INTERNATIONAL CONFERENCE ON ENGINEERING AND PRODUCT DESIGN EDUCATION
6 & 7 SEPTEMBER 2012, ARTESIS UNIVERSITY COLLEGE, ANTWERP, BELGIUM

STRUCTURED UNIVERSITY COURSE CONCEPTION AND CREATION SUPPORTED BY VDI 2221

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ABSTRACT
The Institute for Product Development and Machine Elements (pmd) of Technische Universität Darmstadt developed the teaching, learning and application system called pinngate. The pinngate system does not just aim to display product development knowledge appropriately and user-specific, but also aims to support the whole creation process of teaching documents.
Creating teaching documents is straightforward connected to the conception of courses. Despite of any user-specific display it is very important to provide a clear and didactically useful course concept along with didactically well structured and designed teaching units.
Conceptualizing work on the whole course requires completely different kinds of considerations and tasks than concrete design of single teaching units. But currently no methods are available to support the conceptualizing work on courses. To develop a methodology supporting the conception and creation of a university course, it is important to pay attention to these different kinds of actions. To achieve this necessary differentiation, an approach is introduced which differentiates between a macro-level and a micro-level. One prerequisite for developing the method was not invent a complete new methodology, but to use and combine existing methods and tools.
At the macro-level university course creation is treated like a product and its concept development is done with the aid of the VDI 2221. At the micro-level teaching units were designed using enhanced rules based on the work of Heinrich Roth.
It will be shown, that the combination of these methods used to plan and design courses will result in a course design with less iteration steps and less amount of time.

Keywords: Education, design education, university course creation, conceptional course creation, teaching unit design, design methodology, product development

1 INTRODUCTION

The Institute for Product Development and Machine Elements (pmd) of Technische Universität Darmstadt has two teaching assignments: machine elements and product development. Especially teaching product development knowledge is challenging, because this kind of knowledge is so called unsharp and frequently consists of situation dependent instructions. Therefore the teaching, learning and application system called pinngate was developed at pmd. The pinngate system does not just aim to display product development knowledge appropriately and user-specific, but also aims to support the whole creation process of teaching documents resulting in an improvement of content quality.
The origins of pinngate can be found in the project "the key to innovation" [1], which aimed to transfer product development knowledge and by returning it to a uniform understanding the project should simplify product development methodology and improve the quality of the product development knowledge itself. [2]
So far the development of the pinngate project mainly focused on didactical and IT-technology aspects. To be able to offer more features for teachers and students and to continue the project successful in general, the process of knowledge transfer was analysed more exactly. [3]
This research is focused on the processes starting from the author up to the learner. The actual cognitive learning process, meaning the succeeding processes in a student's mind, are not considered because they are the subject of a separate research discipline.
The part visible to the students was implemented as plug-in for the learning management system Moodle and a didactic concept was introduced to combine the developed digital parts with the classical lectures and script. [4]

Since the existing lecture had very high quality, a very good concept for the combination of analogue and digital content was quite easily worked out. Nevertheless the necessity of a methodology to create modern course concepts was clearly identified.

2 COURSE CREATION

In the field of course-creation primarily instructions are found for the production of single teaching units with a certain subject. The concept of a whole lecture is not almost to be found in the literature.
The approach of Tulodziecki suggests for the conception of a lecture a procedure of four steps. The first step consists of preclarifications. On this occasion, the aim of the lecture is defined, as well as the foreknowledge of the learners is determined. In the second step, the design, a draft of the lecture is constructed directly. The third step is named technical production during which the materials required to the lecture are produced. At last follows the step of the optimisation and evaluation which serves as a starting point for an iteration loop. The approach of Tulodziecki is shown in Figure 1. [5]

Figure 1. Approach of Tulodziecki [5]

This procedure describes the necessary steps very roughly and is therefore not a great benefit to the conception and creation of courses.
How a single topic of a teaching unit is created or edited, is however described even more often. The vast majority of instructions are based on an approach which Heinrich Roth has formulated already in 1963. [6] He formulated in six steps how a teaching unit should be built up. In the first step, the motivation, the interest of the students is woken up. In the next step the students should recognise the problem of the subject and try to overcome the difficulties. In the third stage, one possible solution will be discussed before in the stage of doing and performing the things learned are applied to the shown example. In the next step, practising and remembering, the learned things are further strengthened by working on slight variations of the example, before in the last step the learned will be transferred to new issues. The six steps are shown in Figure 2.

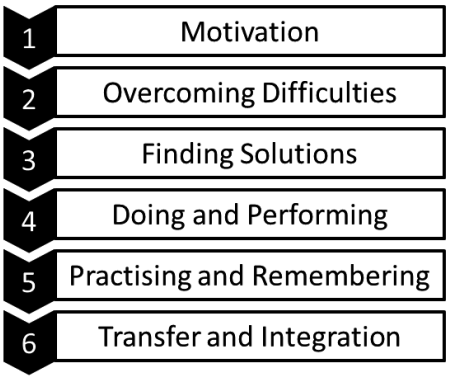

Figure 2. 6 Steps to create teaching units by Heinrich Roth

The strength of this model is that it can be used on every knowledge discipline. It is held absolutely general.
From the exemplary literature extracts a first insight can be drawn: There must be a differentiation between the concept of a teaching unit and the concept of a whole lecture.
Since the conception of the whole course is superior to the creation of a single teaching unit, the conception of the lecture is called macro-level in the following and the creation of a single teaching unit is called micro-level.

3 APPLYING THE VDI TO THE MACRO-LEVEL

At the macro-level course creation is treated like a product and its concept development is done with the aid of the VDI 2221. The VDI 2221 discusses a method for general, branch-independent methodical development, meaning that the VDI 2221 can be used for the development of all kind of products. [7]

In this case the product is a lecture. The procedure of the VDI is shown in Figure 3 on the left side.

Starting with a product idea the VDI 2221 goes through the following process steps: In the project definition process the problem is analyzed in detail and the requirements to the course are gathered. In the concept process, the product functions are defined, the partial solutions developed and the first overall basic solution created. In the embodiment design process the product is further detailed, before being finally developed in the detail design process. The documentation is the last step of the VDI.

Applying this process for the product "developing a course", the following tasks within the phases of the VDI 2221 arise.

In the 'product definition process' the requirements for the lecture are collected. These include the aim of the course, the overarching theme, as well as the target group and their prior knowledge. Further all additional boundary conditions must be also noticed. As the result of this phase a requirement list should be used. Even if this strikes as very technical and seems at first sight for a lecture concept only badly suitable, it helps that all important details for the later work are available and structured and not forgotten. For the production of a requirement list a checklists helps which contains the most important questions, so that as little as possible information is forgotten.

In the phase 'specify product functions' of the concept process all single subjects which must be contained in the lecture are extracted from the requirement list. The phase 'develop partial solutions' consists of the investigation and gathering of the teaching contents of the single subjects with the help of the requirement list. This step it is still about a very wide solution field, so that also teaching contents can be twice gathered.

The next stage, 'developing the overall solution', the structure of the subjects is specified. Now here a structure is compiled in this way, the single subjects will appear in the lecture. This arrangement must be in a didactical useful order. Here fits no universally valid instruction to arrange the subjects, because this depends very strongly on the knowledge domain.

The 'embodiment design process' symbolises the micro level. In this step every single subject must be worked off didactically meaningfully. Here the found solutions are selected or combined with each other to achieve an optimum preparation.

By the fact that in this step the found solutions are selected or parts of them are combined, the whole amount of solution decreases, so that at the end for every subject only one didactically sensibly processed teaching content exists. How a didactically meaningful preparation is done, is explained in the next chapter.

In the last step, the 'detail design process', the individual documents for the course are created according to further optical design criteria.

The transfer of the VDI 2221 to the conception of a course is shown in Figure 3 on the right side.

Finally the result should be documented in the step of the 'documentation'.

Starting from every step an iteration step may start for evaluation purpose and improvements.

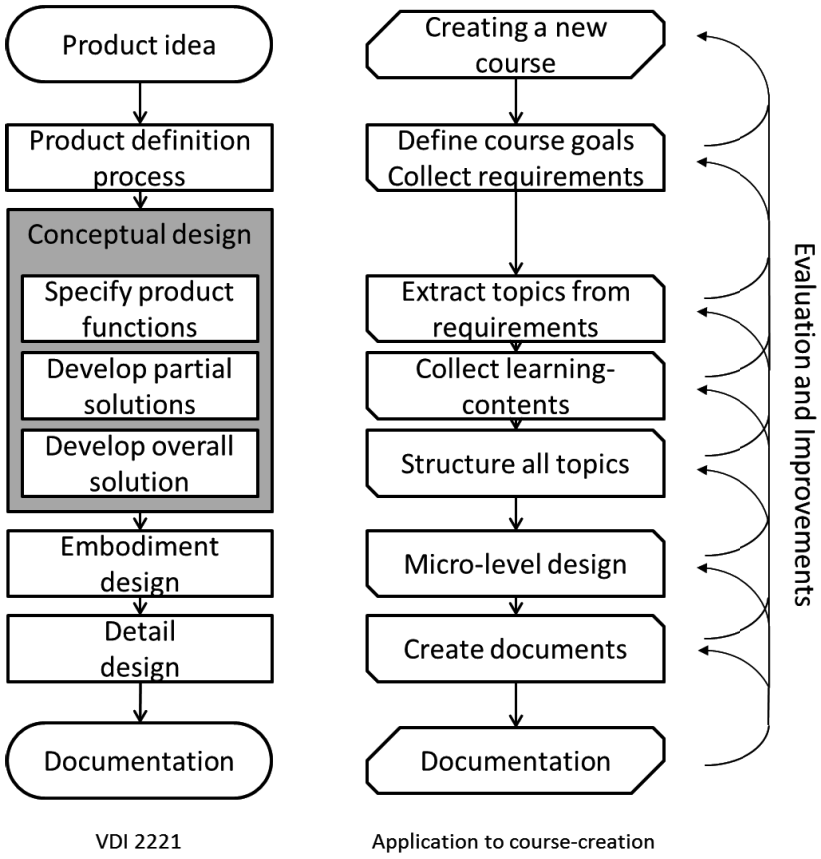

Figure 3. VDI and its application to course-creation

4 THE MICRO-LEVEL

In the embodiment design process of the VDI 2221 the processing of the contents follows according to didactic criteria. For this the scheme by Roth was slightly extended. The six steps by Roth are suitable in principle very well. But by introduction of two more steps the knowledge transfer process can be even better described and supported.

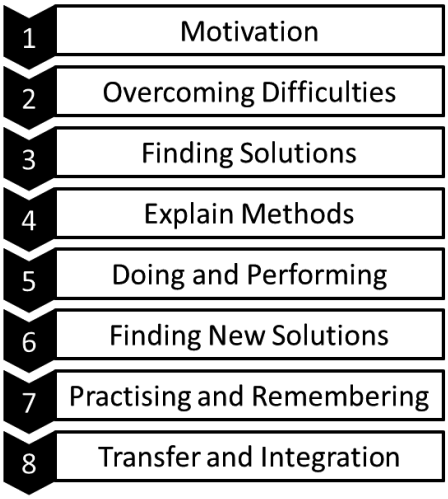

Figure 4. Enhanced schematic based on Heinrich Roth

The steps of explaining methods and finding new solutions were complemented. It is an advantage if the found solution was led back on a generalised solution or pattern and this generalised solution, or the method is exactly explained.

Often there is more than one correct solution for a task. For example in the product development there are often hundreds of other solutions existing for the same problem. To further strengthen the learned knowledge, it is useful to generate other solutions with the same method. This strengthens the learning effect.
According to the enhanced schematic, which is illustrated in Figure 4, every teaching subject is processed. In the following the eight steps are discussed with the example of product development content. First the problem is shown to the students within a motivation example. Afterwards one way is presented to overcome the problem, followed by the demonstration of a solution. Now the shown approach is methodically analysed and discussed. In the next step the classical lecture has come to an end and the students will try to apply the learned knowledge in a supervised tutorial to generate new solutions for the same problem. In the seventh step the students will further practice the learned to be able to transfer it in the last step on others problems, for example during an exam.

5 COMBINED METHOD

As already described, the VDI 2221 is perfectly suited by the very general estimate to create a lecture structured as well. The VDI gives the frame for further development methods, therefore, forms the macro-level.
In the field of the project definition phase checklists do help very much for developing a lecture just like they do for the development of technical products. They make sure that all possible facets of the planned lecture can be lighted up early. Exactly as with technical products the product functions are derived from the requirement list. With the lecture primarily the planned subjects are meant. To reduce the complexity of the whole development the whole problem is in a technical development divided into several small ones, which are possibly enclosed and each one is developed individually. With the lecture the totality can be divided analogously into single subject blocks and teaching units, which can be worked off individually. For these parts, explanations and teaching materials are collected or new material is written. The basic overall solution would be in the field of course creation the design of the teaching-topic structure. Here iteration loops are expected, because often it is found out only while structuring that one more subject is absent to a better explanation.
The embodiment design is like in the previous chapter described the micro-level and is supported by the enlarged methods by Roth. In the detail design phase also additional methods are required. Now with the lecture creation the teaching materials must be produced. These are books, scripts, slides, tutorial documents and others. These must be worked on after didactically formative points of view.
The last step serves with the evaluation of the created lecture as an entrance point for an iteration loop to improve the whole course even further.
The whole methodology is shown in Figure 5.
The pinngate system benefits directly from this combined model. Because pinngate should display information and course content user-individually, so that each user should get the right level of detail of information he needs at the time, the necessity of high quality content is very high. First due to the increase of quality of content, which is achieved by the combined model, the value of the system increases directly. But second to be able to display the content user-individual, the content source must be also very well structured, so the system profits again.

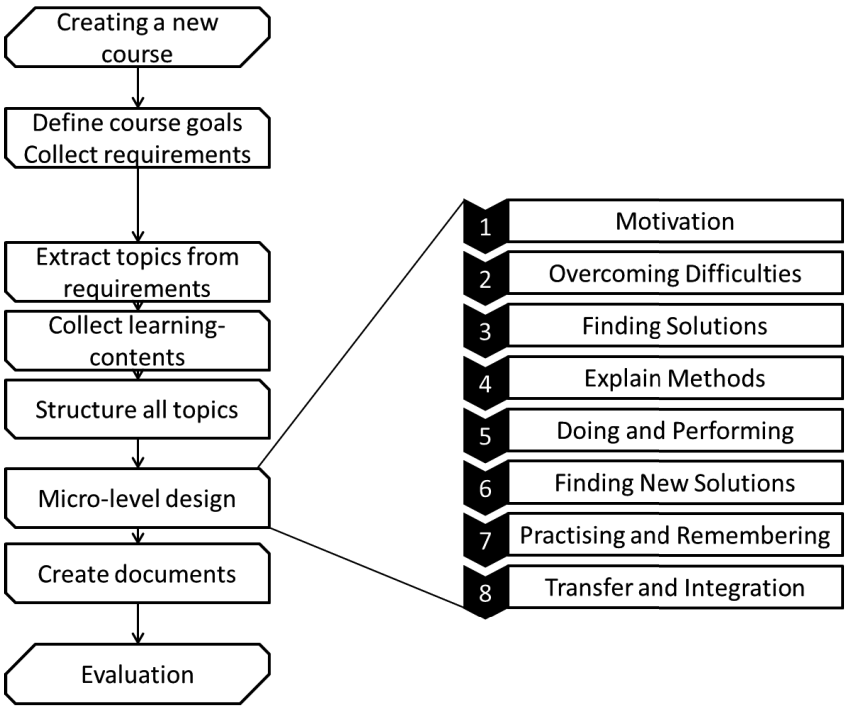

Figure 5. Final method combination

6 FUTHER WORK AND EVALUATION

The first evaluation of the method combination was done so far only with the help of an available lecture. For this a lecture was analysed which is classified as very good by students and in addition is completed with extremely good average grades. On this occasion, it could be found out that the single subject blocks were built up precisely according to the presented schematic for the micro-level. Also it was revealed that this construction out of 8 stages was not found in only few topics, because it makes sense for some subjects to be able to let out one step. The presented schematic is therefore a first approach and assists in the preparation of documents, but must not be followed strictly. This from case to case adaptation of methods takes place in the industry with technical products also very often.
The next steps will be an evaluation of the method combination by designing a completely new lecture and the exact elaboration of the checklists for the requirement inquiry. These checklists will probably be specific to knowledge domains.

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