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PROJECT GUIDE: A TOOL TO SUPPORT THE REALIZATION OF INDUSTRIAL WORKSHOPS IN THE EARLY PHASES OF DESIGN ENGINEERING

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1. Introduction and Objectives

This paper describes the development and application of a tool supporting the realization of workshops in industry. This tool is called *Project Guide* and deals with the project definition phase and the conceptual phase. The realization of workshops in industry is one main activity of the department Product Development and Machine Elements (*pmd*) and its responsible associates at the Darmstadt University of Technology. Three project types are here differentiated:

Seminars

Seminars allow one to access and become acquainted with selected design engineering methods. These methods are introduced over one or two seminar days. Their application is worked out on the basis of examples together with the participants. In the context of these seminars, a competent training and/or a consulting support in the implementation of design methods is provided. The selected methods are adapted to the customer wishes. To this end, a configuration of the relevant documents orientated at the targets is carried out (e. g. forms, handouts, presentations, training material). However, these seminars are geared more towards standardized processes and examples, and not concrete projects and processes of our customers.

Cooperation projects

In the context of a cooperation project, we bring our knowledge of and experiences in design methodology together with the technical know-how of our partners. This occurs by processing specific problems. The team of a cooperation project normally consists of three to eight members from both *pmd* and the project partner. The industrial designers contribute specialized knowledge of products and processes, while the *pmd* researchers responsible for the project exercise their role as agent and moderator of development methods and processes.
Organizationally, the span of such cooperation ranges from strongly result-oriented projects to projects in which the information exchange and the exemplary method application are in the foreground. In result-oriented projects, *pmd* takes on essential parts of the result formulation. In regular workshops, the information about the current state of the results is acquired and the current procedure as well as the coordination of further procedures carried out.

Transfer workshops

Transfer Workshops are a further development of cooperation projects and standard seminars; they are a combination of both. They are adapted more strongly to the special situation by designers in practice. Standard seminars normally cannot take the special tasks and requirements of the participants into account. Therefore, standard examples are used to explain methods. In the context of a transfer

workshop, a special development task is taken up and worked on. The involved designers work directly on a current problem and are supported methodically by *pmd* associates. This form of method transfer meets the expectations of designers in practice much better, since the learned methods can be used immediately on a concrete problem in their field.
To support the moderation of these workshops, it is necessary to regularly prepare and provide documents such as slides and explanations of design methodology, general theory, examples from theory and practice, forms and/or handouts. Moreover, subsequent work is necessary after most workshops, e. g. with regard to consolidating, concretizing and completing the results. These are then ready to be processed in further sessions. Depending on the participants, each document has to be provided in English and/or German.
In the times before the Project Guide tool introduced in this paper, these documents were created, from workshop to workshop, or adapted or derived from already available documents. Every workshop had to be anticipated and prepared with regard to its content and the required documents. This implied an effort consisting of four parts (it is assumed that the content of the workshop was already anticipated):

- Completely new documents are created
- If existing documents are (partly) used, then documents are searched for, which can serve as templates. In this situation, there is the latent feeling or knowledge that the suitable documents already exist. The search can proceed successfully or unsuccessfully. If the search is successful, then:
- Already available documents are directly accepted.
- Already available documents are adapted and/or modified with regard to content, scope, language, etc.

This procedure is characterized by time-consuming searches and/or adjustments. Besides this, there are other danger spots:

- From project to project (and within a project from workshop to workshop) documents are created, modified and saved. This results in a number of individual documents. From a cross-project view, these documents are contextually interdependent, e. g. all documents concerning the analysis of function structures of different projects.
- Documents of related content are located in different computers or in different directories making them more difficult to find. This occurs, for example, when different associates are involved in projects and save documents locally because no central and well-structured folder exists, or if this process is not well-defined.
- Duplicates of already available documents are created unintentionally.
- There is no system for the administration of such documents.

Therefore, it was aimed at to develop an information platform which fulfills the following requirements:

- The providing of content especially regarding the realization of workshops in the early phases of design engineering
- Direct and context-dependent access
- Simple (re)configuration and extensibility of the system and contents (e.g. the integration of work results)
- Recording of the actual project course
- Configurable online portal

Enabling direct access to integrated content aims to always make important objects available in the foreground during the moderation. All the others are moved to the background. When necessary (e. g. abandoning the planned topic due to an iterative procedure) a contextual change is processed and the most important objects for the new topic are emphasized.
The platform should also be available as an online portal. This means that its configuration takes place at the department before actual workshop. The portal is used at the company via internet connection, beamer and browser. If this technology is not provided by the company, the platform will be installed on a notebook or provided on a CD. Moreover, it should be possible to integrate elaborated results directly, to interlace them with already existing objects and to document the real course of their

creation. Another aspect (not discussed in this paper) is the consideration of secrecy agreements concerning the processing of contents online. The recording of the project course and the identification of interdependencies of the results (by themselves as well as within a theoretical context) are further aims of this approach.

2. The pinngate-Approach and the Navigator

The ***pinn****gate* approach is the scientific basis for the realization of the set goals. ***pinn****gate* stands for Product and Process Innovation Gate and stands for an integrated learning, teaching and application system in the field of design engineering. The ***pinn****gate* system provides unified, well structured and high quality contents and tools to support different users (e.g. students, designer) in a goal-directed, flexible and individual way. At the center of ***pinn****gate* is a central database containing various modularly constituted contents.

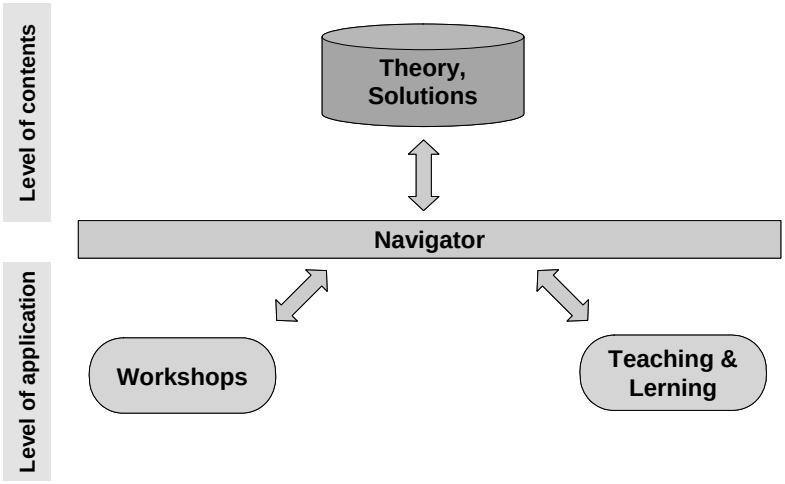

Figure 1. The pinngate approach (schematic)

Different components are considered [www.pinngate.de]:

- The theory component describes theoretical content (such as background, examples, methods, explanations and definitions) as modularly constituted units [Berger 2004].
- The solution component depicts well-structured solutions and the course of their creation [Sauer et al. 2003].
- A process construction kit renders modular building blocks to statically define process structures or dynamically create them. Items become superposed by these structures so that they can be read contextually [Weiß 2006].

The context defines the level of contents. It has to be distinguished from the level of application where all the contents are used. The level of contents and the level of application are separated by the so-called navigator. The navigator is a central unit that contains all the information about modular contents and processes requests from users. The navigator

- Selects saved contents,
- Considers the user's context,
- Structures extracted contents,
- Displays the results in the front-end [Weiß et al. 2003].

With this approach, contents are represented modularly. Modularization is the prerequisite for the individual and flexible configuration of user-specific contents [Berger 2004].
Among other things, the navigator provides a subsystem to arrange content according to the user's context on a procedural level. Two concepts have to be distinguished:

- **Static navigation**: static process structures are defined and each subprocess of this structure is linked to suitable, modularly represented content. The process structure may be arbitrarily branched. Also conditional branchings that are influenced by the user are taken into account. Among other things, this enables the illustration of central threads. This can be used to define or suggest ideal or prescriptive paths. For instance, design methodological procedures (e. g. VDI 2221 [VDI-Richtlinie 2221, 1993]) can be abstractly illustrated.
- **Dynamic navigation**: process structures are dynamically generated. The general conditions arise from the requirement after the transformation of an initial state in a final state. The initial state describes the actual situation and the final state the situation aspired to by the user. Concepts to describe the situation are available [Weiß 2006].

Besides VDI 2221, the methodical procedure in the design engineering of Pahl/Beitz [Pahl and Beitz 1996] combined with appropriately configured, modularized contents was implemented. So this approach (Pahl/Beitz) is the process-related, logical basis for the configuration of process units within the Project Guide concept.
The *pinngate* approach should be used to implement the Project Guide in conjunction with content from the lecture script for product development [Birkhofer and Kloberdanz 2005] and Pahl/Beitz [Pahl and Beitz 1996]. Therefore, the main aim is the creation of a collection of contents in a design engineering context, which supports the moderation of industrial workshops in a flexible and dynamical way.

3. Methods

Modular content is described by the Self Link Objects (SLO) approach [Weiß and Birkhofer, 2004] [Weiß 2006]. Self Link Objects consist of four parts:

- The so-called Base Documents (BD) contain pure, unformatted content, such as text, images or equations.
- The Constructor Code (CON) defines the logical order of Base Documents, so that a semantic content arises.
- Base Documents are superposed by Style-Sheets to achieve their formatting.
- Metadata describe the objects.

Self Link Objects have potential interfaces defined by metadata, which link SLO's of similar content to each other following the key-lock-principle. An advantage is that the content can be modularized at first and sequentially entered. The Self Link Object property of automatic conglomeration is used to arrange groups of similar objects.
The Self Link Object concept takes the classification of contents into account. Finally, the classes to be defined are freely configurable. Concerning the Project Guide, the following content classes are used: definition, background, example, method description, solution, form sheet, literature.
In the *pinngate* approach, examples form a special class of objects. They are derived based on an independent sub-concept [Sauer et al. 2004]. Methods also form a special class of objects, but within the context of the Project Guide, their descriptions are only modularly described using Self Link Objects. The description is based on the Process Oriented Method Modell (PoMM) approach [Birkhofer et al. 2002] [Berger 2004]. The successful application of methods depends on the appropriate selection and adaptation of methods [Braun and Lindemann 2003]. This demands the flexible adaption of their descriptions. Among other things, this is supported by the modular representation of Self Link Objects and their contents. Internally, Self Link Objects are implemented both by a self-defined format and by using XML.
With regard to the depiction of content, a summary of contents to be taken into account was drawn up. These contents were derived based on already existing documents, literature and experience. Finally, contents were implemented as Self Link Objects. Concurrently, first steps concerning the identification of processes to be supported were made. Consequently, contents and processes were identified and gradually elaborated and concretized. Moreover, the Project Guide contains content at different levels of concretion.
Concerning the project definition phase, contents are supported as follows: checklists for the clarification of the task, brainstorming to find first requirements and/or solutions, requirements of rival

products or investigations of competitors, KANO model, matrix of consistency, checklist to find requirements, market portfolio, process analysis, process synthesis, process structure, process variation, process model and building structure.
As regards content, the conceptual phase consists of the following areas: functions, fundamental partial solutions, fundamental total solutions, properties of solutions and concretization as well as selection and evaluation. Supported contents refer here to total function, function analysis, function synthesis, partial functions, description of functions, function structure, variation of the function structure, minimal structure, brainwriting, brainstorming, gallery method, synectics, investigation of real and virtual solutions (own products, rival products, ancillary industry, property rights, collections of solutions), experience and experts, systematic variation, morphological matrix, reduction strategies, concretization, solution description sheets, compatibility matrix, alternating combination and selection, selection list, pair comparison, etc.
Contents represented by Self Link Objects are put in the context of design engineering by the navigator. Therefore, it is necessary that the navigator consider, at least ideally, the basics of design engineering methodology. Regarding the implementation of procedural structures in the ***pinn****gate* approach (here specifically for the case of design methodology), the concept of the Process Navigation Objects (PNO) was developed. This is carried out both on the level of predefined (static) process structures and on the level of dynamically generated process structures, which are composed based on modular process units in view of its interfaces.
Process Navigation Objects is the collective term concerning five defined Objects [Weiß 2006]:

- **Method Objects**: These describe methods with regard to their requirements, which have to be fulfilled (partly) so that the method works (inputs) and its potential results (outputs). Moreover, this object refers statically (predefined) or dynamically (algorithmically composed) to the description of the method, which is implemented as a Self Link Object.
- **Cluster Objects**: Cluster Objects combine different method objects into one. For instance, different methods for finding solutions or creativity techniques can be bundled together and treated as one object.
- **Process Objects**: These define processes as modular process units by describing the initial and final states. This approach requires methodical work. Therefore, with regard to their realization, processes are supported by one or more methods. So there is an m:n relationship between methods and processes. Consequently, the definition of process objects also contains many supporting methods. Moreover, the description of the process may be implemented as a Self Link Object.
- **Process Structure Objects**: Process Structure Objects arrange process objects according to their logical (static) sequence.
- **Decision Objects**: Decision Objects define conditional, configurable and user-influenced branches within process structures.

By means of Process Navigation Objects, the basic contexts of design engineering methodology were depicted; on the one hand, statically on the basis of VDI 2221, and on the other hand, on the basis of modular process objects. These can be processed by an algorithm to identify logical relationships among inputs and outputs, and thus process chains can be composed.
The navigator is the central interface, which links Self Link Objects and Process Navigation Objects to each other, manages user requests and controls the front-end. The navigator has an external and an internal component. The external component establishes the interface to the user. The internal component provides various procedures and algorithms to achieve the desired system behaviour. For instance, the internal component contains algorithms concerning the automatic linking of Self Link Objects and the dynamical building of process chains and the coupling to contents [Weiß et al. 2003] [Weiß 2006].
The Navigator provides different methods of access for users to choose from:

- **Standard structures** provide an organized and direct access to appropriately defined classes of content, such as definitions, examples and literature.
- A **search engine** provides access to Self Link Objects by metadata and full text.

- The so-called **Associativity Object** identifies Self Link Objects of similar content. This identification is based on Levensthein [Baeza-Yates and Ribeiro 1999]. It also informs the user if contextually similar documents are found.
- **Process networks** provide guided and stepwise navigation over process structures.
- An integrated tool supports the **dynamic generation of process chains**. At first, the user defines the (actual) initial state by stating input and the (desired) final state by stating output. The tool then establishes dynamically possible process chains, which transform the initial into the final state. The navigator displays matching contents according to the composed process chain, which are presented to the user.
- Methods are defined by means of Method Objects. So the definition contains also information about their inputs and outputs, which can be used to gain **access to methods**. On the one hand, the user may state existing inputs to obtain a selection of methods that require these inputs. On the other hand, the user may state outputs he wants to achieve and the system selects methods in this way. Contents (e. g. method descriptions) for the selected methods are also provided.

Users always have the choice of jumping between these various access modes. In view of the moderation of industrial workshops, the Project Guide is a flexible device for gaining structured access to contents on file. Aside from pure access to defined contents, existing contents and processes can be directly modified. For instance, this may occur for reasons of adaptation or extension/completion.

Moreover, elaborated results from workshops can be implemented or linked to already existing content (manually and/or automatically). This can be done collaterally or later in the context of subsequent work. By means of Process Navigation Objects, it is also possible to depict one or more process structures of the actual development and to link content to it.

4. Results

An information platform based on modular contents is the result. Static process structures and dynamically generated process chains allow the navigation through (logical) design methodological proceedings. Particularly, the Project Guide was implemented within the ***pinn****gate* concept to support the realization of industrial workshops. Industrial workshops differ from other scenarios (such as teaching or learning) mainly by content and process. As regards content, the project definition phase and the conceptual phase are widely supported. In view of navigation, the Project Guide may be used differently:

- **Ad hoc**: The various methods of accessing content provide a completely flexible application dependent on the workshop progress.
- **Static navigation**: The progress of the workshop can be (partly) anticipated and modelled by means of static process structures. This leads to an extraction of contents along a defined path.
- **Dynamic navigation**: the dynamic generation of process chains and their coupling to contents leads to a situative extraction of contents with reference to the current task in the workshop.
- **Combined**: The possibilities just mentioned can be used compositely. Each project at its beginning requires a minimum of anticipation regarding its course. This is true because each project has an aim and at least the very first workshop has to be planned (assuming a methodological proceeding). So a rough project course can be at least formulated. Correspondingly, course corrections can be carried out ad hoc, statically or dynamically. Here, it is particularly an advantage that one can skip over some content anytime without losing the (logical) thread.

The Project Guide is available in a basic version and can be adapted as an instance from project to project. On the one hand, this concerns the real contents with regard to their extent (add, remove, extend, reduce, modify) and presentation (appearance). On the other hand, this also concerns the static and dynamic links between these contents. Thus, it is reasonable to leave all the available contents in a basic version in the system, but to activate Method Objects and Process Objects that are really necessary for the project. This reduces the total number of objects and helps make them more manageable.

The system is available both as a workstation and as a web version. Both versions are interactive. Thus, the particular instance of the Project Guide may be supplemented with contents (workshop results) and processes (real course) for several workshops within a project, and the web version given to the company. Moreover, the documenting of entire projects also favours their traceability/comprehensibility.
The Project Guide has three functions:

- First, the function to support the moderation of the workshops directly.
- Second, a documentation function to record work results and/or the course (collaterally or as subsequent work).
- Third, a structuring function, since contents are related to each other and put into the context of processes.

In this context, an alliance between theory and practice is made, since theoretical contents are used in practice to elaborate the results of the project. By means of Self Link Objects and Process Navigation Objects, theoretical and practical contents become interlaced. So it is easier to understand contents within the given context.
Moreover, this structure leads to the derivation of practical examples, which may be used for teaching. However, this is only valid subject to a secrecy agreement with the industrial partner.
In general, it has been proven in several projects, that the Project Guide is a flexible device for moderation and documentation. Its acceptance by the industrial project partners was extremely high and will be studied separately. However, the first configuration of the Project Guide instance was quite complex, since contents have to be determined, collected, depicted, and processes have to be identified and depicted.
In retrospect, it is recommended to identify contents and processes collaterally and to concretize them successively until a suitable granularity is achieved.

5. Conclusions

The Project Guide is one possible approach in the procedural context of design projects with regard to the documentation, storage and structuring of contents. These contents and processes concern both the design engineering methodology theory and practice in the progress of the project. The automatic context-dependent linking of contents and processes makes the specific orientation (navigation) within the project possible. The classification of the contents as well as the various granularities of defined processes enable specific and flexible access to contents and guarantee the fast retrieval of contents. The advantage of this attempt lies in the complete structure of the depicted project, which follows from the combination of the four parts:

- Theoretical proceeding (prescriptive recommendation of action)
- Practical proceeding (real course of the project)
- Theoretical contents (information about design methodology)
- Practical contents (elaborated work results)

Finally, the Project Guide supports the moderation effectively and efficiently.

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