for practitioners in industry, who often show some scepticism towards such theoretical approaches.

5.2 Supporting different situations

The types of situations that are considered here are to a certain degree related to the types of users mentioned above. Method novices most probably have to deal with situations where **learning and understanding** of contents on processes, tasks and methods is important. Here, glossary entries in the CiDaD system explain the most important terms and bibliographical references allow for a deeper engagement on the topic. In order to carry out a certain design task systematically, the **selection of appropriate methods** plays an important role. In the method environment, related methods are listed to allow for an efficient selection of alternative methods or a combination of various methods. In situations where no explanation of processes or methods is required and a method has already been chosen, a quick support in the **method application** is needed. Here, working documents that are linked to courses and methods can be downloaded and used right away.

5.3 Providing various method access mechanisms

Braun & Lindemann suggest three starting points for method selection: the assignment to superior product development processes, the assignment to elementary tasks and the selection according to method attributes [Braun & Lindemann 2003]. The implementation of these mechanisms in the CiDaD system will be explained in the following.

With respect to the **method access via processes**, the CiDaD portal offers support in the course environment. Here, one of the elements from the Munich Procedural Model can be chosen as starting point (see figure 2). The seven elements in the model form a general problem solving procedure that can either be processed in a standard sequence or in the way that the elements are combined flexibly [Lindemann 2005]. The CiDaD course that corresponds to each MPM element leads to a number of task-oriented questions and stories, which are in turn linked to suitable methods.

A second mechanism is the **method access via design tasks**. Whereas the MPM elements represent tasks on a superior level, tasks on a more basic level can also be considered for method selection. The number of available basic or elementary tasks is limited and they are applicable in all sorts of processes. Within one process such as the evaluation of alternatives, a lot of elementary tasks are usually carried out e.g. the selection, weighting and organization of criteria, the rating of the alternatives and the selection of the best alternative. Some of these tasks, such as the weighting of criteria, do not make sense in situations, where a rough and fast evaluation is needed. The actual tasks that are considered as necessary in a particular situation also determine adequate methods (see [López-Mesa & Thompson 2003] for an elaboration on evaluation methods and elementary tasks that are performed within these methods). In the CiDaD system, particular design tasks are represented in the form of questions. They are meant to motivate the designer to actively reflect on his situation and take appropriate measures. Usually, there are several possible answers (in the form of applicable methods) to one question. The selection of methods according to design tasks is possible in CiDaD both in the course and the method environment.

The third mechanism is the **method access via method attributes** such as purpose, required input, achievable output (effects) and situational boundary conditions. The standardized structure of method descriptions in the method environment guarantees, that these criteria can easily be compared. The decision whether a method is suitable or not is therefore facilitated.

5.4 Working with CiDaD – Examples

In the following, two examples are described as application scenarios of the CiDaD system. Hereby, the concepts that were described in the previous chapters shall be illustrated. The examples underline the flexible navigation in CiDaD that is enabled by bidirectional linking mechanisms among methods and courses in between (navigation paths are represented by the arrows in figure 2 and 3).

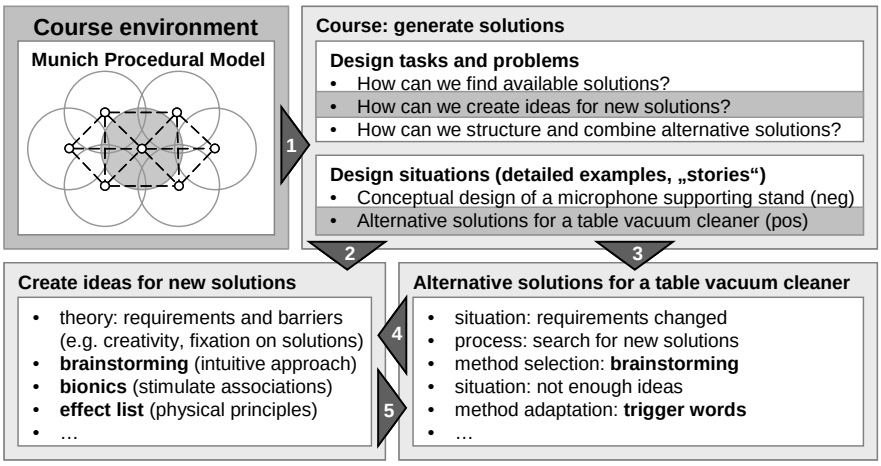

Figure 2. Method access via course environment

Method access via course environment: Imagine a group of designers in the conceptual design phase who have clarified the requirements and determined the functions to be realized within a new product. For the continuation of the process, the CiDaD system is consulted for assistance and the MPM element "generate solutions" is chosen as the starting point in the course environment (see figure 2, arrow #1). Depending on the details of the situation (product type, design task etc.) one of the given task-oriented questions might be applicable, e.g. "How can we generate ideas for new solutions?". Following the corresponding link (#2), the user is guided to a chapter that discusses the task itself and adequate methods such as brainstorming, bionics or effect list. When looking into one of the stories (#3), the designers' understanding is improved, because the application of regarded methods (including their adaptation and combination) is illustrated within a specific context.

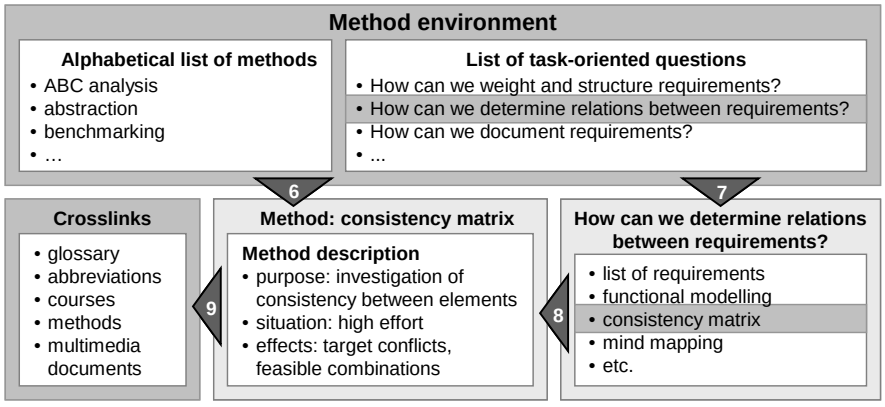

Figure 3. Method access via method environment

Method access via method environment: If a designer is confronted with a large number of requirements and needs methodological support, he can consult the CiDaD method environment, where there exist two possibilities for navigation (see figure 3). He may have heard that a consistency

matrix is supposedly a feasible method for his problem without actually having generated one before himself. By browsing to the alphabetical list of methods, he can directly access the underlying information about the method consistency matrix (#6). An alternative way is to navigate to the complete list of task-oriented questions, when the designer is yet uncertain with respect to the choice of method. Here, the question "How can we determine relations between requirements?" could be applicable (#7). Alternative methods that are suggested in the context of this question (besides consistency matrix) are list of requirements and mind mapping® among others. The matching between situational characteristics and method attributes helps in the choice of a suitable method. For instance, personal characteristics of the involved actors such as preferences for graphical or tabular depictions will potentially play a role in the question, whether a mind map or a consistency matrix is more suitable. Once a method is selected, working documents can be downloaded (#9) (e.g. an Excel® template for a consistency matrix) and the method may be applied right away.

6. Discussion and Future Work

In this chapter, some aspects concerning the system's contents and features as well as its utility in the context of product development processes are subjected to a critical discussion. Further research topics regarding the CiDaD method portal are described.

Quality of the contents: A lot of attention has been paid to providing high quality state-of-the-art contents concerning product development processes and methods, and presenting these contents in an adequate structure. The Munich Procedural Model serves as navigator through design processes and allows for a flexible view on problem solving procedures and corresponding methods. However, some other aspects still need to be addressed. Current revision work on the system deals with the implementation of an additional view on product development and additional contents, considering different levels of product concretization during conceptual and embodiment design.

Quality of the method access mechanisms: In the context of specific situations, the designer is not only interested in a list of methods that are potentially applicable with respect to process, task or method attributes. Good or bad experiences ("best practices") gained in similar situations are often equally if not more valuable. Certain specifics of the situation (type of problem, boundary conditions etc.) will have an influence on the benefit a particular method can produce. Therefore, it is planned to extend the existing number of stories and use cases in order to address a broader range of design situations. A method access via stories will serve as a supplement to the existing mechanisms. One question in this regard that is currently being investigated is: How can stories be extracted from projects efficiently and how can CiDaD users be provided with stories containing relevant issues for their particular needs? The goal is to create a systematic proceeding and template for extracting that kind of information from design projects in an efficient way and with justifiable effort.

Benefit of the crosslinking mechanisms: Innovative crosslinking mechanisms have been mentioned as one of the key success factors of the CiDaD system. All the crosslinks are updated dynamically and allow for a flexible navigation through the system's contents. The actual quality of these crosslinks is still to be evaluated. The development of a rated cross linking index promises to optimize the existing mechanisms. A feasible scenario includes hints given by the system similar to references given on popular websites (e.g. amazon.com) in the manner of: "Users who downloaded the template for a list of requirements were also interested in methods that help structure the requirements."

Didactical aspects: A method database can never substitute the personal transfer of knowledge by academic institutions or professional consultants in industry. One significant advantage of the interaction between people is the "soft factor" of a personal motivation and assistance. However, personal knowledge transfer can be facilitated and supplemented by a method portal such as CiDaD. To do this properly, further investigations in the field of psychological and pedagogical aspects of computerized knowledge transfer are necessary. The way how methods are presented plays e.g. a crucial role in this context [Jänsch et al. 2003].

Customizing CiDaD: In several discussions with representatives from industry and science, great interest for the CiDaD concept was expressed. Projects are planned to create specific method environments for particular topics (e.g. customization of CiDaD for a company in the automotive sector, development of a method database containing "Design for Casting" methods and techniques).

7. Conclusions

The CiDaD portal contains state-of-the-art contents on methods of product development. According to the requirements of different types of users and situations, it offers adequate access to method knowledge in two environments (courses and methods) that provide several alternatives in the navigation. Methods can be selected according to their fit to corresponding processes and design tasks or considering their attributes. The Munich Procedural Model serves as structuring element for the available courses in the course environment as well as a guideline in the individual navigation through design processes. Direct method access is possible in the method environment where methods can be selected from an alphabetical list or according to task-oriented questions. The system is addressed to students involved in product development as well as practitioners in industry. For their assistance, CiDaD offers innovative mechanisms for selecting and applying methods. Flexible structures and dynamic crosslinking mechanisms (to courses, methods, glossary entries, references or multimedia documents) are indispensable prerequisites as well as an adequate modularization of contents. Thus, learning and understanding of methods and their use is facilitated. Also, the quick application of methods supported by working documents is enabled.

The CiDaD portal receives a lot of positive feedback, but still shows further optimization potential. The support of design processes will be increased by the addition of new contents concerning conceptual and embodiment design. Investigations are planned e.g. in the field of psychological aspects of computerized knowledge transfer, the evaluation of link quality and development of new linking mechanisms as well as the customization with respect to specific applications.

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