SOFTWARE SUPPORTED KNOWLEDGE TRANSFER FOR PRODUCT DEVELOPMENT

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ABSTRACT
The pinngate project aims to display product development knowledge appropriately und user-specific. To achieve this objective the following considers the knowledge transfer process starting at a teacher or an expert to a learner or student. Based on the detailed consideration of the knowledge transfer process and the extent of standard software available on the market, usage scenarios and research fields will be introduced.

Keywords: Engineering design education, modularization, user-specific documents

1 INTRODUCTION
The pinngate-system developed at the Institute for product development and machine elements of Technische Universität Darmstadt is a teaching, learning and application system with the aim of preparing product development knowledge appropriately and user-specific. The motivation for the pinngate project is to create a powerful teaching tool for product development knowledge combined with an improvement in quality of content. This is achieved by a broad knowledge base. The broadening of the knowledge base also increases the profit for scientific work. In addition a significant reduction of the effort in the preparation of documents is to be gained by the multiple use of knowledge representations.
Since the system is specifically tailored to the needs of knowledge transfer in product development and the understanding of product development methodology is simplified through the reduction to a consistent scientific basis, the quality of the product development knowledge can also be increased.
The origins of pinngate can be found in the project "thekey to innovation" [1], which should specifically tailored to the needs of knowledge transfer in product development and returning to a uniform understanding of the scientific base it should simplify the product development methodology and improve the quality of the product development knowledge itself. [2]

So far the development 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 analyzed more exactly. This research is focused on the processes up to the learner. The actual cognitive learning process, meaning the succeeding processes in a student’s brain, are not considered here because they are the subject of a separate research discipline.

2 KNOWLEDGE TRANSFER PROCESSES
To support the process of knowledge transfer as well as possible, this process must be very well known and understood. Only after a very good understanding of the process it is possible to be worked out, which process elements can be supported computer-based or even have to be supported, to enable a truly user-dependent, flexible provision of knowledge. Therefore, in the following, this process is analyzed in detail.
First a side note about the included diagrams: To ensure comparability to the first batches of the "thekey to innovation" project, see Figure 1, all plots are designed against the usual reading direction from right to left.

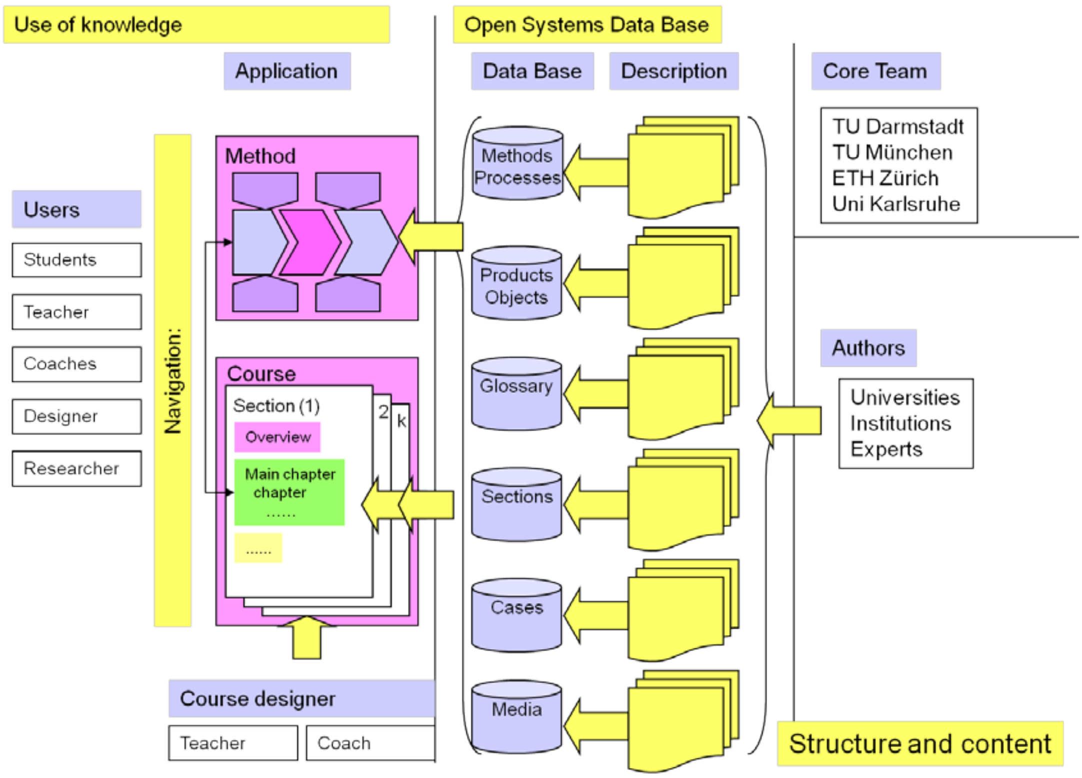

Figure 1: thekey Process [1]

2.1 Simple knowledge transfer process

The objective of the pinngate project is not to write another book, but to create a powerful tool for knowledge transfer of product development knowledge. Therefore let us take a closer look at the process of knowledge transfer:

On process-level the basic idea standing behind the pinngate concept, can be regarded, highly simplified, as a knowledge transfer process from one person to another person. This is shown in Figure 2.

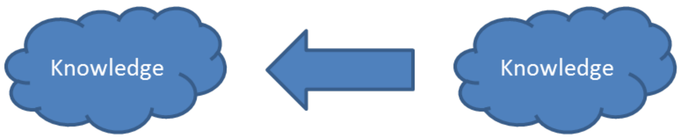

Figure 2: Simple knowledge transfer

Analyzing this process more detailed, the transfer of knowledge can occur in different ways. The easiest way at first sight is one person passing his or her knowledge to another person just by telling it to him or her without further aids. Even this simple process can be broken down further.

Much more often a transfer is done by means of a written document, such as a book, a script or a presentation slide. In this case it requires that an author first creates the document. Only then the student can read the prepared written document. This learning process can also be supported by a tutor or a similar person. An example in university practice would be a supervised exercise. Here, the student reads a text with a task and works on it. For questions, the tutor is with explanations to the side.

But even in a university lecture the reading of the presentation slides is supported by additional notes of a professor. The student reads the slides and receives additional explanations by the professor.

This more refined process is shown in Figure 3: The author brings his knowledge in a preparation process in a written form of presentation and a learner reads this information within a learning process. He may be assisted by another person during the process.

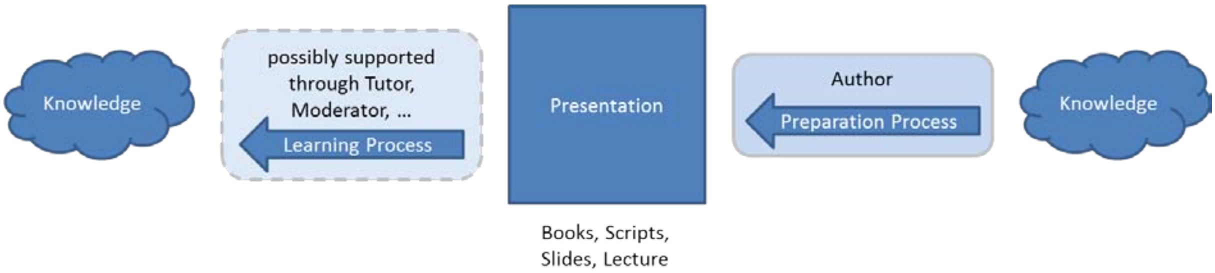

Figure 3: Detailed process

But let us consider once again the example of a purely verbal knowledge transfer. Even in this case we can identify a structure similar to the one shown in Figure 3. By thinking about what he or she wants to say and to convey the teaching person prepares his or her knowledge before presenting it orally. The preparation process takes completely place in the teacher's mind. In this case no written document is used as presentation medium, but the speech itself can be understood as presentation medium. So the detailed process of Figure 3 remains generally valid.

Depending on the form of presentation of the documents the learner will prepare certain notes while learning. In a lecture he will for example take notes. When reading a book the student could mark small passages or even add text comments to particular passages. During the further learning process, the learner will always access its own notes or documents. These relations are shown simplified in Figure 4. We will not look into more details of the much more complex cognitive part of the learning process.

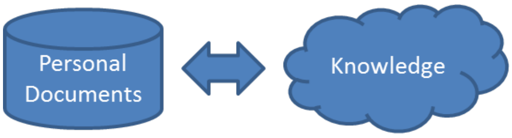

Figure 4: Personal Documents created by the student

Next, we consider the preparation process of knowledge to documents a little bit closer. An author selects certain parts of his knowledge and then brings them depending on the chosen form of presentation in the appropriate form of documents. To perform a selection of knowledge it is necessary that the author can select from the total amount of his knowledge parts. The knowledge must be available as several units or modules. From the modularized knowledge parts the documents will be created subsequently. In the style of computer science Duval and Hodgins call this process aggregation. [3] To our understanding of the knowledge transfer process it is important to differentiate between modularization of content and design of documents. Therefor the design of documents is carried out by a designer at the first approximation. The presentation of the documents is the source of the learning process of the learner.

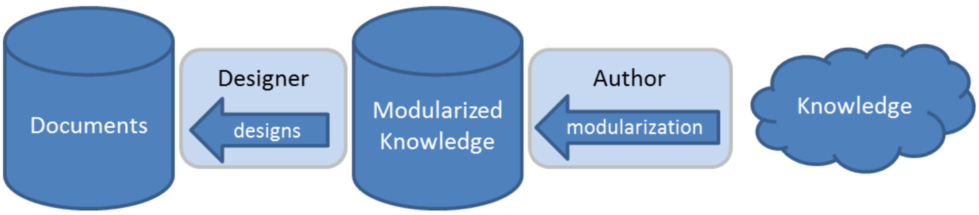

Figure 5: Another version of the process

2.2 Detailed knowledge transfer process

First we want to look at the familiar process starting with the knowledge of a teacher or an expert. Being an author he or she will classically write a book, script or create something similar as shown in Figure 6. At first only this part of the process is regarded in detail, the other part of the process, in which a learner increases his own knowledge based on the processed documents during a learning process, will be described later on.

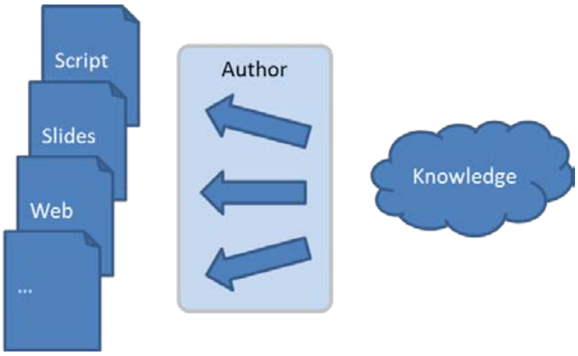

Figure 6: Simple authoring process

In detail, the activities of the author can be broken down into other elements. In order for an author to write different documents, he must be capable of structuring his knowledge in small, semantically self-contained modules. He can use these modules of knowledge afterwards for different occasions and externalize them by composing knowledge modules in a design process to documents and writing those down. The preparation of these documents must obviously make didactic sense. The according to that further detailed process is shown in Figure 7.

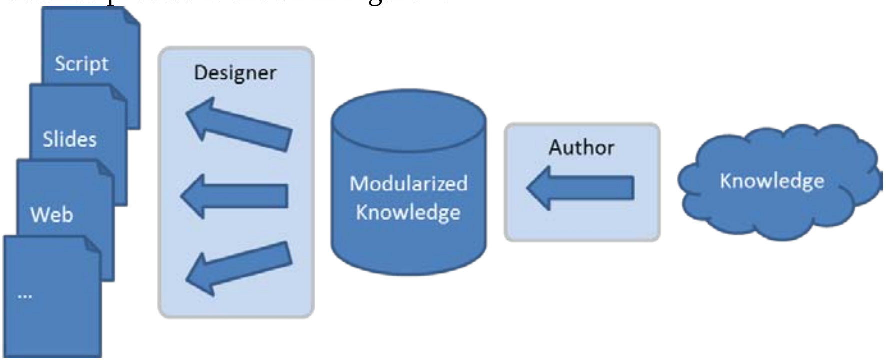

Figure 7: Detailed authoring process

So far we have assumed that modularized knowledge is present in the author and describes an ability of people to access parts of their knowledge. To be able to support that process also from the software side, we must have the modularized knowledge to be transferred to a database. As it was the traditional way of publishing knowledge by writing a book, a lot of knowledge representations exist in the form of books. So there must be a process path, offering the possibility to modularize already existing written material. Basic approaches for modularizing written texts are done by Berger. [2, 4] Additionally, there must be a second process path to store newly acquired knowledge, e.g. from current research, directly in a modularized way. Generally the granularity of the modules is in competition with the complexity of the module-system.

To sum up, there are two paths toward modularized knowledge. First, already existing documents must be modularized and second knowledge modules must be able to be stored directly as modules in the system. These two paths are shown in Figure 8.

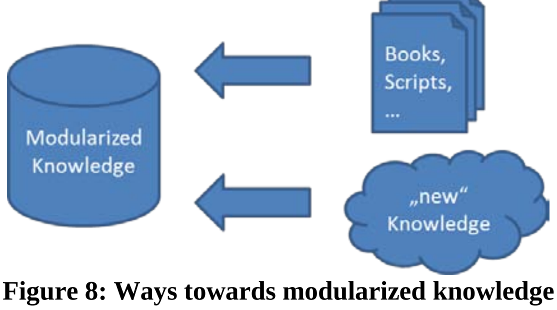

Figure 8: Ways towards modularized knowledge

The design process, meaning the selection of appropriate knowledge modules and the subsequent didactic treatment can again be detailed. The first step contains selecting the adequate contents to

create the documents and to arrange them in a certain order. When selecting and combining the content modules it is necessary to apply discipline or domain-specific didactic criteria. In the following the assembled content modules are designated as didactic content units.
Subsequently, the didactic content units have to be suitably prepared for the corresponding output medium. This means a purely visual design at this point. Certainly, the optical preparation also has to consider aspects of didactically reasonable design. This leads to the further detailed process flow shown in Figure 9.

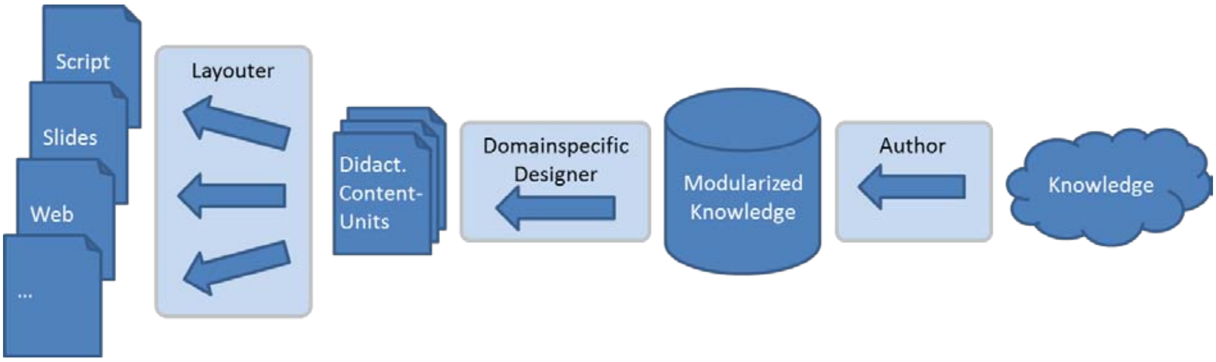

Figure 9: More detailed authoring process

The various activities of a domain-specific designer differ so widely that it appears reasonable to divide the process, selecting contents from the pool of knowledge modules and structuring them in a didactically reasonable way, right into these two sub-processes. First, the selection of knowledge modules occurs. The results are didactic content units, which are still unstructured at this point. In the following step, these content units are structured in accordance with discipline or domain-specific didactic aspects. This step results in structured didactic content units.
Experience shows that this step is a very complex process whose results cannot always be fully predicted, meaning that it might happen during the structuring of the content modules that the domain-specific designer notes that content modules are missing. On the one hand it is possible that important units have been forgotten and on the other hand the necessity of a better explanation of an issue might lead to the need of additional knowledge units. This means, that an iteration loop between structuring and selection is attached. This much more detailed process is shown in Figure 10.

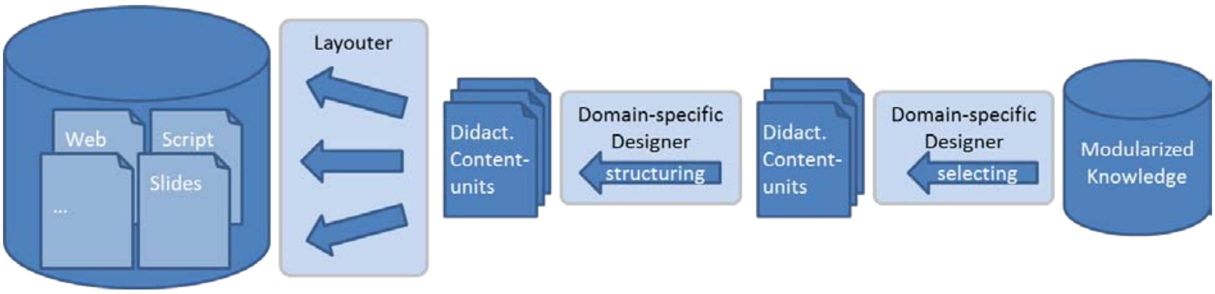

Figure 10: Much more detailed authoring process

After the structuring process the didactic content modules do not contain formatting. Therefore it is necessary that a layout process is attached at this point to adjust the appearance to the chosen presentation medium. This process further includes didactic aspects that give requirements in accordance to the chosen presentation medium for the preparation of the content units.
The result of the layout process is a digital representation of the final version of the prepared documents. The possibility to use these documents during the learning process requires their presentation in different forms. These various presentation forms can be stored in a database. The presentation process itself will be analyzed in the next section.

The processes of cognitive learning mainly run in the learner's personal responsibility and therefore will not be considered in detail. But the peripheral processes surrounding the learner will be analyzed: As already mentioned it is possible to mark certain passages or add short comments to passages while reading them. It is also quite common to take notes during lectures. This is mainly for memory support, meaning a reminder. But also while working through documents students will write summaries to filter the knowledge by personal criteria. Doing that the student filters out part of the information on the one hand and on the other hand he also structures the remaining knowledge. Finally, the students will use their own personal documents in order to learn the knowledge. There are three processes arising in personal knowledge storage, which are for memory support, for structuring and for learning documents. This is shown in Figure 11.

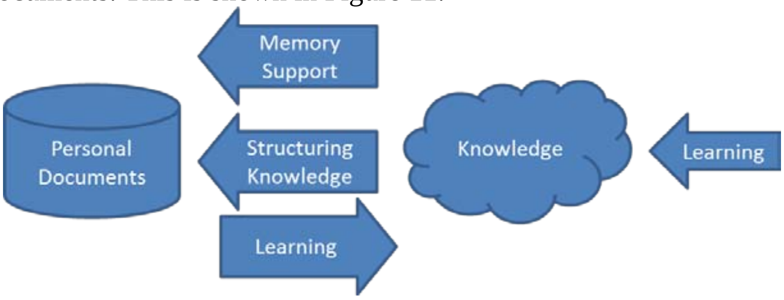

Figure 11: Personal notes for various reasons

3 USE OF STANDARD-SOFTWARE

First, we regard the capabilities of learning management systems. After the times of exuberant use and creation of eLearning software [5], meanwhile there are extremely good software solutions available, such as Moodle. Learning management systems are complex Internet-based software systems that integrate several task-specific sub-programs combined in a central graphical interface. In particular, parts of a learning management system are a user administration with role and rights management, a course management, communication methods, various display modes for course content, and tools for learning. [6]

Learning management systems therefore integrate a content management system for the storage of course materials, learning objects and multimedia content and a course management system for course management with various methods of communication, like chat, forums, or mail.

In addition, opportunities are given to create personal notes and documents, and to create calendar entries. These functions are normally integrated in learning management systems in personal desktops.

This leads to the classification within the pinngate concept in the way that prepared documents can be stored in the content management system of the learning management system. Students are granted access to these documents and they can create personal documents on educational materials. This means that learning management systems support a wide range of the described knowledge transfer process. Figure 12 shows the visualization of the classification of the learning management systems.

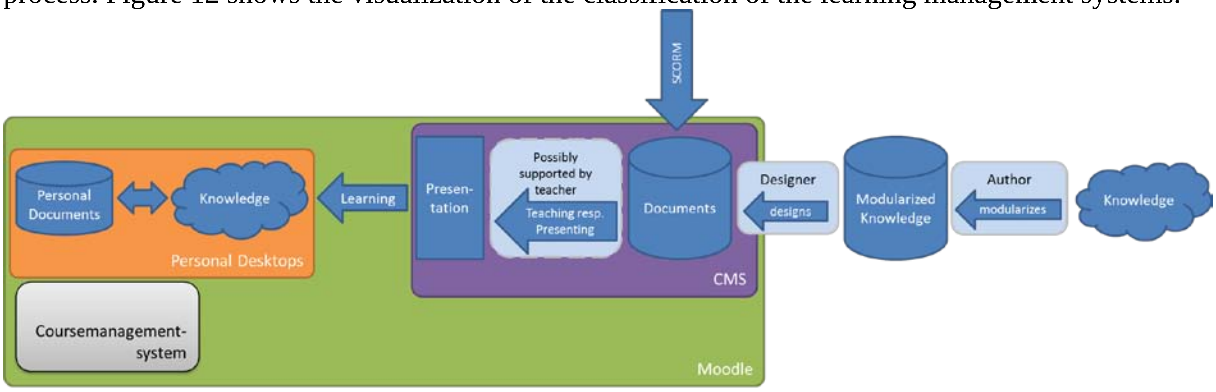

Figure 12: Learning Management Systems in the pinngate process

In the field of modular storage of knowledge modules wiki systems appear to offer the best possibilities. They are able to store small items with the modular information. With wikis, the content is in the foreground. The basic idea of a wiki is that users work collaboratively on information. So from many angles, new information can be added. This results in support of the pinngate process, as shown in Figure 13. In addition a wiki can become self-sustaining above a critical mass of users, because the number of users will then increase exponentially.[7]

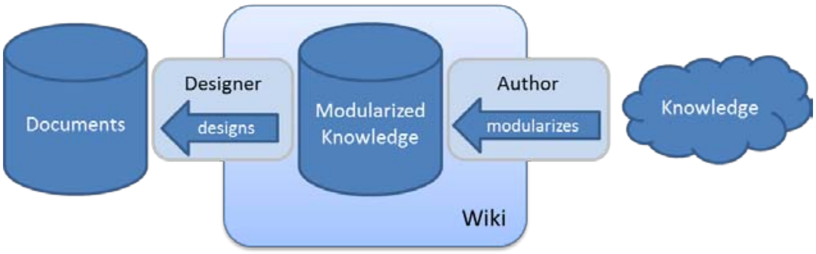

Figure 13: Wikis in the pinngate process

4 ADDITIONAL BENEFIT FOR TEACHING AND RESEARCH

A big advantage for teachers is the general effort reduction. New documents can be easily configured from the existing modular units. Also, existing documents can easily be configured to change and need not be created from scratch. Still the repeated use of modular content units for different types of documents is possible. That way, it is quite simple to create documents for lectures, exercises, or the Web based on the same modules. The combination of modules works like a configuration.

For students, the advantages are mainly the central learning environment and the specially prepared documents. They do not have to rely on generally designed documents, but they receive documents that are tailored especially to their needs.
In the learning environment, students find all the documents in one central location and they are able to mark or even comment the required texts while reading them. The orientation to the natural functioning and the adaptation of this procedure in the context of IT workflows, makes students learn better.
In addition, very good communication possibilities within a learning management system encourage students to align student learning activities better. Coordination comes through communication. [8]

For the research, the advantages lie in the way of working itself. New modular contents can be included easily in the fundus of the modular contents. There is no necessity to rely on a single author, as many people can write content units. Academic staff is also capable to store knowledge units from current research in the system directly. But even more interesting is the system for researchers, when the database contains content modules from more than one source. If there were various other modularized textbooks stored in the database, researchers could display with very simple means all the modules that explain a given situation. From the comparison of different descriptions similarities, differences and even possible errors might be derived. Such a comparison would also offer the opportunity to identify indirectly put constraints, which could formulated explicitly then. If the researcher stores his findings back into the database, this would increase the quality of the content enormously. This is illustrated in Figure 14.
In addition this could become the key to improve the basic approaches of Sauer to describe design methods completely and standardized. [9]

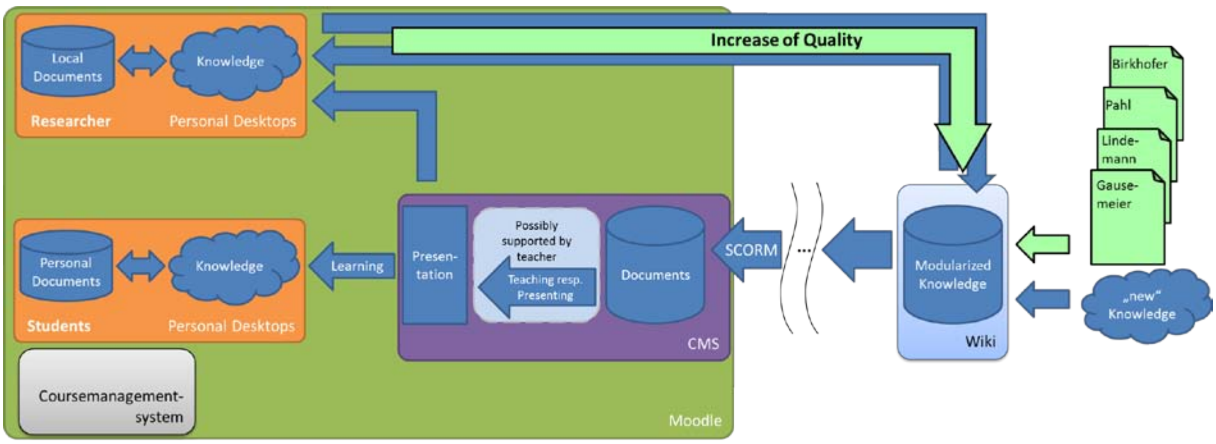

Figure 14: Increase the quality of content

5 CONCLUSION AND FURTHER WORK

The detailed analysis of the processes of knowledge transfer showed on the one hand the supporting possibilities offered by standard software, and on the other hand it showed that the occurring sub-processes could be understood more precisely than it was previously the case. In particular, the configuration of the documents within the process could be identified as a major focus in the pinngate project. This process is not supported by any standard software so far.

Supporting this part of the process with software tools and above all with technical rules and methods for selection and design, results in a very large ratio potential.

For example this allows the creation of quiz questions within a learning management system, like Moodle, for the use as learning control consuming a very little amount of time. Also the assembly of new material for lectures and exercises will be drastically simplified. The principle mode of preparation of documents by the configuration of modules was successfully verified by revising the script for the lecture Product Development at Technische Universität Darmstadt. [10]

A validation of the IT support with the detailed process steps of selecting and subsequent design and layout trailing is aimed in the near future. Just as the extension of application on the level of university education, so that experiences can be collected with the user-specific configuration of documents for other target groups.

First validations and the insights in the field of knowledge transfer processes clarify the great potential of the pinngate project.

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