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Procedia CIRP 119 (2023) 919–925

www.elsevier.com/locate/procedia

33rd CIRP Design Conference

Knowledge Transfer Quality Improvement – The Quality Enhancement of Knowledge Transfers in Product Engineering

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Abstract

Developing a new product generation requires the transfer of knowledge among various knowledge carriers. Several factors influence knowledge transfer, e.g., the complexity of engineering tasks or the competence of employees, which can decrease the efficiency and effectiveness of knowledge transfers in product engineering. Hence, improving those knowledge transfers obtains great potential, especially against the backdrop of experienced employees leaving the company due to retirement, so far, research results show, that the knowledge transfer velocity can be raised by following the Knowledge Transfer Velocity Model and implementing so-called interventions in a product engineering context. In most cases, the implemented interventions have a positive effect on knowledge transfer speed improvement. In addition to that, initial theoretical findings describe factors influencing the quality of knowledge transfers and outline a setting to empirically investigate how the quality can be improved by introducing a general description of knowledge transfer reference situations and principles to measure the quality of knowledge artifacts. To assess the quality of knowledge transfers in a product engineering context, the Knowledge Transfer Quality Model (KTQM) is created, which serves as a basis to develop and implement quality-dependent interventions for different knowledge transfer situations. As a result, this paper introduces the specifications of eight situation-adequate interventions to improve the quality of knowledge transfers in product engineering following an intervention template. Those interventions are intended to be implemented in an industrial setting to measure the quality of knowledge transfers and validate their effect.

Keywords: knowledge transfer; product generation engineering; improvement; quality; intervention.

1. Introduction

In product engineering, the collaboration of different disciplines, e.g., product and production engineers, is required [1]. This involves the transfer of knowledge, which can take place via a variety of channels, such as in-person or online meetings, by e-mail, or via information databases [2]. Either way, several factors influence knowledge transfer, which may cause a decrease in efficiency and effectiveness [3,4]. The focus is on increasing the efficiency and effectiveness of knowledge transfer in product engineering. Effectiveness and efficiency are primarily determined by the target variables speed of transfer and quality of the transfer result: Effectiveness is characterized by a high quality of results, and efficiency by the ratio of quality of results and transfer time, which results from the transfer speed. Research results show, that the speed of knowledge transfers can be raised by following the Knowledge Transfer Velocity Model (KTVM) and implementing so-called interventions in a product engineering context [3]. To examine the quality of knowledge transfers, Grum et al. [4] presented a draft of empirical research. This serves as a basis to investigate

10.1016/j.procir.2023.02.171

the situations and conditions of knowledge transfer and their intended effect on outcome quality.

Therefore, this paper focuses on the development of interventions, which intend to improve the quality of knowledge transfers in a product engineering context. In the second section, the theoretical foundation and current state of research knowledge transfer and product engineering are presented. Influencing factors on knowledge transfer and velocity-dependent knowledge transfer interventions are introduced as well. In section three, design requirements for quality-dependent knowledge transfer interventions are elaborated. The fourth section introduces the Knowledge Transfer Quality Model (KTQM) and eight interventions. The last section, the conclusion, appraises the progress critically and gives an outlook on further research steps such as validation.

2. State of Research

2.1. Knowledge Transfer in Product Engineering

In this paper, knowledge is defined as the entirety of skills, cognition, and capabilities one individual has and can use for problem-solving, a knowledge-intensive process [5]. Knowledge transfer is the core activity of knowledge management and is the only way to ensure that relevant knowledge stays in a company [6]. Knowledge transfer consists of three stages: knowledge identification, transfer from the carrier to a receiver, and application of the newly obtained knowledge by the receiver [7].

The SECI model [8] provides a foundation to describe these knowledge transfers by four types of conversion. Two additional conversion types are introduced by [9]:

- Socialization: knowledge transfer of tacit knowledge into tacit knowledge
- Externalization: knowledge transfer of tacit knowledge into explicit knowledge
- Combination: knowledge transfer of explicit knowledge into explicit knowledge
- Internalization: knowledge transfer of explicit knowledge into tacit knowledge
- Extraction: a physical object is analyzed and transferred into tacit knowledge
- Engineering: tacit knowledge is used to create a physical object

The competitiveness of companies is determined by the quality and speed of their product engineering processes among others. Therefore, they reuse knowledge gained from within their company, e.g., past product documentation and experience of employees, or other external references to develop a new product generation efficiently and effectively [10]. The transfer of knowledge among various knowledge carriers (e.g., product and production engineers) is crucial for successful product engineering [11-15]. Therefore, it is necessary to establish knowledge management processes [e.g., [16,17]. Rauter [18] compares different knowledge transfer models and concludes, that the complexity of the process is a major factor, that determines the success of inter-organizational projects. VDI 5610 [16], for example, introduces six stages to do so: sensitizing, definition of the strategy, assessment, conception, realization, operation and continuous improvement. They also suggest cyclical reviews to improve knowledge management. Aiming for the investigation of interventions to improve knowledge transfers, product engineering processes serve as a suitable research environment, because process outcomes can be evaluated regarding the time required and quality achieved [4].

2.2. Influencing Factors of Knowledge Transfer

Several factors influence knowledge transfers, e.g., the competence of employees or time pressure, which might lead to a decrease in the speed or quality of knowledge transfers [19]. On the one hand, the knowledge transfer velocity is defined as the amount of knowledge that can be transferred during a certain amount of time by Gronau and [20]. They identified the following variables increasing the knowledge transfer velocity: increasing competence, increasing stickiness, decreasing complexity, using the mother tongue, and if the educational background is close to knowledge transfer. On the other hand, the knowledge transfer quality can be derived from a high quality of results, which means, that characteristics of process outcomes (artifacts) to fulfill certain needs must be defined before the knowledge transfers are realized [4]. Looking at variables, that increase the quality of knowledge transfers Albers and Gronau [21] also identified the variables above in mostly the same correlation: increasing competence, decreasing stickiness, decreasing complexity, using mother tongue, and if the educational background is close to knowledge transfer. Additionally, they identified time pressure as a further variable. If these variables and the conditions under which required knowledge must be transferred change, so-called interventions are to be implemented to increase the speed or quality of knowledge transfers.

2.3. Interventions to Improve Knowledge Transfer Velocity

When improving knowledge transfers in a product engineering context, any adjustment made to improve those situations concerning a specific goal causes changes in the as-is situation. Those changes are therefore called knowledge transfer interventions [7]. To improve the speed of knowledge transfers Grum et al. [7] developed seven velocity-dependent knowledge transfer interventions, which are as follows:

- *Animation*: visualizing dynamic aspects of knowledge transfer by the presentation of images or objects
- *Instructions*: simplifying aspects of knowledge transfer by a guided process (e.g., orally, visually, or haptic instructions)
- *Labelings*: simplifying knowledge transfers by using the same (technical) terms to avoid conflicts
- *Repetitive layouts*: simplifying knowledge transfer by using the same layouts
- *Entropic visualizations*: simplifying knowledge transfer by combining the same type of visualizations
- *Functional integrations*: simplifying knowledge transfer by integrating different, e.g., images or function sketches, in

one working space to make interpretation easier
- *Realizations*: simplifying knowledge transfer by providing real objects or models rather than, e.g., sketches or illustrations

In a workshop with experts in knowledge management as well as in product engineering of universities and companies, those interventions have been validated. In addition, their effect on the speed-optimization of knowledge-intensive processes has been empirically proved [3]. All velocity-dependent knowledge transfer interventions have been summarized in an intervention catalog [7]. As an orientation for the design of quality-dependent knowledge transfer interventions in section 4.1, these interventions have been considered as the basis. Thus, in the long run, a catalog of interventions improving knowledge transfers can be set up.

3. Aim of Research and Methodology

3.1. Aim of Research

The effectiveness and efficiency are primarily determined by the target variables' speed and quality of knowledge transfers. While the current state of research shows how the speed of knowledge transfer can be raised by implementing interventions, it does reveal a research gap regarding the improvement of knowledge transfer quality in a product engineering context. Therefore, this paper aims to develop a model based on existing theoretical findings, which enables the development of situation-adequate interventions to improve the quality of knowledge transfers. Hence, the research questions (RQ) addressed here are:

1. How can the improvement of the quality of knowledge transfers in a product engineering context be described?
2. How can quality-dependent knowledge transfer models be used to derive interventions, which improve the quality of knowledge transfers in a product engineering context?

While designing interventions several generic objectives need to be considered, which have been introduced by Gronau, et al. [7]. Those have been adapted to the context of quality-dependent knowledge transfers:

O1. Interventions must consider empirically proven factors that influence the quality of knowledge transfers.
O2. Interventions must consider all kinds of knowledge transfers, which up to now the externalization, internalization, socialization, extraction, and engineering.
O3. Interventions must be able to be implemented in any company or university.
O4. Interventions must be controllable, which demands their measurability and changeability.
O5. Interventions must show effects in short-term horizons.

These objectives are relevant for the design and validation of interventions for the improvement of knowledge-intensive business processes and serve as input for the following sections.

3.2. Methodology

To answer RQ1 the KTVM was used as a reference to design the Knowledge Transfer Quality Model (Sec. 4.1). As part of the KTQM, empirically proven factors, that influence the quality of knowledge are identified, which are used for the description of the knowledge transfer situation in a product engineering context as well as for the intervention characterization (Sec. 4.2).

To answer RQ2 an implementation model is designed to make the knowledge gained in by the KTQM accessible for an application in any kind of area. Therefore, artifacts and a template to describe knowledge transfer interventions are designed (Sec. 4.2). Based on previously characterized knowledge transfer situations concrete interventions are developed and formalized using the template (see Appendix). Internal validation of the defined knowledge transfer interventions is performed. External validation in a Live-Lab study and a workshop with experts in knowledge management as well as in product engineering of universities and companies is presented in Klippert et al. [22].

4. Results

4.1. Implementation Model for Product Engineering Contexts

The KTVM, which was developed by Albers et al. [3] was used as a reference and adapted to develop the KTQM (Fig. 1). The implementation model for the Knowledge Transfer Quality Model (KTQM) is described in the following.

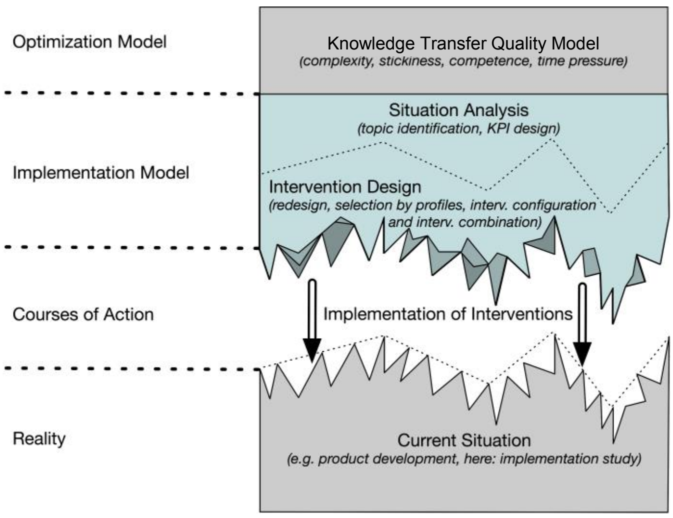


Fig. 1. Knowledge Transfer Quality Model (KTQM)

The underlying variables of the Optimization Model are complexity, stickiness, competence, and time pressure. They do not directly adjust to highly specific situational demands. Therefore, they have a visually flat surface, which does not match the sharp edges on the bottom half (current situation). The Implementation Model entails the Situation Analysis and the Intervention Design. Analyzing the situations means identifying improvement objectives and operationalizing them by KPIs, which refer to concrete variables of the Optimization Model. The design of interventions includes either a selection of interventions, which are based on a comparison of situation profiles and intervention profiles, or the development of new and a redesign of old interventions or their combination. The aim is to identify and select interventions, so that situational characteristics are met best. The Implementation of Interventions is visualized by very well-fitting edges of the Implementation Model to the Reality, which represents the current situation, e.g., from a product engineering context.

4.2. Quality-Dependent Knowledge Transfer Interventions

Fig. 2 presents the template to characterize the knowledge transfer interventions, which is based on the intervention template of Grum et al. [3,7].
Each intervention has a title, which refers to a concrete intervention. First, a knowledge transfer situation before and after the intervention is described and visualized by a schematic representation of the product engineering context. The separation into the as-is situation ("Before") and to-be situation ("After") helps to describe a current situation and makes the effect of an intervention visible in a future situation. Then concrete interventions, which transform the current to the future situation are textually described. In addition to that, the theoretical background, the conversions of knowledge transfer, and an evaluation of the feasibility are provided. The extent to which the empirically proven influencing factors of knowledge transfer (O1: competence, stickiness, complexity, mother tongue, or time pressure) [4,7] re changed and which knowledge transfer conversions (O2: externalization, internalization, socialization, extraction, and engineering) are affected by the intervention are reflected. Lastly, the intervention is characterized by practicability (O3) and short-term feasibility (O5). Practicability is divided into three categories according to Grum et al. [7]:

- A – Interventions that can be implemented in any company and university.
- B – Interventions that can only be implemented when they are modified regarding the specific need of an organization.
- C – Interventions, that are highly specific and can only be implemented in organizations under very high modification efforts.

In addition to seven velocity-dependent knowledge transfer interventions developed by Grum et al. [7], the approach described in Sec. 3.2 enabled the development of eight quality-dependent knowledge transfer interventions, which are fully described according to the intervention template in the Appendix. Those are:

- *Best Practice*: The important aspects of a specific task are getting explained using an example. By presenting key aspects and giving an example, the knowledge is simplified and easier to comprehend.
- *Example evaluation*: Knowledge to be transferred is presented in the form of solutions for a similar task. This way the knowledge is shown in action and is easier to understand and use.

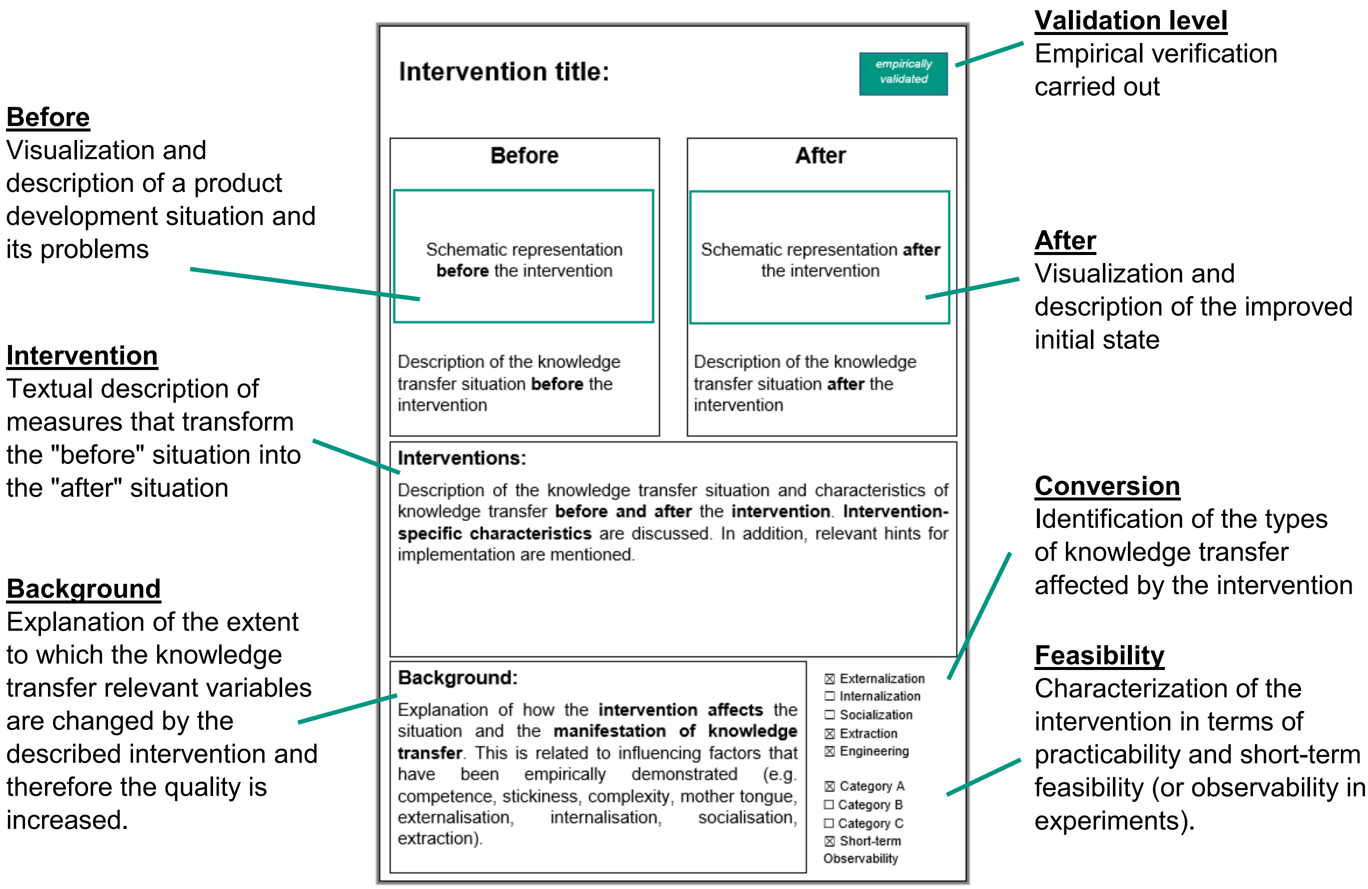


Fig. 2. Template for Quality-Dependent Knowledge Transfer Interventions

- *Evaluation of own solutions*: Knowledge to be transferred is taught by discussing own solutions. This makes it possible to find knowledge gaps and specifically focus on those.
- *Transfer to a presentation*: Knowledge to be transferred will be provided in a presentation.
- *Setting a list of requirements*: Relevant requirements are provided in the form of a list. Knowledge is transferred in a very structured way and is easy to comprehend.
- *Introduction of intermediate milestones*: By introducing Intermediate Milestones it is possible to regularly check for knowledge gaps and specifically focus on those.
- *Increase of time pressure due to deepening of content*: In addition to the primary necessary knowledge, additional secondary knowledge is being taught, which helps to better understand and deepen the primary knowledge.
- *Defined working times*: Specific time frames are being given, in which the knowledge needs to be put into action. At the end of the time, the solutions must be presented and are being discussed. This ensures that the knowledge is being used and worked with, shortly after learning it.

To this point objective O4 (see Sec. 3.1) is initially met by the design of the knowledge transfer interventions but must be validated according to their measurability and changeability.

5. Conclusion and Outlook

This paper focuses on knowledge transfer in product engineering and emphasizes the importance of effective and efficient knowledge transfer to e.g., secure a company's competitiveness. Effectiveness and efficiency are here primarily determined by the target variables speed of transfer and quality of transfer derived from the transfer result. Based on the findings of previous research studies, which present a KTVM to improve the speed of knowledge transfers by implementing interventions to a specific situation, this paper introduces the KTQM and factors which influence the quality of knowledge transfers (answer to RQ1). The implementation model of the KTQM describes how knowledge transfer situations need to be analyzed to identify and select interventions so that their situational characteristics are met best. Based on this model, eight interventions are developed, which are intended to improve the quality of knowledge transfers (answer to RQ2). Those interventions are fully described according to the defined template (see Appendix).

Following this research, the developed quality-dependent knowledge transfer interventions should be validated in an industrial setting [22]. So, the main question that arises is: How can those interventions be validated and implemented in a product engineering context, and their effect on the quality of knowledge transfers be evaluated?

Acknowledgments

The scientific project is sponsored by the German Research Foundation DFG (ID AL 533/33-3 and GR1846/19-3).

Appendix. Quality-Dependent Interventions to Improve Knowledge Transfers

Presentation of a best practice

Before

Necessary knowledge about the product profile template is presented frontally as a lecture and a template is provided.

After

Important aspects of the product profile template are repeated and explained using a concrete example.

Intervention:

In a 30-minute discussion, the discussion leader first repeats the essential criteria (regarding structure, content and presentation) of the product profile template.

Based on this, an exemplary completed product profile template is presented, and possible implementations of the corresponding criteria are pointed out.

Background:

Participants are asked to evaluate their current understanding of the product profile template and the task at hand. This provokes self-reflection.

By explaining the issue with a concrete example, the understanding of the topic should be improved and contribute to increase the competence of the participants and to reduce the (perceived) complexity of the task.

☒ Externalization
☐ Internalization
☐ Socialization
☒ Extraction
☒ Engineering

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

Example evaluation

Before

Necessary knowledge about the product profile video is presented frontally as a lecture incl. examples.

After

Important aspects of the product profile video are analyzed using various examples.

Intervention:

In a 30-minute discussion, the discussion leader first repeats the essential criteria (in terms of structure, content and presentation) for a product profile video.

Based on this, exemplary product profile videos are analyzed and both positive and negative aspects are discussed in relation to the implementation of the defined criteria.

Background:

Participants are asked to evaluate their current understanding of the product profile video and the task at hand. This provokes self-reflection.

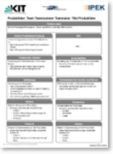
By evaluating the sample videos, participants learn to better understand the task and thus increase their competence as well as reduce the stickiness of their knowledge by explicating their thoughts.

☐ Externalization
☒ Internalization
☒ Socialization
☒ Extraction
☐ Engineering

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

Evaluation of own solutions

Before



Necessary knowledge about the product idea template is presented as a short introduction and a template is provided.

After

Important aspects of the product idea template are discussed using specific examples of your own.

Intervention:

In a 30-minute discussion, the discussion leader first repeats the essential criteria (in terms of structure, content and presentation) of the product idea template.

Based on this, the participants discuss how the defined criteria can be implemented using their own completed product idea templates.

Background:

Participants are asked to evaluate their current understanding of the product idea template and the task at hand. This provokes self-reflection.

By evaluating their own solutions, participants learn to understand the topic and the task better and thus increase their competence as well as reduce the stickiness of their knowledge by explicating their thoughts.

☐ Externalization
☐ Internalization
☒ Socialization
☐ Extraction
☐ Engineering

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

Setting a list of requirements

Before

Necessary knowledge about the task will be imparted in a lecture and/or workshop.

After

Relevant requirements for the result are sorted by category in a list and thus clearly communicated.

Intervention:

The participants are given a list of requirements for a deliverable (e.g., product profile template, video, or business model) with the relevant criteria (in terms of structure, content, and presentation). With the help of this list, they can work on the task.

Background:

The participants get the opportunity to compare their current understanding of the topic and the task to be worked on with the list of requirements. This increases their competence and reduces the stickiness of their knowledge.

⊟ Externalization
☐ Internalization
☐ Socialization
☐ Extraction
⊟ Engineering

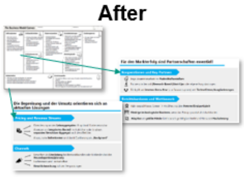
⊟ Category A
☐ Category B
☐ Category C
⊟ Short-term Observability

Transfer to a presentation

Before

Necessary knowledge about the business model is imparted in a workshop and a template is provided.

After



The integration of relevant aspects of the business model into a presentation will be discussed using your own example.

Intervention:

In a 30-minute discussion, the discussion leader first repeats the essential criteria to be considered (in terms of structure, content and presentation) of a business model.

Based on this, relevant aspects of the own business model are identified and their meaningful integration into a presentation is discussed.

Background:

Participants are asked to evaluate their current understanding of the business model and the task at hand. This provokes self-reflection.

By repeating theoretically conveyed content and identifying the relevant aspects of the business model, the participants manage to transfer their knowledge into a presentation. In this way, they increase their competence and reduce the stickiness of their knowledge.

☐ Externalization
☐ Internalization
☒ Socialization
⊟ Extraction
☐ Engineering

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

Introduction of intermediate milestones

Before

The task is worked on in a fixed period and handed in and evaluated at the end.

After

During the processing time, intermediate milestones take place at which participants can consult and receive feedback.

Intervention:

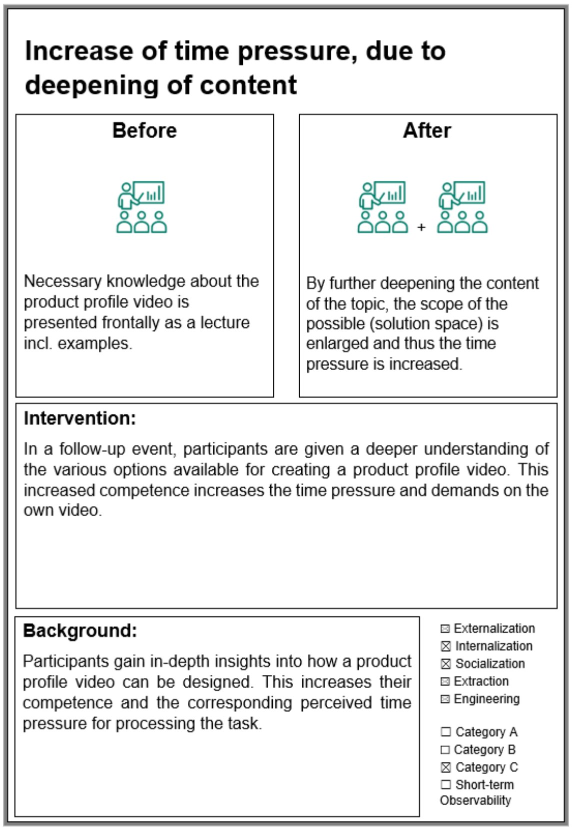
The participants are given a fixed date for consultation and feedback through (interim) milestones. They also have a first deadline at which interim results must be presented.

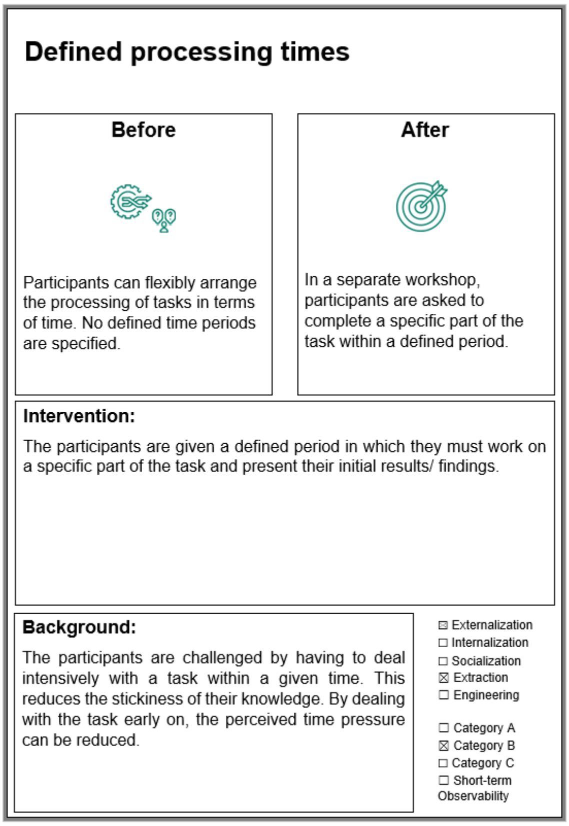
Background:

The participants get the opportunity to validate their results before the milestone and thus to recognize critical aspects at an early stage and, if necessary, to take countermeasures. Additional feedback on improvement potentials increases the competence of the participants. At the same time, the pressure to have produced partial results at a defined point in time increases.

☐ Externalization
☐ Internalization
☒ Socialization
☐ Extraction
☐ Engineering

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





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