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IDENTIFICATION OF KNOWLEDGE AND PROCESSES IN DESIGN PROJECTS

Schmidt, Danilo Marcello; Kammerl, Daniel; Schultz, Bernhard; Schenkl, Sebastian Alexander; Mörtl, Markus
Technische Universität München, Germany

Abstract

As market's requirements change, companies have to conserve, develop and manage their knowledge to provide more complex products. For this reason and in the background of knowledge management, it is necessary to detect knowledge gaps in the company or in a department. We built a methodology, which firstly identifies the processes running in the concerned unit and the knowledge, which is needed to complete those processes. Thereby, our approach focus on the granularity of the knowledge and process elements. This enables quantitative analysis methods for knowledge structures to provide results that are more valid. To evaluate this granularity, we applied our approach in a design project.

Keywords: Design process, Knowledge management, Knowledge elements, knowledge mapping

Contact:
Danilo Marcello Schmidt
Technische Universität München
Institute of Product Development
Germany
danilo.schmidt@pe.mw.tum.de

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1 INTRODUCTION

For the design of complex and functional products, designers have to possess the required knowledge. Today's design departments are confronted with varying technologies and changing user requirements. Those challenges demand for more and more specific knowledge. In contrast, increasing staff fluctuation means increasing knowledge fluctuation: retirement of employees causes always drain of knowledge. Therefore, companies have to control and update the knowledge employees bring into the company that all knowledge needed for designing new products is available.

In literature, many approaches exist to acquire knowledge, to analyse knowledge, to visualize knowledge or to develop knowledge (Eppler 2008, Gordon 2000, Probst et al. 2000, Schenkl et al. 2014, Schmidt et al. 2013a). They deal with knowledge, which needs the company to develop and to provide their products or services to the customer. In this paper, we develop an approach how to identify a knowledge gap. As knowledge is brought into the company to fulfil tasks or to complete processes, we use a process-oriented approach of knowledge management and knowledge mapping.

2 STATE OF RESEARCH

The objective of our methodology is to detect lack of knowledge. Thereby, our approach will not only focus on the lack itself, but also in which context the knowledge is missing. This context means the processes the knowledge is needed for. The advantage of this approach is that the need for elimination of the knowledge lack can be evaluated by including the processes' importance. First, we conducted a literature research to detect the need for research. For this, we identified other approaches from the literature and analysed a knowledge mapping approach from previous work (Schmidt et al. 2013a, Schmidt et al. 2013b, Schmidt et al. 2014, von Saucken et al. 2014, Wickel et al. 2013).

2.1 Approaches for analysis of knowledge

A common approach for analysing knowledge is the evaluation of knowledge. Knowledge can be evaluated regarding the economical or strategic value (Kaplan and Norton 1992), the competitiveness (Probst et al. 2000, Schenkl et al. 2014), relevance for the company (Probst et al. 2000, Schmidt et al. 2014) and other criteria. Kaplan and Norton developed the balanced scorecard, which is a strategic tool to identify how the knowledge situation fits to the company's goals. This evaluation method measures the benefit of the whole knowledge basis for the company's strategy and may be interested for investors but not to identify missing knowledge in the company. Other evaluation approaches, which focus the holistic view on the knowledge structure are (Ahn et al. 2006, Housel and Nelson 2005, Oliver et al. 1996) to compare the benefit of a company's knowledge to other assets of the company. However, these kinds of evaluation are not suitable to identify knowledge in the regarded company.

"Bloom's taxonomy" (Bloom and Krathwohl 1956) from the educational science was made to evaluate learning objectives. It is used to evaluate how deep knowledge is available. Accordingly, a person can possess knowledge in six sequent levels: knowledge, comprehension, application, analysis, synthesis and evaluation. The higher the level is knowledge shall be acquired, the more efforts have to be spent to reach the level. One level of this taxonomy includes all lower levels. If a knowledge element is available on the level "application", it is also available on the levels "knowledge" and "comprehension" (Bloom and Krathwohl 1956). Crooks took up this taxonomy and claimed that six levels are too much for practical application (Crooks 1988). Based on this finding and on (Bloom and Krathwohl 1956), Schenkl et al. (2014) defined a scale for evaluating the depth of knowledge and introduced the three levels "retain knowledge", "comprehension" and "problem solving" which summarize the six levels of Bloom to three levels. Even though this evaluation of knowledge depth cannot identify missing knowledge, this dimension is necessary to determine if the available knowledge is deep enough for the usage in the company. A car salesman and a car designer must have knowledge in a car's architecture but the car designer's knowledge is needed in a deeper level.

Probst et al. (2000) introduced the competency matrix to order knowledge according the two dimensions competitiveness of knowledge assets and degree of knowledge usage . Dependent on the position of knowledge in this matrix, Probst et al. (2000) distinguish between non-utilized competencies, unique competencies, non-essential competencies and fundamental competencies. For all of these competency categories, they suggest an activity, like outsourcing or larger usage. This approach helps in identifying knowledge, which in not necessarily required by the company. Especially this dimension of competitiveness is crucial for the need of knowledge and is further described in Schenkl et al. (2014). However, needed but missing knowledge cannot identified using this approach.

Another approach for analysing knowledge are knowledge maps. in literature a lot of knowledge mapping methodologies exist (Eppler 2002, Herman and Melan 2000, Howard 1989). They differ in different criteria, for instance the purpose, the content, the graphic form or the creation method (Eppler 2008). The knowledge map's purpose is to visualize a great quantity of elements and relations in a manageable form. A collection of layouts to visualize information is given in (Herman and Melan 2000), for example a tree-map whereas the colour of rectangular elements represents the level of hierarchy (Johnson and Shneiderman (1991). In the knowledge mapping approach, the knowledge to illustrate is divided in knowledge elements. The representation of these elements and their relations depicts the structure of knowledge. According to Eppler (2002), a knowledge element can describe experts, written text, applications or lessons learned. Eppler (2002) visualized knowledge maps by building different shapes for different kinds of knowledge elements. Gordon (2000) hierarchized the knowledge and developed accordingly a visualization with knowledge elements on different levels. The force-directed graph was applied for displaying knowledge distribution by Maurer et al. (2009). In this approach, knowledge elements and relations between them were shown while numbers of relations determine distances between elements. In these cases, the interpretation of a knowledge map happened by analysing the knowledge map's visualization.

2.2 Developing company's knowledge

In a previous research project for the analysis and development of company's knowledge, we built a methodology to collect knowledge elements and tasks in a department, which were analyzed regarding the fitness for the future and regarding weak points in the knowledge structure (Wickel et al. 2013). The first step is the elicitation of knowledge and tasks by interviewing departments' employees. The knowledge required in the future was identified by interviewing departments' managers or lead employees using scenario techniques (Schmidt et al. 2013b). This knowledge structure was visualized in a Multiple-domain matrix (Maurer et al. 2009), which consists of the domains tasks, knowledge and employees and the relations between them (Wickel et al. 2013). The current knowledge structure was analysed using structural criteria and critical knowledge elements regarding the availability could be identified (Schmidt et al. 2013a). The comparison of current and desired knowledge map happened by the application of the competency matrix (Probst et al. 2000), which revealed the need for improvement of some knowledge elements (Schmidt et al. 2014). Based on this analysis results, a method was built for eliminating the weak points of the knowledge structure (von Saucken et al. 2014).

The main weakness of this methodology is the elicitation of tasks in the first step. Employees were asked without a systematic approach for their tasks. Thereby, tasks had different granularity. This granularity described the range and level of abstraction the tasks were defined. Therefore, the number of tasks an employee fulfils in the department cannot be a measure for the worth of the work in the department. The lack of same tasks' granularity reduces the quality of analysis results of the knowledge structure (Schmidt et al. 2013a, Schmidt et al. 2014, Wickel et al. 2013). This is also relevant for the knowledge elements. As the knowledge elements describe different ranges of knowledge, the results of the quantitative analysis of the knowledge structure as it happens in (Schmidt et al. 2013a) are not as valid as they were for granular knowledge elements.

2.3 Identification of knowledge: need for research

None of the mentioned approaches from literature is able to identify missing design knowledge. Some of them are helpful and necessary for decisions if knowledge should stay in the company or will be required for the future. For example the competency matrix of Probst et al. (2000) and its application for the comparison of current available knowledge and knowledge required for future (Schmidt et al. 2014) are reasonable approaches to decide if knowledge can be outsourced or how it should be developed. In this context, Bloom's taxonomy turned out to be a useful taxonomy to evaluate the knowledge regarding the knowledge depth. In our previous research project, the tasks definition is a problem, which is based on the lack of the process-relevant integration of the employees' tasks.

Employees mention their tasks only randomly, therefore they might forget some of them, as the tasks are elicited in only one interview, and they do not consider tasks' ranges and granularity.
For this reason, we propose to integrate the employees' work in a reference process by characterizing the existing design situation before. For this, we have to find a suitable reference process and a way to describe design situations, which enables us to identify all tasks with same granularity. A knowledge model, which includes all possible knowledge elements has to be identified that will be used to identify knowledge elements employees need to fulfil their tasks. Finally, a method for the identification of missing knowledge has to be built. In the next section, we describe the methodology we constructed to cover those mentioned needs. Afterwards, we evaluate the utility of our approach using a case study.

3 METHODOLOGY TO IDENTIFY KNOWLEDGE IN DESIGN PROJECTS

The methodology we built compares existing knowledge to reference knowledge on the basis of initial design processes. We firstly introduce the whole methodology in the next subsection and then explain every step more detailed.

3.1 Methodology

The approach is shown in figure 1. The first step is the determination of the regarded design situation. This is a classification of the current status of the regarded design department. Then, the processes and knowledge, which is needed to fulfil the processes, are identified. Then, the relations between the knowledge and the processes are identified for the current and the optimal status. Those data are depicted in two matrices. After that, the delta-matrix of those two matrices is calculated and analysed. The analysis results serve as the basis for the derivation of activities to improve the knowledge structure of the regarded company. As knowledge management is not a method statically to apply, a continuous process of knowledge development has to follow.

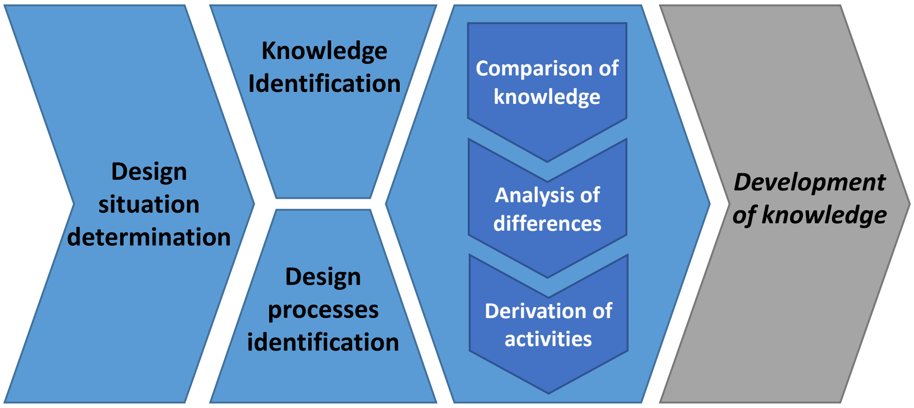

Figure 1. Methodology for knowledge identification

The next subsections will outline the described steps.

3.2 Step 1 - Design situation determination

For this step, we built a datasheet to characterize the design situation. For this, we combined three models from the literature for characterization of a design situation (Kabel 2001, Ponn 2007, Schenkl et al. 2014). Ponn defines several criteria of a design situation, e.g. the type of product, type of market, customer or complexity (Ponn 2007). This characterization focuses the product itself but is not sufficient for our purpose, as we focus the knowledge. Knowledge is not only a matter of the product but also of the department, the company and the design team, because employees possess knowledge and use it for designing products. Roelofsen extends this model of describing a design situation and introduces three levels of criteria to determine design situations: the project level, the operational level and the overlapping level (Roelofsen 2011). The project level includes parameters about the design project, e.g. customer, risk or financial. The operational level describes criteria concerning concrete operational conditions, e.g. existing product models, preceding processes or desired output. The overlapping level includes criteria which fits to both project and operational level or generic criteria, which cannot assigned to one of the other levels, e.g. requirements or product's complexity (Roelofsen 2011). Roelofsen considered relevant aspects besides the product to describe a design situation (Roelofsen 2011). However, Roelofsen considered aspects of teams and team structure only roughly, which are still important for our view on a design situation (Roelofsen 2011). Kabel (2001) developed a model for the evaluation of team-performance in Systems-Engineering-projects, including aspects and factors of teams.

Combining the product-focussed view of Ponn (2007), the more holistic view of Roelofsen (2011) and the team-focused view of Kabel (2001), we built a datasheet, which is exemplary shown in figure 3. This description of the design situation is the basis for the following steps and includes the system boundaries.

3.3 Step 2 - Design Process Identification

The identification of processes happens in interviews or workshops with the employees (Wickel et al. 2013). A generic model of a design process and process modules supports this step. Using this model, interviewed employees have to check which of the processes they handle and which they do not handle. The process model are used as a checklist for the interviews. Therefore, the generic design process model must be complete and holistic. Roelofson built such a model by analyzing other process models and combining them to the FORFLOW-model (Roelofsen 2011). The model is structured in three levels of detail, whereas the first two levels include the processes in a predetermined sequence and the processes of the third levels have to be adapted to the regarded design situation. The most abstract level consists of six steps: clarifying the task, determination of functions and their structures, search for solution principles and their structures, development of overall concept, system design and start and supervision of series production (Roelofsen 2011). Using this pre-defined design process model, the processes employees work on can be identified on a level with same granularity. Before employees are asked to identify the processes, generic processes from the FORFLOW-model can be pre-processed according to the design situation. This simplifies the identification of processes.

If the regarded company or department has a set of predefined processes, this model should be used instead of the FORFLOW-model. The FORFLOW-model is a generic process model, while processes defined by the company are on a more concreter level and more suitable for this methodology.

3.4 Step 3 - Knowledge Identification

Similar to the identification of design processes, we use a checklist for knowledge elements. This checklist is based on the work of Petermann, who analysed interviews with employees working in different departments of capital goods industry (Petermann 2011). The outcome of this analysis was a collection of knowledge elements, which employees need for their work. To make this list generic for design projects, we add some knowledge elements and added elements from other sources (Ahmed 2005, Czichos 2005, Lindemann 2005, Schwab 1999). We categorized in two main categories: product-dependent and product-independent knowledge (Schenkl et al. 2014). Product-dependent knowledge focuses not only the product to design but also products of competitors or previous products. Knowledge elements of this category are product characteristics, e.g. properties and models or components and material, or reasons for product characteristics, e.g. customer needs or quality and safety. In contrast, product-independent knowledge cannot be associated to a certain product. This category is divided in basic knowledge, e.g. software tools or documentation, and specific knowledge, e.g. electronics or biology. Like the processes, the design knowledge used by employees for their work is identified in interviews, described in (Wickel et al. 2013). This checklist supports the interviewer in his work and provides results of higher quality, because the checklist ensures granularity and completeness of identified knowledge elements. The entire list of knowledge elements is shown in figure 2.

In a design project, it is not sufficient that knowledge is available; knowledge has to be available on the needed knowledge depth. (Schenkl et al. 2014) and (Schmidt et al. 2014) compared the knowledge depth of same knowledge elements for the current situation and for the future situation. In this way, we compare the status quo of the current situation of knowledge structure to the optimal knowledge structure. For this, we use the approach of Schenkl et al which is based on Bloom's taxonomy. In this approach, depth of knowledge is evaluated in three levels: retain knowledge (1), comprehension (2) and problem solving (3).

Product-dependent Knowledge		*Product-independent Knowledge*	
Reasons for product characteristics	**Product characteristics**	**Basic Knowledge**	**Specific Knowledge**
• Functionality models • Properties and models • Design of components • Design of interfaces • Simulation, test and properties • Components and material • Bills of materials	• Customer requirements • Requirements • Application • Operating • Assembly and disassembly • Sales • Laws and rules • Diagnosis, maintenance, repair • Packaging, transportation, storage • Production and assembly • Quality and safety • Purchase of materials and components	• Mechanical skills and tools • Engineering basics • Programming (software, machines) • Communication and language • Software tools • Measurement and revision • Information acquisition • Documentation • Project and resource management	• Biology/Bionics • Chemistry • Process engineering • Electrical engineering and electronics • Mechatronics • Computer sciences • Power engineering • Environment engineering • Measurement and control engineering • Simulation engineering • Mechanical Design • Technical mechanics • Dynamics of machines • Fluid mechanics • Thermodynamics • Materials engineering • Adaptronic • Drive engineering • Manufacturing and production engineering • Human resource management • Marketing • Controlling

Figure 2. Knowledge Elements

3.5 Step 4.1 - Comparison of Knowledge

In this step, the relations between knowledge elements and tasks are identified. This is also done in interviews (Wickel et al. 2013). This is done for two cases: the current status (actual matrix) and the optimal knowledge structure (optimal matrix), therefore two matrices are built. In contrast to the approach in (Wickel et al. 2013) is this optimal knowledge structure not the knowledge structure of the status desired for the future scenario. In this approach, this optimal knowledge structure describes how deep is which knowledge required to accomplish the selected design processes in the current design situation. If two different persons or groups fill those two matrices, the quality of result is higher. For this, the current status should be filled by employees who are working in the project and the matrix for optimal knowledge structure should be filled by the management. With this step, the data acquisition is completed and the actual analysis can start in the next step.

3.6 Step 4.2 - Analysis of Differences

The basic for the analysis of differences is the delta-matrix. This matrix is calculated by matrix-subtraction of the actual matrix and the optimal matrix. The delta-matrix has as many rows and columns as the actual and optimal matrices have. If a knowledge element is available for a process on the knowledge depth of comprehension (2) in the actual matrix but is needed in the knowledge depth of problem solving (3) in the optimal matrix, the corresponding cell in the delta-matrix has the number -1.

Using this delta-matrix, we calculate degrees of conversion for knowledge elements and processes. The degree of conversion for knowledge elements describes range of processes, which are sufficiently supplied by the knowledge element. The degree of conversion (DOC) for a knowledge elements (k) is calculated using the number of processes, the knowledge element is needed for in the optimal matrix (p_k) and the number of deficient processes for the knowledge element in the delta matrix (dp_k). This deficient processes are those processes, whose cells in the delta-matrix include values smaller than 0 for the regarded knowledge element. The equation for the calculation of the degree of conversion for a knowledge element is shown in (1).

$$DOC_k = \left(\frac{p_k - dp_k}{p_k}\right) \qquad (1)$$

The DOC for a process describes the knowledge-driven fulfilment of a process. This is a measure if the process involves enough knowledge. Analogous to the DOCk, the number of knowledge elements needed for the regarded process (kp) and the number of deficient knowledge elements (dkp) are required for the calculation, which is shown in (2). A deficient knowledge element is a knowledge element whose value is lower than 0 in the delta-matrix for the regarded process.

$$DOC_p = \left(\frac{k_p - dk_p}{k_p}\right) \qquad (2)$$

The described DOCs are the main measure to analyse the knowledge structure. Using them, critical knowledge elements and critical processes can be identified, which we will see in the case study. A critical knowledge element is a knowledge element with a low DOC_k, which either is on a too low depth available or is missing at all in the regarded department. Analogous, a critical process is a process with a small DOC_p, which either have knowledge on too low depths or lacks of required knowledge. Those are the measures, which identify missing but needed knowledge in a department.

3.7 Step 4.3 and 5 - Derivation of Activities and Development of Knowledge

Dependent on the type of missing knowledge, e.g. if it is product-dependent knowledge or not, many methods, measures and strategies of knowledge management exist how the weaknesses in the knowledge structure can be eliminated. Gretsch et al. (2011) distinguish between three main strategies: Knowledge generation, knowledge communication and knowledge documentation. For every strategy, several methods can be used. Which of them should be selected for which case, is mentioned in (von Saucken et al. 2014). Saucken et al. (2014) identified 3 strategies, 40 measures and 69 methods from literature and linked those measure to specified cases. The last step of our model is the development of knowledge. This describes the ongoing development of knowledge, as the knowledge management is not over after the applying the previous steps of our methodology. Knowledge management is not a static onetime method; it is a continuous process to hold the required knowledge in the company and to bring new knowledge in the company if necessary (Probst et al. 2000). As this step is already done in other research, we do not focus in this paper on methods of knowledge management.

4 CASE STUDY

As a case study, we took a student design project. The objective of this project was the development and prototypical implementation of a deflection cover of a machine tool. We chose a project with one employee as we only focus on the granularity in this case study. Evaluation of other aspects of this methodology are already made in other studies (Schenkl et al. 2014, Schmidt et al. 2013a, Schmidt et al. 2014, Schmidt et al. 2013b, Wickel et al. 2013).
The first step is the determination of the design situation. This happened by filling the datasheet, which was mentioned in subsection 3.2 and is shown in figure 3. This description depicts the project and its system boundaries.

Generic Description	
Development of an arable unit at a 3-axis milling machine for deflecting chippings and protecting a laser beam against chippings during the milling process. The unit has to be adjustable to parameters of the milling process (depth and width of cut). The unit must not touch the work piece during the milling process and it should not restrict the optical accessibility.	
Current Status of Project	Project completed
Objective of Knowledge Identification	Retrospective knowledge identification as project evaluation
Product Level	
Type of Design Task	New development
Type of Production	Customer specific extension
Sales Market	• Not for sale • Necessary unit to support measurement series in a research project
Planned Production Batch	1
Degree of Novelty	High
Integration Degree	Medium
Complexity	High (lack of time)
Type of Main Objective	Proper provision of all needed functions to fulfill the products requirements
Project Level	
Duration of Project	6 Months
Cost Estimation of Project	< 2000 € for material and components
Integration of Customer	High
Project Risk Estimation	Low
Process Level	
Task Structure	Mainly linear, following a process model
Available Artefacts/Documents	Preceding model
Team Level	
Size of Core Team	One person
Involved Departments	• One customer • Team of the workshop responsible for the production • One consulter concerning the process model and methods application
Involved Contractors	None
Cross-functionality	Low (one designer)

Figure 3. Design Situation

		Knowledge element	Designer
Product-dependent knowledge	**product characteristics**	Functionality models	1
		Properties and models	1
		Design of components	2
		Design of interfaces	2
		Simulation, test and properties	3
		Components and material	1
		Bills of materials	3
	Reasons for product characteristics	Customer requirements	3
		Requirements	2
		Application	2
		Operating	1
		Assembly and disassembly	1
		Sales	
		Laws and rules	
		Diagnosis, maintenance, repair	
		Packaging, transportation, storage	
		Production and assembly	1
		Quality and safety	
		Purchase of materials and components	1

Figure 4. Designer's Knowledge

The project was a one-person project and the designer's knowledge was identified using the built knowledge checklist, described in subsection 3.4. Figure 4 shows a part of the knowledge list and how deep the designer possesses the knowledge elements.

For the identification of the processes, we used the FORFLOW-process-model. We first defined the tasks of the project based on the project documentation. As a second step, we assigned the tasks to the generic processes of the FORFLOW-model. This process synthesis was helpful in understanding the processes in the project: By defining the tasks before, we prioritized the tasks implicitly regarding the importance, as only relevant tasks were mentioned. The comparison with the FORFLOW-model identifies forgot processes or not mentionable processes. This project dealt only with three processes of the abstract processes of the FORFLOW-model: clarifying the task, determination of functions and their structures, search for solution principles and their structures. The process synthesis for "clarifying the task" is shown in figure 5. With the knowledge elements and the processes, two matrices were built by the designer: The actual matrix and the optimal matrix. Furthermore, the delta-matrix was built by subtraction and the values of DOC_k and DOC_p were calculated for knowledge elements and processes.

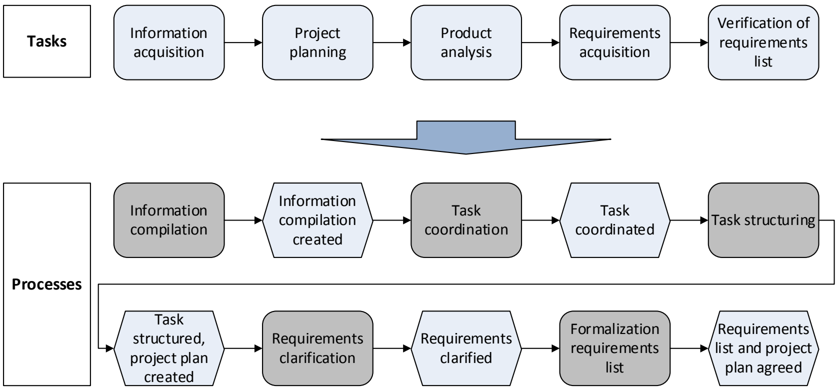

Figure 5. Process synthesis for "clarifying the task

The average of DOC_k of the 51 knowledge elements is 0.6. Around the half of the knowledge elements have a DOC_k greater than 0.8. Those knowledge elements should not focused for the optimization of the knowledge structure, as they are almost sufficiently available in the project. 17 % of knowledge elements had a DOC_k greater than 0.2 and smaller than 0.8. Those are available in the company but they need optimization, they should developed, as there is a need for development in the project. The remaining 33% of knowledge elements had a DOC_k smaller than 0.2. Those elements are available on a not sufficient level in the project and all actions for optimization should focus those knowledge elements. For example, the designer had only retain knowledge (1) in programming of software or machines, which is required on the level problem solving (3) for producing the prototypical version of the product. Because of this knowledge gap, the designer lost a lot of time in the project, because other people from the workshop had to support him.

The average DOC_p of the 21 identified processes is 0.55, while one third of processes have a DOC_p greater than 0.7, for one third of processes, the DOC_p is smaller than 0.7 and greater than 0.4 and one third has a DOC_p smaller than 0.4. The later the process happened in the project, the smaller is the DOC_p. One reason for this is that knowledge about product requirements, functions and characteristics of previous steps is needed and the deficits in knowledge are transferred from the earlier to the later processes. Furthermore, deep knowledge in combining and assembling the components is necessary which did the designer not possess. The DOC_p identifies processes with insufficient knowledge and those processes, which knowledge management measures should focus first.

Concrete measures and strategies of the two last steps, derivation of activities and development of knowledge, are already mentioned in (von Saucken et al. 2014). We mentioned already, that those two steps are not in the focus of this paper but point out that measures and methods for improving the knowledge structure have to be applied after the knowledge identification. In this case, we concluded, that another designer has to work in this project and we defined the knowledge structure that new designer has to possess.

5 CONCLUSION

Using our methodology, we identified the knowledge, which is underrepresented in the project and we identified the processes, which the lack of knowledge affects.

The benefit compared to the approach (Wickel et al. 2013) is, that the usage of pre-defined list guaranteed the granularity of identified processes (tasks) and knowledge elements. This increases the quality and validity of quantitative evaluation methods (Schmidt et al. 2013a, Schmidt et al. 2014). Furthermore, it improves the distinction between different elements. The risk of individual knowledge or process elements is that two or more elements describe the same thing or overlap each other. The usage of a pre-defined model eliminates this risk. Another advantage of our approach is that considering the whole knowledge- and process-model ensures a complete identification of elements. The risk of forgetting one or more elements in the acquisition process is reduced as the whole lists are regarded. However, it might be a problem if such a reference list is not complete and lacks of one or more elements. Therefore, the lists have to be kept up-to-date. Furthermore, there is no guarantee, that the lists and models we used in this paper are complete.

The results' quality of rating the depth of knowledge has to be considered critically. Especially the case of self-rating where employees rate their own depth of knowledge may be problematic. According to (Harris and Schaubroeck 1988), the self-assessment of performance differs widely from external assessment by peers or supervisors. Transferred to rating the depth of knowledge, this difference has to be regarded in the analysis of the results. The Dunning-Kruger effect describes the issue that employees may overestimate and some employees may underestimate their own competences (Dunning et al. 2004). Dunning et al. (2004) claimed that people could not estimate their own competences because they do not have enough information and they sustain information for an adequate evaluation. The results of a survey conducted by Zenger (1992) correspond to this effect. In this survey, engineers of two companies assess their performance relative to their peers and 36 percent placed their performance in the top five percent in the company. Only one respondent of in total 714 responded employees placed his or her performance below the average.

As already stated in (Schmidt et al. 2013a, Schmidt et al. 2013b, Wickel et al. 2013), this approach of acquiring the company's or department's knowledge structure have more benefits than just the described results from analysis. During the information acquisition process, employees and/or managers have to think about their work, the processes and the knowledge. They become more aware of their tasks and the other employee's tasks. This leads to a clearer distinction of tasks in the company, they realize the borders and interfaces of their task area between and to other employees, which can improve the efficiency of the organization. Levitt and March point out that clear responsibilities in organizations simplify to retrieve routines and to learn (Levitt and March 1988). Furthermore, the allocation of clear responsibilities is seen as a success factor for projects (Karlsen et al. 2006, Young 2003).

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