IMPROVING KNOWLEDGE TRANSFERS AT PROTEKTORWERK FLORENZ MAISCH GMBH & CO. KG THROUGH THE APPLICATION OF THE INKTI – INTERDEPARTMENTAL KNOWLEDGE TRANSFER IMPROVEMENT METHOD

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ABSTRACT

In the development and production of new products, interdepartmental knowledge transfer is essential. Successful knowledge transfer faces several challenges, such as a lack of willingness to transfer knowledge or an inappropriate selection of tools. These can lead to the reduction of efficiency and effectiveness of knowledge transfers. Therefore, the InKTI – Interdepartmental Knowledge Transfer Improvement Method is developed to support the improvement (in terms of speed and quality) of knowledge transfers, particularly in product and production engineering.

This paper presents the first validation of the InKTI Method through a field study at the company Protektorwerk Florenz Maisch GmbH & Co. KG, which is a leading European company in the construction industry, to support the successful knowledge transfer into practice. Therefore, the research need is pointed out, and a concept for validation is developed and implemented. Afterward, the InKTI Method is evaluated based on its success, support as well as applicability.

Keywords: Knowledge management, Integrated product development, Product-Production-CoDesign, Optimisation, Validation

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1 INTRODUCTION

In the development and production of new products, interdepartmental knowledge transfer is essential (VDI, 2019). Successful knowledge transfer faces several challenges, such as a lack of willingness to transfer knowledge or an inappropriate selection of tools (Albers et al., 2018; Klippert et al., 2022). These can lead to the reduction of efficiency (speed) and effectiveness (quality) of knowledge transfers. Various models emerge from the state of research, as well as studies, which show, that knowledge transfer interventions have a positive effect on increasing the speed and quality of knowledge transfers (Albers et al., 2019; Klippert et al., 2023a). The focus of these studies is either on product development only or on various areas outside an engineering context. Therefore, the InKTI – Interdepartmental Knowledge Transfer Improvement Method was developed to support the improvement of knowledge transfers in product and production engineering (Albers et al., 2023). This paper describes the first validation of the InKTI Method through a field study at the company Protektorwerk Florenz Maisch GmbH & Co. KG (Protektor), which is a leading European company in the construction industry focusing on plaster, facade, and construction profiles, to support the successful knowledge transfer into practice., the application of the InKTI Method at Protektor previously requires evidence of the research need and the analysis of the status quo of knowledge transfer. This is done by several surveys, observations, and interviews with employees of Protektor. Secondly, a concept for validation was developed including the initial process of the application of the method, the data collection, and a ranking of the objectives and requirements concerning the method. Thirdly, the InKTI Method is applied at Protektor. Lastly, the validation of the method is based on the evaluation of the success, the support, and the applicability, and the validation by comparing the objectives and requirements. Based on those findings, it is necessary to further validate the method and to draw comparisons between the studies.

2 STATE OF RESEARCH

2.1 Product and production engineering

According to VDI 2221 (2019) each product life cycle starts with strategic product planning and ends with the recycling or disposal of the product. The product life cycle also includes the product and production system development as well as the production, product distribution, and usage. This paper focuses on product and production system development as well as production, which in the following is referred to as product and production engineering (PPE). In literature, several approaches and models describe how to design PPE, e.g., integrated product development (Lindemann and Lorenz, 2008) or simultaneous engineering (Putnik G. and Putnik Z., 2019), which aim to increase the effectiveness and efficiency of engineering processes. Nevertheless, most of them neither display the process throughout the whole product life cycle nor over more than one product generation. Therefore, an approach on integrated PPE across generations and life cycles is introduced, which is described as Product-Production-CoDesign (Albers et al. 2022). However, in practice, the processes of developing and producing a product are often rather sequential than simultaneous. Hence, it is necessary to know, that the design of PPE processes is influenced by several factors. Those influencing factors can be clustered in *organization* (e.g., leadership and project management), *human* (e.g., qualification and soft skills), and *tools* (e.g., for optimization and validation) as well as *knowledge* (e.g., expertise and knowledge transfer) (Albers and Gausemeier, 2012; Albers et al., 2018, Grum et al. 2021; Klippert et al., 2022). This paper focuses on knowledge transfer as one of the main influencing factors in PPE.

2.2 Knowledge transfer in product and production engineering

Knowledge transfer is defined as the "identification of knowledge, its transmission from knowledge carrier to knowledge receiver, and its utilization by the knowledge receiver" (Grum et al., 2021). It is based on the transfer of tacit to explicit knowledge (externalization) and vice versa (internalization). In addition, the transfer of tacit or explicit knowledge without transformation is defined as socialization or combination. These four knowledge conversions are referred to as SECI. (Nonaka and Takeuchi, 1995)

In an engineering context, the transfer of knowledge does not only depend on the knowledge conversion but also on the transfer content, the needed transfer activity, the persons included, the transfer direction, and the transfer goal as well as on the organization and the way it designs the process of the transfer (Albers and Gausemeier, 2012; Rauter, 2013). Successful knowledge transfer is defined differently in literature. According to Cummings and Teng (2003), successful knowledge transfer is defined by the

"number of knowledge transfers engaged in during a certain period of time" and the "degree to which the knowledge is re-created in the recipient and a recipient obtains ownership of, commitment to, and satisfaction with the transferred knowledge". In addition, knowledge transfer is successful, when it is "on time, on budget, and produces a satisfied recipient" (Cummings and Teng, 2003). Whereas, Klippert et al. (2023b) define its success by the speed and quality of knowledge transfers to name only a few.
According to Liyanage et al. (2009) successful knowledge transfer results in reduced errors (e.g., by not repeating mistakes), improved quality (e.g., by using best practices), reduced response time (e.g., by getting better cross-functional coordination), lower costs (e.g., by quickly identifying expertise) or learning and innovation. Even though there are several benefits, there are at least as many challenges and problems in knowledge transfer, which occur on different levels (Gericke et al., 2013). Some examples are given in Figure 1. To address the challenges, there are some models and methods in the literature, which are described in the following section.

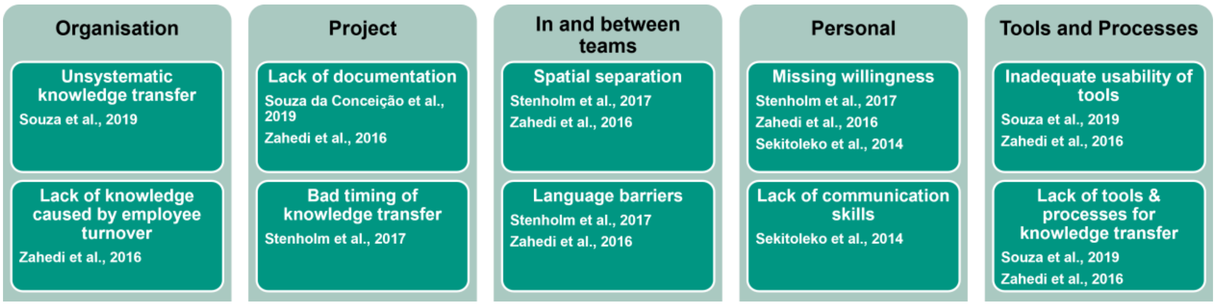

Figure 1. Challenges in knowledge transfer in product and production engineering

2.3 Support of knowledge transfer in product and production engineering

To decrease the impact of challenges and to support knowledge transfer, several methods and models have been developed. The knowledge transfer process model developed by Liyanage et al. (2009) includes various steps of knowledge transfer, different modes of knowledge transfer (Sec. 2.2), performance measurements (e.g., end-product quality, level of accuracy, and success and effectiveness of the knowledge transfer process) and influence factors. Similarly, Schmidt et al. (2015) introduce their model of knowledge transfer which also takes the transfer mode into account but considers the different ways knowledge transfer may take place like face-to-face conversations or documents. Furthermore, it defines requirements such as motivation (the willingness to transfer or to use) and coordination (the potential to transfer or to use). These models are not particularly developed for a product and/ or production engineering context. Albers et al. (2019) presented the Knowledge Transfer Velocity Model (KTVM) to improve the speed of knowledge transfers. On the other hand, Klippert et al. (2023b) introduce the Knowledge Transfer Quality Model (KTQM) to improve the quality of knowledge transfers. Both models focus on the product engineering context. They describe factors that influence the speed or quality of knowledge transfers and how knowledge transfer situations need to be analyzed to identify and select interventions so that their situational characteristics are met best.

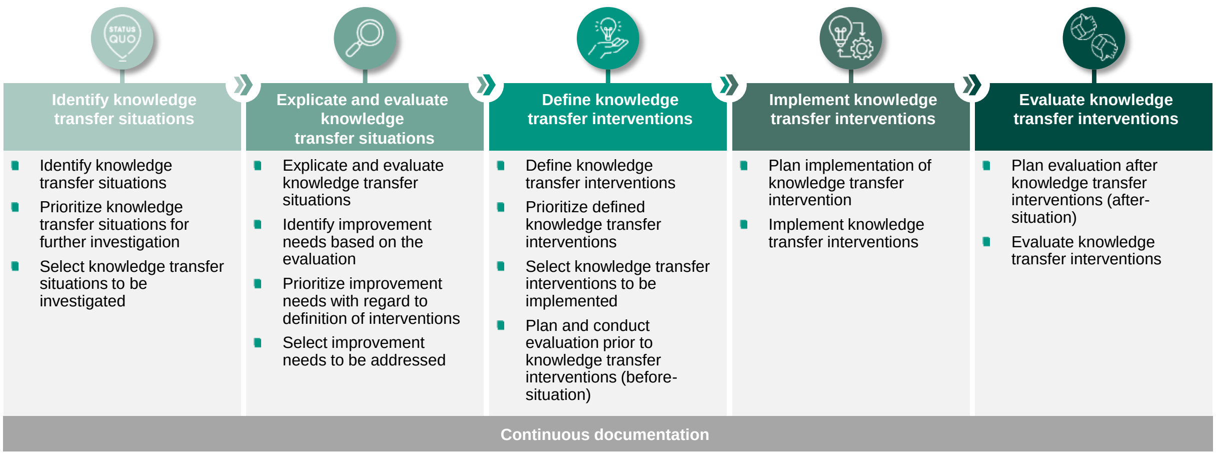

Figure 2. InKTI – Interdepartmental Knowledge Transfer Improvement Method (Albers et al., 2023)

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Grum et al. (2021) introduce eight dimensions and their characteristics to describe a knowledge transfer situation (e.g., number of participants and duration). In addition, they conceptualize knowledge transfers for experimentation, providing a basis for how knowledge transfers can be examined. Based on that, an initial five-step procedure to identify and exploit improvement potentials in knowledge transfers is provided (Klippert, 2023b). Following this procedure, studies show, that by implementing speed- or quality-dependent knowledge transfer interventions to a specific situation, the speed (Albers et al., 2019) or quality (Klippert et al., 2023a) of knowledge transfers in product engineering can be increased. Since those models only focus on product engineering, Albers et al. (2023) developed the InKTI Method, which aims to support the improvement of knowledge transfers in PPE. This method consists of five activities, which are shown in Figure 2.

2.4 Validation of methods, process, and tools

Although validation shall be an essential activity in the development process, it is often not transferred to validating methods while being developed (Badke-Schaub et al., 2011). Klyatis et al. (2012) identified the following types of validation: First, there is the field study, which is a validation under normal/real conditions whereby the length of periods may be cut short to accelerate the validation process. Second is the laboratory or specific field study. It is the "testing of the actual test subject based on physical simulations of field input influences" (Klyatis et al., 2012). The third and last validation type is laboratory testing through a computer simulation of the test object and the field input influences. To improve the development of methods, those must also be validated during the process of development to minimize or even eliminate problems like lack of tool support or unsatisfactory adaption of the method to the application environment (Dühr et al., 2022). By validating a method, it is important to consider external influences such as the motivation or condition of the participants. For the results of a method to be meaningful, the method needs to fulfill the following quality criteria: objectivity, reliability, and validity. To fulfill objectivity the results of the method must be unattached to the participants and the lead of the method. Reliability is about getting the same results when repeating the implementation of the method whereas validity is a matter of ensuring the method measures the right conditions and creates improvement where it is supposed to (Himme, 2007). Dühr et al. (2022) designed an approach specifically for validating methods in field studies, which ensures transferability to other research environments. They outline the following approaches to validate methods: The Validation Square by Pedersen et al. (2000), the Concept map by Üreten et al. (2019), and the Design Research Methodology (DRM) by Blessing and Chakrabarti (2009). The latter serves as a basis for the validation of the InKTI Method, which will be done through a field study at Protektor.

3 AIM OF RESEARCH AND METHODOLOGY

The state of research emphasizes, that knowledge transfer is an important factor in ensuring efficient and effective PPE. Successful knowledge transfer has a lot of benefits, but often several problems occur (e.g., production constraints are not always considered in the product design). There are already existing approaches and models, which address certain problems, but the main challenge is to identify the situations in which knowledge is being transferred, evaluate the situation, and identify improvement needs. Then it is possible to define suitable interventions to improve the knowledge transfer. Therefore, the InKTI Method is used, which was initially developed but has not been validated yet. Hence, there is a need for the validation of the InKTI Method through a field study in a PPE environment. To ensure the need to improve knowledge transfer in PPE at Protektor, a survey was conducted. Due to the size of the company, there are 13 employees in total working in the fields of product development, design, tool manufacturing, production, and the innovation team. They participated in this survey. The results of the survey (summarized in Figures 3 and 4) show that the employees mostly agree with the need and the potential to improve knowledge transfer. The willingness to improve knowledge transfer is high for almost all of the participants whereby some do not totally agree to put in the additional effort. The participants of the survey confirm, that a method to support the identification, explication, and evaluation of knowledge transfer situations is helpful. Also, methodological support for the definition and implementation of knowledge transfer interventions is mostly seen as helpful. In addition, the participants agree, that the application of a method shall be supported by a tool or guideline. According to the survey results, there is a need at Protektor for a method to support the improvement of knowledge transfers in PPE.

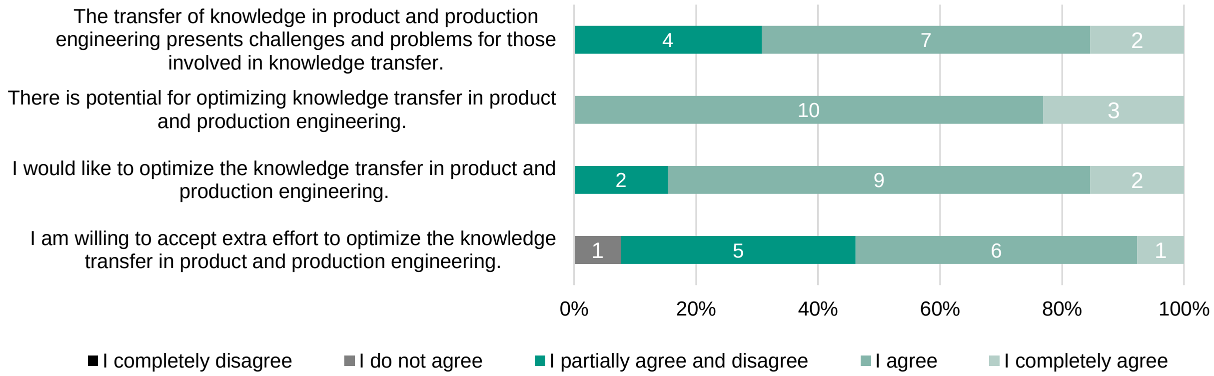

Figure 3. Results of the survey regarding challenges, problems, and potential for improvement as well as the readiness for improvement

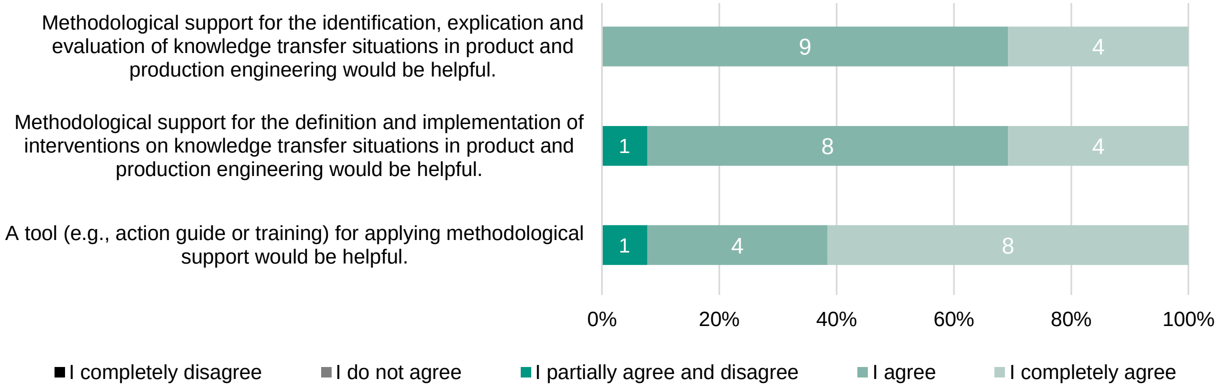

Figure 4. Results of the survey regarding the need for methodological support and a tool to improve knowledge transfers in product and production engineering

This research aims to increase the speed and quality of knowledge transfers in PPE. For this purpose, the InKTI Method is validated in a field study at Protektor. Hence, the following research questions (RQ) are addressed:

1. In which field of application can the InKTI Method be applied at Protektor?
2. How can the InKTI Method be validated at Protektor in terms of its contribution to success, support performance, and applicability in a field study?
3. Which measurable added value does the InKTI Method offer in terms of improving knowledge transfer in product and production engineering at Protektor?

RQ1 will be answered by analyzing the PPE process to identify the current state of knowledge transfer at Protektor. By this, a field of application shall be identified to apply the InKTI Method. Additionally, an analysis of the prerequisites for the application of the InKTI Method at Protektor is conducted to verify Protektor as a valid validation environment. The concept of validation to answer RQ2 includes an initial process, after which the InKTI Method shall be applied. The way to collect data is identified and the objectives and requirements for the success evaluation, support evaluation, and application evaluation of the method are evaluated regarding their relevance. To answer RQ3, the method is applied in the defined field of application and its results are discussed. Furthermore, the results of the evaluation and the improvement of the method are presented. For that, criteria will be identified to receive the measurable added value implemented through the application of the InKTI Method.

4 CURRENT STATE OF KNOWLEDGE TRANSFER AT PROTEKTOR AND ANALYSIS OF REQUIREMENTS FOR THE VALIDATION ENVIRONMENT

New products are developed, validated, and produced by Protektor, which implies, that there are several knowledge transfers between the product development and production department. At Protektor the process of product development includes product and tool design, and manufacturing. By analyzing the product development process at Protektor several knowledge transfer situations such as regular appointments and consultations to technical drawings, design changes, or new products have been identified. Knowledge transfer takes place either in person via phone, face-to-face, e-mails, or shared

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documents. The transferred knowledge either concerns technical information on the product or production system or organizational information on the schedule, milestones, or deadlines. The analysis also showed that there are challenges concerning the knowledge transfer between product development, design, tool manufacturing, and production. The employees involved at Protektor ranked those challenges by their relevance. The three challenges with the highest relevance are *late integration of involved departments*, *inexplicit priorities*, and *missing information*, which are mostly organizational challenges (Fig. 1, Organisation). Less relevant challenges are *non-uniform processes* (Fig. 1, Tools and Processes), *confusing folder structures*, *repeated discussions on the same topics* (especially caused by repeating tasks), and *inexplicitly defined responsibilities* (Fig. 1, Organisation). The survey in Sec. 3 also includes the quantitative analysis of the prerequisites for the application of the InKTI Method at Protektor. Figure 5 shows, that most participants take the view that support in knowledge transfer is not yet existent or not sufficient at Protektor and thus needed. This includes supporting the identification, explication, and evaluation of knowledge transfer situations as well as the definition and implementation of interventions. Lastly, continuous documentation needs to be supported.

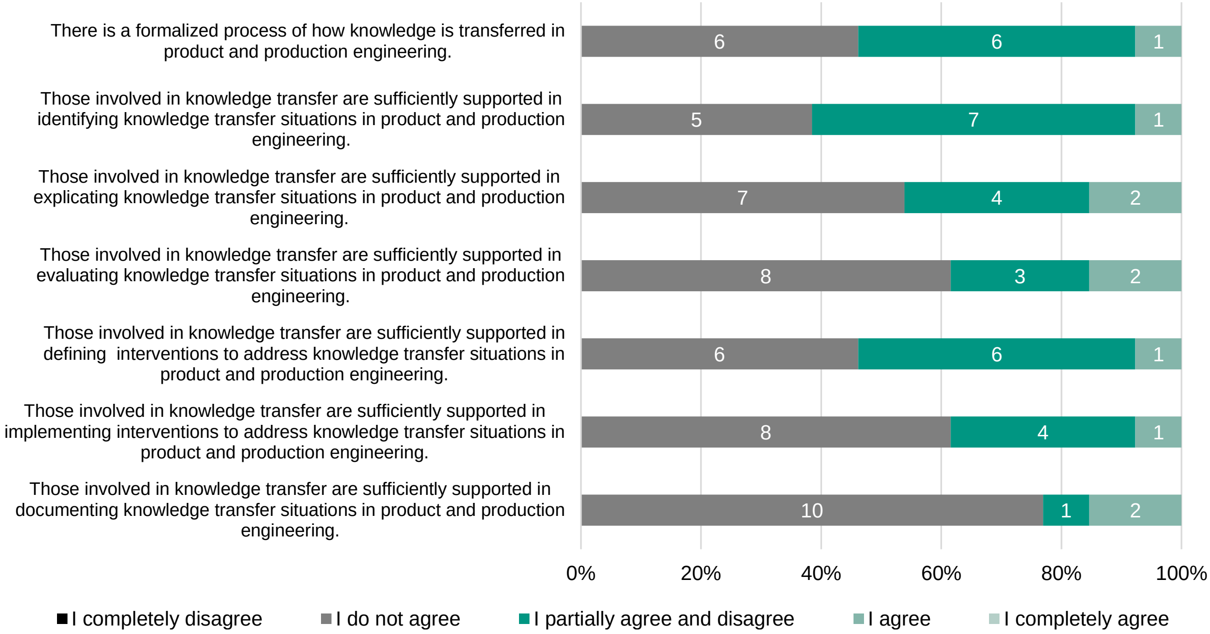

Figure 5. Results of the survey regarding the support in knowledge transfer in product and production engineering

5 CONCEPT FOR THE VALIDATION OF THE INKTI METHOD AT PROTEKTOR

The concept for the validation of the InKTI Method includes the application and the evaluation of the application of the method. The initial process for the validation at Protektor is visualized in Figure 6. The activities differ from the InKTI Method presented in Figure 2. This is due to the fact, that the method is implemented in two consecutive field studies to continuously validate the method by applying it to different industrial environments (one study is presented in this paper). The method presented in the state of research is the result of several iterations. The first iteration of the method is the basis for the validation at Protektor. On the left-hand side, each of the five activities of the InKTI Method is shown (application of the method). On the right-hand side, the timeline is shown. Additionally, the first milestone (selection of the knowledge transfer situations to further investigate) and the intervention workshop (definition of interventions by the participants) are displayed. The validation will be completed by evaluating the measurable added value through the application of the method. The data is collected through surveys and interviews (subjective qualitative data collection), as well as observations of employees and participation in meetings (objective qualitative data collection). These different ways of data collection shall ensure objectivity in the holistic analysis of the current situation and the measurable added value. Figure 6 also displays the real process of the validation. Notable here is, that the evaluation of the knowledge transfer situations took longer than planned due to the analysis of the evaluation sheets. Thus, the whole process was shifted back whereby the time of implementation was cut

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short. As a result, the implementation time was too short to receive accurate results in the evaluation of the knowledge transfer interventions, which should be repeated.

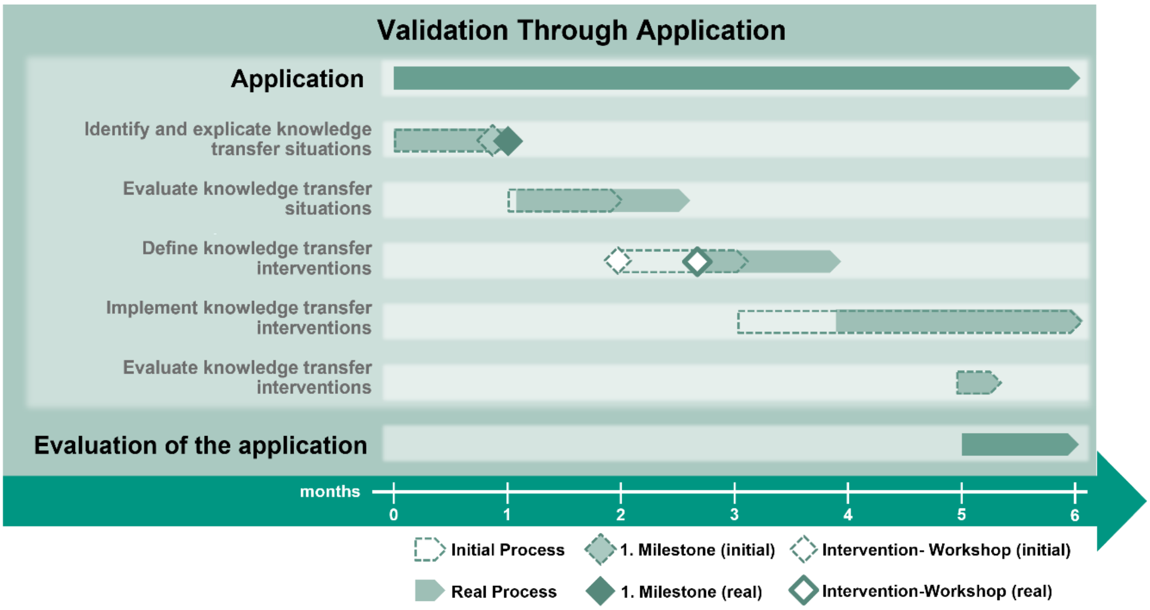

Figure 6. Initial vs. real process for the application and validation of the InKTI Method at Protektor

As the field study environment at Protektor a team of seven participants was chosen. This team consisted of product developers, designers, and tool manufacturing and production employees in the branch of synthetic construction profiles and projects. For the evaluation of the InKTI Method, 16 objectives and requirements have been defined for the success evaluation, application evaluation, and support evaluation (Albers et al., 2023). Through the same survey as in Sec. 3 and 4, these objectives and requirements were evaluated regarding their relevance which will be considered at the end of the validation to increase the significance of the evaluation.

6 IMPLEMENTATION OF THE VALIDATION CONCEPT OF THE INKTI METHOD AT PROTEKTOR AND ITS RESULTS

By implementing the validation concept all five steps of the InKTI Method were applied at Protektor. The application of the steps will be described and discussed in this section.

Identify and explicate knowledge transfer situations: In the initial analysis of Sec. 4, knowledge transfer situations had been identified. Additional knowledge transfer situations were identified and analyzed. As planned in the validation concept (Sec. 5) the situations were analyzed through interviews with all the participants and observations of the participants doing their daily work. Participation in the identified meetings was also part of the analysis, although this was not possible for all meetings due to the time frame of the validation. All knowledge transfer situations were explicated according to Albers et al. (2023) and the findings were summarized. In general, there are many face-to-face conversations and agreements, that are not documented and therefore not retrievable. If relevant information is explicit, an unintuitive folder structure makes it more difficult to file documents and make them accessible. Furthermore, interdepartmental understanding is lacking to some extent. The summary also shows, due to non-uniform, undefined processes in PPE, the timing of integrating other departments is individually handled. Some of those findings are equal to the first findings in Sec. 4, which showed that the explication of the knowledge transfer situations underlined the initial findings. A relevant topic not explicitly mentioned in the explication of the knowledge transfer situations is tacit knowledge. The findings here were that there was a lot of tacit knowledge, which is neither actively explicated in the company nor exists a concept for transferring it. For the evaluation of the knowledge transfer situations, those were ranked according to the challenges and their relevancies of Sec. 4 and the changeability of the current situation. In the first milestone, the following three knowledge transfer situations were chosen to be evaluated in the next step: *face-to-face conversations on profile development, email correspondence on profile development,* and *agreements on technical drawings.*

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Evaluate knowledge transfer situations and identify improvement needs: The evaluation of the selected knowledge transfer situations was done by the participants. Therefore, they filled out an evaluation sheet for each situation in which they classified several characteristics concerning the situation and decided whether there was an improvement need for this characteristic (e.g., the structure of documented knowledge or level of confidence in other departments). Afterward, all evaluation sheets were analyzed, and improvement needs were defined by filtering so only characteristics, that most participants saw an improvement need were left. The characteristics were then summarized into improvement needs: *Relationship and trust between participants, interdepartmental understanding, Structure, maintenance and retrievability of knowledge,* and *Timing and extent of integration of different departments.*

Define knowledge transfer interventions: For the definition of knowledge transfer interventions, a workshop was held in which the participants gathered potential interventions concerning the identified improvement needs. At first, the participants defined the as-is state and the target state for each improvement need. For instance, for s*tructure, maintenance, and retrievability of knowledge,* the as-is state was *difficult or no retrievability of knowledge*, whereas the target state then was *retrievability supporting folder structure.* This was followed by the gathering and discussion of potential interventions that should support the transition of the as-is state to the target state. In the end, the interventions were ranked according to their expected effort and benefit. The follow-up was to cluster the interventions into topics like folder structure or meetings and select interventions based on the benefit-effort ranking. The decision on which intervention to investigate further was based on a high benefit expected with low effort. The interventions chosen were a *regular meeting for project overview* and a *common structured folder structure.*

Implement knowledge transfer interventions: Before implementing the selected interventions, it was essential to again capture the as-is state of the planned interventions through a survey in which the participants answered questions about the as-is state of *regular meetings* and the *folder structure* (see Fig. 7). In addition, it was necessary to further concrete the interventions to when, where, and mostly how they can be implemented. When sufficiently defined, the interventions were implemented step by step and further improved throughout the implementation.

Evaluate knowledge transfer interventions: The evaluation of the knowledge transfer interventions was done by conducting the same survey as before the implementation of the interventions again and comparing the two as-is states (before and after implementation). The results of both surveys are shown in Figure 7 and Figure 8. Generally, there is an improvement in all questions. Regarding the *regular meeting for project overview* the highest improvement is in the last question: *I know all the milestones and deadlines for the development of products or production systems* (see Fig. 7). Considering the results on the *common structured folder structure* the highest improvements are in the following questions: *It is explicitly defined which knowledge to share interdepartmental, I have access to all the knowledge I need interdepartmental,* and *I am completely certain, that the knowledge I have access to is up-to-date.*

The participants evaluated the objectives and requirements for the success evaluation, application evaluation, and support evaluation of the method, which had been ranked to their relevancies in Sec. 5. Combining the evaluation through the participants and their relevancies, the objectives and requirements with the highest potential for improvement and relevance are: *The method should be easy to apply* and *be divided into meaningful steps* (application evaluation) and *support the definition of interventions to address knowledge transfer situations in product and production engineering* (support evaluation). It is relevant to consider the small number of participants, which is why the evaluation should be repeated.

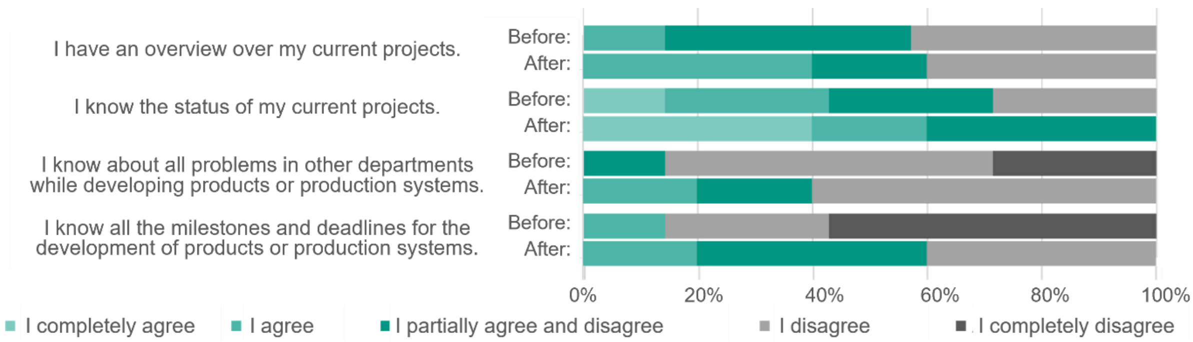

Figure 7. Comparison of the two as-is states on the regular meeting for project overview

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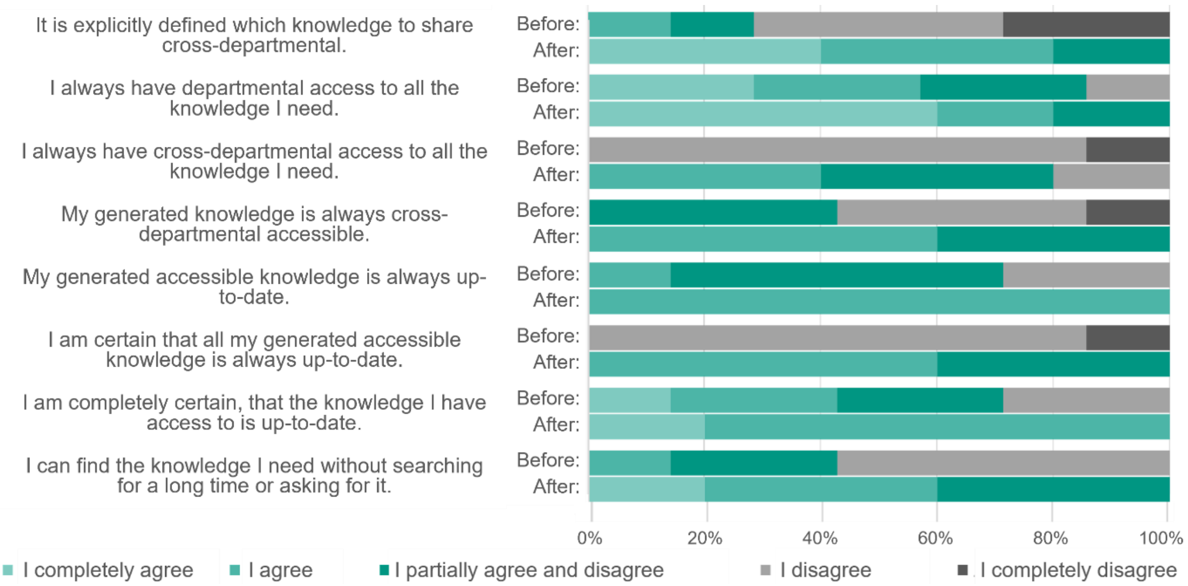

Figure 8. Comparison of the two as-is states on the common structured folder structure

7 CONCLUSION AND OUTLOOK

Knowledge transfer has a big impact on efficient and effective PPE. There are already existing models, which describe how to improve knowledge transfers, but most do not particularly relate to PPE. Hence, the InKTI Method was chosen to support the improvement of knowledge transfer speed and quality at Protektor. To answer RQ1 and RQ2 a validation field at Protektor was identified and a concept for validation was developed. This concept includes an initial process for the application and validation of the method as well as objectives and requirements for the evaluation of success, contribution, and applicability. RQ3 was answered by implementing the concept of validation, which includes the application of the method and the evaluation of the application. The result of the validation of the InKTI Method shows an increase in the speed and quality of knowledge transfers in PPE at Protektor. Additionally, throughout the validation potentials for further improvement of the method were identified. The identification of knowledge transfers should e.g., include an overview of exemplary knowledge transfer situations in PPE to make it easier and faster to prioritize and select those for further investigation. The evaluation of knowledge transfers is mainly based on the participants' subjective opinions, and whether they see improvement needs. Therefore, further validations to improve its reliability are necessary, e.g., by realizing an objective evaluation and a semi-automated analysis of the evaluation to simplify a time-consuming manual evaluation and analysis of the results. In terms of the interventions, it is necessary to ensure the long-term use of interventions (e.g., detailed documentation, defining responsible persons). Furthermore, interventions not yet implemented can be selected and implemented to further improve knowledge transfers in PPE at Protektor. Defined interventions should be continuously evaluated and further improved to increase their benefits. In general, the method should be validated in other environments. Lastly, an additional tool, e.g., an action guide or training could support the application of the method and therefore should be considered in future research works.

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