Quantification of Knowledge Transfers

The Design of an Experiment Setting for the Examination of Knowledge Transfers

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Abstract. Faced with the triad of time-cost-quality, the realization of knowledge-intensive tasks at economic conditions is not trivial. Since the number of knowledge-intensive processes is increasing more and more nowadays, the efficient design of knowledge transfers at business processes as well as the target-oriented improvement of them is essential, so that process outcomes satisfy high quality criteria and economic requirements. This particularly challenges knowledge management, aiming for the assignment of ideal manifestations of influence factors on knowledge transfers to a certain task. Faced with first attempts of knowledge transfer-based process improvements [1], this paper continues research about the quantitative examination of knowledge transfers and presents a ready-to-go experiment design that is able to examine quality of knowledge transfers empirically and is suitable to examine knowledge transfers on a quantitative level. Its use is proven by the example of four influence factors, which namely are stickiness, complexity, competence and time pressure.

Keywords: Knowledge Management, Knowledge Transfer, Conversion, Empirical Examination, Experiment.

1 Introduction

Process management traditionally improves business processes by either small modifications at a company's actual process models [2] or by the effortful reengineering of those processes [3]. Recent research about the process-oriented knowledge management contributes here because of novel forms of process improvement approaches: knowledge is controlled at knowledge-intensive tasks to systematically improve business processes [1]. This research aims to expand the knowledge about knowledge transfers by experiments, so that relevant influence factors on knowledge transfers can be identified in a first step. Based on these factors, the target-oriented modification of knowledge transfers is enabled further, so that business processes are improved by more efficient knowledge transfers.

The importance of knowledge for the realization of competitive advantages of organizations is well accepted [4]. Although first insights about influence factors on knowledge transfers are present, these mostly refer to qualitative research, such as [5–7]. First quantitative results can be found at simulations [8], experiments [9] and field studies [10]. By now, these focus only on factors influencing the time consumption of knowledge transfers. Although various target dimensions are suitable to measure the effect of knowledge transfers in addition, here one can find costs required [11] and quality of knowledge transfer outcomes, the following focuses on quality aspects and intends to discuss how to empirically research knowledge transfers. So, the following research will address the examination of knowledge transfers and focuses on the following research question:

"How can quantitative effects of influence factors on knowledge transfers be examined by an experiment?"

This paper rather outlines the design of an experiment than presenting a ready-to-go experiment implementation. The core conceptual question structuring the research process and focused here refers to the identification of requirements for its implementation and the demonstration of the design's usefulness to examine example influence factors.

In accordance with MacKenzie et al., the following assumes an experiment to be useful in regard with the research question, if it describes the measurement of the construct of knowledge transfers and supports validation procedures [12]. So, for instance, the evaluation of the influence factor significance, direction and proportion on concrete constructs of knowledge transfers to be examined shall be enabled through their experimental manipulation. Hence, the design needs to characterize the process of data gathering in an experiment setting, that is suitable to examine the quantitative influence of factors on knowledge transfers with the aid of statistical methods. For this reason, the research presented provides a modeling attempt specifying the experiment process and relevant knowledge transfers.

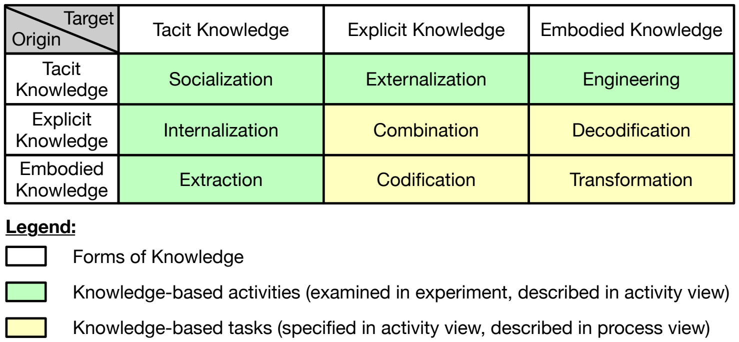
The research approach is intended to be design-oriented in accordance with the Design-Science-Research Methodology (DSRM) [13]. Thus, the second section provides the foundation of knowledge transfers, from which requirements are derived that need to be reflected by the experiment. The third section justifies the concrete requirements for the experiment. The design artifact is presented in the fourth section. Its usefulness will be demonstrated with the aid of four example factors in section five. It issues how to examine quantitative effects on knowledge transfers and clarifies how to manipulate the construct to be examined in experiments. In section six, it will be evaluated inhowfar the experiment design is suitable to examine knowledge transfers on a quantitative level. The insights are concluded in the last section.

2 Theoretical Foundation

The theoretical foundation mainly refers to the characterization of knowledge, knowledge transfers as well as the modeling of knowledge transfers. Each is issued in the following.

Knowledge. Knowledge is present at explicit and tacit forms of knowledge [14] as well as embedded knowledge [15]. While the first refers to a well documentable form of knowledge, that can be handed among any kind of process participant easily (e.g. a book), the second form of knowledge is hard to document as it is knowledge-bearer-bound (e.g. experience), and the third form of knowledge refers to their physical manifestation (e.g. produced circuit bords).

Knowledge Transfers. Knowledge transfers are considered as the process of the identification of knowledge, its transmission from knowledge carrier to knowledge receiver and its application by the knowledge receiver [9]. Particularly, the application is essential, so that the result or manifestation of knowledge transferred can be observed. In terms of knowledge forms, nine kinds of knowledge form interrelations (the so called *conversions*) can be found in knowledge transfers. While Fig. 1 presents them as an overview, the following characterizes them in detail.



Target Origin	Tacit Knowledge	Explicit Knowledge	Embodied Knowledge
Tacit Knowledge	Socialization	Externalization	Engineering
Explicit Knowledge	Internalization	Combination	Decodification
Embodied Knowledge	Extraction	Codification	Transformation

Legend:

☐ Forms of Knowledge

🟩 Knowledge-based activities (examined in experiment, described in activity view)

🟨 Knowledge-based tasks (specified in activity view, described in process view)

Fig. 1: The different compartments of knowledge transfers.

1. **Internalization:** An explicit knowledge carrier (origin) is perceived by a knowledge carrier (target), so that the target integrates perceived knowledge with its individual knowledge base [14]. An example refers to a person studying a book about process modeling. As knowledge about process modeling is enriched e.g. by mental models and personal experiences, new knowledge is constructed at the target carrier.
2. **Extraction:** Embodied knowledge (origin) is perceived by a knowledge carrier (target), so that the target recognizes knowledge by interpretation and integrates it with its individual knowledge base [15]. For instance, the modeling notation is recognized by studying process model examples. If a person recognizes the notation rule set, person-bound tacit knowledge is created.
3. **Socialization:** Knowledge carrier-bound tacit knowledge is transferred among knowledge carriers through interactive data and information exchange [14]. For example, two persons are speaking about how to create process models. Here, each person functions as both origin and target. Because of their interaction, knowledge is integrated with their individual knowledge bases.
4. **Externalization:** Knowledge carrier-bound tacit knowledge (origin) is explicated so that the knowledge carrier-unbound explicit form of knowledge is created (target) that can be transmitted easily [14]. When a person writes a book, its tacit knowledge is made explicit so that the book can be easily passed among people.
5. **Engineering:** Knowledge carrier-bound tacit knowledge is applied in a task to embody knowledge at a physical object [15]. For instance a person constructs process models. Here, tacit knowledge about the act of process modeling and about the modeling language notation are applied to the process model.

6. **Codification:** Embodied knowledge (origin) is perceived by a knowledge carrier and transferred to an explicit form of knowledge (target) [16]. If a person recognizes the notation rule set on the basis of process models (extraction) and the rule set is written down to a book (externalization), the description holds the codified knowledge about the notation rule set.
7. **Combination:** Explicit knowledge (origin) is perceived by a knowledge carrier and conversed to new explicit knowledge (target) [14]. For instance, an evaluation of a process model shall be realized on the basis of a notation rule set. Here, explicit knowledge forms of the process model and notation rule set are combined into the explicit form of a failure report.
8. **Decodification:** Explicit knowledge (origin) is perceived by a knowledge carrier and transferred by engineering activities into an object embodying knowledge (target) [16]. If a person studies the rule set of a modeling notation (internalization) and comes up with a process model example (engineering), the model constructed holds the decodified knowledge about the notation rule set.
9. **Transformation:** Embodied knowledge (origin) is modified by a knowledge carrier so that a new object manifests embodying knowledge (target) [17]. For instance, a process model is transformed from one modeling notation to another. If both modeling languages satisfy the same notation rule set, both of its process model examples would lead to the same rule set description (codification result).

This research will focus on the examination of knowledge-based activities, which have been highlighted in green at Fig. 1. Since the kind of knowledge-based tasks (highlighted in yellow) are considered as a kind of composition of knowledge-based activities and therefore show numerous kinds of conversions simultaneously, these are not suited for the individual examination of knowledge conversions in a laboratory study or rather experiments. A field study that focuses on more complex tasks than an experiment can encompass is more suitable for their investigation.

Modeling Knowledge Transfers. In order to specify the experimentation of knowledge transfers, particularly the process-oriented knowledge management has been proven to function efficiently, because of the objectification of knowledge, which means its provision as impartial form as modeling object. By this, the dynamic of knowledge can be specified over the course of time and visually represented by process models. So, knowledge changes can be identified during the knowledge transfer and by whom they occur. This regards the behavioral perspective of knowledge [18]. Further, conditions of knowledge transfers can be addressed that need to be reflected by the experiment tool [10].

Hence, beside the dealing with different forms of knowledge and their conversion through activities, at this research, the sequential description of a knowledge-intensive process (process perspective) will be separated from the process of knowledge creation, transfer and application (knowledge perspective). So, the knowledge transfer can be specified individually. As it will be embedded in the experiment process, the dynamic of the transfer can be captured and visually represented. It becomes controllable and an object to modifications [19]. Following comparable experiments on knowledge transfers [9], knowledge transfers will be specified with the KMDL [20].

3 Objectives of a Solution

Following the DSRM [13], requirements are defined before the design of artifacts is carried out. These have served as the design maxims for the experiment design. Further, they have functioned as quality gates for artifacts presented here and they can stand as quality gates for subsequent research, which supports comparability.

In accordance with the process of deriving requirements [21], requirements have been elicited from the theoretical foundation provided at section 2 and represented in a written form. These were then discussed and supplemented with experts from the fields of business process management, product development and knowledge engineering, and illustrated in a workshop session with examples from business context. Based on expert consensus on key requirements, the following collection of requirements was validated.

1. The experiments need to address relevant forms of knowledge transfers. Here, one can find conversions presented at Fig. 1. Since the socialization is based on the interaction of at least two test persons, the experiment needs to differentiate single and team experiments.
2. The different kinds of conversions need to be observed individually, so that effects of interrelating activities can be controlled.
3. The experiment needs to observe novel knowledge, so that no pre-experience about the knowledge to be transferred is available.
4. The experiment has to differentiate between the creation of explicit knowledge, such as a written description of a process modeling language, and further forms of knowledge. Here, one can find tacit knowledge, such as person-bound knowledge about a process modeling notation, and embodied knowledge, such as example models corresponding to a process modeling notation.
5. Since the creation of tacit knowledge cannot be observed directly because of its non-transparency, the experiment has to provide a test to infer what is not visible because of the tacit nature of knowledge.
6. Even if different kinds of tasks are presented in the experiment in order to observe the required kinds of knowledge transfers, artifact quality needs to be measured by the same type of measurement instrument.
7. The experiment must perfectly control the kind of subjects that is faced with a certain kind of knowledge at a specific moment.

4 Design

Following the DSRM [13], the design phase produces a blueprint for solving the research problem in the form of artifacts, the use of which is demonstrated in section five. As was identified in section two, this artifact refers to the experiment design. It is presented in form of process models of the KMDL because it can capture the complex behavior of experiments examining knowledge transfers. Individual knowledge transfers are specified with the aid of the *activity views* first (knowledge perspective). Then, the experiment behavior is concretized by *process views* presenting the sequential order of knowledge-intensive tasks (process perspective). Finally, these models are interlinked by one experiment process that supports the experiment controlling.

4.1 Activity Views on the Experiment

The knowledge perspective on the experiment can be found at Fig. 3 and Fig. 4 of Appendix 1. Here, one can see that five different kinds of activity views have been specified to examine conversions in accordance with Fig. 1 individually. Since relevant conversions to be examined have been highlighted by individual colors (directed arcs having arrowheads) and conversions used for controlling the experiment (directed arcs having arrowheads, no color and dashed lines) have been separated, the knowledge transfer situations on which the focus is placed can be identified. Variations in the experiment realization have been indicated by directed arcs having arrowheads and doubled lines - these will be issued at the demonstration section 5. Modeling objects used throughout the models are explained in the following:

1. **Instruction:** It is clarified that relevant knowledge about a novel process modeling notation is provided by the given material, which either refers to an explanatory video (internalization, externalization, engineering, socialization focus) or example process model (extraction focus).
2. **Explanatory Video:** For the *Task 1/2* required knowledge about a novel process modeling notation is presented by audio and image material.
3. **Explanatory Model:** For the *Task 1/2* required knowledge about a novel process modeling notation is presented by an example process model embodying knowledge.
4. **Task 1:** The first kind of tasks refers to the construction of a process model on the basis of a case study given using the process modeling notation presented before. It so provides an engineering focus. It is considered as control task (in the case of internalization, socialization and extraction) in order to infer the quality of the tacit knowledge because this knowledge form cannot be examined directly.
5. **Task 2:** The second kind of tasks refers to the description of the process modeling notation presented before by writing. It so provides an externalization focus.
6. **Task Solution 1:** The first kind of task solutions refers to the process model constructed by the test persons called *Test Person R*.
7. **Task Solution 2:** The second kind of task solutions refers to the description of the process modeling notation written down by the test persons called *Test Person R*.
8. **Sample Solution 1:** The first kind of sample solution refers to a sample process model. It perfectly satisfies the quality criteria demanded.
9. **Sample Solution 2:** The second kind of sample solution refers to a sample description. It perfectly satisfies the quality criteria demanded.
10. **Survey Grid 1:** A collection of questions about the knowledge transfers experienced allows the assessment of the tacit knowledge because it cannot be examined directly.
11. **Survey Grid 2:** A collection of questions about the solutions constructed allows the assessment of the embodied knowledge called *Task Solution 1* and explicit knowledge called *Task Solution 2* because it addresses the same quality criteria.
12. **Knowledge Understanding:** On the basis of the *Survey Grid 1* conducted by the test persons, the quality of the tacit knowledge shall be inferred because this knowledge form cannot be examined directly.
13. **Experience:** Individual knowledge carrier-bound impressions about the knowledge transfer emerge on the basis of the conversion being part of the knowledge transfer examined.

14. **Modeling Notation:** Individual knowledge carrier-bound tacit knowledge about the process modeling notation emerges when test persons study the *Explanatory Video* or *Explanatory Model* presented.
15. **Quality Evaluation of Artifact 1:** On the basis of the *Survey Grid 2* conducted by scientists, the quality of the process model can be assessed on the basis of the by comparison of *Task Solution 1* and *Sample Solution 1*.
16. **Quality Evaluation of Artifact 2:** On the basis of the *Survey Grid 2* conducted by scientists, the quality of the notation description can be assessed on the basis of the by comparison of *Task Solution 2* and *Sample Solution 2*.

4.2 Process Views on the Experiment

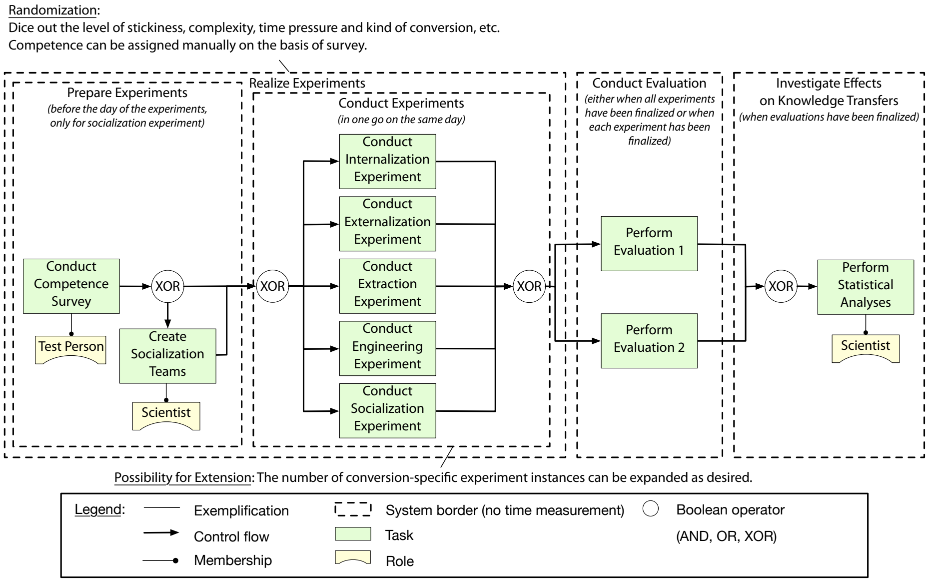
The process perspective on the experiment can be found at Fig. 5 and Fig. 6 of Appendix 2. Here, one can see that five different kinds of process views have been specified to describe the conversion-specific sequence of experiment tasks by control flows (directed arcs having arrowheads) and resource allocation by memberships (directed arcs with circular heads). While ingoing objects have been presented at the left of each task's vertical center and outgoing objects have been presented at the corresponding right, modeling objects used throughout the models are explained in the following:

1. **Tasks:** Each green rectangle represents one period of time in the experiment. As long as a test person is part of that period, it is faced by a task-specific experiment screen presenting instructions,, experiment tasks, explanatory material or demanding for realizing a process model by a modeling software, etc.
2. **Time Measured Tasks:** Green rectangles having a bold border indicate tasks at which the time measurement is essential for quantifying the knowledge transfer examined. Time is measured automatically by an IT system called *Experiment Tool*. The corresponding activities can be identified by the activity view's system borders having the same labels.
3. **System Borders:** Rectangles having dashed borders indicate the separation of physical or virtual spaces. For instance, the team experiment consists of two virtual spaces that bring *Test Person R* and *Test Person S* together at the task called *Perform Task of Socialization*.
4. **Experiment Tool:** Since the single experiment (internalization, externalization, extraction and engineering focus) can be realized by one person, only one instance of the experiment tool can be used to guide the test person through the experiment and survey relevant items. At the socialization experiment, two experiment tool instances need to be synchronized so that both test persons can meet in one virtual space to communicate about the process modeling notation presented.
5. **Knowledge Recipient:** The *Test Person R* takes the role of the *Knowledge Recipient*. It gets knowledge about the process modeling notation presented either by video (internalization, externalization, engineering), by interaction with *Test Person S* (socialization) or by an exemplary process model (extraction). Then, the *Knowledge Recipient* will use the knowledge presented to solve a certain task.
6. **Knowledge Source:** The *Test Person S* takes the role of the *Knowledge Source*. It is only present at the team experiment (socialization) to present knowledge about a process modeling notation to *Test Person R*.

7. **Scientist:** Experiment organizers are responsible for the team assignment (socialization) as well as the evaluation of task solutions of test persons. As Fig. 2 shows, the team assignment can be realized before the experiment day and the evaluation can be realized after test persons have completed the experiment.

Bringing the different kinds of conversion-specific process views of Fig. 5 and Fig. 6 together, Fig. 2 interlinks these detailed models and presents one experiment process. The direct association can be identified by the same label of tasks at Fig. 2 and system borders at Fig. 5 and Fig. 6. So, the controlling of the joint experiment realization can be issued effectively as follows:

- **Randomization:** Before the experiment starts, the experiment-specific configuration is diced out. So, the level of *stickiness*, *complexity*, *time pressure* and *kind of conversion* are characterized.
- **Preparation:** Before the concrete experiment is conducted, the competence is surveyed. In the case of team experiments, this will be realized before the day of experiments, so that socialization teams can be built that consider the test person's competences. In the case of single experiments, the competence can be surveyed right before the experiment conductance.
- **Genotypical Treatments:** The task *Characterize Transfer* will be realized right when the corresponding knowledge transfer has been finalized by design decision (compare with Fig. 5 and Fig. 6). This is because stickiness has been defined genotypically as something that exists inside of a person that causes a distinctive pattern of behavior over time and across situations [12]. Hence, the transfer characterization will be carried out by the test persons themselves as the best source of information, so that the situation is avoided in which the incorporation of experience 'pollutes' the understanding of tacit knowledge that has been transferred.
- **Follow-Up:** The evaluation will be conducted either right when the corresponding experiment has been conducted or all experiments have been realized. This is because knowledge quality has been defined phenotypically as the tendency to exhibit a particular distinctive pattern of behavior over time and across situations that cause the creation of a certain artifact quality. Hence, the quality assessment will be carried out by experts who know the artifact domain well and are good sources of information about the extent to which the test person exhibits the distinctive pattern of behavior [12].
- **Extension:** The number of conversion-specific experiment instances can be expanded as desired. So, for example, dynamic effects can be focused in a sequence of experiment conductances. Further, later experiment instances can increase in complexity, so that test persons are challenged more and more similar to an education. In addition, the forgetting of test persons can be examined by a greater number of experiment instances.
- **Investigation:** The statistical analysis can be carried out right when all evaluations have been finalized. As conversion-specific process views are interlinked by one experiment process, knowledge transfers can be investigated at a common level.


Randomization:
Dice out the level of stickiness, complexity, time pressure and kind of conversion, etc.
Competence can be assigned manually on the basis of survey.

Possibility for Extension: The number of conversion-specific experiment instances can be expanded as desired.

Fig. 2: The process of the experiment.

5 Demonstration

As demanded by the design-oriented research [13], the demonstration applies designed artifacts and demonstrates their use for the examination of four example influence factors. The four factors have been chosen by following experiments of Gronau and Grum [9]. The following assumes that experiments present a new modeling notation, so that test persons need to build relevant knowledge from the ground up for the experiment.

Stickiness. The attribute of knowledge tending to remain at the outgoing perception border of a knowledge carrier or to remain at the incoming perception border of a knowledge receiver and thus retard the transfer of knowledge is defined as stickiness of knowledge [9]. Faced by activity views of Appendix 1, the stickiness can be varied by modifying the *Explanatory Video* or the *Explanatory Model*. For example, the stickiness can be increased if modeling shape labels are not presented. Since it is more difficult to understand the presented knowledge when faced with blank modeling shape labels, more difficulties and problems in knowledge transfers are to be expected [6, 7] and we hypothesize that the quality of knowledge transfer outcomes will worsen. Inhowfar this indeed has lead to a knowledge transfer variation can be verified by the task called *Characterize Transfer*. It conveys information about the individual knowledge carrier-bound experience of the knowledge transfers and so can be used to verify the level of stickiness.

Complexity. The reversed relation of the number of mental elements required to represent a clearly distinguishable amount of knowledge by the knowledge carrier and knowledge receiver relative to interdependencies among those elements is defined as complexity of knowledge [9]. Faced by activity views of Appendix 1, the complexity can be varied by modifying the *Explanatory Video* or the *Explanatory Model*. For example, the complexity can be increased, if the number of modeling objects and syntactic association rules among these objects is increased. Since it is more difficult to understand the presented knowledge when faced with more complex modeling notations, more difficulties and problems in knowledge transfers are to be expected and we hypothesize that the quality of knowledge transfer outcomes will worsen. Inhowfar this indeed has lead to a knowledge transfer variation can be verified by the control task called *Perform Evaluation 1/2*. It assesses the *Task Solutions 1/2* as outcomes of individual knowledge transfers.

Competence. The competences are defined as cognitive abilities and skills of individuals which are available or learnt in order to solve certain problems, along with their connected motivational, volitional and social willingness and abilities to create and implement problem solutions in variable situations responsibly [9]. Faced by activity views of Appendix 1, the competences can be varied by modifying the *Test Person R* and *Test Person S*. These are assigned into teams before the experiment is conducted (Fig. 2). For example, the competence can be increased, if another test person is selected that has a higher competence. Since it is more easy to understand the presented knowledge when faced with a modeling notation, less difficulties and problems in knowledge transfers are to be expected and we hypothesize that the quality of knowledge transfer outcomes will improve. Inhowfar this indeed has lead to a knowledge transfer variation can be verified by the control task called *Perform Evaluation 1/2*. It assesses the *Task Solutions 1/2* as outcomes of individual knowledge transfers.

Time Pressure. The presence of time in order to solve certain problems by the creation and implementation problem solutions in variable situations is defined as time pressure [22]. Faced by activity views of Appendix 1, the time pressure can be varied by modifying the time provided in order to realize the conversions in the experiment. For example, the time pressure can be increased, if the time provided is reduced. Since it is more difficult to understand the presented knowledge when being faced with the task to understand a modeling notation (internalization, extraction, socialization), to describe the modeling notation (externalization) or to construct a process model by a modeling notation (engineering), more difficulties and problems in knowledge transfers are to be expected and we hypothesize that the quality of knowledge transfer outcomes will worsen. Inhowfar this indeed has lead to a knowledge transfer variation can be verified by the control task called *Perform Evaluation 1/2*. It assesses the *Task Solutions 1/2* as outcomes of individual knowledge transfers.

6 Evaluation

In order to satisfy design-science-oriented research approaches [13], the following evaluates inhowfar requirements of section 3 have been fulfilled. Since this is based on the requirements presented, the following considers the same requirement numbering.

1. The first requirement has been fulfilled, as all forms of knowledge have been reflected by the experiment. While the extraction, internalization, externalization

and engineering can be realized by a one person efficiently, the socialization needs to be realized in a more expensive two person experiment.

2. The second requirement has been fulfilled, as relevant conversions (highlighted in green in Fig. 1) have been reflected by the experiment. Since each conversion-specific activity has been considered by separate control flows in the experiment process (Fig. 2), the effects of interrelating activities can be controlled throughout the experiment.
3. The third requirement has been fulfilled, as a novel process modeling notation is designed and presented by the experiment as *Explanatory Video* or *Explanatory Model*. Since the test persons do not know the modeling language before the experiment, knowledge to be transferred can be controlled efficiently.
4. The fourth requirement has been fulfilled, as two different kinds of tasks are considered by the experiment. Explicit knowledge is constructed when performing *Task 2*. The knowledge constructed here is called *Task Solution 2*. When performing *Task 1*, embodied knowledge is constructed, which is called *Task Solution 1*. With the aid of this knowledge transfer outcome, the presence of tacit knowledge is inferred because it cannot be observed directly.
5. The fifth requirement has been fulfilled, as *Task 1* functions as control task to infer about the characterization of knowledge about the modeling notation presented. Although a description of the modeling notation presented would be suitable to do this inferring, too, this resembles *Task Solution 2*, the embodied knowledge form has been chosen because the analysis of process models can be realized more efficiently than a text analysis.
6. The sixth requirement has been fulfilled, as the quality of different kinds of artifacts (process models as *Task Solution 1* and descriptions as *Task Solution 2*) is measured by the same type of instrument. Here, a task-specific quality grid called *Survey Grid 2* shall be used that addresses the same quality criteria, which are in regard with *Sample Solution 1* in the first case and in regard with *Sample Solution 2* in the second case.
7. The seventh requirement has been fulfilled, as process views have been used for specifying the experiment behavior. Here, it becomes clear at which time and under what conditions a test person is asked to realize a certain activity. The specific form of a conversion and the characterization of the knowledge transfer is specified by the associated activity view. Here, it becomes clear which test person is faced with a certain kind of knowledge.

7 Conclusion

In accordance with the DSRM [13], design-science oriented research demands for being communicated. Thus, the following concludes the paper by outlining insights achieved and justifying its contribution to the state-of-the-art.

Summary. This paper has presented a design for an experiment that examines the quantitative effects of influence factors on knowledge transfers. While the different kinds of conversions have been specified by conversion-specific activity views (Appendix 1), the knowledge transfers have been specified by process views (Appendix 2). The conversion-specific activities were separated by non-overlapping knowledge-intensive tasks. Since these were integrated in one experiment process (Fig. 2), the experiment behavior has been specified and the experiment controlling has been enabled. This is required to examine relevant knowledge transfers. The meaning of all the modeling objects being part of these process models have been explained in detail. The experiment design usefulness has been demonstrated by the simulated modification of four example factors, which is required for the examination of statistic effects by experiments [12]. Further, it has been confirmed that requirements specified in advance have been satisfied, which is required by the design-oriented experiment creation [13].

Critical appraisal. The research question (*"How can quantitative effects of influence factors on knowledge transfers be examined by an experiment?"*) can be answered with regard to the experiment design presented. This refers to the design of activity views specifying relevant knowledge transfers, the design of process views characterizing the experiment behavior, as well as the specification of the meaning of all the modeling objects being part of those views. It has been shown that relevant knowledge transfers can be observed by the experiment design presented because of the following two reasons. First, the demonstration has shown that the experiment was able to capture the modification of influence factors selected. Second, the experiment design enables the observation of the effect of those modifications at conversion-specific outcomes. The experiment design was validated, because the evaluation clarified how the requirements for observing relevant quantitative effects are met.

Limitations. The results and insights presented here are limited in regard with the following points. First, the demonstration refers to four example factors, which have not been realized in the experiment setting presented, yet. The number of influence factors being examined by this design is limited by four factors. Next experiment configurations can extend the number of factors to be examined, because this will lead to further insights. Second, the experiment designed has been demonstrated in proof-of-concept context only. It still needs to be verified in a practical investigation. Third, the concrete implementation of the task layouts of *Task 1* and *Task 2*, the concrete modeling notation presented at the *Explanatory Video* and *Explanatory Model* as well as the grids for conducting information about knowledge and quality (*Survey Grid 1* and *Survey Grid 2*) have not been presented, here. Their concrete implementation needs to be worked out in order to operationalize knowledge transfers further and realize the concrete experiment design.

Outlook. The article presented has aimed to present a design for experiments examining the quantitative effects of influence factors on knowledge transfers. The design shall be suitable to guide numerous different kinds of experiments. Next research attempts will focus on the concretization of modeling objects presented, so that one further concrete experiment can be carried out. Thereafter, data gathered will be analyzed and concrete kinds of business process improvements can be derived. Finally, these need to be integrated or rather harmonized with insights of experiments of Gronau and Grum [9].

Appendices

1 Activity Views of the Experiment

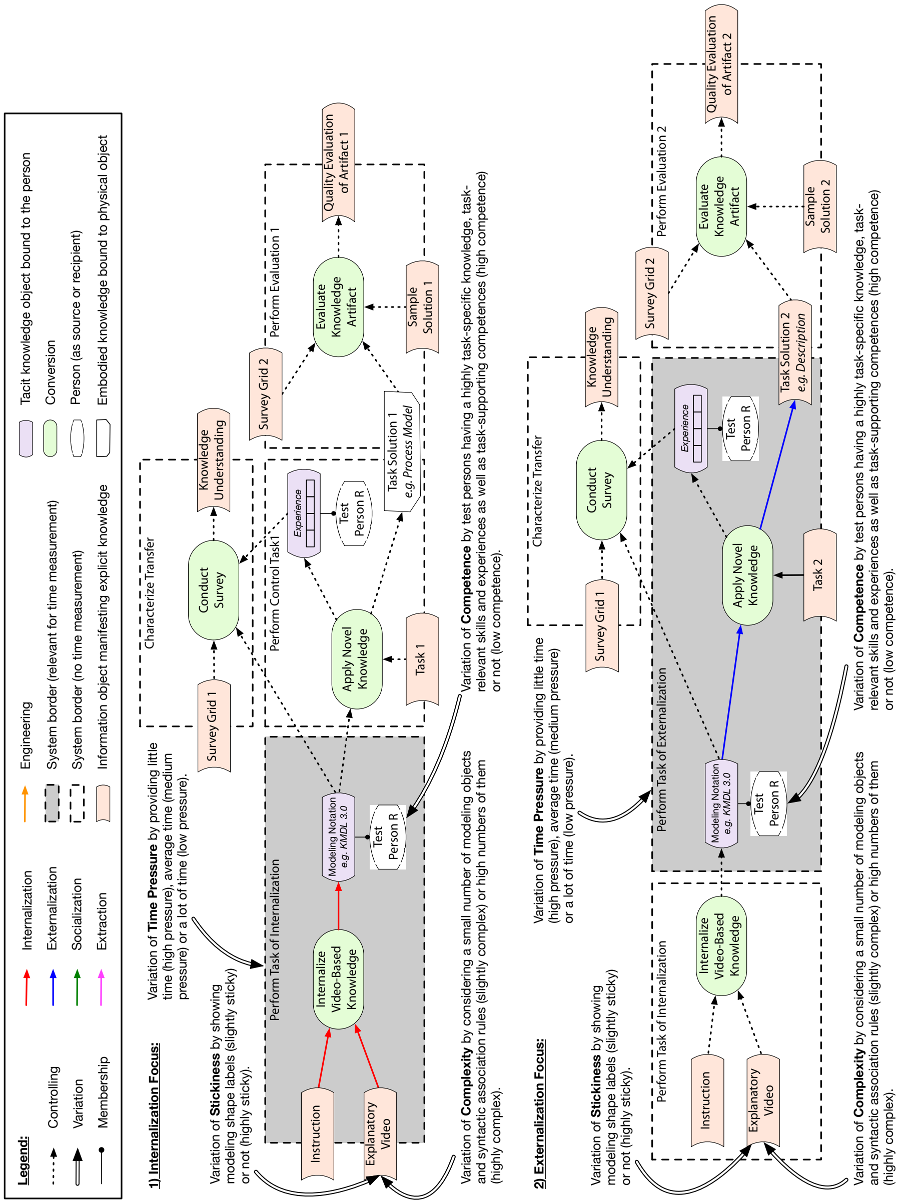
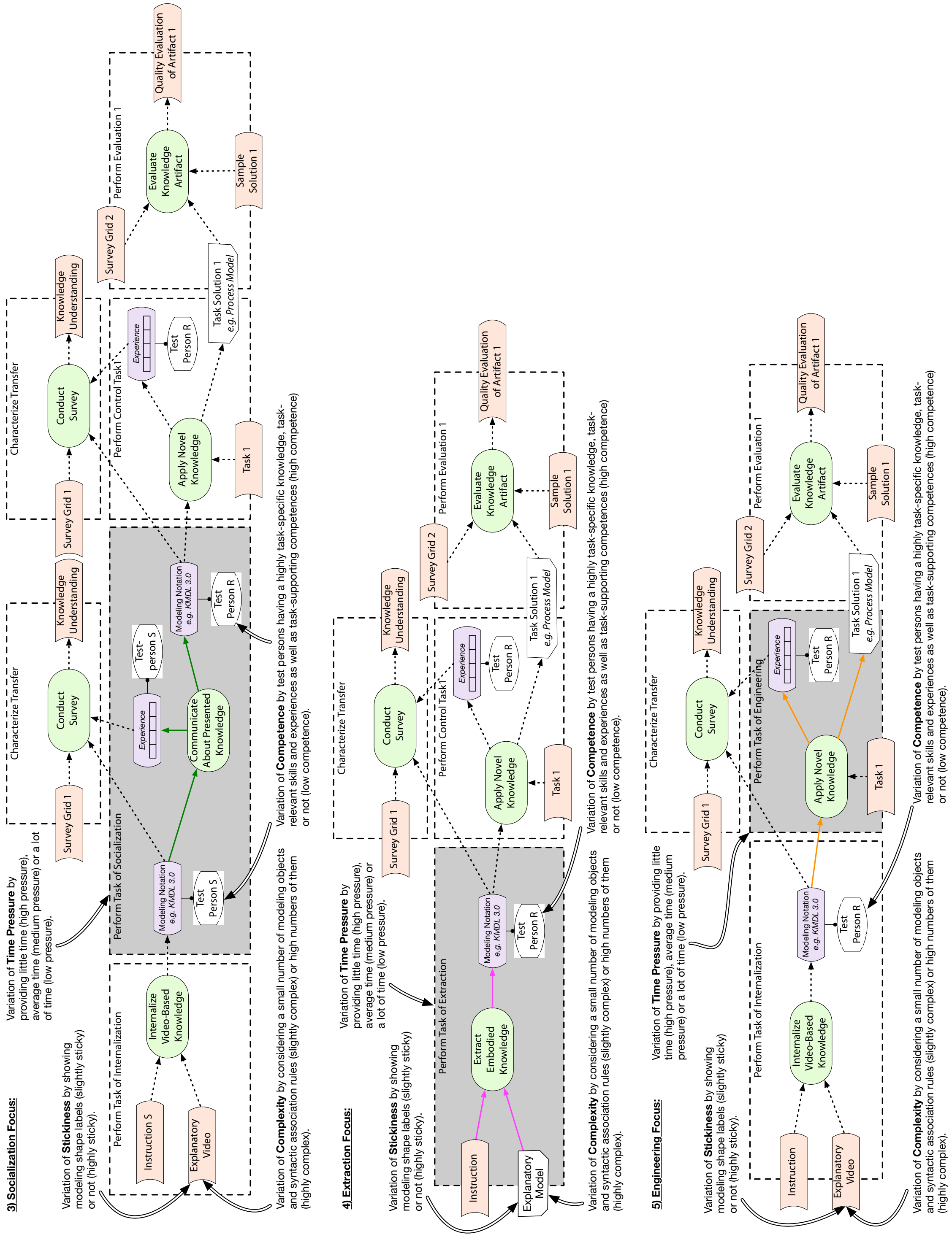


Fig. 3: The activity views of the experiment (part I).



3) Socialization Focus:

Variation of **Time Pressure** by providing little time (high pressure), average time (medium pressure) or a lot of time (low pressure).

Variation of **Stickiness** by showing modeling shape labels (slightly sticky) or not (highly sticky).

Variation of **Complexity** by considering a small number of modeling objects and syntactic association rules (slightly complex) or high numbers of them (highly complex).

Variation of **Competence** by test persons having a highly task-specific knowledge, task-relevant skills and experiences as well as task-supporting competences (high competence) or not (low competence).

4) Extraction Focus:

Variation of **Time Pressure** by providing little time (high pressure), average time (medium pressure) or a lot of time (low pressure).

Variation of **Stickiness** by showing modeling shape labels (slightly sticky) or not (highly sticky).

Variation of **Complexity** by considering a small number of modeling objects and syntactic association rules (slightly complex) or high numbers of them (highly complex).

Variation of **Competence** by test persons having a highly task-specific knowledge, task-relevant skills and experiences as well as task-supporting competences (high competence) or not (low competence).

5) Engineering Focus:

Variation of **Time Pressure** by providing little time (high pressure), average time (medium pressure) or a lot of time (low pressure).

Variation of **Stickiness** by showing modeling shape labels (slightly sticky) or not (highly sticky).

Variation of **Complexity** by considering a small number of modeling objects and syntactic association rules (slightly complex) or high numbers of them (highly complex).

Variation of **Competence** by test persons having a highly task-specific knowledge, task-relevant skills and experiences as well as task-supporting competences (high competence) or not (low competence).

Fig. 4: The activity views of the experiment (part II).

2 Process Views of the Experiment

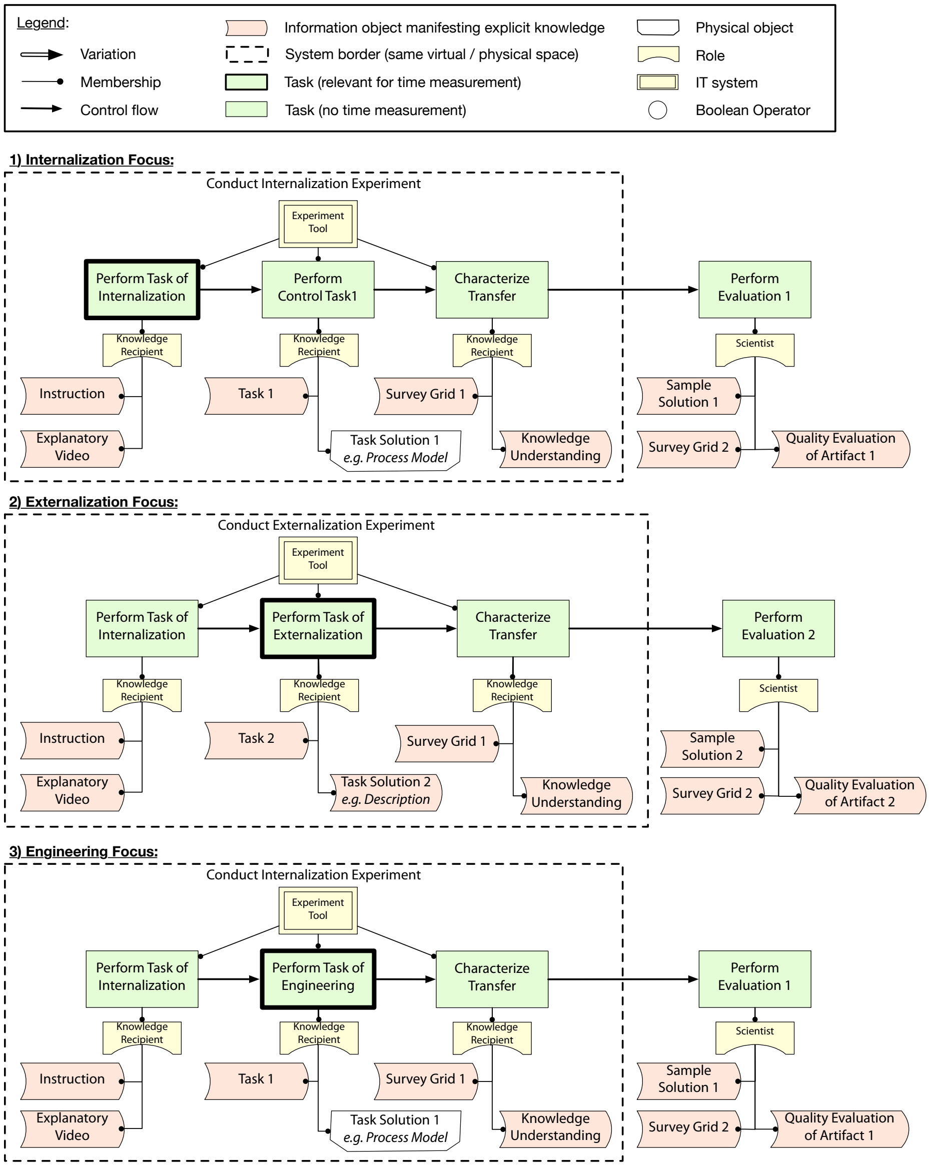


Fig. 5: The process views of the experiment (part I).

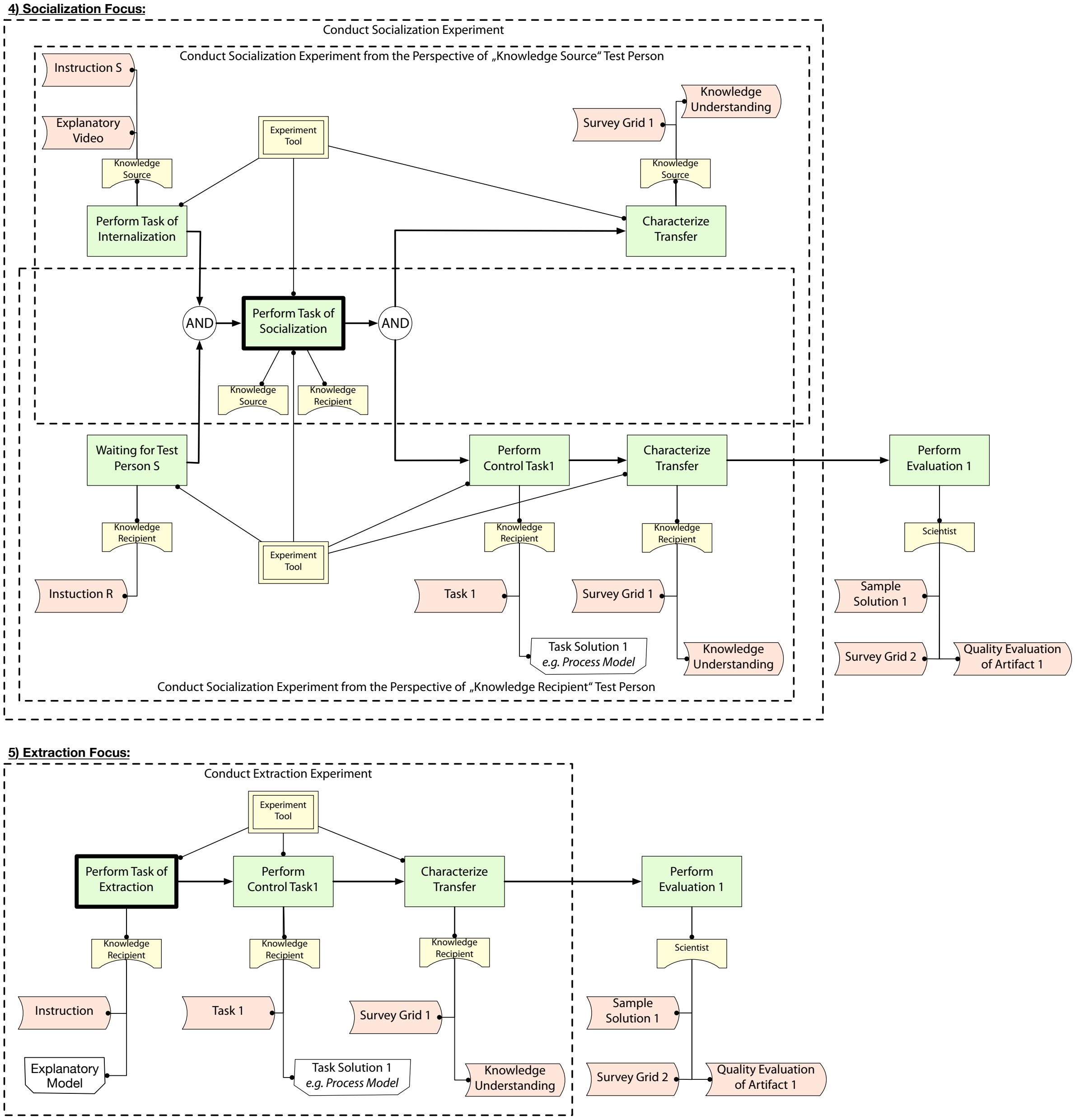


Fig. 6: The process views of the experiment (part II).

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