CLASSIFICATION OF TOOLS AND METHODS FOR KNOWLEDGE MANAGEMENT IN PRODUCT DEVELOPMENT

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Keywords: knowledge management, VDI 2221

1. Introduction

„Der Fortschritt lebt vom Austausch des Wissens" (Progress is based on the exchange of knowledge - Albert Einstein), is only one of many famous sayings that underline the importance of knowledge. [Vajna et. al. 2001] quote a statement from 1907 saying that besides dedicated employees the application of knowledge had already been one of the most decisive factors of success for companies that time. This is more applied to our, by globalization characterised, time. A neglect of existing potentials of the employees' knowledge has negative impacts on product development [Krause et. al. 2007]. That is why the missing accessibility of personal knowledge to the company and its employees leads to wasting in the company in the form of redundant developments or dissimilar decisions [Probst et. al. 2006]. Only a structured and systematic management of knowledge resources enables a company to benefit from yet unused personal knowledge [Krause et. al. 2007] and, thus, to positively influence the main targets cost, time and quality [Klabunde 2003].
Recently, a huge number of innovative knowledge management methods and tools have been developed, but only few of them have been applied. Problems that hinder the application of those methods and tools have been discussed by [Klabunde 2003]. Among these is also the limited usage of the tools due to missing knowledge about the usage.

The aim of this paper is to combine knowledge management tools and methods with product development. The method to do this is to consider the knowledge management blocks according to Probst [Probst et.al. 2006], deriving from the area of business administration, in the context of the product development process according to VDI 2221 [VDI 1993]. Based on this consideration, the goal of this contribution is to identify and propose existing solutions for knowledge management in the different phases of product development.

2. Knowledge and knowledge management

2.1 Data, information knowledge

Most of theories about knowledge distinguish between symbols, data, information and knowledge. The transition from one level to the next can be seen as an enrichment process. So, symbols e.g. become data by using syntax rules. They are composed of symbols and numerical values without meaning. The linking of information allows their use in a certain field of activity, which can be interpreted as knowledge [Probst et. al. 2006].
So, knowledge is an aim oriented connection of information that requires acquaintance about the interrelations and between them [Gronau 2001]. Unlike data and information, knowledge is always

linked to a person. It is created by individuals and represents their expectations about cause-effect-connections [Probst et. al. 2006].

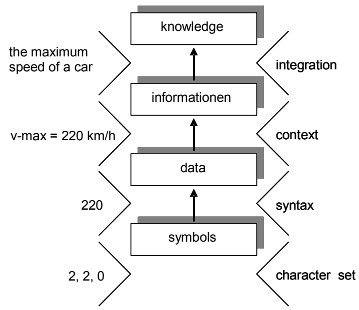

Figure 1. Symbols, data, information, knowledge [Probst et. al. 2006]

2.2 Classification of knowledge

Knowledge can be distinguished in implicit and explicit knowledge. Implicit knowledge is in the heads of experts and exceeds the amount of explicit and codificable knowledge, which can be extracted from implicit knowledge as a subset.

Implicit knowledge is personal, context specific and often very difficult to formalise and to communicate. On the one hand it consists of models individuals perceive and define their word subjectively by. On the other hand it consists of cognitive elements. This could be technical elements like abilities of an individual, which are developed by experiences in practical situations [Bügel 2004]. In contrast explicit knowledge is codeable, which means, that it can be captured by a systematic language and be stored, manipulated and transmitted on different media [Bügel 2004]. So, this is the precondition for the support of knowledge management by using communication and information techniques. A further distinction between forms of knowledge can be made by regarding the accessibility of knowledge. While private knowledge is only available for individuals, collective knowledge can be accessed by several people. Both distinctions (implicit-explicit, private-collective knowledge) build the basic dimensions of a company's knowledge base.

2.3 Knowledge management

According to Probst et. al. [Probst et. al. 2006] the term knowledge management means the improvement of organisational abilities on all levels of the company by a better treatment of the resource of knowledge. Thus it can be seen as the management of activities and processes which can raise the efficient use of knowledge and thereby the competitive ability. The efficient use of knowledge means that gained knowledge has to be purposefully integrated in the development of products and processes [Klabunde 2003]. This is the precondition for a company to realise innovations and to stay competitive. The main object of knowledge management is the knowledge base of a company, which consists of the integration of different knowledge stocks and experts. The main aim is to offer tools or methods for the planning, organisation, steering, usage and control of the knowledge base [Klabunde 2003]. The blocks of knowledge management (see figure 2.) clarify the scope of duties of knowledge management. The linkage between the blocks is typical and inevitable in practise. Two Circles can be combined. The outer circle consists of the specification of knowledge targets as well as their implementation and evaluation within the company. These blocks build an oriented and coordinated framework which has to be established by the company's top management to be able to perform interventions within the operative business units, the so called inner circle. Thus the inner circle describes the realisation of knowledge management within a company, forms possible fields of intervention and consists of the elements of knowledge identification, knowledge acquisition, knowledge development, knowledge sharing, knowledge storage and knowledge use.

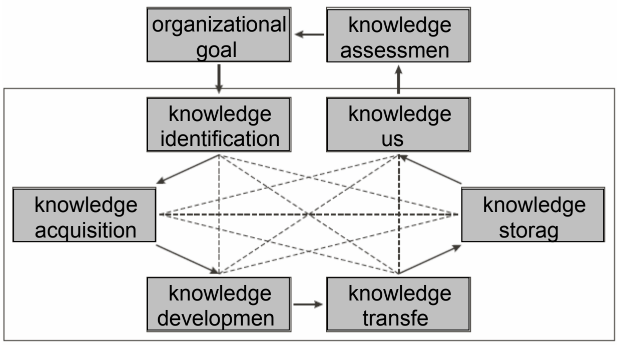

Figure 2. Building blocks of knowledge management after [Probst et. al. 2006]

3. Knowledge management in Engineering Design

The product development process according to VDI 2221 is divided into seven stages. Those steps can be clustered in the four phases task clarification, conceptual planning, preliminary and definitive layout [VDI 1993].

3.1 Knowledge management in task clarification

This phase is to formulate and to specify the requirements of the developing product [VDI 1993]. The requirements of all the stakeholders in the product life cycle, i.e. the customers themselves, manufacturing and assembly departments, marketing and service, have to be considered. Therefore all the relevant requirements have to be identified, assessed and documented systematically [Klabunde 2003]. The objectives of the knowledge management activities in the project preparation phase are the determination of knowledge targets in order to arrange project teams due to the optimal achievement of objectives and to initiate a knowledge process [Probst et. al. 2006]. Based on the formulation of the knowledge targets, it is determined what knowledge had to exist when and in which extent. Part of this is also the identification of adequate knowledge carriers, including experts, data bases and documents as well as artefacts. Artefacts are in this context knowledge carriers in form of already existing products, processes or technologies. Result of the knowledge management activities in the task clarification phase is to have an as-is profile, describing the degree of required knowledge which is covered by internal knowledge carriers and the amount of required knowledge which has either to be acquired externally (e.g. by hiring consultants) or developed internally (e.g. by qualification activities). According to that, activities have to be defined which support the identification, acquisition and development of knowledge.

3.2 Knowledge management in conceptual planning

The phase of conceptual planning can further be subdivided into determining functions, searching solution principles, conceptual selection and conceptual realization [VDI 1993], [Beitz et. al. 1997] and [Ulrich et. al. 2003]. During determining functions the main goal is to get to the core problem of the requirements through abstraction. It has to be verified which main requirements a fully functional solution has to fulfil [Beitz et. al. 1997]. In the following the overall function of the product has to be identified, divided into sub-functions and the functional structure has to be developed [VDI 1993]. In the phase of searching solution principles solution for the identified sub functions have to be found and to be combined to concepts [VDI 1993]. This search can be executed using an internal or external search [Ulrich et. al. 2003]. While using an internal search it is the main goal to use and develop the potentional which is available in the company. However it is also possible to perform an external search which can include the usage of existing solutions to be found through literature research or the questioning of lead users [Ulrich et al. 2003]. The concept selection phase is focused on weighting the identified conceptual solutions [Klabunde 2003]. The degree of performance of each concept has to be valuated. It is possible to use therefore a concept-screening-matrix, in which the degree of performance of each concept in respect of a selected sub-function is valuated [Ulrich et al. 2003]. In the conceptual realization phase the selected concept has to be subdivided into realizable modules [Klabunde 2003], elaborated and reviewed. Several iterations can be the result.

In respect to knowledge management the main focus is on the activities of knowledge development in using for example creativity techniques and knowledge acquisition. Knowledge acquisition can be fulfilled for competence needs which can not be developed in the company itself. Further the use of existing knowledge is getting more and more important. In the phases mentioned before an efficient use of knowledge is necessary to be able to develop innovative products [Klabunde 2003]. Activities such as contacting identified experts for special subject or methods, the transfer of existing knowledge about tools and methods, whose adoption to the current problems and the use of efficient mechanisms for knowledge storage and transfer can here be mentioned. It has to be ensured that each project member has the same level of knowledge of methods and tools. Otherwise unnecessary iterations can be a result. Here the use of a best practise and lessons learned database can be helpful.

3.3 Knowledge management in embodiment and detailed design

Embodiment design is defined as the part of construction in which the technical shape is transformed from its conceptual solution into detailed solution [Pahl et. al. 1993]. Real scale plans and complete booms of materials are the result of the [VDI 1993]. The aim is to transfer the product into a concrete shape which fulfils the specified technical and economical requirements [Klabunde 2003]. The following detailed design is defined as the part of construction in which the conceptual solution is fixed through definite instructions for shape, measurements and surface features for all parts and the definition of materials [Pahl et. al. 1993]. The result of the work is the product documentation which also includes the code of practice [VDI 1993]. With the change over into the phase of realization the main focused of the activities of the knowledge management is now on actives such as knowledge use, transfer, evaluation [Klabunde 2003]. The main goal in the embodiment design phase is to allocate and provide the knowledge which is needed. The reuse of documented knowledge in databases such as lessons learned can be very helpful [Klabunde 2003]. But not only has the use of such databases during a current project to be supported. It is also important that new created and acquisitive knowledge is conserved for following projects. In a last step the knowledge assessment has to be performed. It is important to evaluate the knowledge process of a project to get new inputs for following projects. This can be performed in defining key-data which a screened over several project. The key-data should then be analyzed and evaluated and give a feedback of the quality of the knowledge process performed in a certain project [Klabunde 2003].

3.4 Conclusion / Recap

On basis of the product development process according to VDI 2221 (chapters 3.1 to 3.3), the relative characteristics of the knowledge processes following [Klabunde 2003] can be depicted as in figure 3.1. In figure 3. a significant offset in the emphasis of the required modules in the early phases of product development (knowledge targets and knowledge identification) and those in the late phases (knowledge allocation, conservation and assessment) can be identified. Furthermore, it can be seen that the usage of knowledge is most important in the stages of concept realisation and laies outing, whereas the acquisition and development of knowledge take centre stage when synthesising solutions.

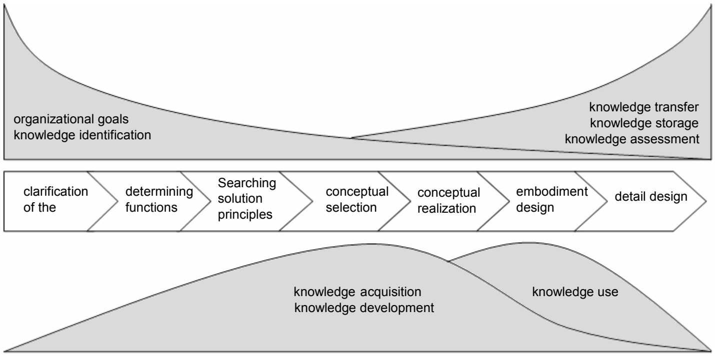

Figure 3. Relative characteristics of knowledge modules related to VDI 2221

4. Software solutions for knowledge management in Engineering Design

The implementation of knowledge management is not only a software problem. Successful knowledge management should always consider the three dimensions: technology, organization, human [Lucko et al. 2005]. However, none of the dimensions is optional, so also the technology dimension crucial. It is a prerequisite for an efficient application of knowledge management [Bügel 2004].
In this paper, the integration of software solutions in the design process according to VDI2221 is key issue. In a first step, it is considered at a selection of the existing methods and tools which of them are adequate in which module. The result is shown in figure 4.

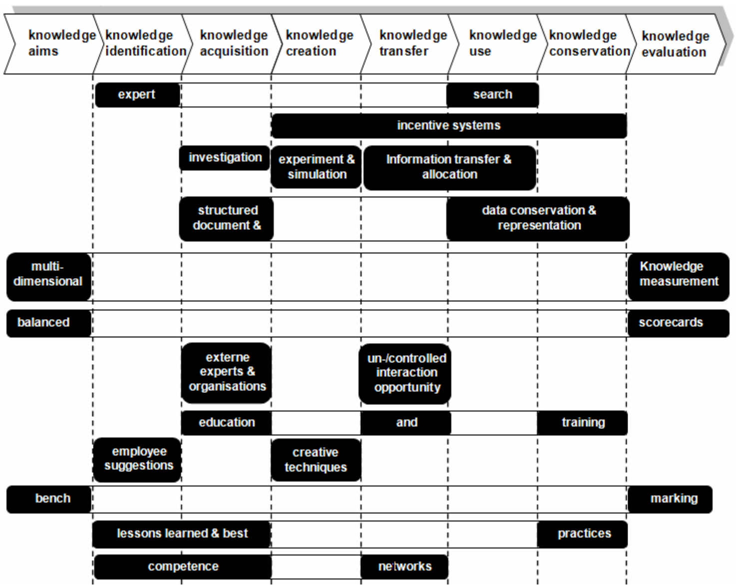

Figure 4. Classification of knowledge management tools and methods

In a second step, it is necessary to determine software solutions, which can support the presented tools and methods. A selection of possible software tools and their application is shown in figure 5.

tools and methods	IKT-solution?	IKT-example:
•expert search	✓	yellow pages
•incentive systems	×	
•information transfer and allocation	✓	groupware & portals, workflow-applications
•structured document & data conservation & representation	✓	document/content-management-systeme
•multidimensional kowledge measurement	×	
•balanced scorcard	×	
•un/controlled interaction opportunity	✓/×	e-mail, black boards
•education & training	✓	e-learning systems
•employee suggestions	×	
•bench marking	×	
•lessons learned & best practises	✓	databases such as document/ content-management-systems
•competence networks	×	
•investigation	✓	text & data mining, expert systems, knowledge mapping
•external experts & organisations	×	
•experiment & simulation	×	
•creative techniques	✓	concept & mind maps, white boards

Figure 5. Possible application of software solutions

In a last step, a synthesis of figure 3., figure 4. and figure 5. is carried out in figure 6. Here, it is visible, which tools and methods can be used in which step of the product development. The relative characteristics of the knowledge processes can be depicted according to these tools and methods.

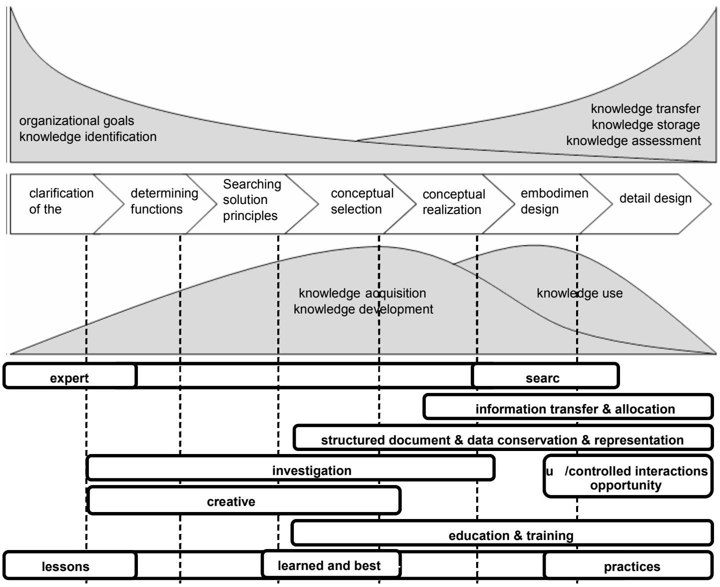

Figure 6. Tools and methods in the phases of product development after [Klabunde 2003]

To implement them, a broad field of software developers offer software solutions to deal with them. Figure 7. shows, which software solutions exists for the different tools and methods. This figure can be used to select a fitting technique. Of course it is only a selection and not a complete overview.

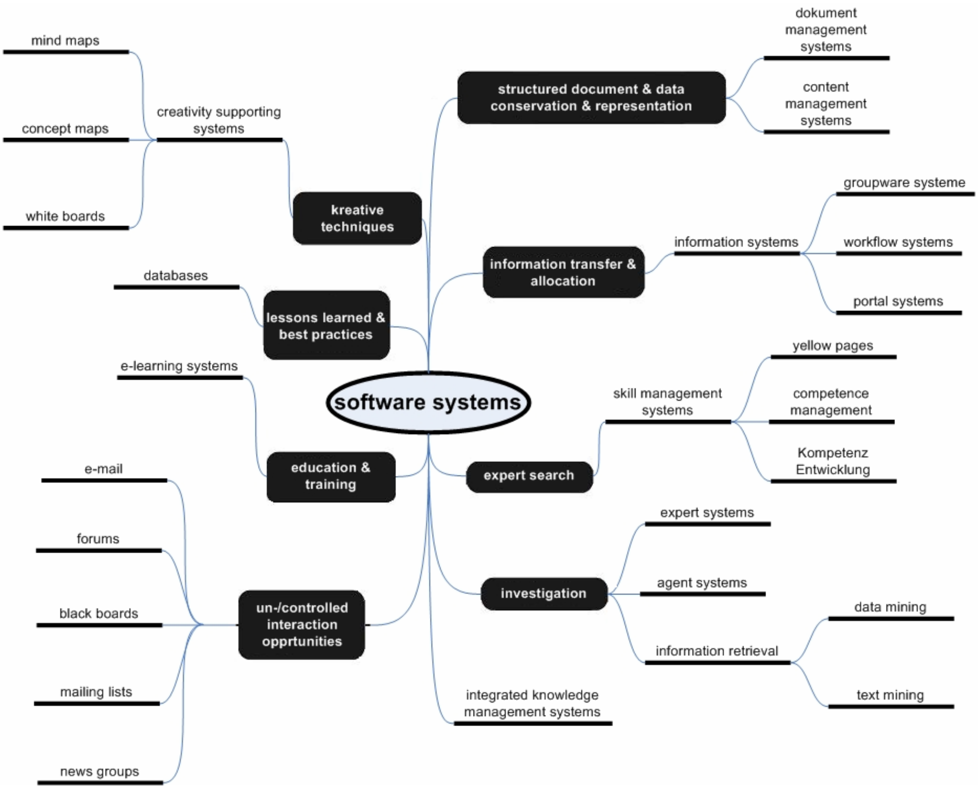

Figure 7. Software solutions for knowledge management

5. Conclusion

knowledge management is a very important topic in engineering design. The application of information technologies is an important part in the implementation of knowledge management.
This paper combines the knowledge management approach of Probst [Probst et.al. 2006] with the approach to design technical systems VDI2221. These are summarized in figure 4. and figure 6.To allow an application of this combination, possible tools and methods to support knowledge management in engineering design are presented in a second step, summarized in figure 7. A classification of them according to Probst and VDI2221 is done.
So it is shown in this research that a set of tools and methods is already available, but the application has to be structured and adapted to the development step.
In future work, a selection of available tools has to be done according to the developed structure. This set can be basis for further design processes.

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