Accelerating Knowledge
The Speed Optimization of Knowledge Transfers

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Abstract. As knowledge-intensive processes are often carried out in teams and demand for knowledge transfers among various knowledge carriers, any optimization in regard to the acceleration of knowledge transfers obtains a great economic potential. Exemplified with product development projects, knowledge transfers focus on knowledge acquired in former situations and product generations. An adjustment in the manifestation of knowledge transfers in its concrete situation, here called intervention, therefore can directly be connected to the adequate speed optimization of knowledge-intensive process steps. This contribution presents the specification of seven concrete interventions following an intervention template. Further, it describes the design and results of a workshop with experts as a descriptive study. The workshop was used to assess the practical relevance of interventions designed as well as the identification of practical success factors and barriers of their implementation.

Keywords: Knowledge Transfers, Business Process Optimization, Interventions, Product Development, Product Generation Engineering, Empirical Evaluation

1 Introduction

Knowledge-intensive business processes are characterized by the exchange of knowledge and information among process participants [13, 10, 25, 24, 17] as well as the knowledge application within concrete situations [1]. While many aspects of knowledge-intensive processes have been examined in-depth, e.g. modeling methods, the use of information systems (IS) in business processes and the potential of knowledge management systems (KMS) for knowledge transfers, findings on the speed of knowledge transfer are quite rare and just have been quantified by empirical findings once [12]. Grounding on statistically proven models, which quantify the influence of the velocity and quality of knowledge transfers, the knowledge transfer itself as well as its situation can be controlled and used in IS in order to effectively transfer knowledge among organizational units. Regrettably, neither a situation-specific collection of concrete measures optimizing the speed of knowledge transfers, nor a framework for the validation of corresponding measures is not available in literature, yet. This particularly refers to measures building on statistically proven, quantitative knowledge transfer models.

Following the motivation to optimize knowledge transfer speed by concrete adjustments of the manifestation of knowledge transfers in their concrete situation, here called intervention, the modification of statistically proven influence factors on the speed of knowledge transfer can directly be connected to the adequate speed optimization of knowledge-intensive process steps. If it were possible to adjust this speed by interventions, the design of IS, their integration with business processes, the use of KMS and technical as well as organizational strategies are enabled. The original contribution of this paper therefore refers to the design of an intervention standard leading to concrete interventions, which fit to statistical proven, quantitative findings on knowledge transfer velocity available in literature. Based on them, for the first time, the model-driven and quantitative effect of knowledge transfers as method of process optimization can be determined. Further, the original contribution of this pater refers to the demonstration of the standard defined (here called *intervention template*) by seven example cases and their empirical validation by experts on behalf of a workshop designed. All together, this forms an *intervention validation framework*, which enables the practicable and effective optimization of knowledge transfers.

The following research will focus on the optimization of knowledge transfers with the intention to answer the following research question: ”How can the speed of knowledge transfers in knowledge-intensive processes be optimized?” As the development of new products can be interpreted to be always based on existing products, knowledge is transferred among product development situations via persons and media. Hence, the product generation engineering context is very suited for the observation of knowledge transfers [4]. This paper intends not to draw an all-embracing description of concrete, technical realizations of those novel process optimization techniques. It intends to set a first step to a speed-optimized business process design. Before the examination of concrete interventions in laboratory studies, their selection and validation by practitioners was carried out described here. Hence, sub research questions addressed here are:

1. ”How can time-dependent knowledge-transfer models be used in order to derive interventions, which optimize speed of knowledge-intensive business processes?”
2. ”How can process interventions be best realized by practitioners?”

The research approach is intended to be design-oriented as Peffers proposes [20, 21], such that the remaining paper is structured as follows: The second section presents a foundation and underlying concepts, the third section derives objectives and presents a methodology for the specification and validation of knowledge transfer speed optimizations in knowledge-intensive processes. Those are separated from the design of required artefacts, which will be presented in the fourth section, because of their function as quality gates. Their demonstration presented in the fifth section shows the application of designed artefacts. This is evaluated in the sixth section. The final section concludes the paper.

2 Theoretical Foundation and Underlying Concepts

Concepts underlying the the research presented here refer to the domain of process optimization and knowledge transfers. As interventions designed in this contribution are considered in the context of product development, relevant concepts are presented thereafter.

2.1 Business Process Optimization

Activities and decisions leading to a desired optimization of business processes, are designated as *business process optimization* [14]. Considering processes as they are (as-is processes) to be a reference, any adjustment carried out in order to optimize these processes in regard to a certain objective are called process optimization. Since those adjustments implement changes of the as-is process, we call them *intervention*.

Focusing on the optimization of knowledge-intensive business processes, all activities and decisions that lead to the improvement of a certain knowledge transfer in its concrete situation and application context, are therefore designated as *knowledge transfer intervention* [4]. The success of any intervention then can be measured by key performance indicators (KPIs), such as assembly times, failure rates and success rates, the number of produced components, etc. There can be found two basic approaches for business process optimizations that are reflected in various methods and variations:

First, a management concept called *Kaizen*. Originally, it was inspired by a Japanese living and working philosophy. Realizing an iterative never ending improvement of processes and products in small steps, they are optimized continuously. Therefore, these kinds of optimization approaches are referred to as *continuous improvement process* (CIP) cycles [16].

Second, the redesign of as-is processes from the scratch refers to an optimization concept called *business process reengineering* (BPR) [15]. Since this is mostly connected with far reaching changes or a completely redesign of products and processes, experiences and knowledge of the former design are reused but only considered implicitly in new process designs.

As both kinds of optimizations realize adjustments of a process, the implementation of interventions can be considered in both. So, the dealing with interventions intends to realize a common process optimization character and interventions designed in this contribution intend to be implementable in both, cyclic process optimization approaches and BPR approaches.

2.2 Knowledge-Intensive Processes and Knowledge Transfer Models

Based on the definition of *knowledge* to be the unity of skills, cognition and capabilities, which are used by individuals for the solution of given problems [9, 26, 22], the processual consideration of a problem solution refers to knowledge-intensive processes. These demand for knowledge to be transferred from a knowledge carrier to a knowledge receiver and the definition of knowledge transfer has to consider the transfer process itself as well as its content to be transferred. Following the conceptual model of Minbaeva et al. [18], the knowledge transfer further includes the application of knowledge, so that the knowledge transfer can be observed. This research therefore defines a *knowledge transfer* as the identification of knowledge, its transfer from knowledge carrier to knowledge receiver, and its application by the knowledge receiver. Hence, a successful knowledge transfer intervention is intended to be implemented in knowledge-intensive processes, and the effect of a successful knowledge transfer can be measured by KPIs at the correct knowledge application.

Following the definition of the *knowledge transfer velocity* of Gronau and Grum, who define it to be the relation of a clearly distinguishable amount of knowledge, which is required for the successful solution of a certain task and transferred from a knowledge carrier to a knowledge receiver within a certain amount of time [12], the knowledge transfer velocity can be made concrete, as the time for the realization of a knowledge-intensive process is measured and the successful transfer of knowledge is conducted. Therefore, interventions designed in this contribution have to consider this operationalization and implement adjustments here.

The only empirical model available about a knowledge transfer velocity is given by Gronau and Grum [12]. It sets focus on the following variables to influence the knowledge transfer velocity:

- As the *competence* of process participants is raised, the knowledge transfer velocity can be increased.
- As the *stickiness* of knowledge to be transferred is raised, the knowledge transfer velocity can be increased.
- As the *complexity* of the task to be solved is lowered, the knowledge transfer velocity can be increased.
- As the *mother tongue* is used for the knowledge transfer, the knowledge transfer velocity can be increased.
- As the *educational background* is close to the knowledge transfer, knowledge transfer velocity can be increased.

Statistical models are even established for the four *conversions* of the SECI model [19]:

- The *socialization* considers knowledge transfers of tacit knowledge into tacit knowledge.
- The *externalization* considers knowledge transfers of tacit knowledge into explicit knowledge.
- The *combination* considers knowledge transfers of explicit knowledge into tacit knowledge.
- The *internalization* considers knowledge transfers of of explicit knowledge into explicit knowledge.

For the implementation of interventions focused here, this means a consideration of the only available empirical model inclusive its influence variables. Following the research overview of Gronau and Grum, the application of an empirical knowledge transfer velocity model has not be realized, yet. Hence, the implementation knowledge transfer interventions focused here is missing and a research gap becomes visible.

2.3 Product Generation Engineering

The approach of Product Generation Engineering (PGE) describes fundamental aspects of product development as such with two main hypotheses [3]. Both are provided in the following:

First, existing technical systems are the basis for every development of new technical products. The development of a new product is therefore perceived as the development of a new product generation. Those already existing technical systems, which serve as a basis or starting point for the development of a new product generation, are *reference products*. Reference products can be preceding product generations from the same company, but also from competitors products, products from other branches or systems from research projects, which are not even present in the market, yet. A basic distinction is the one between internal reference products of a company and external reference products [5].

Second, with reference products as a basis and starting point for the structure and subsystems of a new product generation, the development of the new product generation consists of three types of variation. *Carryover variation* (CV) refers to the direct carryover of a subsystem from a reference product with changes occurring only at system boundaries due to system integration. *Embodiment variation* (EV) and *principle variation* (PV) include changes in the embodiment of a subsystem or its working principle, respectively, using the corresponding subsystem from a reference product as starting point for development activities. All subsystems developed by embodiment or principle variation together form the share of new development in the development of the new product generation.

Both elements, reference products and variations, especially the share of new development, contribute to development risks and costs and connect to knowledge transfer as well [7]. On the one hand, the organizational origin of a reference product is important. External reference products imply an increased development risk compared to internal reference products because a product documentation is usually not available and it is impossible to gather the same amount of information just by analyzing an external reference product. Furthermore, looking at reference products from other branches rather than at reference products from its own branch, a company tends to lack more knowledge, which is necessary to analyze a reference product successfully. Because of the described lacks of competence and knowledge, building up and transferring knowledge is crucial for successful product development. This applies as well when using internal reference products, if the developer of the reference product is another person than the developer of the new product generation as there is always a certain amount of knowledge, which is not explicated in the product documentation. On the other hand, challenges and costs come along with the share of new development. This is due to the degree of technical novelty [2]. The successful realization of new technical solutions demands the creation and transfer of new knowledge. For todays products, this usually includes knowledge transfer within interdisciplinary development teams.

All together, this makes product generation engineering environments very attractive for interventions optimizing the knowledge transfer velocity. Although aiming to create interventions optimizing the common knowledge transfer, the focus of this contribution will be on this kind of environment as a first step.

2.4 Product Profiles and Knowledge Transfer Interventions

Product profiles are a tool, usually at an early stage in a product development process [6]. They aim at specifying the need for a certain product without limiting the search for potential technical solutions by making too precise technical specifications. Product profiles consist of a product profile claim, an initial product description and information about the benefit for the provider, customers and users. Furthermore, information about the competitive context, use cases, intended reference products, demands, validation approaches and boundary conditions is included, as far as available. A possible way for the evaluation of product profiles is the use of short videos, which depict especially the identified demand situation that is to be covered with the planned product [23].

Albers et al. have analyzed important influence factors on the speed of knowledge transfer and provided a prioritization taking into account the time span in which those factors could be influenced [4]. They also collected and characterized some typical settings in product development where successful knowledge transfer is important according to practitioners. Building up on the set of influence factors, they propose a *framework for the analysis of knowledge transfer situations* based on the idea that a low speed of knowledge transfer is caused by the use of inappropriate transfer methods. The selection of interventions here is derived by the match of concrete knowledge transfer situations and interventions, both being characterized by profiles using influence factors identified similar to the tool of product profiles.

Using the framework for the analysis of knowledge transfer situations and the concepts of interventions presented by Albers et al. [4], this contribution designs a first collection of concrete interventions, which are going to optimize the knowledge transfer in product development environments.

3 Objectives and Methodology

In accordance to the DSRM of Peffers [20, 21], before the realization of required artefacts was carried out, requirements were defined that serve as design maxims for the definition and validation of interventions for knowledge transfer optimizations. The separation of requirement definition and artifact creation guarantees that artefacts are finalized, only when all requirements are fulfilled. Hence, they work as quality gates for artefacts presented here and facilitate to connect subsequent research with research presented here.

3.1 Objectives

As one assumes to have a given process model and one aims to implement interventions within a concrete situation of that process model inclusive its manifestation of knowledge transfers, the following generic objectives have to be considered about the creation of interventions:

1. Interventions must consider empirically proven factors that influence the speed of knowledge transfers.
2. Interventions must consider all kinds of knowledge transfers, which is up to now the socialization, externalization, internalization and combination.
3. Interventions must be able to be implemented in any company or university.
4. Interventions must be controllable, which demands for their measurability and changeability.
5. Interventions must show effects in short-term horizons.

As interventions created are intended to be validated by practitioners and experts are faced with novel concepts, a workshop design was chosen. It considers the following objectives:

6. Since the practicability focuses on both, universities and companies, the workshop must include experts form both kinds of institutions.
7. The workshop must include experts form the domain of knowledge management and the specific knowledge application context, which is here product development.
8. The workshop must enable experts with concepts required for knowledge transfer speed optimizations.
9. The workshop must ensure that experts consider interventions within their individual situation.

Each objective identified is relevant for the validation of interventions for the optimization of knowledge-intensive business processes and serves as input for the following sections.

3.2 Methodology

In order to answer the question regarding the specification and validation of interventions optimizing knowledge transfer situations and corresponding manifestations in knowledge-intensive business processes as well as the characterization of best implementation strategies from perspective of practitioners, a workshop with experts was realized as descriptive study in compliance with Blessing and Chakrabarti [8]. This includes four *main stages* as follows:

First, literature is analyzed in a *research clarification*. This helps to clarify goals for a research, which here refers to the design and validation of interventions.

Second, empirical data available is analyzed in a *descriptive study I*. Typically, influence factors are identified here, which serve as initial description of the excising situation. In the context presented here, this refers to the identification of empirical proven influence factors, that can be used for the characterization of the knowledge transfer situation as well as for the intervention characterization. Hence, this stage helps to create an understanding for the intended research. Further, it becomes clear, which factors a workshop should address for validation by practitioners.

Third, a *prescriptive study* is realized, which builds on the increased understanding of researchers. Here, artefacts are designed, such as the concrete interventions presented in section 4.1 and the workshop design presented in section 4.2.

Fourth, empirical data is analyzed in a *descriptive study II*. Here, the support of artefacts designed is investigated, so that an evaluation is established. This refers to the support of practitioners from the area of knowledge management as well as from product development of universities and companies.

Since those stages are designed to be cyclic, insights of consecutive stages can be used in iterative stage realizations. Artefacts and insights presented here therefore refer to the final iteration of stages.

4 Design of an Intervention Validation Framework

The following conceptualizes knowledge transfer interventions in a first sub section and designs a workshop-based way to validate interventions (second sub section). All together, this forms an *intervention validation framework*, which can be used in order to expand and systematically collect validated interventions for knowledge transfer speed optimizations, which go beyond the context and examples presented here.

4.1 Knowledge Transfer Interventions

Fig. 2 (a) presents the template to characterize interventions for the optimization of knowledge-intensive business processes. While an *intervention title* helps refer to concrete interventions, a *short description* characterizes the situation of knowledge transfers. Each is accompanied by a *schematic*, which summarizes the current situation, supports a medial processing and guarantees a fast access and recognition of the intervention. The separation in *before* and *after* helps to characterize as-is situations and make the effect of interventions visible in to-be situations.

The transfer from as-is situation to to-be situation is realized by the implementation of a concrete *intervention*. It is characterized in a further text block and makes the best realization subject of discussion.

The connection of the concrete intervention to theory and grounding, empirical models is provided in a *background* section. Here, the meaning of the concrete intervention in regard to empirically proven influence factors, such as *competence*, *stickiness*, *complexity*, *mother tongue*, *educational background*, *internalization*, *externalization*, *socialization* and *combination*, is reflected (see section 2.2).

The following *intervention categories* are designed to be applied in concrete contexts. Since categories can be carried out by various communication channels and manners, concrete interventions can be connected to all: socialization, externalization, internalization and combination.

- **Animation:** Knowledge to be transferred can not only be presented in a static manner. By the presentation of images or objects that show how they evolves over time, dynamic aspects of knowledge transfers can be visualized.
- **Instructions:** Knowledge to be transferred can be involved in a guided process. Various kinds of instructions (orally, visually, haptic, etc.) draw attention to a specific aspect, which is required for consecutive steps and therefore simplify knowledge transfers by providing structure.
- **Labellings:** Knowledge to be transferred can be augmented by labels over the whole object of investigation. The use of the same technical terms simplify knowledge transfers since conflicts in the use of terms are avoided and improve the stickiness.
- **Repetitive layouts:** Knowledge to be transferred can be provided by the same layouts. The use of the same layout simplifies knowledge transfers since mappings among different layouts can be avoided. This improves the stickiness.
- **Entropic visualizations:** Knowledge to be transferred can not only be presented by various visualizations. Several visualizations of the same type can be combined

so that the entropy of the resulting visualization can be raised. This simplifies the knowledge transfers since mappings among visualizations can be avoided.

– **Functional integrations:** Knowledge to be transferred can not only be presented by various visualizations. Several visualizations of different types can be combined so that the entropy of the resulting visualization can be raised. This simplifies the knowledge transfers since mappings among visualizations can be avoided.
– **Realizations:** Knowledge to be transferred can be provided as realization. By dealing with the realized object of interest, relations are made clear easily, which have not been considered before. This simplifies the knowledge transfers.

4.2 Workshop Design

The workshop is designed to be carried out with knowledge management experts and context-specific experts. The teaming is a crucial element since both kinds of experts have the assignment to consider their individual background, their personal experience made in concrete projects and to reflect in regard to concrete relevant knowledge situations of the intended context. Only then, fruitful discussions will evolve and a validation considers multiple perspectives. The workshop was structured by the following steps:

1. **Individual context identification:** The workshop is started by an introduction to the general idea of knowledge transfer speed optimization. Then, participants are introduced and objectives for the workshop are clarified. A first brainstorming about the meaning of knowledge transfer optimizations in individual knowledge transfer situations intends to activate participants.
2. **Relationship establishment:** Workshop participants are enabled by the provision of basic knowledge. In concrete, this refers to concepts of knowledge transfers, empirical experiments about knowledge transfers and statistical models of the knowledge transfer velocity. Further, this includes context-specific knowledge, such as product generation engineering for the product development context. A second brainstorming about *intervention categories* in regard to the individual context prepares the dealing with interventions and establishes the relationship of theory and the individual's knowledge transfer situations.
3. **Selection of interventions:** Concrete examples of interventions for the intended context are provided by posters. Each participant has the chance to study the interventions carefully and create an opinion about their application in the individual situation. As questions occur, they are clarified for all participants. Workshop participants are asked to create further examples using clean template sheets following the design of Fig. 2 (a). Those are presented and discussed by all. The group consensus selects interventions to be considered in consecutive workshop steps.
4. **Identification of success factors and barriers:** Selected interventions are collected and each participant is asked to identify one main success factor and one main barrier for each intervention. Those are written on separate cards, which were pinned next to intervention posters. Identified factors are then presented and discussed. The group consensus selects success factors and barriers to be considered in consecutive workshop steps.

5. **Assessment of interventions:** Each participant is equipped with a printout following the design of Fig. 1. Here, only by the consensus selected interventions, selected success factors and selected barriers can be found. Each participant then is asked to assess elements in regard to individual knowledge transfer situations. A consensus is found thereafter.

Interventions / Factors	Success Factors							Barriers							Assessment	
	Main Factor Intervention 1	Main Factor Intervention 2	Main Factor Intervention 3	Main Factor Intervention 4	Main Factor Intervention 5	Main Factor Intervention ...	Main Factor Intervention n	Main Factor Intervention 1	Main Factor Intervention 2	Main Factor Intervention 3	Main Factor Intervention 4	Main Factor Intervention 5	Main Factor Intervention ...	Main Factor Intervention n	Practicability (A/B/C)	Short-term Controllability
Intervention 1	✓							✓								
Intervention 2		✓							✓							
Intervention 3			✓							✓						
Intervention 4				✓							✓					
Intervention 5					✓							✓				
Intervention ...						✓							✓			
Intervention n							✓							✓		

Legend:
A - Interventions, that can be implemented in any company and university.
B - Interventions, that can only be implemented when they are modificated in regard to the specific need of an organization.
C - Interventions, that are highly specific and can only be implemented in organizations under very high modification efforts..
✓ - Interventions are controllable and show results in short-term horizonts.

Fig. 1: Intervention Assessment Design.

While the applicability of a certain success factor or barrier on an intervention is indicated by a checkmark put to the corresponding cell, its practicability is categorized by three kinds of interventions. A first kind refers to interventions, that can be implemented in any company and university. A second kind focuses on interventions, that can only be implemented when they are modified so that they fit to the specific need of an organization. A third kind issues the intervention's impractically high modification effort because of a high specification. Here, the participants is asked to denominate the corresponding cell. Further, the short-term controllability is indicated by a checkmark, that is put by the participant if the intervention is controllable and shows results in short-term horizons.

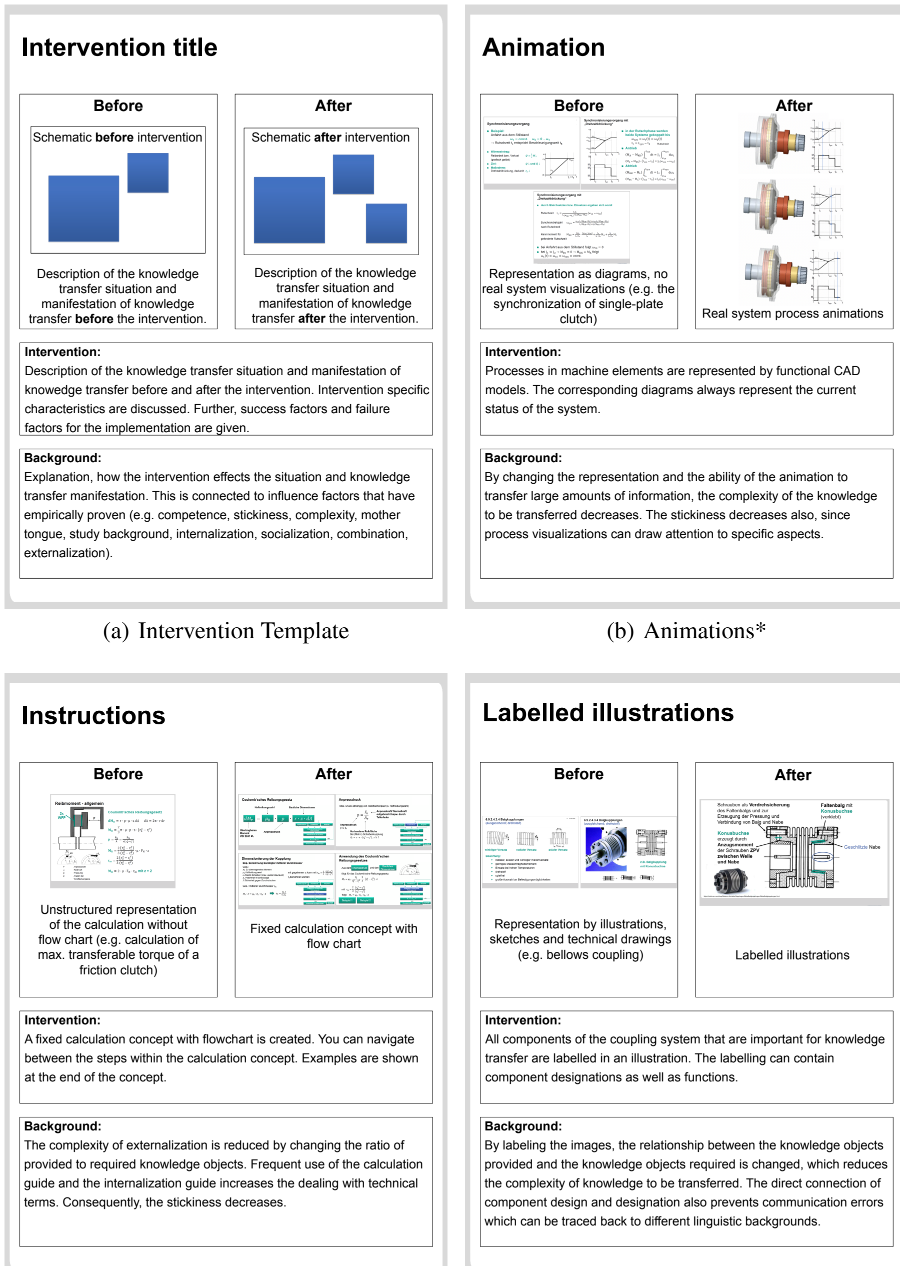
5 Demonstration of Interventions in PGE

Following the DSRM of Peffers [20], the *intervention validation framework* designed in section 4 is demonstrated by the realization of the workshop designed (section 4.2) and the application of the intervention design in the PGE context. The *workshop design* was carried out with 2 knowledge management experts (1 from university, 1 from a company) and 3 product development experts (1 from university, 2 from companies). Applying the seven *intervention categories* of section 4.1 to the PGE context with help of the template design (see Fig. 2 a), seven PGE-specific interventions have been prepared as they can be found in Fig. 2 (b) - (d) and Fig. 3 (a) - (d). They have been presented in the third phase of the workshop. Assuming to have universities or companies, which show as-is situations presented here, those interventions optimize the speed of knowledge transfers observed in the individual's situations if relevant relevant influence factors are adjusted.

As it was task of the participants to identify further interventions, the following have been identified:

- **Fantasy denominations:** If new products are developed, that are thematically positioned between several domains, technical terms can be overloaded. Experiences showed, that long-lasting discussions about the current understanding of engineers about technical components can be shortened as fantasy denominations are used until components have been finalized. This guarantees a small stickiness because terms are used impartially.
- **3D prints:** 3D printouts fasten the realization process of real components. Hence, this intervention is similar to explanations of the intervention *realizations* with the following exception: printing temperatures, procedures and materials still are an evolving research domain, so that the creation process itself can be more complex and prints might show typical 3D printing errors or are bad compromises. Then, the stickiness is increased since they are more complicated to interpret.
- **Expert presentations:** Presentations of experts help to avoid pitfalls, structure unknown terrain, mention relevant vocabulary and therefore decrease stickiness. Particularly educational concepts support the raise in competences.
- **Language glossary:** A collection of technical terms supports the use of correct technical terms in multiple languages. Long-lasting discussions about different understandings, translation inaccuracies and failures because of incorrect technical terms can be avoided as definitions provided by the glossary have high quality entries in all languages.
- **Standardized descriptions of machine elements:** The stickiness can be decreased and failures can be reduced as descriptions of machine elements are standardized. Only then, all relevant attributes are described and the knowledge transfer can be structured commonly. Hence, long-lasting discussions and search processes about missing information can be avoided.

While the first three workshop steps focused on the enabling of workshop participants and the identification of participants with interventions in their concrete situation, phase four and five focused on the validation of interventions and the identification of best implementation strategies. Fig. 4 presents validation-relevant interventions and factors forming a matrix. Factors presented here, were identified and selected for consecutive steps. Success factors refer from the understanding of workshop participants to the following:



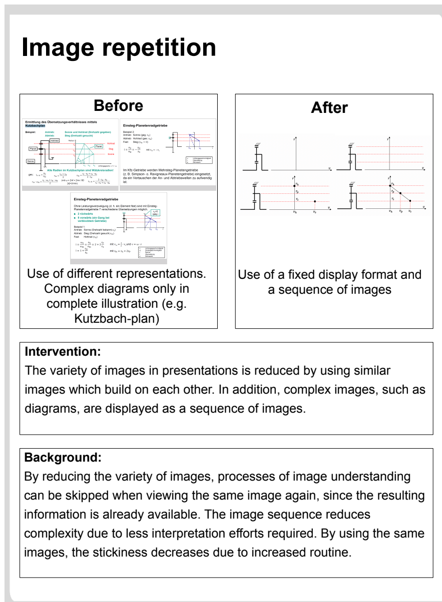
(a) Intervention Template

(b) Animations*

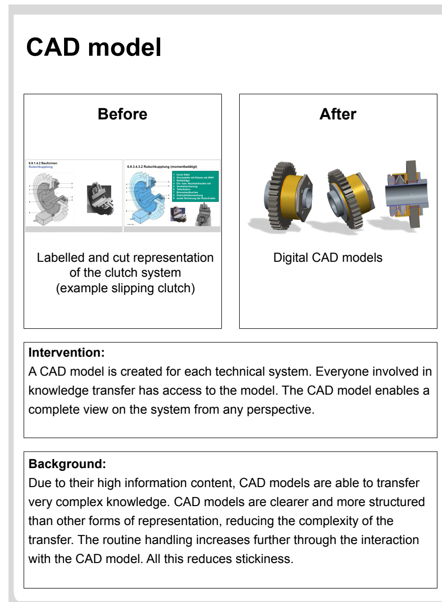
(c) Instructions*

(d) Labellings*

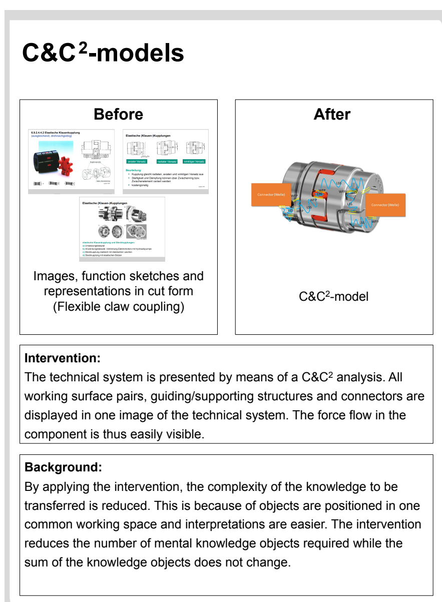
Fig. 2: Intervention examples (*exemplified with product development context).



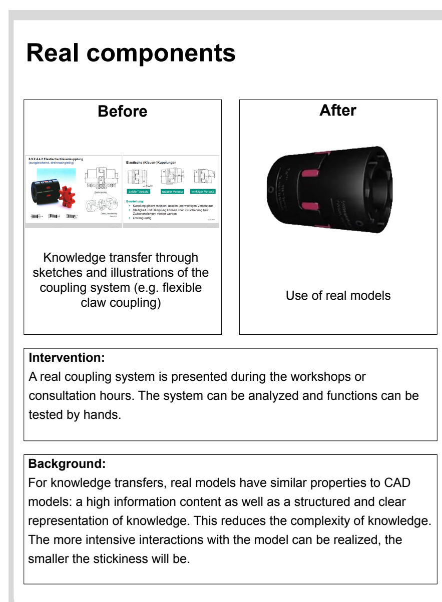
(a) Repetitive Layouts*



(b) Entropic Visualizations*



(c) Functional Integrations*



(d) Realizations*

Fig. 3: Intervention examples (*exemplified with product development context).

- **Simplicity of adaption:** Relevant knowledge can be adapted easily and efficiently to the form required by the corresponding intervention.
- **Clarity of visualization:** The visualization can be interpreted easily, as the intervention has been implemented.
- **Conclusiveness:** Relevant knowledge is understandable after the intervention has been implemented.
- **Function-based mapping:** Knowledge can be mapped function-wise by the intervention.
- **Need for action:** The knowledge to be transferred is essential and as-is knowledge transfers are bad so that the need for action exceeds inactivity.
- **Simplification:** The intervention simplifies relevant knowledge.
- **Scope of internalization:** The scope of knowledge to be transferred is clearly characterized and interventions focus on exactly this scope.

Barriers identified and selected for consecutive steps are from the understanding of workshop participants the following:

- **Intellectual property protection:** Relevant knowledge is intellectual property and it is infringed by the intervention.
- **Linguistic expression:** The intervention does not consider linguistic nuances, so that knowledge transfers can be hampered.
- **Update effort:** The effort to keep knowledge uptodate is to big so that outdated knowledge objects hamper knowledge transfers.
- **Creation effort:** The effort to modify knowledge in regard to the intervention is to big so that the intervention is rejected by process designers.
- **Standard operating procedure problem:** The transfer of relevant knowledge is simplified by the optimization, but regrettably then is not supporting the act of thinking any more. It enables only the processing of standard procedures.
- **Prerequisites:** Competences required to interpret knowledge after the intervention are high and knowledge carriers are not able to receive knowledge.
- **Limitations:** Relevant knowledge is hindered because of intervention-specific limitations, e.g. space limitations, color limitations or decoding limitations.

6 Evaluation

An evaluation of interventions by the workshop is built on the following: First, only relevant interventions have been selected by workshop participants. Second, interventions have been assessed in regard to their practicability by individuals. Third, interventions have been applied in imaginary projects in order to assess their short-term controllability.

The evaluation of best realization strategies is built on the following: First, the identification of relevant success factors as well as barriers of each intervention by individuals and the discussion by all. Second, the verification of their influence on several interventions. Third, the act of consensus identification.

So, interventions have been validated and attractive interventions can be identified for subsequent research.

Interventions / Factors	Success Factors							Barriers							Assessment			
	Simplicity of adaption	Clarity of visualization	Conclusiveness	Function-based mapping	Need for action	Simplification	Scope of internalization	Intellectual property protection	Linguistic expression	Update effort	Creation effort	SOP problem	Prerequisites	Limitations	Practicability (A/B/C) A	B	C	Short-term Controllability
CAD model	**✓**	✓	✓			✓	✓	**✓**		✓	✓			✓	0,4	0,6	0	0,6
Labeled illustrations		**✓**	✓			✓			**✓**	✓					0,8	0,2	0	0,8
Image repetition	✓	✓	**✓**			✓	✓			**✓**					1	0	0	0,8
Animation	✓	✓		**✓**		✓	✓			✓	**✓**			✓	0,4	0,4	0,2	0,6
Instructions	✓		✓	✓	**✓**	✓			✓			**✓**			0,4	0,4	0,2	0,8
Real components				✓		**✓**		✓			✓		**✓**	✓	0,2	0,4	0,4	0,6
C&C² models	✓	✓	✓	✓	✓		**✓**		✓				✓	**✓**	0,2	0	0,8	0,2

Legend:
A - Interventions, that can be implemented in any company and university.
B - Interventions, that can only be implemented when they are modificated in regard to the specific need of an organization.
C - Interventions, that are highly specific and can only be implemented in organizations under very high modification efforts..
✓ - Factors are relevant for indicated interventions.
✓ (colored) Main factor of a certain intervention in consens of participants.
(purple) - Main category of practicability
(green) - Interventions are controllable and show results in short-term horizonts.

Fig. 4: Intervention Assessment (consensus of participants).

Success factors: While only the main success factor of a certain intervention has been colored in Fig. 4, their effect on further interventions has been highlighted on a consensus base by checkmarks. There is not any success factor, that is only relevant for its original intervention. Further, main factors are not redundant. This underlines the specific consideration of each intervention and draws attention to some factors, that are very meaningful. The factor showing the most influences is the *simplification*, which is relevant for six interventions. The factor showing the fewest influences is the *need for action*, which is relevant for two interventions. The intervention demanding for the most success factors is the *C&C² models*. The intervention demanding for the fewest success factors is the *real components*.

Barriers: On a consensus base, the effect of barriers has been highlighted with checkmarks and the main factor is colored in Fig. 4. There is not any barrier, that is only relevant for its original intervention. Further, main factors are not redundant. This underlines the specific consideration of each intervention and draws attention to some factors, that are very meaningful. The factor showing the most influences is the *update effort*, which is relevant for four interventions. The factor showing the fewest influences is the *SOP problem*, which is relevant for one intervention. The intervention demanding for the most success factors is the *CAD model*. The intervention demanding for the fewest success factors is the *instructions*.

Practicability: Considering the assessment of all participants, the average assessment is visualized by values element-wise in Fig. 4. The maximum highlighted in purple is interpreted as the main category of an intervention. Interventions clearly showing the ability to be implemented in universities and companies are *labeled instructions* and *image repetitions*. The interventions *CAD model* and *real components* can be identified without doubts as interventions requiring modifications before their implementation. Only the *C&C*^{2} *models* have been characterized as highly specific and to be able to be implemented only under high modification efforts. The interventions *animation* and *instructions* can be both: either, they can be implemented immediately or they require modifications. Discussions showed that this is connected to the specific animation object and instruction example. The intervention *real components* can be either categorized as practicability type B or C. Discussions showed that this is again connected to the specific component example: Highly specific components, such as complex molecule models, demand for high modification efforts and the realization of simple components, e.g. printable by 3D printers, just demands for simple modification efforts.

Short-term controllability: Considering the assessment of all participants, the average assessment is visualized by values element-wise in Fig. 4. Elements above the threshold of 0.5 are highlighted in green and can be interpreted as an intervention, which is controllable in short-term horizons. Nearly all interventions can be identified to be controllable and show short-term effects. Hence, they are very suited for an implementation in universities and companies. Only *C&C*^{2} *models* are not evaluated to be an intervention, which can be implemented quickly, is controllable and shows short-term effects.

7 Conclusion

The first research question (How can time-dependent knowledge-transfer models be used in order to derive interventions, which optimize speed of knowledge-intensive business processes?) can be answered by interventions, that consider a modification of empirically proven influence factors. While generic intervention categories have been defined, twelve concrete interventions have been characterized. The concrete situation is considered similar to product profiles, so that a best intervention can be selected.

The second research question (How can process interventions be best realized by practitioners?) can be answered by the consideration of success factors and barriers, which support or hamper the implementation of intervention in concrete situations or process instances. The assessment of interventions by practitioners identified representatives, which are very suited for both, universities and companies. This was realized on base of the practicability and the short-term controllability.

Faced with workshop results, interventions have been validated by practitioners on a quality-based level. With exception of the *C&C*^{2} *models*, all interventions have been identified to be very attractive for the observation in project settings. Only the *CAD model* and *real components* intervention are attractive for this, when required modifications are manageable. Hence, the validation of their functioning will be evaluated on base of product development projects in labor studies, which allow the observation of projects under realistic circumstances. Here, best implementation strategies can be proven and success factors and barriers can be relativized.

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