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Knowledge Transfer Quality Model Implementation – An Empirical Study in Product Engineering Contexts

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Abstract

Employee turnover, especially of experienced employees, is a constant challenge for companies as they are confronted with a loss of knowledge which they must compensate for. This leads to an accepted need to successfully transfer knowledge. Knowledge transfer has been reviewed in literature by multiple disciplines, whereas this paper focuses on a product engineering context. In this context, empirical research results show that knowledge transfer situations, e.g., communication of complex product specifications, can be improved regarding the speed of knowledge transfers by so-called interventions. Based on those findings, the quality of knowledge transfers is investigated further. Velocity-dependent, as well as quality-dependent interventions, are summarized in an intervention catalog. Whereas the effect of those velocity-dependent interventions has been investigated in empirical studies, the quality-dependent interventions have not yet been implemented in an industrial setting. This paper, therefore, describes the design and results of a workshop with experts from the area of knowledge management as well as from product development of universities and companies. The workshop was used to validate previously developed interventions and further add quality-dependent interventions. Further, the implementation of selected interventions in a product engineering context, using a Live-Lab as a research environment, is presented. The interventions intend to improve the quality of knowledge transfers in specific knowledge transfer situations. As this is validated by an empirical implementation study, the validity of this approach is justified.

Keywords: knowledge transfer quality; product development; empirical studies; validation; improvement

1. Introduction

In recent years, there has been an increasing awareness that the retirement of a company's older employees represents a major loss of expertise and experience [1,2]. At the same time, employee turnover is often on the rise. To maintain efficiency and effectiveness, good knowledge transfer is required. There are many challenges and potentials concerning knowledge transfer that are not being exploited [3]. This is due to various reasons, one of which is that the benefits of good knowledge management are mostly not quantified and, consequently, priorities are set differently [4]. Gronau and Grum compared different research approaches focusing on knowledge transfer [5]. The improvement of the speed of knowledge transfers in a product engineering context has already been investigated in studies and the effect of interventions has been demonstrated. While interventions, that are intended to increase the quality of knowledge transfers are known from the literature [6], their effect has not been investigated in studies yet.

To fill this research gap, the following research focuses on the improvement of the quality of knowledge transfers in a product engineering context. Section two presents the state of research in product engineering and ties it to knowledge transfer by presenting interventions to improve knowledge transfers and a schema to measure their effect on quality. Furthermore, validation environments are presented, which might serve as a basis for the intended implementation study. Section three elaborates on the design requirements for the validation and

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implementation of those quality-dependent knowledge transfer interventions in a product engineering context. Further interventions have been developed, which of four have been implemented in a study (Sec. 4 and 5). The results show a positive effect on the quality of knowledge transfers (Sec. 5). In conclusion, further 7 interventions to improve the quality of knowledge transfers have been developed and an outlook is given (Sec. 6).

2. State of Research

2.1. Knowledge Transfer in Production Engineering

Product engineering is part of the product life cycle and essentially entails strategic product planning, product development, and production system development as well as production [7]. The interaction results in various fields of activity in overlapping areas, such as integrated product development and production system development. The integrative collaboration of these areas is also reflected in systems engineering [8]. One characteristic of foresighted and system-oriented product engineering is the management of knowledge [9]. It is important to understand knowledge management as a socio-economic challenge [8] and to recognize the significance of different forms of knowledge, e.g., tacit, explicit [10], or embodied knowledge [11]. The conversion from one form to another is described by [10] externalization, internalization, socialization, and combination or extraction and engineering [11]. Here, knowledge transfer is defined as the identification of knowledge, the transfer from one knowledge carrier (e.g., product engineer) to a knowledge receiver (e.g., production engineer), and the application by the knowledge receiver [12]. To improve knowledge transfers regarding their speed or quality, so-called interventions can be implemented, which are described in the following section.

2.2. Interventions to Improve Knowledge Transfers

Grum et al. presented velocity-dependent interventions to improve the speed of knowledge transfer [13]. In addition, Klippert et al. developed quality-dependent interventions to increase the quality of knowledge transfer [6]. All interventions are summarized in an intervention catalog and are shown in Table 1.

Table 1: Intervention catalog with Velocity- and Quality-Dependent Knowledge Transfer Interventions [6,13]

Velocity-dependent knowledge transfer interventions	**Quality-dependent knowledge transfer interventions**
Animation	Presentation of a best practice
Instructions	Evaluation of examples
Labeling	Evaluation of own solutions
Repetitive layouts	Transfer to a presentation
Entropic visualizations	Providing a list of requirements
Functional integrations	Instruction of intermediate milestones
Realizations	Deepening
	Defined working times

Each intervention is described using a designed intervention template. Those templates consist of an intervention title, which helps to refer to a specific intervention, a short description of the as-is-situation (“Before”) and to-be-situation (“After”), a description of the intervention itself, and a field to explain the theoretical background behind the intervention. Klippert et al. [6] added a field to specify the present knowledge transfer type and the practicability and feasibility of the intervention.

2.3. Measuring the Quality of Knowledge Transfers

Quality is always described as either the absence of deficiencies or the properties something needs to fulfill its requirements. The quality of knowledge transfers is measured by the quality of artifacts. Therefore, requirements, that knowledge artifacts need to fulfill are defined beforehand. To assess if the artifact is fulfilling its requirements the evaluation schema according to Grum et al. [11] is used:

1. **Correctness**: knowledge artifacts need to represent the expectations of the knowledge carrier and receiver at least in essential features
2. **Relevance**: knowledge artifacts do not need to be complete, but the facts relevant to the purposes must be represented
3. **Clarity**: knowledge artifacts must be legible, understandable, and as clear as possible. They should be as simple as possible and only as complicated as necessary
4. **Systematic structure**: knowledge artifacts must follow a systematic structure to reduce complexity
5. **Comparability**: knowledge artifacts must follow the same guidelines and rules to be comparable

The scales for the five principles are operationalized with the Likert scale [14], which describes to what extent a requirement was fulfilled (1 (requirements not fulfilled) to 5 (requirements fully fulfilled)). This makes it possible to compare the quality of different artifacts.

2.4. Validation Environments for Design Methods, Processes, and Tools

Albers et al. [15] compared three different design research environments: a laboratory study, a Live-Lab study, and a field study [16] introduced Live-Labs as a validation environment for design methods, processes, and tools, which is situated between laboratory and field studies. Laboratory studies have the advantage of high controllability of attributes, reproducibility, and internal validity of results but lack external validity of results. On the contrary, field studies have a medium to high external validity of results, but do not offer a controllable environment in which results are reproducible. Live-Labs offer medium to high proficiency in all defined criteria. So, Live-Labs combine both advantages and aim to support the transferability of the results into an industrial setting. In the context of this paper, the Live-Lab IP - Integrated Product Development is used [17]. In IP, 42 full-time master's students of the Karlsruhe Institute of Technology (KIT) worked in seven interdisciplinary teams on a development task originating from an industrial company for five months.

3. Aim of Research and Methodology

3.1. Aim of Research

According to the current state of research, transferring knowledge within an organization is key to securing a company's competitiveness, especially when experienced employees retire or simply change positions or companies. Two main variables to improve knowledge transfers are quality and speed, which are already addressed in the literature. Based on knowledge transfer models, which are presented by Grum et al. [13] and Klippert et al. [6], it is necessary to implement interventions in a product engineering context, which suit the specific knowledge transfer situation to improve either the quality or speed. Whereas the effect of those velocity-dependent interventions has been investigated in empirical studies, the quality-dependent interventions have not yet been implemented in an industrial setting. The following research questions addressed here are:

1. How can quality-dependent interventions be validated by practitioners? (Sec. 4)
2. How can knowledge transfer quality be raised by the systematic implementation of interventions on behalf of the Knowledge Transfer Quality Model (KTQM)? (Sec. 4.1 and Sec. 5)
3. How can the effect of those interventions on the quality of knowledge transfers be measured? (Sec. 4.2 and Sec. 5)

In this empirical study, quality-dependent knowledge transfer interventions [6] are used to measure and validate their effect on knowledge transfer quality improvement. Those interventions consider generic objectives to be adapted to the context of quality-dependent knowledge transfers in product engineering. Additionally, Grum et al. [12] defined generic objectives that must be considered in the design of a workshop, which is intended to validate research results by practitioners and experts. Those have been adapted to the context of quality-dependent knowledge transfers and are as follows:

O1. Since the practicability focuses on both universities and companies, the workshop must include experts from both kinds of institutions.

O2. The workshop must include experts from the domain of knowledge management and the specific knowledge application context, which is here product engineering.

O3. The workshop must enable experts with concepts required for knowledge transfer quality improvements.

O4. The workshop must ensure that experts consider interventions within their individual situations.

O5. Each objective identified is relevant for the validation of interventions for the improvement of knowledge transfers in a product engineering context.

3.2. Methodology

A research approach has been defined to answer the research questions regarding the design of an empirical study for the validation of interventions improving knowledge transfer situations in product engineering. The implementation model of the Knowledge Transfer Quality Model (KTQM) and quality-dependent interventions [6] serve as a basis for the intended study. To answer RQ 1 a workshop with experts from the area of knowledge management as well as from product development of universities and companies is held to validate quality-dependent interventions (Sec. 4). To answer RQ2 an empirical study is designed to be implemented in a Live-Lab to validate the effect of selected interventions on the quality of knowledge transfers (Sec. 5) since Live-Labs are promising validation environments for the research of design processes, methods, and tools. External validation of four interventions, which suit different knowledge transfer situations, is performed in the Live-Lab IP (Sec. 6) to answer RQ3.

4. Validation of Quality Dependent Knowledge Transfer Interventions with Experts

The workshop design was carried out with a total of 11 *experts in knowledge management* and *product development* (O2) of universities and companies (O1) in an online format (see Appendix B). The aim here was to validate the developed interventions (see Sec. 2.2) and add further quality-dependent knowledge transfer interventions (O3). The workshop consists of three parts and the experts have been divided into two groups.

Intervention / Factor	Knowledge Conversions					Evaluation			
	Externalization	Internalization	Socialization	Extraction	Engineering	feasibility A	feasibility B	feasibility C	Short term observability
Best Practice	✓			✓	✓	1	0	0	✓
Evaluation of examples		✓	✓	✓		0,6	0,2	0,2	✓
Evaluation of own solutions			✓	✓		1	0	0	✓
Transfer to a presentation			✓	✓		1	0	0	✓
Providing the list of requirements	✓				✓	0,6	0,2	0,2	✓
Introduction of Intermediate Milestones			✓			0	1	0	✓
Deepening	✓	✓	✓	✓	✓	0	0	1	✓
Defined working times	✓			✓		0	0,8	0,2	✓
Mediation of the common problem solving space	✓	✓	✓			0,4	0,6	0	✓
Create commitment to change	✓		✓			0,8	0,2	0	✓
Representation of interrelationships of linked systems		✓				0	0,8	0,2	✓
Linking theory with real objects		✓	✓			1	0	0	✓
Introduction of a mentoring program			✓			1	0	0	✓
Formation of a common target image		✓	✓			0,2	0,6	0,2	✓
Creating an understanding for cultural specifics	✓	✓	✓		✓	0,8	0,2	0	✓

A - Can be usefully implemented in almost all companies and universities.
B - Can only be implemented with adaptation to the specific needs of the organization.
C - Specific, are only useful in specific organizations and cannot be readily adapted.
✓ - Factors are relevant for the respective intervention
0...1 - Feasibility (Scale 0 (not feasible at all) to Scale 1 (feasible))
(white) - Empirically validated
(light grey) - Not empirically validated
(dark grey) - Validated during workshop with experts

Fig. 1: Overview of all interventions to increase the quality of knowledge transfers with addressed knowledge conversions and evaluation according to their applicability and short-term observability.

Each group has been confronted with tasks considering their specific knowledge as follows. In the first part, the *product* *development experts* identified specific product development situations and described interventions to improve these situations, whereas the *knowledge management experts* described abstract interventions as well as the background to knowledge conversions and evaluated the application area and short-term observability of those interventions (O4). In the second part, the experts first presented their results one by one and then complemented and validated the results of the other group in the opposite direction of their knowledge domain (O5). In the third part, the results of the second part of the workshop have been presented and the evaluation of all interventions has been discussed and changed if needed (see Fig. 1). A total of seven additional quality-oriented interventions were developed in the workshop (see Appendix A).

5. Implementation Study Design

5.1. Procedure to Improve Quality of Knowledge Transfers

The following procedure is defined to identify and exploit improvement potentials in the quality of knowledge transfers:

A. Identify and describe knowledge transfer situations in product engineering.
B. Precisely analyze the knowledge transfer situations in product engineering and boundary conditions (recording the influencing factors and their characteristics) and define the target system of the intervention (e.g., increasing quality or speed).
C. Evaluate those knowledge transfer situations to identify improvement potentials.
D. Define and select an intervention that is appropriate to the situation and needs (speed or quality oriented) (e.g., from a given intervention catalog).
E. Implement interventions into the product engineering context and if necessary, adapt those to the specific knowledge transfer situation.
F. Assess the quality of the process and/ or results and evaluate the effect of the implemented intervention (regarding quality or speed). Then improve those interventions if necessary and document changes. If you have implemented a new intervention, then add it to the intervention catalog.

5.2. Implementation Study in the Live-Lab IP – Integrated Product Development

Here, IP – Integrated Product Development will provide a research environment to validate and measure the effect of interventions on the quality of knowledge transfers (Fig. 2).

Firstly, knowledge transfer situations in the Live-Lab environment have been identified (A), using the list of knowledge-intensive product development situations of Albers et al. [18] as a reference. Fig. 2 shows the process in the Live-Lab IP, which is divided into five phases. In this empirical study knowledge transfer situations in phase 2. Potential Finding to 4. Precision has been investigated. Each phase begins with a kick-off, in which the students are informed about their tasks and deliverables (artifacts). Here, necessary knowledge is transferred by the teachers to the students (*knowledge transfer situation*). At the end of each phase, each of the seven student teams must deliver certain artifacts (in Phase 2 *Product Profile Template* and *Video*, in Phase 3 *Product Idea Template,* and in Phase 4 *Business Model Presentation*).

After that, the knowledge transfer situations have been analyzed and the target system is defined (B). In this case, the quality of knowledge transfer should be improved.

The improvement potentials in those knowledge transfer situations have been identified (C), e.g., increasing the competence of the students or decreasing the stickiness of the knowledge.

To do so four quality-dependent knowledge interventions have been selected (D) from an intervention catalog [6]. Those interventions are *Presentation of a Best-Practice* (Phase 1), *Evaluation of Examples* (Phase 2), *Evaluation of own Solutions* (Phase 3), and *Transfer of Content into a Presentation* (Phase 4).

Each intervention was implemented (E) in the middle of each phase after the kick-off and before the milestone. The detailed description of each intervention is described in the templates of Klippert et al. [6]. Lastly, the effect of the implemented intervention on the quality of knowledge transfers has been evaluated. The evaluation is described in detail in the following Sec. 5.3.

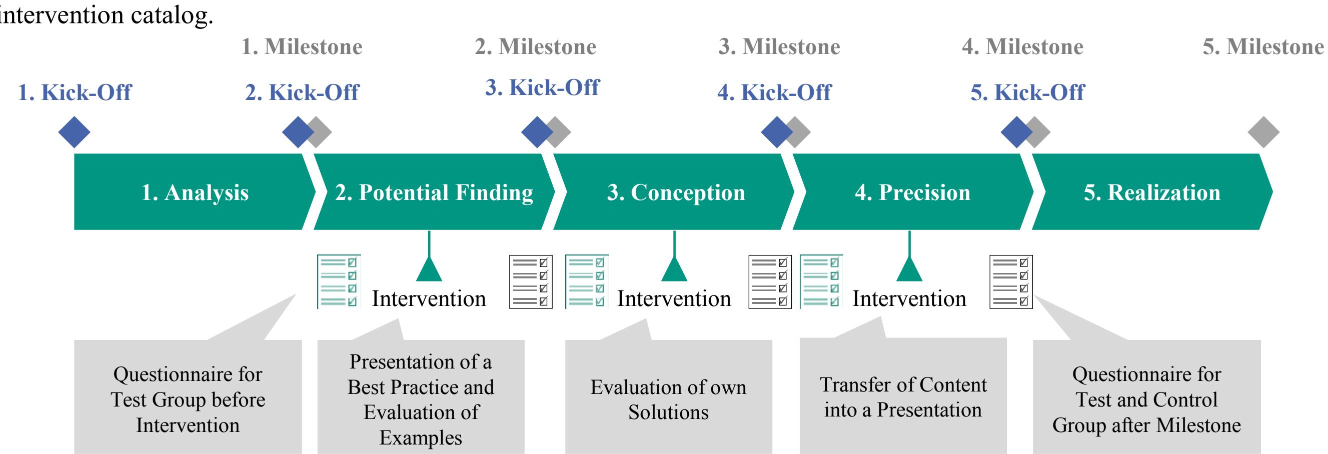

Fig. 2: Scheme of the process in the Live-Lab IP – Integrated Product Development and the Implementation of Quality-Dependent Knowledge Transfer Interventions.

5.3. Measuring the Effect of Interventions on the Quality of Knowledge Transfers

In the Live-Lab IP, the student teams were divided into four test groups and three control groups with each six students. Both groups participated in the accompanying survey after the milestone, but only the test groups participated in the survey before the intervention and the intervention itself (see Fig. 2).

The intervention was implemented in a meeting for each test group separately on one defined day during phases 2 to 4. Each meeting was moderated by one of the authors and started with a short survey right before the intervention. In this survey, the students were asked about how well a certain topic was introduced to them and how well they understood the tasks.

After that the intervention took place. Given the example of *Presentation of a Best Practice*, the requirements on the artifact of a *Product Profile Template* were repeated. Those requirements and an example have already been presented in the kick-off by the teachers, so there is no disadvantage to the control group regarding the transferred knowledge. This example serves as a Best Practice since it fulfilled the defined requirements. The students were able to discuss the Best Practice and compare it to their Product Profiles to find potential for improvement. The meeting ended after 30 minutes.

The second survey (after the milestone) consisted of three parts. In the first part, the general rating of the intervention and its effect on the quality of knowledge is evaluated. The second part evaluates the influencing factors (competence, complexity, time pressure). The third part evaluates the artifacts (e.g., Product Profile Template) based on the evaluation schema of Grum et al. [11].

In addition, to obtain an objective evaluation, an independent third party evaluated the quality of the artifacts based on the same evaluation schema for both test and control groups. With all of this, it is possible to empirically measure how effective an intervention is.

6. Results of the Implementation Study

Table 2 presents the results of the four interventions that were implemented into the Live-Lab IP.
All interventions were highly successful regarding participants' acceptance. All test groups rated the interventions as very positive (see right column). They stated that the interventions helped them to understand the knowledge better and gave them more confidence in using their knowledge to solve the given tasks.

Furthermore, the first three interventions also strongly improved the rating given by the participants compared to the ratings of the control groups (see fifth column). The independent third party also rated their results higher. Because of this, we can say with confidence that these three interventions are empirically proven to increase the quality of knowledge transfer.

The fourth intervention, “Transfer of Content into a Presentation”, did not improve the perceived quality of the results. This may be related to the specific boundary conditions. In this task the process and result formalization were open, and a deeper understanding of the knowledge might lead to the participants receiving their solutions as worse as they objectively are. This thesis is supported by the fact that the independent third party did rate their results as higher than the results of the control groups. So even though the rating was lower by the participants we can say with confidence that this intervention did also work.

7. Conclusion and Outlook

This paper addressed the main question of how quality-dependent knowledge transfer interventions can be validated and implemented in a product engineering context, and their effect on the quality of knowledge transfers be evaluated.

Seven quality-dependent interventions were validated and eight further interventions were added in a workshop with experts from the area of knowledge management as well as from product development of universities and companies.

Based on the state of research and these research results seven velocity-dependent and 15 quality-dependent knowledge transfer interventions are summarized in an intervention catalog, which helps product engineers in choosing suitable interventions or adapting those to their situation characteristics (answer to RQ1). By applying the implementation model of the KTQM it is possible to adapt the KTQM to a specific situation to improve the quality of knowledge transfers. The implementation of four out of 15 quality-dependent interventions in a product engineering context was conducted in the Live-Lab IP – Integrated Product Development (answer to RQ2).

Table *2*. Results of the implementation of four quality-dependent knowledge transfer interventions in a product engineering context (Scale 1 (not helpful at all) to 5 (very helpful)).

Deliverable (knowledge artifact)	Relevant influencing factors	Implemented Intervention	Evaluation of intervention by test group	Difference in evaluation of the results of test group to control group	Improvement
Product Profile Template	High Competence High Complexity	Presentation of Best-Practice	Ø 4,35 (σ = 0,7 | n= 23)	+ 0,6	✓
Product Profile Video	High Competence High Stickiness	Evaluation of Examples	Ø 4,25 (σ = 0,71 | n= 23)	+ 1,1	✓
Product Idea Template	High Competence High Stickiness	Evaluation of own Solutions	Ø 4,55 (σ = 0,68 | n= 23)	+ 0,6	✓
Business Model Presentation	High Competence High Stickiness	Transfer of Content into a Presentation	Ø 4,25 (σ = 0,72 | n= 19)	- 1,0	✗

Those interventions have led to an improvement in the initial knowledge transfer situation. The only exception to this is the Business Model Presentation. This may be because the exercise was simple and did not require a lot of knowledge. Further research would be necessary to test this. This justifies the idea to improve the quality of knowledge transfers by interventions reflecting the KTQM on behalf of the implementation model presented (answer to RQ3). Even though not all interventions were validated, others may now use the KTQM and the intervention catalog as a guide to improving their knowledge transfer.

The following research should focus on proving the positive effect of interventions in a real-life product engineering context. This could be done, by implementing the velocity- and quality-dependent knowledge transfer interventions in a field study. Since the variables speed and quality are addressed in several studies the implementation of interventions aiming for different types of improvement dimensions, such as costs, is attractive. The examination of domains aside from product engineering is attractive as well.

Acknowledgments

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Appendix A. Quality-Dependent Interventions to Improve Knowledge Transfers

Increasing commitment to change

Before

A company wants to increase its vertical range of manufacture and allow the complexity of the components to emerge only at the end of the value chain. However, the introduction of a new manufacturing technology is met with incomprehension and resistance from the people concerned.

The need for a new technology and the relevance for the company are not clearly communicated.

After

All parties involved in the product development situation are aware of the need and necessity to introduce a new production technology and are actively involved (e.g., allocating capacities) to realize it.

The need for a new technology and its relevance for the company are clearly communicated.

Intervention:

In a public event, the problem and the resulting need and necessity for the introduction of a new production technology (here as an example) are presented to all those involved in the product development process (e.g., developers, production operators, marketing, procurement).

In workshops based on this in interdisciplinary small groups, concrete effects on the product development process are identified and measures are derived as to how the goal can be achieved. In the process, a common understanding is built regarding the changes in technology, systems and processes. The stakeholders understand the reason for the changes in the product development process and build commitment for the implementation.

Background:

By involving all persons involved in the product development process, a common understanding is created. By specifically addressing upcoming changes and developing concrete measures, the implementation path is concretized on the one hand and time management becomes more effective on the other. This reduces complexity and time pressure.

☒ Externalization
☐ Internalization
☒ Socialization
☐ Extraction
☐ Engineering

☒ Category A
☐ Category B
☐ Category C
☒ Short-term Observability

Mediation of the common problem-solving space

Before

Those involved in the product development situation have knowledge in sub-domains (e.g., project planning, sensor technology, actuator technology, test execution). If problems occur, the knowledge is not shared openly because of fear of being blamed/ being the cause.

Knowledge transfer cannot take place unhindered because participants do not share their specific knowledge.

After

All participants in product development situations have a shared problem-solving space in their heads and can solve problems. There is neither blame nor fear of being the cause.

Knowledge transfer can take place unhindered, as participants in the individual sub-domains exchange specific knowledge.

Intervention:

In a workshop, the people involved in the product development situation are introduced to knowledge transfer barriers in companies, which often lead to problems and errors. Based on this, values and norms are agreed upon to be able to establish a healthy error culture in this project team. These values must be made transparent by the participants and consolidated in their project team as well as exemplified by the management level to enable sustainable changes.

In addition, all participants are trained in problem-solving methods and apply them to their own development situation. The goal is for the project team members to see themselves as part of a team and to solve problems together, despite different sub-domains.

Background:

The people involved in the product development situation build a common understanding and it is communicated how problems are solved. This increases competence with regard to problem solving and reduces stickiness through documentation.

☒ Externalization
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Representation of interrelationships of linked systems

Before

A new subsystem generation, e.g., of a servomotor for drive axles, is to be introduced. Since only a few references are available to the development team, it is unclear to which versions the new subsystem is compatible, which other subsystems must be adapted and what additional work will be required in the future.

There is a lack of sufficient overview and knowledge of the number of dependencies in different system variants.

After

After selecting the affected reference system element, i.e., the previously used subsystem generation, in a suitable model, the developers receive an overview of which other subsystems currently and previously used are affected by this and which activities must now be initiated as a result.

The necessary knowledge about dependencies in different system variants is graphically represented and made available to all participants.

Intervention:

It is assumed that relevant data and information are available and accessible.

First, all available references are collected in a workshop, and it is identified which interrelationships and dependencies need to be represented. Based on this, relevant data and information are identified, linked and presented with the help of visual-supporting elements (e.g., heat map, or interactive maps). By linking the data and information, the development context can build knowledge about relevant fields of action and create as much transparency as possible about subsequent activities.

The visual representation is made available to all developers.

Background:

By networking data and information and including references, the developers build up competencies. The visual elements reduce the complexity of the interrelationships and dependencies of the individual subsystems as well as the time pressure for processing the task.

☐ Externalization
☒ Internalization
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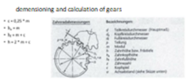
☐ Category A
☒ Category B
☐ Category C
☐ Short-term Observability

Linking theory with real objects

Before

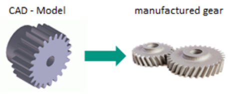
Product developers are given a lecture on, for example, the dimensioning of gears. Theoretical basics as well as practical experience reports, e.g., on typical sources of error, are presented in the form of keyword descriptions.



Theoretical as well as practical knowledge is imparted as a frontal lecture in the form of bullet points.

After

Product developers are given a lecture on, for example, the dimensioning of gears. Both the theoretical basics and practical experience reports on various real objects will be explained.



Theoretical and practical knowledge is imparted as a lecture using real objects.

Intervention:

Theoretical as well as practical knowledge is imparted using real objects (e.g., gear wheels) as examples. For this purpose, the theoretical basics as well as practical experience reports on various real objects are described. For example, typical sources of error in the dimensioning of gears on the CAD model as well as physical object are presented, thus presenting relevant core aspects as well as possible problems.

In addition, free access to these real objects is provided so that the product developers have the opportunity to deepen their knowledge even further on their own.

Background:

By externalizing tacit knowledge through the lecturer, product developers can link theoretically conveyed knowledge to real objects and thus put it into context. This reduces both the complexity and the stickiness of the knowledge.

☐ Externalization
☒ Internalization
☒ Socialization
☐ Extraction
☐ Engineering

☒ Category A
☐ Category B
☐ Category C
☒ Short-term Observability

Formation of a common target image

Before

A new development project starts. Relevant requirements for the project outcome are handed over from the management level to the development team. The goals, responsibilities, and potential outcomes of the first six months of the project are unclear.

Knowledge transfer between the management and operational levels is rudimentary.

After

Everyone involved knows the goals and potential outcomes of the first six months of the new development project. In addition, the responsibilities are distributed within the team.

Knowledge transfer between the management and operational levels takes place very intensively.

Intervention:

In an internal project kick-off, the management level and the development team jointly define goals and potential results for the first six months of the new development project. Initial checklists are created for the overview, which are then made available to all those involved (e.g., development, production, marketing, procurement) and continuously adapted to create transparency over the entire course of the project.

Background:

Through the joint discussion and preparation of goals and results, the developers are prepared for the project and can thus increase their level of knowledge and competence. At the same time, the complexity is reduced, especially regarding the introduction to the topic, which means that the implementation of the project can be more effective in terms of content and time, and the time pressure to achieve the goals in the specified period is thus potentially also reduced.

☒ Externalization
☒ Internalization
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☒ Category A
☐ Category B
☐ Category C
☒ Short-term Observability

Introduction of a mentoring program

Before

New employees in a company are responsible for planning a new production line. However, there are few references available to guide the employees, since the required knowledge consists largely of empirical values and is only partially documented.

Necessary knowledge is not or only partially explicit. There is a lack of transfer of explicit and tacit knowledge.

After

New employees in a company are assigned a mentor to provide the opportunity to observe and learn from the actions of others. In this way, experience is shared directly with new employees.

Necessary knowledge is made explicit. In the process, a knowledge transfer of explicit and tacit knowledge takes place.

Intervention:

New employees are assigned an experienced person right at the beginning of their entry into the new development team who acts as a mentor and contact person for questions over a longer period. This person carries out development activities and describes them verbally. By observing, the new employees capture tacit knowledge that is not documented and accessible in this way and thus expand their own knowledge.

Background:

New employees gain in-depth insights into development activities as experienced employees impart their knowledge concretely in the applied situation. This reduces the stickiness of the knowledge and embeds their actions in a context. At the same time, this promotes competence building among the new employees and reduces the complexity of the task, for example by explaining and prioritizing important aspects in a way that is specific to the target group.

☐ Externalization
☐ Internalization
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☐ Category C
☒ Short-term Observability

Creating an understanding of cultural specifics

Before

A location-distributed development team is to work together on a development task and initially develop creative solution approaches. Due to limited non-verbal communication and cultural peculiarities, misunderstandings occur, which cause problems in the cooperation.

Knowledge transfer cannot take place unhindered because cultural peculiarities are not known.

After

Through the mutual understanding of cultural differences in cooperation and a fundamental acceptance of cultural diversity, creative solutions can be developed for the development task to be worked on together.

Knowledge transfer can take place unhindered, since cultural peculiarities are known, and acceptance is present.

Intervention:

In a hybrid exchange format (in presence at one location and in video conference across countries), cultural peculiarities and differences in communication are first collected and discussed. From this, guidelines for joint collaboration are derived and documented.

Taking these guidelines into account, initial creative approaches to solutions are developed and examined from various points of view (e.g., technical and cultural).

Following the meeting, documentation of the results is sent to all participants and feedback is obtained so that a common basis is created.

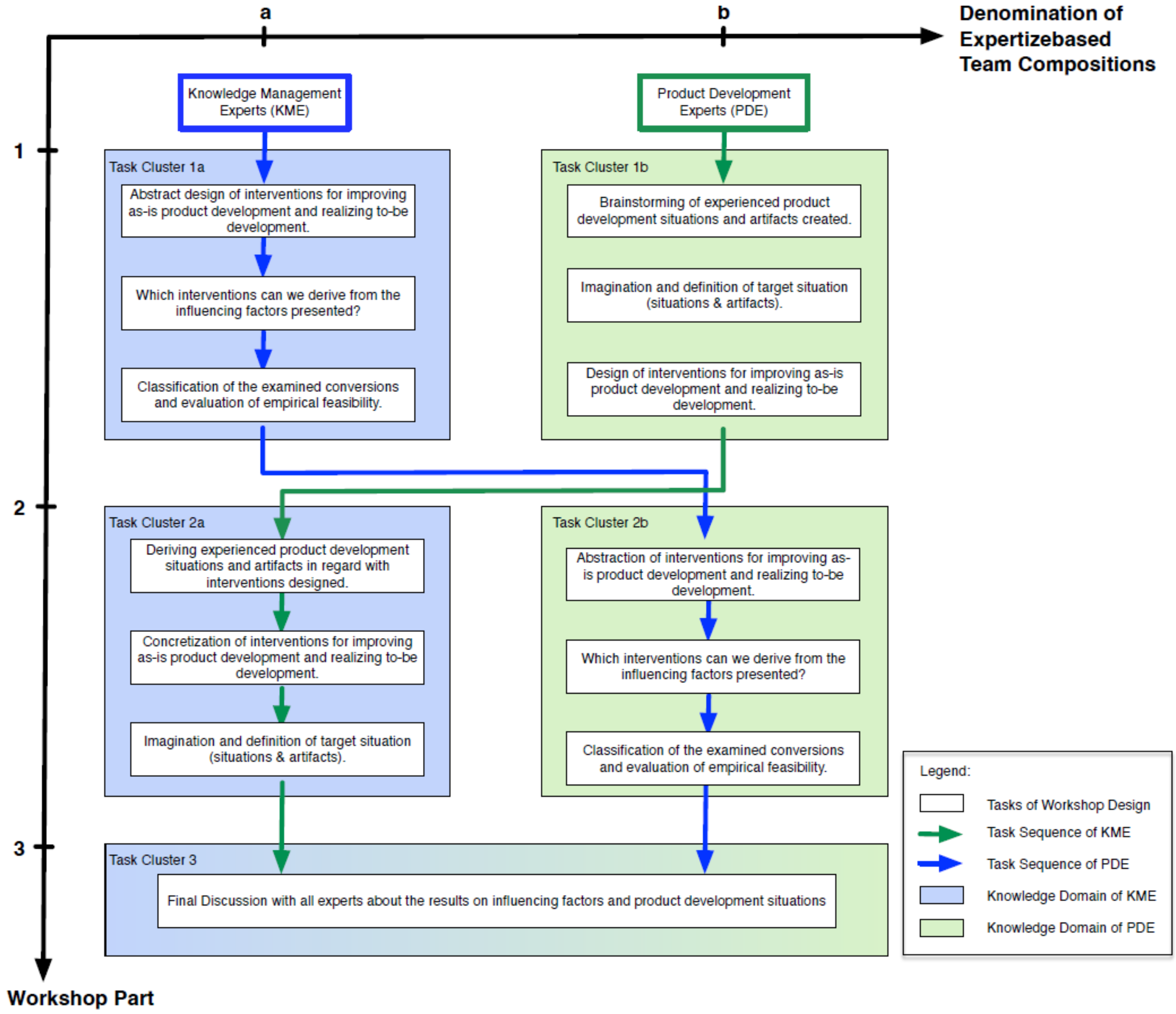
Background:

The participants strengthen their intercultural and professional competence as well as their understanding of the team by discussing various cultural differences and peculiarities. This reduces the stickiness of their knowledge and the perceived complexity of the task, since potential cultural hurdles are known and how to deal with them is learned.

☒ Externalization
☒ Internalization
☒ Socialization
☐ Extraction
☒ Engineering

☒ Category A
☐ Category B
☐ Category C
☒ Short-term Observability

Appendix B. Workshop Design



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