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FAKULTÄT
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Transfer Monitoring from University to Industry

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Erklärung zur Verfassung der Arbeit

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Abstract

The measurement of the knowledge change of employees as well as the subsequent transfer within their companies is discussed in this thesis. Although these two terms are often used synonymously, there is a clear difference between them. Learning is adapting to a situation whereas transfer is applying this knowledge to similar situations.

There are various approaches to measuring learning success or transfer, most of which originate in educational science. In this thesis we consider the special case of innovation courses, where there are various additional requirements that must be met for the measurement. Unfortunately, the existing frameworks are not designed for these requirements and are therefore not sufficient.

An innovation course is a long-term course in which employees of various companies are taught and trained in a certain topic. Such an innovation course consists of several modules for which both the measurement of learning success and knowledge transfer for the individual participants must take place in the various modules. To achieve this and to make the measurements repeatable and objective, we have developed a framework for transfer monitoring from university to industry.

We use the Design Science Approach to develop the framework. However, the goal is not to create a static artefact that can only be applied to the course of our case study, but to design a framework that is also easily adaptable and applicable in other innovation courses or in a similar environment. To test and improve this framework, we use it in four modules of the DigiTrans 4.0 innovation course.

For three of the four modules of our case study, the difference between the knowledge before the module and at the end is statistically significant. We also create linear models to explain or predict the transfer. The necessary variables for linear regressions are derived from literature research. The models are created both with and without heteroscedasticity adjustment. The results of the models are slightly different, but show a common trend, which originates from the same background formula. Since these characteristics are known in the literature of knowledge transfer, the framework created is well suited for measuring the transfer.

Kurzfassung

Die Messung der Wissensveränderung von Mitarbeitern sowie der anschließende Transfer innerhalb der Unternehmen wird in dieser Arbeit behandelt. Auch wenn diese beiden Begriffe oft synonym verwendet werden, so gibt es doch einen klaren Unterschied zwischen ihnen. Lernen ist das Anpassen an eine Situation wohingegen der Transfer das Anwenden des Wissens für ähnliche Situationen ist.

Um den Lernerfolg oder den Transfer zu messen gibt es verschiedene Ansätze, die meist aus der Bildungswissenschaft stammen. In dieser Arbeit betrachten wir den Sonderfall der Innvationslehrgänge, bei denen verschiedene zusätzliche Auflagen für die Messung erfüllt werden müssen. Die bestehenden Frameworks sind für diese Anforderungen leider nicht ausgelegt und deshalb nicht ausreichend.

Ein Innovationslehrgang ist ein längerfristiger Kurs in dem Mitarbeiter von verschiedenen Unternehmen in einem festgelegten Thema unterrichtet und weitergebildet werden. Ein solcher Innovationslehrgang besteht aus mehreren Modulen wobei für diese sowohl die Messung des Lernerfolgs als auch des Wissenstransfers für die einzelnen Teilnehmer in den verschiedenen Modulen erfolgen muss. Um dies zu bewerkstelligen sowie die Messungen wiederholbar und objektiv zu gestalten haben wir ein Framework für die Transfer-Messung von der Universität zur Industrie entwickelt.

Zur Entwicklung des Frameworks nutzen wir den Design Science Approach. Das Ziel ist aber nicht ein statisches Artefakt zu kreieren, dass nur für den Lehrgang der Fallstudie anwendbar ist, sondern ein Framework zu konzipieren, dass auch in anderen Innovationslehrgängen oder in einem ähnlichen Umfeld leicht anpassbar und anwendbar ist. Um dieses Framework zu testen und zu verbessern setzen wir es in vier Modulen des DigiTrans 4.0 Innovationslehrgang ein.

Bei drei von den vier Modulen unserer Fallstudie ist der Wissenszuwachs vom Anfang des Moduls bis zum Ende statistisch signifikant. Außerdem erstellen wir noch lineare Modelle um den Transfer erklären oder prognostizieren zu können. Die nötigen Variablen für die linearen Regressionen stammen aus der Literaturrecherche. Die Modelle werden sowohl ohne als auch mit der Heteroscedastizitätsanpassung erstellt. Die Ergebnisse der Modelle sind leicht unterschiedlich, zeigen aber einen gemeinsamen Trend, der von der gleichen Hintergrundformel ausgeht. Da diese Merkmale in der Literatur des Wissenstransfers bekannt sind, ist der geschaffene Rahmen für die Messung des Transfers gut geeignet.

Contents

CHAPTER 1

Introduction

1.1 Motivation

Knowledge is an important asset for enterprises [MacMillan, 2015]. But knowledge regularly gets outdated especially in the technological domain. IT knowledge, for example, has only a half-life of one and a half years [Blum and Dübner, 2012]. Trainings or coaching are ways to keep pace with the changes and to expand the knowledge of employees [Nischithaa and Narasimha Rao, 2014]. Learning new skills for employees could also be one of the reasons why they are trained or sent to an education course.

However this education is expensive and employees may not be able to work while they are getting their training. It is therefore important for a company to know how employees' knowledge has increased and what new skills have been acquired through the training to determine whether it has been worth the expense.

1.2 Problem Statement

In order to quantify the benefits of training the company has to measure this transfer, but only a few companies do that [Phillip and Phillips, 2016, p. 14]. The measurements do not have to be carried out on the enterprise side but can be conducted by the trainer. This is a good concept if there are several employees from different companies, all of whom receive new knowledge from the same trainer. A particular advantage in this case is that the measurement is carried out from a single source and companies do not have to do any surplus work. In addition employees and trainers benefit from an evaluation on the trainer side. The teacher can adapt the instruction method if he or she knows that participants already understand the concept or if they need more background knowledge to keep pace with the lessons. On participants side, their self-esteem could increase, if they see how much they have learned and thus improve the learning process of the upcoming lessons.

This means that companies must trust that teachers are doing this right and that teachers must make more efforts to set up the monitoring system. This may not be necessary for individual trainers if the number of employees is limited. But if the teacher is employed at a university, such a monitoring system could be very beneficial. Since the audience is usually larger than in normal training environments a transfer monitoring tool would be ideal. A university teacher has to manage many things in parallel, such as teaching, testing or monitoring the knowledge increase of the students. That is why his or her university usually provides an e-learning system [Edutechnica, 2017] to manage all this. Such a system is a good starting point for transfer monitoring.

However there is a difference between learning and transfer. Simplified learning is understanding a new concept or acquiring new skills [Skinner, 1950]. Transfer, on the other hand, is the application of newly learned strategies to a similar situation or in the real world [Bartscher, 2016]. Most universities test their students by subjects, but usually they do not monitor the transfer. Another problem is that most courses at university do not have an exam until after the entire lecture. Since there was no test before the courses started, it is impossible to know the participants starting knowledge. Therefore it is out of question to compute the knowledge increase of them.

Furthermore, the setting must also be considered. A company may have different demands on transfer measurement than a trainer or an innovation courses. Take the innovation course as an example [Pflügl and Pichler-Rohrhofer, 2015]. In order to be able to offer such a course, several conditions have to be met. All participants in such a course must be employees of enterprises. The course is about imparting knowledge to employees so that participants can apply and disseminate it in their companies. However, the transfer must be measured by the trainers, as this is stipulated in the contract of an innovation course. In this context, though, there are no previous frameworks for measuring the transfer over the length of the course.

1.3 Aim of the Work

The goal of this thesis is to create an artefact. This artefact is a framework that measures the transfer of participants in a training or course. However, this framework must also meet other requirements: It should be reusable in similar contexts and it should be simple to modify it in the future if, for example, requirements change. The following research questions are answered in this paper:

1. What is an appropriate framework which measures the transfer of employees?
2. What are applicable metrics to verify the results of the transfer?

1.4 Methodological approach

We use the Design Science Approach for the framework. This is done based on the Hevners methode [Hevner et al., 2004]. The aim of Design Science research is to scientifically develop an artefact that meets the requirements and has additional value for the community. The artefact

we created is designed to measure the transfer of participants. This was done using the seven guidelines of the method by Hevner. Through the framework we have created questionnaires to survey the participants of the training. The resulting artefacts are used in a case study. The case study is a project of the TU Vienna titled 'DigiTrans 4.0'. This is done with the method of Runesons and Höst [Runeson and Höst, 2009]. We use the following steps for this work:

- Researching literature

In order to gain a better insight into the design of the framework, knowledge transfer and monitoring techniques, a literature research must be conducted. In addition, we need to gain a better understanding of meta-cognition to better understand how to measure the improvement of knowledge or skills efficiently and effectively and how transfer affects it.

- Designing the questionnaire

As next step the questionnaires are created to measure the knowledge changes of the participants and also their transfer. This is done with the knowledge we have acquired as we need to find out how to create questionnaires and what pitfalls we need to avoid. The questionnaires should be adaptable to our needs, as we expect that we need to change them through the case study.

- Conducting the questionnaire

During the case study employees fill out the questionnaires. A questionnaire is completed at the beginning of the module by the participants and one at the end of the module. With the help of these two the change in knowledge can be measured. The third questionnaire is carried out six months after the end of the module and is used to measure the transfer. By this approach the improvement of the employees can be calculated and the transfer can be shown.

- Evaluating the questionnaire

The collected data of the questionnaires are evaluated quantitatively. We analyse the differences between the individual parts of the project and evaluate how much the employees have learned through the parts they have attended. Furthermore we examine the transfer of every employee of each individual part. We also check whether the questionnaire meets our needs or whether it needs to be adapted.

- Evaluating the framework

Based on the results of the questionnaires we evaluate the fit of the framework. This allows us to better adapt it to our needs in later parts of the project or reuse it later in similar environments.

After completing these steps, we are able to answer the research questions and present our scientific findings on this topic.

1.5 Structure of the work

The chapter 'Background and State of the Art' deals with the important basics that need to be understood in order to gain a deeper insight into the following chapters. Since this thesis has transfer measurement as a core element, most of the theory deals with educational sciences such as the difference between learning and transfer or the Kirkpatrick model. Nevertheless, there is also state of the art knowledge that does not come from this discipline, such as the Design Science Approach and the case study research. If the reader is already familiar with these topics he or she can move on to the next chapter.

Next the research questions are presented and described in detail. This should help the reader to better understand the aim of this work and to understand the steps we have taken. The first research question is how to develop a framework to measure the transfer using the Design Science Approach. Last but not least we look at which metrics can be used to better understand and perhaps even predict the transfer.

After that the created framework is specified in more detail. In this section we go into the basic structure of the framework and questionnaires. We explain why we made our decisions and also make a comparison Design Science Approach.

However the framework described above should not only be of theoretical nature but should also be used. Therefore, in chapter 'Case Study' the practical application of the framework is introduced to the reader. The case study is conducted in a project consisting of several modules. Various employees from different companies are participating in this project. In addition the questionnaire will be discussed once again, as the time of its execution contains important aspects. These and other time components of the case study can be found in this chapter.

We then present the results of the data analysis of the case study. First there is a comparison of the previous knowledge of the respective modules as well as the knowledge that the participants had at the end of the segment. In addition the discrepancy between these two values, i.e. the learning success, is also discussed. Then the measured transfer of the participants is evaluated with the help of other variables in a linear model. This model is used to answer research question two.

Finally the summary gives a conclusion about the findings and knowledge gain in this thesis. In addition possible future work is also presented.

In the appendix the three questionnaires are presented as well as the collected data. The data is anonymized so that no conclusions can be drawn about the individual participants.

CHAPTER 2

Background and State of the Art

This chapter presents some fundamental aspects of this work. These were split into three parts. First, learning and transfer theory is discussed. This includes the difference between learning and transfer. This distinction is very important for the work, as the two terms are often used synonymously, but they have a completely different meaning. This is followed by the Kirkpatrick model and a brief outlook on training in general. This is a short discourse on the subject of In-House and Out-House training and the difference between these two.

The next section deals with methodology. We discuss the Design Science Approach, followed by a brief overview of the Likert scale, which is often used in questionnaires to determine the attitudes of people to given topics. Then we examine the question of what to include in a case study and what suggestions from the literature we should consider. Afterwards we look at different existing approaches to measure learning progress or transfer.

In the last part we discuss the evaluation methods used in this paper. Our first excursion is the box plot and how to visualize data with it. Then we take a look at the linear regression, because it is necessary to create a linear model, which we present in the chapter evaluation. But first we want to discuss the theory of learning and transfer.

2.1 Theory of Learning and Transfer

For better understanding this thesis you need a basic knowledge about learning and transfer, especially if you have a technical background. You must understand the difference between learning and transferring and the Kirkpatrick model to get a good understanding of this work.

Difference between Learning and Transfer

In daily practice the terms 'learning' and 'transfer' may seam similar, but they are different. For this thesis it is important to distinguish between them, because the primary goal of this thesis is to measure the transfer of participants and not what they have learned.

”Learning is the adjustment, or adaptation to a situation” [Skinner, 1950]. This is a rather abstract view of the term, but it describes the concept of learning sufficiently. But in this definition is no explanation of how this adjustment was realized. The adaptation could come from the individual itself because it wants to adapt or change. It could also be that external factors such as studies, experiments or new knowledge have made this modification possible.

Apart from the abstract declaration the effects of learning are not defined. The subject that has learned something might have gained new knowledge, experience or skills. With these new capabilities it could gain greater insight, improve existing solutions or even find new and better ones.

Comparison transfer is ”the ability to apply a learned task to another comparable situation” [Bartscher, 2016]. This situation can occur in or immediately after the learning phase. In general, it takes a while for the transfer to occur, as the new information, knowledge, experience or skills need time to consolidate. An important aspect of the transfer measurement is the selected time frame. The chosen time span is always a compromise between the short-term effects and the medium- and long-term results of the training. If you were to measure the transfer shortly after the end of the training, you would only notice the short time effects of the lessons. However, the short-term effects are not always equivalent to the medium- or long-term result [Hyland and Hyland, 2006][p. 83]. It is possible that the subject changes his or her daily tasks shortly after training and forms a new, lasting habit. However it can also happen that this habit disappears after a few weeks and the person falls back into their old routines. In order to really measure the effectiveness of the training, it is therefore necessary to take some time to see how much the daily work of the trainees has changed as a result. You can then use this information to draw conclusions about the transfer. Failure to comply with the time frame can lead to data being falsified or even mistaken conclusions being drawn about the transfer.

In short: learning is the modification to a situation and transfer is the application of the learned behaviour in similar scenarios. An example of this is when a colleague shows you a new solution to an already known logical problem. If you can use this approach alone to solve the same problem, you have learned this method. If you are confronted with a different problem and find out that the solution you have learned beforehand can also be used for this problem, we speak of a transfer.

After clarifying learning and transfer terms we must have a look at the Kirckpatrick model. This topic is relevant in this work, since many concepts and ideas on the subject of transfer are based on this foundation.

Kirkpatrick Model

The book *Evaluation of Training* [Browning, 1970] is another relevant source of information for this thesis. In the chapter 'Evaluation of Training' the Kirkpatrick model is described. The concept consists of four steps, which we review:

1^{st} Step: Reaction

2^{nd} Step: Learning

3^{rd} Step: Behaviour

4^{th} Step: Results

The first step is the reaction level. This level monitors the participants' reactions to the course. However there is no measurement of what they have learned or how the knowledge of the trainees has increased as a result of the training in this step. The only goal at this stage is to measure how much the participants liked or enjoyed the training.

The second step is called learning. In this phase, we measure what the participants have learned by participating the training. Skills that have been improved or acquired by the trainees are also measured.

The third step is the behaviour one. What has changed in the daily tasks of the participants after the training is determined. Perhaps new skills might be developed, integrated into everyday life and used by the trainees on a regular basis. It is possible that employees gain a new perspective on their work flow through the knowledge they have acquired and thus change some parts of it. However, it is also possible that the training was only a short-term increase and the productivity of the employees has not changed. In short, the goal of the current phase is to detect behavioural changes in trainees.

The fourth and last step is called the result. The product and the final outcome of the training are analysed. This investigation should not be started before the third stage. If the fourth step is done before, the result of this level can be manipulated, as the behaviour step is most likely to affect the result. The reason for this is that the results are based on or build on the behavioural changes of step three.

Next we discuss the topic of training in general. This is important to better understand the context of this thesis. The main focus is on the different types of training.

Training in general

There are two different types of training: In-House and Out-House. If the training is held in the company or at the workplace of the employees, this is referred to as In-House training [Roll-Hansen, 2012]. It doesn't matter if the company has own teachers or if an external one is schooling the worker. Both options are called In-House training. "For in-house training to be effective, the best is to have the appropriate expertise within the organisation. [...] If no one has the expertise, it must be brought in from outside the organisation" [Roll-Hansen, 2012]. The advantage of this type is that it is cheaper, as only the educator, if at all, has to travel to the training location and be paid additionally. Moreover, if the training only takes place in one company, it can be tailored to the needs of the enterprise. One disadvantage is that the infrastructure must be available for In-House training. A second disadvantage is that employees may not be able to concentrate fully on learning because they are in their normal workplaces and their daily work

life could catch up with them.

Out-House training or external training is when the instruction takes place at an external location. One advantage is that the learning infrastructure does not have to be present in the company and is therefore independent of the current workspace utilization of the company. Furthermore, it is easier to diversify this type of teaching as different places for this type of education can be booked more easily. In most cases, however, the out-house approach is more expensive than in-house training, since the costs for the location and the journey of the employees to their destination as well as all salaries must be covered. In addition, it can be difficult if external training takes half a day and the employer expects the employees to be back at work immediately after their training.

2.2 Methodology

After the short overview of the theories of learning and transfer, we now address the basics of methodology. This begins with the Design Science Approach and Likert scales. Then we deal with case study research and how other case studies with a similar background have dealt with this topic. The first topic in this section is the box plot and what statements can be made with such a visualization utility. Then there is a small recap of linear regression and what heteroscedasticity is.

Design Science Approach

Design Science was established by the paper *A Comprehensive Anticipatory Design Science* [Buckminster Fuller, 1957] and is a systematic form of designing. Nowadays there are many different approaches to realise this in research. One of them is the paper *Design Science in Information Systems Research* [Hevner et al., 2004] that we have chosen. It specifies seven guidelines for Design Science research. These instructions must be considered when designing or developing an information system. Therefore, these should be discussed:

1. Design as an Artefact

   The outcome of a design science research is an artefact. This artefact has to be designed with a defined problem and an approach for a solution to this problem in mind. Without fulfilling these requirements the artefact is unsuitable for the Design Science Approach. If these conditions are met, the artefact helps to improve the understanding of the problem or to realize the solution process. A phrase that expresses this perspective well is ”Solving a problem means representing it so as to make the solution transparent” [Simon, 1996, p. 132].

2. Problem Relevance

   The second guideline of the Design Science Approach deals with the problem itself. The problem must be significant and unsolved in the domain. If this requirement is not met, then the development of the artefact would not be necessary, as the solution effort would

exceed the problem burden. If the problem is solved, there is already an existing solution to the problem, so the new artefact is not needed.

3. Design Evaluation

   The evaluation of the designed artefact is an essential part of the design method. Without knowledge of the usefulness, quality and effectiveness of the artefact, it can't be compared with other models that try to solve the problem. There are several methods of classifying such qualities such as observation, analysis, experiments, tests and descriptions. However the chosen evaluation practice must fit for the designed artefact.

4. Research Contributions

   When the artefact is designed and evaluated, the scientific conclusions should be drawn. They must add distinct contributions to the area of the research. This can happen on three levels:

   a) The Design Artefact

      The designed artefact itself could be the new input for the domain. It can expand general knowledge or open up a new field of research. This can be done with unique or original methods to use existing know-how or methods.

   b) Foundations

      The new knowledge could improve the fundamentals of the research area. For example could this happen when designing algorithms or modelling problem or solution representations [Storey et al., 1997].

   c) Methodologies

      The outcome of the research could also improve the use of methodologies in the domain. It can bring new or improve existing ones, e. g. through better metrics or measurement methods.

   If there is no improvement in at least one of these levels, then research has not contributed to the scope of the designed artefact, foundations or methodologies. If this is the case, the research does not comply with the guidelines of design research.

5. Research Rigour

   The artefact must be designed and evaluated using rigorous research methods. These methods must be used properly to meet the scientific standard. The rigour must be assessed with regard to the applicability and generalisability of the artefact created. However, Hevner notes that too much rigour can lessen the relevance [Lee, 1999]. Both, rigour and relevance, are important for the design science [Applegate, 1999].

6. Design as a Search Process

   The design itself is a "search process to discover an effective solution to a problem" [Hevner et al., 2004]. Often a solution to a problem is not obvious and the exploration to get an answer is a large and complex part of the research. The solution generally has to comply

with some laws or rules. The best solution to the problem is useless if it takes more than a year to solve the problem, with the requirement that a solution must be found in a few minutes. The same applies if the solution requires too much storage space to calculate a solution or requires information that is not available. When designing or developing an artefact we have to keep two states in mind. Our current one and our goal. During our research we use actions to reduce or eliminate the differences [Simon, 1996] between these two conditions.

7. Communication of Research

   The research results must be presented to two different audiences. The communication of the conclusion must therefore be adapted for each one of them.

   The first requires more details of the designed artefact, since they are part of the community that needs to understand it better in order to enhance or further develop it. The second one requires less detail, but a broader overview to decide whether this artefact is needed in the business domain. The idea and design of the artefact must be made clear to the public, but simplifications might be necessary.

These are the seven guidelines proposed in the paper *A Comprehensive Anticipatory Design Science* [Buckminster Fuller, 1957]. Each of them is meaningful and helps designing and building the framework. Since the result of the guidelines, the artefact, is also used in a case study, we must also deal with the literature on this topic. We have chosen the case study research approach.

Case Study Research

There are many papers that deal with the implementation and coverage of a case study. We use the methode of Runeson and Höst [Runeson and Höst, 2009] which recommends practices for planing, performing or reviewing a case study research. The whole paper is a good basis for this thesis case study element, still we highlight only the relevant parts of it.

One essential aspect are the different methodologies from research which could be applied. The following classifications are based on Robson [Robson, 2002] and subsumed in this paper.

- Exploratory
  Sometimes the problem of the research itself is not well studied or understood. If this is the case, the exploratory approach would be a good way to change this. The goal of this methodology is to establish a better look and feel for problems that are not well investigated. Through this access to new information, researchers can find new insights and develop new ideas or hypotheses in dealing with the problem. The simplification of this approach is that it is easier to find the right answers when the question is better understood.

- Descriptive
  Often the problem itself is thoroughly examined and understood, but the researchers have no control over the variables. Therefore, the data for research may be incomplete or

missing. The descriptive methodology tries to ”cast light on current issues or problems through the process of data collection” [Fox and Bayat, 2008]. Usually, this approach describes different aspects of the problem and identifies the characteristics or behaviour of the situation.

- Explanatory
  When the problem is investigated and sufficient data are available, researchers might use the explanatory methodology. This would be to find an explanation for the behaviour or characteristics of the system or problem. One approach is the creation and validation of a cause-effect relationship or the forecasting of new data using the currently available data.

- Improving
  The last method of Robson is improving. The aim of this technique is to improve existing aspects of studies or research and thus advance research. Some applications include, for example, improving the data retrieval process or using a better algorithm for a particular task. Another result could be that the variables required for forecasting are reduced while maintaining the same result and conclusion without significantly increasing the variance.

Before carrying out the case study, it is important to choose the right methodology, as not all are suitable for every purpose. For example, the improvement methodology is not appropriate if the research field is rather new and only little information is known or documented.

Once the methodology has been selected, the conducting phase must be entered into. In this stage there are five steps to be covered.

The first one is the design part. It defines the objectives and plans the case study itself. The second step is the preparation for the data collection. Procedures or protocols for the data collection must be established to make the case study reproducible and the data collection traceable. The third step is to collect the data with the artefacts created previously. The fourth step is the analysis of the information found. Reporting the results of the study is the final step.

All these steps are important for a case study, but the design phase has yet another necessary prerequisite. It should at least consist of the following aspects proposed by Robson [Robson, 2002].

- The object: The goal we want to accomplish
- The case: The focus point of the study or research
- The theory: The frame of the reference of the research
- The research questions: The questions which should be answered after the research
- The methods: The rules to answer the research questions
- The selection strategy: The policy of the data selection

Once the preparation for data entry has been completed, the data can be acquired. There are three distinct levels of how this can be done according to Lethbridge et al. [Lethbridge et al., 2005].

1. First degree
   ”The first degree or the direct method means that the researchers are in direct contact with the subjects and is collecting data in real time” [Runeson and Höst, 2009]. Methods of first degree data collection are, for example, interviews. Since both, the researchers and the subjects, must be present at the same time this method is often the most expensive data collection method.

2. Second degree
   The second degree or indirect method is when the researchers collect the raw data themself but are not interacting with the subjects during the data collection [Runeson and Höst, 2009]. An example of second degree data collection is filling in forms without the presence of researchers. As with the first degree method, researchers can still control which data they want to collect in which context. However, there is no direct contact between them and the test persons. Therefore, this method is often more time-economical for both sides than the first one.

3. Third degree
   In the case of third-degree data collection, the information is not collected by the researchers themselves, but uses existing data that is already available or is compiled from such data. The use of the data obtained from other studies is an example of the use of the third level of data collection. While this may look like a labour saving approach, it can be costly to preserve the data, as the data may not be available in the right format or need to be transformed according to the researchers' requirements. Other costs that could arise are fees for the use of the data itself. Since the data are collected in advance, the control of the data is not in the hands of the researchers and therefore may not have the desired quantity or quality for research. Another problem is that the purpose of data collection may not be the same as in current research. Therefore, the requirements for validity may differ as well.

When the data is collected the analysis part comes next. There are two different forms of data analysis: The quantitative and the qualitative one.

Where the quantitative method is used, observations must be examined by statistical or mathematical means. This approach tries to create a mathematical model, theory or hypothesis from the observations. In general, many observations are required for a meaningful and significant model. Otherwise, the small sample may be distorted or a significant model may not be constructed because the background noise is greater than the importance of the collected data. With a sufficiently large sample size, you can check whether theories fit a population. This is usually not possible with the qualitative approach, as the sample is often very limited. Another advantage is that the quantitative way can express phenomena in numerical values. Therefore, it is easier to compare the result with similar data or models.

In summary, the quantitative approach uses mathematical methods, e. g. statistics with a significant sample size. Thus, a hypothesis can be found or a thesis can be proven for a population.

Sometimes it is not possible to obtain sufficient data for the quantitative approach. This could be because it is too expensive to get enough observations or because it is not possible to obtain a large sample size. However, the limitation of the sample size could be due to the design of the study or the type of research area. Nevertheless, the few data could still be sufficient to draw conclusions or gain a deeper understanding of the problem [Ben-Eliyahu, 2014]. A better understanding could generate hypotheses and thus advance research. For example, the research area may not be fully aware of the problems and their far-reaching effects. When researchers conduct interviews, they can better understand the causes and effects. The correlation between cause and effect could have been overlooked if the researchers had used a questionnaire. But it could just be a local phenomenon.

Conclusion of the qualitative approach: Even with smaller sample sizes you can still draw conclusions. They may not be expressive enough for a theory, but from them a hypothesis could be developed. However, different approaches make it possible to identify new phenomena or gain a deeper understanding of the research problem.

After analysing the case study, the results must be reported. Robson has defined a series of traits which should be in any report [Robson, 2002].

The paper must communicate what the case study is about. It should be easy for the reader to get a clear picture of it. They also need to understand what was done, why and how. The data must be made available in such a way that the reader can verify the conclusions and that they are reasonable. However, it may be sufficient to display only the basic data and summarize the information in a reader friendly way. The conclusions must be clear and unambiguous and in the context of research.

Another aspect, which has to be kept in mind, is that there might be different audiences such as policy makers or industry partners which read the report [Yin, 2002]. In order to meet the needs of the different groups, several reports may have to be written.

Now that we have dealt with case study research, we are looking at the Likert scale. This is an integral part of our questionnaire and is therefore discussed in detail.

Likert Scale

The Likert scale is named after its inventor Rensis Likert [Likert, 1932] and is a method for measuring personal attitudes. It is often used in questionnaires and consists of a statement and a scale or predefined answers. The declaration stated are aimed at a variable that you want to estimate or evaluate. The possible answers are called items and are predefined. Either on a scale, where at least both ends are marked with approval or disapproval, or with predefined levels of approval or disapproval. The subject must then select the most appropriate answer to the statement on the scale or from the possible answers. The Likert scale is based on the consideration that the subject rejects the statement all the more the further their own attitude deviates from the formulation of the declaration. Therefore, several such queries are used to measure the attitude and thus determine the underlying position of the subject.

	Strong disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strong agree
This paper is easy to understand						

Table 2.1: Example for a Likert Scale

A Likert scale could look like this (Table 2.1): The statement in this example is 'This paper is easy to understand'. The subject can then choose between predefined response options such as: 'Strong disagree' - 'Disagree' - 'Slightly disagree' - 'Slightly agree' - 'Agree' - 'Strong agree' If enough data has been collected, conclusions can be drawn about the simplicity of the paper or possible background factors.

An important part when using a Likert scale is the decision if you use an even or odd one [Thomas, 2014]. When using an even scale, like in the example before, there is no neutral answer possibility. Therefore, the user must choose a side, either one that slightly agrees with the statement or one that does not. This can be problematic, because the user can be completely neutral to the statement and thus the data can be distorted or the user cancels the filling out of the questionnaire out of frustration. On the other hand the odd scale can also distorted the data, since the users might tend to take the neutral answer when the question is too personal or they don't want to answer it. Another problem with a neutral statement is that it is not possible to determine exactly what this statement actually is. It may be that the subject is completely neutral in relation to the statement, or that the subject does not know how it thinks about it. However, it could also be the case that this answer was chosen in order to avoid a decision at all.

The data of a Likert Scale is ordinal. Therefore, you can only use the median or mode to compare two data sets. However, if you sum up Likert scales which test the same variable some treat the sum as interval data and therefore use the arithmetic mean. There are some requirements to do that:

- The answer items on the Likert scale must be set at equal intervals.
  This is often achieved with a symmetrical formulated answer possibilities, as can be seen in the example above.

- The Likert scales which should be summed must have the same answer items.
  This is important for the sum to be meaningful. If the different scales offer a different number of possible answers or the possible answers are different between the scales, no summation is possible.

However, in the paper *The seven deadly sins of statistical analysis* [Kuzon Jr et al., 1997] the following counter-argument is put forward: 'The average of 'fair' and 'good' is not 'fair-and-a-half'; which is true even when one assigns [...] [values] to represent 'fair' and 'good' ' On the other hand, the paper *Multipoint scales: Mean and median differences and observed significance levels* [Lewis, 1993] states that the arithmetic mean is a better measure of the central tendency

than the median. This was found in two series of usability studies using 5 or 7 item scales as basis.

As with many other survey methods, there is another limitation of validity, namely social desirability. Social desirability is the tendency of a participant to answer in a way that would be seen positively by others. One example for this is that more desirable personality characteristics are reported if the subjects have to report their names, address and telephone number in the questionnaire than when they are told not to put identifying information at all [Paulhus, 1984]. In order to reduce or eliminate this effect, the questionnaires should be made anonymous.

Now that we have gathered enough knowledge about the Design Science and case study research, we are looking at the practical work of other scientists. This is done by selecting different approaches of the literature to the transfer topic and its possible measurement methods.

Selection of existing approaches

The book *Transferkompetenz und Transfer: Theoretische und empirische Untersuchung zu den Wirksamkeitsbedingungen betrieblicher Weiterbildung* [Seidel, 2012] (in English: Transfer competence and transfer: Theoretical and empirical research on the conditions of effectiveness of continuing vocational training in enterprises) is a good starting point when dealing with transfer measuring. Jana Seidel describes the creation, validation and result of a questionnaire that measures the transfer in a company. This work was performed in an empirical study.

The first chapter briefly describes the goal of the book. A brief overview of the term transfer is given, but the main purpose of this section is to familiarize the reader with the topic.

The second chapter explains and illustrates the theoretical background necessary for understanding the later chapters. The fundamentals of teaching and learning research are presented as well as the definition of effect and efficacy in the context of transfer. The term transfer is discussed in detail in a dedicated subsection. The aspects of the transfer are examined against the background of competence research and educational science. Then several factors supporting or hindering the transfer are identified and illustrated. The summary of the section is a table with all the factors described previously and whether they are important for learning or transfer success or both.

The design of the questionnaires is explained in the third chapter. The first part of this chapter explains the design approach and the validation of the questionnaires. The second part deals with the case study in which the questionnaire was used. The two courses in which the samples were taken are defined and also the use of three different questionnaires. The first one was carried out before the course starts. The second was done at the end of the course. The last questionnaire was sent to the participants six months after the course has ended. This trade-off was made so that users could potentially apply the knowledge they had learned and not have been trained too long ago. Since the third questionnaire was sent out after the season, which has traditionally been the company's busiest one, Jana Seidel assumes that most users have come into contact with the topic in their daily work. She concludes that the workers could have already been in the phase where the transfer would have taken place and that they could therefore be able to deduce a conclusion.

The fourth chapter deals with the results of the questionnaire. A breakdown of the data sets collected in the case study can be found at the beginning of the chapter. These are also partly important for our work, as possible partial aspects could be taken over. This section provides an additional description of how the data was cleaned up and how missing values were handled. The next section shows the evaluations using the collected data. The first part is a reflective detailing of the quality of the tools used by her. The second part is a precise characterization of the transfer and all other properties that have been measured.

The last chapter deals with the implications of the results and their validity. We can draw important knowledge from this part as well. Even if we only want to improve our basic knowledge about transfer and the components of it.

The article *The transfer of training: what really matters* [Grossman and Salas, 2011] deals with a similar starting assumption as 'Transferkompetenz und Transfer: Theoretische und empirische Untersuchung zu den Wirksamkeitsbedingungen betrieblicher Weiterbildung'. As in Jana Seidel's book, this paper identifies important factors for a successful transfer. Those are cognitive ability, self-efficacy, motivation, perceived utility of training, behavioural modelling, error management, realistic training environments, transfer climate, support, opportunity to perform and follow-up. All these factors are used in the proposed transfer model, which is based on Baldwin and Ford [Baldwin and Ford, 1988]. But there are some improvements to the original, all from literature and publications. The added factors and the variables already present in the base model are described in detail and discussed in depth. If one compares the model with that of Jana Seidel, one can recognize several overlapping points in the models like e.g. self-efficacy, motivation, the perceived utility of the training or support. However, the authors also emphasis that there are problems with the "synthesis" of findings in the transfer domain as well as "mixed findings" [Blume et al., 2009] in the mentioned literature. Nevertheless, the proposed model should represent the base line of current knowledge about transfer since only the strongest and most solid findings were used.

The book *The Training Evaluation Process: A Practical Approach to Evaluating Corporate Training Programs* [Basarab Sr. and Root, 2012] deals with Motorola and the question whether the internal training was an investment or an expense for them. The approach to find the answer was partly based on the Kirkpatrick model discussed earlier.

In research a five-stage process has been developed and named: 'The training evaluation process'. Each of the steps is repeatable, measurable and well defined and documented to enable reproducible outcomes. Since the aim of the study was to derive data for business decisions, the processes were not designed to prove the training transfer, but to improve it. Therefore, the process may not be directly applicable to this thesis, but the explanation of the basics of this book, such as the Kirkpatrick model, are decisive insights that need to be understood.

The two books *Selbstlernkompetenz. Metakognitive Grundlagen und praktische Umsetzung* [Kaiser, 2003] (in English: Self-learning competence. Metacognitive foundations of self-regulated learning and their practical implementation) and *Denken trainieren - Lernen optimieren* [Kaiser and Kaiser, 2006] (in English: Training thinking - optimizing learning) also have

transfer as a key topic. In contrast to the previous sources, the view of these books is rather abstract in its nature. Rather, it emphasizes metacognition or reflection in order to shed light on the subject of transfer.

Competence in self-initiated learning is the central theme of the first book, *Selbstlernkompetenz. Metakognitive Grundlagen und praktische Umsetzung* [Kaiser, 2003]. The almost complete first chapter is dedicated to this topic only. The other part of the first chapter is metacognition. After these concepts have been defined, both are subject of the next chapter. The following chapter deals with seminars and their mediation of metacognitive expertise. Chapter four deals with transfer success and metacognition. The optimization of the transfer and whether a better awareness of metacognition could help in this is discussed in this section. The other chapters are still revealing. However, they are not relevant for this work.

The second book, *Denken trainieren - Lernen optimieren* [Kaiser and Kaiser, 2006], focuses even more on metacognition than the first one. Just like the previous book, the first chapter provides the theoretical background for the reader. Subsequently, various findings of the metacognition are presented and explained. This chapter also deals with transfer, although this is discussed at the meta level rather than directly. The following chapters still convey basic transfer knowledge. The important aspects for this thesis were already discussed in the theoretical part about learning and transfer and cited from other sources. Nevertheless, these books are a viable source for this thesis.

In summary, both books have the metacognition topic in common. However, they have different explanatory approaches and interpret them with transfer concepts.

2.3 Evaluation

We discuss selected statistical foundations that are important for understanding the data obtained from the case study and its evaluation. First we deal with box plot visualization and its principles. Then there is a deeper insight into linear regression and where the difference between single and multiple (linear) regression lies. We also make a brief excursion on the subject of Heteroscedasticity.

Box plots

A box plot is a visualization method to display numerical data quickly and clearly. John W. Tukey proposed the basics of this presentation in book *Exploratory Data Analysis* [Tukey, 1977]. The name-giving box shows the interquartile range (IQR). The interquartile distance is the range in which the middle 50% of the samples are located, i.e. first Quartile (Q1) to third Quartile (Q3). The line inside the box represents the median. The upper whisker starts at Q3 and continues 1.5 times the IQR. At the lower whisker the starting point is Q1, the length of the whisker is also 1.5 times the IQR. Possible outliers are displayed with dots above or below the whiskers.

In addition, there are other features that increase the power of a box plot. An example is the notch that indicates a 95% confidence interval of the median value. This notch is based on *Variations of box plots* [McGill et al., 1978] and *Graphical Methods for Data Analysis (Statis-*

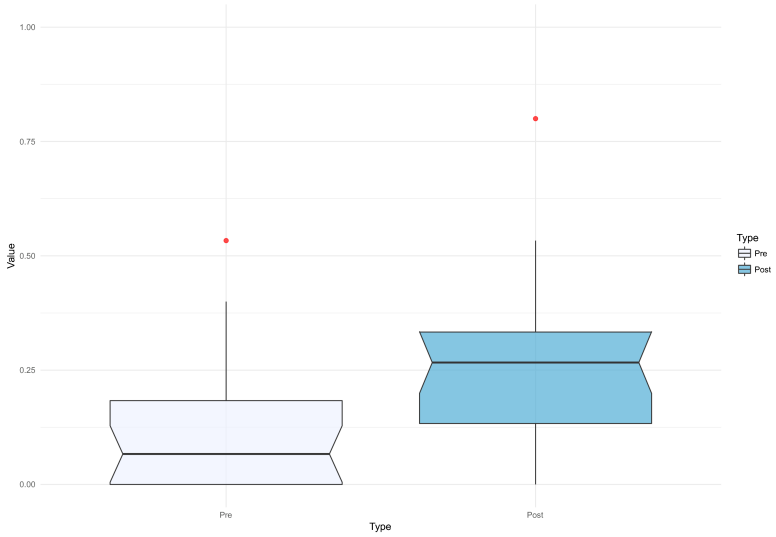


Figure 2.1: Example of Box Plot

tics) [Chambers et al., 1983a]. The inside of the notch is determined by the median, while the notch ends are calculated by the following formula (Equation 2.1):

$$Median \pm \frac{1.58IQR}{\sqrt{n}} \tag{2.1}$$

If the notches of two box plots do not overlap, there is a strong evidence (95% confidence) that their medians differ.

The following can now be seen in the example illustration (Figure 2.1): The data is distributed between zero and one, with most of the observations being below 0.5. There are two types of data, Pre and Post. The notches of the two boxes are not intersecting, therefore the medians are different with an alpha of maximal 5%. Both box plots are not normally formed: With the Pre plot, the lower part of the box is missing, which is not occupied by the notch, while with Post plot it is exactly the other way around. This indicates that the data in this area are very close together and that this data probably does not originate from a normal distribution.

Now that we are more familiar with the visualization of box plots and their messages, we deal with linear regression. We use it in the evaluation of the case study data. In this way, the important transfer factors should be made visible.

Linear Regression

Linear regression is a statistical method in which an observed variable is expressed or calculated by one or more other variables. The observed variable is described as a dependent one, whereby the variables used to describe the dependent variable are named explanatory. In linear regression, an approach is taken to create a model to express the dependent variable through the explanatory

ones with the help of factors. The term linear expresses that the regression is a linear combination of the regression parameters.

Linear regression can be divided into two types, simple and multiple. In a simple linear regression there is only one explanatory variable. The representation for such a model is:

$$y = \beta_0 + \beta_1 * x + \epsilon \tag{2.2}$$

The dependent variable y is now expressed by a constant factor β_1 and the variable β_2 times the observed parameter x (Equation 2.2). Since models are usually not identical with the measurements, there is an error ϵ to illustrate this in the formula.

Multiple linear regression has more than one explanatory variable. Therefore the representation for a multiple linear model is:

$$y = \beta_0 + \beta_1 * x_1 + \beta_1 * x_2 + \cdots + \beta_n * x_n + \epsilon \tag{2.3}$$

Since there are now multiple dependent variables $x_1, x_2, \ldots, x_n$ to explain y there must also be multiple factors $\beta_1, \beta_2, \ldots, \beta_n$ (Equation 2.3). Here, too, an error in the formula is taken into account, since the model can never do justice to the original data for 100 percent. In short, "in the linear model, each of the covariables has a linear effect on y and the effects of the individual covariables are added together" [Fahrmeir et al., 2009, p. 20].

Since you usually do not know the coefficients you have to estimate them. In this paper we use the ordinary least square method. The coefficients "are determined in such a way [...] that the square sum are minimized" [Drmota et al., 2008, p. 401]. This estimator is unbiased, consistent and efficient if the Gauss-Markov assumptions are met. The third assumption of the Gauss-Markov assumption is that the random errors ϵ have a finite constant variance, also know as heteroskedasticity. However, this assumption cannot always be fulfilled, which is why we might need a more robust method. Therefore we also use the heteroskedasticity corrected linear model in this thesis. Besides the previously quoted documents we use the paper *Using Heteroscedasticity Consistent Standard Errors in the Linear Regression Model* [Long and Ervin, 1999] to improve our knowledge about heteroscedasticity.

$$R^2 = \frac{\frac{\sum(\hat{Y} - \bar{Y})}{N-1}}{\frac{\sum(Y - \bar{Y})}{N-1}} \tag{2.4}$$

$$0 \leq R^2 \leq 1 \tag{2.5}$$

The quality of a linear model is determined by the parameter R^2. The value of R^2 is the sum of the residuals from the estimates ($\hat{Y}$) to the expected value ($\bar{Y}$) by the number of observations minus one by the sum of the residuals from the observations (Y) to the expected value ($\bar{Y}$) by the number of observations minus one [Böhm, 2015] (Equation 2.4). This indicates how well the observations can be explained by the model where R^2 = 1 means that all observations are perfectly explained by the linear model whereas R^2 = 0 means that there is no linear connection between the explanatory variable and the dependent varaibels at all (Equation 2.5). However,

one should not rely on this parameter alone when checking the validity of a model. An example would be a model with a high R^2 value, but where none of the coefficients are significant, i.e. have not a lower p-value than alpha. This may look good at first glance, but the expressiveness of the model is at least doubtful.

All previously mentioned and cited knowledge is necessary to be able to understand and assess the full spectrum of the work. Whether concrete or abstract content, the state of the art part provides at least a good basis for getting to know the topic. Even if linear regression is certainly known for people with a technical background and the topic of learning and transfer is only superficially treated for educational scientists, this is enough from both worlds to be able to comprehend and understand this work.

CHAPTER 3

Research Questions

In the previous chapter we discussed the necessary background knowledge and the state of the art for carrying out a case study and measuring the transfer. This chapter is about proposing and discussing the research questions of this thesis. Essentially we deal with the question of how an appropriate framework for transfer measurement could look like, as well as what the variables to be measured are for the transfer.

3.1 Framework Development by the Design Science Approach

The first research question of this thesis is how a appropriate framework that measures the transfer of employees might look if it was created according to the Design Science Approach.

To create a framework that measures the transfer, we use the guidelines of the "Design science in formation systems research" [Hevner et al., 2004]. However, not only the transfer in the framework has to be measured but also a number of previously known requirements must be met. Most of these can be traced back to the environment in which the framework is used. In innovation courses [Pflügl and Pichler-Rohrhofer, 2015], employees of companies are trained in a certain field. In this thesis, industrial Internet of Things is the training domain. The goal of the course is to expand the knowledge of the participants in order to spread it throughout the company.

One of the requirements is, that it must also be adaptable and applicable for similar applications in a similar context. This is important to be able to use the framework in other innovation courses as well. If this flexibility could not be achieved within the framework, it would not meet our requirements. This adaptability is necessary because there are several possible changes that may occur. There are small transformations that have to be performed during the case study. However, since we do not want to create the framework only for this thesis or case study, it should also be reusable in the future. This intended adaptation possibilities should be clearly explained and described in order to meet this requirement.

Another requirement of the framework is that each of the transfer measurements must not take more than half an hour. This time limit results from the case study within the innovation

course. The courses are planned a long time in advance and it is therefore not possible to make major changes, e.g. to carry out a complete transfer measurement. The units of the course are very densely packed and there is no larger time frame to apply the framework or the questionnaire without affecting the lessons. Due to these factors, the maximum time per measurement was set to half an hour. We expect a similar time restriction in any other innovation course or any similar setting.

3.2 Measuring the transfer

The second research question is whether the framework created fulfils the task of measuring the transfer.

We are conducting a case study to test the framework. This is done with the method of Runeson and Höst [Runeson and Höst, 2009]. Within the case study we determine whether what has been created meets the requirements or whether we need to improve or adapt it. If extensions or improvements are made, these take place within the case study. However, these are not applied within one module, but the next modules is experiencing the adaptations. This is done so that the changes are traceable and consistent. In addition, the data within a module remains comparable.

After we have dealt with the transfer measurability we also considered the third question: 'If the transfer is measurable, which metrics can be used to verify or predict the results of the transfer.' This is partly done through the research of the literature as well as through the data of a case study. The evaluation of the addressed data is done with the help of the quantitative approach. Not only the transfer variable is used to evaluate the transfer, but also others variables that we derived from the literature search. Using this additional data, we try to find a statistically meaningful model that can calculate, if not predict, the transfer.

The data collected in the case study is published anonymously in the appendix.

CHAPTER 4

Framework

This chapter describes the framework created. The first section explains why we use questionnaires to measure the transfer and why we decided to create three different ones. Afterwards we discuss the application of the guidelines of the Design Science Approach in the planning and implementation of the framework.

4.1 Questionnaire

We have decided to measure the transfer with questionnaires. This decision was taken because questionnaires can be carried out by researchers and other persons with limited influence on their validity or reliability [Popper, 1935, Ackroyd, 1981]. Generally speaking, they can be analysed faster than other surveys and are easier for the analysts to quantify. Another reason is that they are more objective than other forms of survey such as interviews. This greater objectivity means that changes in data, such as people's change of opinion over time, can be captured very well.

However questionnaires also have their drawbacks: It is difficult to tell whether respondents are telling the truth when they complete a questionnaire. Furthermore, the interviewee can misunderstand the question or interpret something that is not intended or desired by the creator. This could cause a respondent to unwittingly falsify their result.

However, we believe that the advantages outweigh the disadvantages and therefore the questionnaire is the tool of our choice.

When designing the questionnaires, we have tried to keep them as simple as possible for a number of reasons:

The first one is that it should be easy for the participants to understand and complete the questionnaire. This should reduce completion time and improve data quality. Another advantage is that the quicker completion of the questionnaire means that trainees can continue their studies or work earlier, enabling them to be more productively. This may also result in a higher transfer rate.

Another reason for the simple set-up was that the questionnaires are more versatile. They can be queried and answered in paper form or digitally. Digitally, this can be done e. g. in an e-learning system or via an individually adapted spreadsheet. However, we can not expect that all participants answer digitally, therefore we provide also a paper version. With the help of electronic data processing, the data from both processes can be combined with each other. Due to the simplicity of the questionnaires, all of this could be done without great effort or customizing.

Overview of the questionnaires

Through literature research, we have come to the opinion that three different questionnaires cover the needs in the best possible manner. This decision is related to the case study in the book *Transferkompetenz und Transfer: Theoretische und empirische Untersuchung zu den Wirksamkeitsbedingungen betrieblicher Weiterbildung* [Seidel, 2012] and the paper *The transfer of training: what really matters* [Grossman and Salas, 2011].

In the first part, the knowledge of the participants is tested before the course and their willingness to transfer. Both points are important for this work, because both the prior knowledge of the course topics and the willingness to transfer provide valuable information about the participants, namely: Given this data it is possible to reconstruct the unaltered state of the participants.

The second questionnaire is completed at the end of the course. To test the level of knowledge after the course, similar or the same questions are asked as in the first questionnaire. This enables to measure the level of knowledge after the course very precisely and to quantify the increase in knowledge of the trainees. In addition, the observed transfer support of the trainers, the practical relevance and the current willingness to transfer are also queried. Furthermore, the transfer that has been performed up to this point in time is queried.

The third and final form takes place at least six months after the end of the course. We have chosen this time frame as a compromise so that the participants have enough time to experience the transfer and not to forget the lessons learned. In addition, we also examine the self-efficacy of employees as to whether they have potential applications for transfer, as well as their self-monitoring during their transfer. Evidently, the transfer performed is also checked.

Details of the questionnaire

As mentioned above, the first questionnaire consists of two different parts. The initial part of this is the knowledge section. Participants are tested to see what level of initial knowledge they have on the subject before the course. Since this part depends on the course itself, it is necessary to work together with those responsible for the lessons. The other part is a questionnaire with the questions about the participants willingness to transfer. These are almost independent of the course in which they are asked. Some of them still need some minor adjustments to the course, as they have the title of the course in the question text. The possible answers are predefined with a Likert Scale of six items. In total there are four different questions about the willingness to transfer. We chose the Likert scale because this is the best way to measure the willingness of trainees to transfer since it is not obvious to the trainees what should actually be measured.

In addition, we expect that this gives us more honest answers from the participants than other methods such as interviews. Further, this scale is very easy to use both offline and online without any major adaptations. The reason for the even number of items is that we believe the evaluation is easier without a neutral element. Moreover, we are very confident that the participants have at least a tendency to the willingness of the transfer and that the questionnaire is not cancelled due to the lack of a neutral element.

As with the first questionnaire, the second one consists of two different parts. As described previously, the knowledge section of the first part is repeated or held very similarly in order to gain a good understanding of the trainees' improvements. The other segment consists of questions about the perceived transfer support of the participants. Three different questions deal with this impression. Questions regarding practical relevance of the course, the willingness to transfer after the course and the currently performed transfer are also asked. Four questions were asked in each of these categories. One of the questions, one concerning the relevance of the practice, was inverted in order to check whether the participants really read through the questionnaire or only fill in the questionnaire thoughtlessly. The possible answers are as before predefined with a Likert scale of six items. The reasons for using the Likert scale in this questionnaire are the same as above.

The third questionnaire consists only of one part. In this questionnaire there are questions regarding the self-efficacy of the workers concerning the course, as well as whether there were application possibilities for the transfer. Furthermore, they were asked if they have controlled the transfer themselves and questions about the transfer. As in the previous questionnaires, we use predefined answers with a Likert scale of six items. We use the same scales as for the previous questionnaires. The reason for this is not the routine, but the fact that the requirements of the questionnaire have not changed and it is advantageous to continue using the same scheme, in particular to keep the evaluation as meaningful as possible later on. Unfortunately, not all questions are possible with the Likert scale, as one of the questions, "Bitte schätzen Sie: Wie viel Prozent des Gelernten haben Sie bereits angewendet?" (in English: "Please estimate: What percentage of the learned knowledge have you already applied?"), requires a rough percentage estimation of transferred learning. We use an eleven-step scale that ranges from 0 to 100 percent in ten percent increments to cover this question. The created questionnaires are attached in the appendix.

Evaluation of the questionnaire

When dealing with the evaluation we have to distinguish between the knowledge and the Likert Scale part.

The knowledge section should always be evaluated with the same rules and standards in order to ensure a comparability of the data before the course and after. This is especially important if you want to use this part several times and compare the data with each other or when comparing different trainees with each other. Another reason why this is important is that the evaluation of knowledge must be done identically before and after the course in order to be able to make a valid statement about what the trainees have learned and their improvement. If this evalua-

tion changes every time, then you have data before and after, but whether these are comparable remains to be seen.

The part with the Likert scales is easier to evaluate. For each Likert scale a value between 0 and 1 is assumed. The strongest form of rejection gets the value 0 and the strongest form of approval 1, this is in our case: strong disagreement and strong agreement. The remainder is uniformly distributed on an even scale over the remaining elements. Since the elements in our questionnaire are symmetric, the disagree gets a value of 0.2, whereas the agree gets a value of 0.8. The element slightly disagree is assumed with 0.4 and the slightly agree with 0.6. This is done for all questions that have been filled in by the trainees. All questions that are not filled out by a participant are marked as Not Available and are not included in the evaluation. If there are several questions which query the same variable and have been answered by the participant, the arithmetic mean is taken from them. In other words, the values of questions of the same type are summed and then divided by the number of questions summed up. This methodology is used to determine the value of the measured variables, such as willingness to transfer or practical relevance. These calculated values are then used to evaluate the changes in trainees' attitudes and to answer research questions.

4.2 Design Science Approach

The paper *Design Science in Information Systems Research* [Hevner et al., 2004], which was already mentioned in the State of the Art chapter, was used to create this framework. In these paragraphs we discuss how we have complied with the directives in creating this framework.

The first guideline is called 'Design as an artefact' because the result of the design science approach is an artefact. In this thesis, the resulting framework used to measure the transfer is the designed artefact. The framework makes it easy to record and evaluate employee transfers and thus improves the understanding of this topic.

The second guideline is that the problem must be relevant. For the later described project called 'DigiTrans 4.0' it was necessary to have a framework to measure the learning and transfer of the participants. No adequate framework was found in the preliminary phase to satisfy our needs, therefore this framework was created. However, the framework created is not restricted to this course. The aim of the framework is to be suitable for comparable courses or similar environments. Thus the problem is relevant for the project, the executing university and the community.

The evaluation of the design is the third guideline. In order to evaluate the framework, we have chosen the descriptive method. The collected data from the framework is analysed with statistical methods such as regression.

The next rule is that the generated artefact must add meaningful knowledge to the research field. In this case, the framework created is the contribution for the research area. It is explained in detail. The framework has provided for customization options because they are required, which are also specified and described in detail. This can best be seen in the appendix and the corresponding tables of the questionnaires.

The fifth guideline proposed is to have rigorous research methods. Amongst other things, we used the papers *Design Science in Information Systems Research* [Hevner et al., 2004] and

Methode of Runeson and Höst [Runeson and Höst, 2009] in order to rely on accurate and precise research approaches. We used the methods of book *Transferkompetenz und Transfer: Theoretische und empirische Untersuchung zu den Wirksamkeitsbedingungen betrieblicher Weiterbildung* [Seidel, 2012] and the paper *The transfer of training: what really matters* [Grossman and Salas, 2011] to accurately measure and determine the transfer.

The next aspect that should be covered is the design as a search process. The framework created must meet a number of requirements. Firstly, the framework must be able to measure the transfer of several people in several modules. The second requirement is that the measurements should be taken during lessons, as it is very difficult to interview the employees at other times. The third requirement is that the framework is not rigid but can be adapted to similar environments. This means that it can also be used in a similar environment with a different teaching background or organisational structure. The final part of the guide states that research results must be communicated to the audience or to the community. The framework, its development and the results of the case study are presented with this thesis.

In the conception, development and execution of the framework, all presented guidelines of design science were taken into account in information system research. The framework is therefore in line with the guidelines proposed by Hevner.

CHAPTER 5

Case Study

The previously described framework is used in a case study. The case study is part of a project entitled 'DigiTrans 4.0'. DigiTrans 4.0 is an Out-House training program for employees from different enterprises. In terms of content, the topic of industrial Internet of Things is taught to the participants over one and a half years. The program itself consists of six different training modules (Table 5.1).

The first module deals with product life-cycle management. This includes the management of product design variants, as well as release and change management. Another important focus of this module is to provide knowledge of the product life cycle itself.

The second module deals primarily with modelling and the methods of transformation between models. This is important because modelling is an intermediate between the digital and the real world. With the help of modelling, prototypes can be created and tested faster without sacrificing flexibility. In the production environment, modelling also helps reducing operating costs by eliminating errors and supporting operations.

Module three introduces concepts and methods of automation and production technology as well as their applications areas. The relevant basics of industrial communication technology and the interrelationships between automation components are taught in this module. The aim of

Module Nr.	Title
1	Product Life-cycle Management
2	Models and Methods for Digital Transformation
3	Automation Technology and Automated Production Systems
4	Value Added Networks
5	Integration Engineering
6	Gender and Work Space 4.0

Table 5.1: DigiTrans 4.0: Name of the modules

this module is to provide participants with a profound understanding of the vertical integration of automation systems into the production environment.

The fourth module deals with the design of value added networks and the new business models resulting from them. Furthermore, the requirements for cross-company networking from a strategic point of view are explained and demands on software applications to support value-added networks are explained. In addition, practical examples are used to determine the requirements for the various interfaces in a company's own production facilities and possible solutions are given.

The main focus of the fifth module is 'From the Top Floor to the Shop Floor and return'. The requirements for a horizontal and vertical enterprise-wide integration is described in detail, based on case studies. A distinction is made between model-oriented, process-oriented, data-oriented and function-oriented integration within the company and across company boundaries. Building on the previous modules, the content of this module aims at seamlessly linking previous separate data and information flows by merging established industry standards and using modelling techniques.

And last but not least, module six deals with the human factor in the production of the future. The status quo of gender equality must be understood in order to knowingly think about further strategies, e.g. about the employees in the company in the digitalisation. This results in a better knowledge of the employees, their needs and potentials. How independent working and self-organised interactions between employees can be promoted is in the center of this module.

Each of these modules itself consists of several theory and practice units. A unit, whether theory or practice, lasts eight hours. The theory and practice sessions are usually separated and are held on two consecutive days, with the exception of Module 6. Since Module 6 only consists of two days and they are spread over two different months. After a week of training there is usually a break of at least one week for the participants. However, the modules are not held one after another and sometimes whole modules are in between. The exact timeline is explained in the Schedule section.

Within this case study there were six modules, but we used the framework only in four of them. The two modules for which the framework was not used are Module five and six. The reasons for this vary. Module five is the last module in the DigiTrans course. Because it only contains content from the first four modules, it makes no sense to use the framework there. Module six, on the other hand, does not have eight teaching days like the other modules, but only two. There are even several months between these two days. This makes it difficult to measure learning success and transfer, especially since the material is considerably less than in the other modules. It is therefore more difficult to design a good knowledge part for this module. This applies in particular if participants are absent on the first or second of the two days. Therefore, we have decided not to neither use the framework in this module.

Sex	Count	Percentage
Male	25	100%
Female	0	0%
Sum	25	100%

Table 5.2: DigiTrans 4.0: Sex of the trainees

Job	Count	Percentage
Worker	2	8%
Researcher	1	4%
Supervisor	12	48%
Management	3	12%
C-Level and above	7	28%
Sum	25	100%

Table 5.3: DigiTrans 4.0: Distribution of the trainees jobs

Module Nr.	Participation Count	P. Percentage
1	23	92%
2	22	88%
3	20	80%
4	22	88%
5	23	92%
6	18	72%

Table 5.4: DigiTrans 4.0: Modules and their trainees participation

5.1 Trainees

The trainees of the DigiTrans 4.0 project are employees of different companies. Through the entire project, the employees continue to work normally in their companies while they are being taught at the TU Vienna. The employees come from small, medium-sized and large companies. There are altogether 25 different employees from 16 different enterprises. However, all of them are male (Table 5.2). The companies themselves are very heterogeneous. Some of them focus on coaching or writing software, while others are active in the field of energy supply or machine construction. The participant's jobs are also very different. Two are workers, many are supervisors, some of them even in the management. There is even a researcher among the participants. In addition, members of the C-Level or higher are involved in this project (Table 5.3). Even with such a small sample it is a very divers group, with the exception that all participants are male.

Not every participant takes part in each module. Module 1 and 5 have the highest participation rate of 92% while module 6 comprises only 18 of the 25 trainees participating (Table 5.4).

5.2 Questionnaires

Since there are six different modules in the DigiTrans 4.0 project, it is necessary to create uniform rules for the knowledge questionnaires part. As already described in chapter Framework there are two different parts of the questionnaire: The knowledge part and the transfer part. With the help of the first part the learning success of the participants can be measured and compared. Therefore, this part is only collected in the Pre and Post Questionnaire. The second part is important for measuring and possibly forecasting the transfer. Therefore, this is done for all questionnaires, Pre, Post and Ultimo. We have chosen the following specifications for the knowledge part to keep them comparable:

- There are ten to fifteen multiple choice questions for the knowledge section of each module.
- Each knowledge question must have a minimum of four and a maximum of eight possible answers, at least one of which must be true.

Both restrictions were a balance between the exact measurement of the knowledge of the trainees and the respect of time constraints.

The first rule was created to make the questionnaires neither too long nor too short. Moreover, if you only ask MC questions, you can use a standardized evaluation procedure for all questionnaires. Furthermore, this type is resistant to a possible influence of the teacher and thus prevents possible privileges or discriminations of a participant.

The second rule is important to ensure that participants do not have too many chances of answering a question correctly if they make a blind decision. Participants are told before the questionnaire that at least one answer per question is correct. However, they are not informed how many of the possible answers per question are correct or how many correct answers there are altogether. The reason why at least one answer has to be correct is that there are many online questionnaires where this is a prerequisite. Since the questionnaire should work both online and offline, this was taken into account.

The questions and answers of the questionnaire are created by each module leader. Since the lecture is given by them, one can assume that they have a sound knowledge of the topic. They are therefore responsible for the knowledge part of their module questionnaire.

There is another restriction that was relevant to this case study. It was specified that in the case study it is measurable how the knowledge of the individual participants changes over the duration of the modules. Thereby, the questionnaires could no longer be filled out anonymously by the participants, but an opportunity had to be created to link them with their questionnaires. One possibility would have been that the questionnaires are coded and care is taken during the survey release to determine which questionnaire is filled out by which participant. This would give the participants the feeling that the questionnaire is anonymous and the answers could be more honest. However, if this is noticed by the participants or if errors occur during the coding, the confidence of the participants would be lost. It is precisely for these reasons that we have decided against it. We decided that the participants have to write their names on the questionnaires so that we are open and honest with them from the beginning.

Questionnaire	Time when completed	Prefix
First Questionnaire	Right before the first unit of a module has started	Pre
Second Questionnaire	At the end of the last theory lecture of the module	Post
Third Questionnaire	At least six month after the last unit of the module	Ultimo

Table 5.5: DigiTrans 4.0: Overview of when the questionnaires were completed

5.3 Schedule

The schedule of DigiTrans 4.0 starts from March 2017 and lasts to the June 2018. However, the order of the modules is not as clear as described above (Figure 5.1).

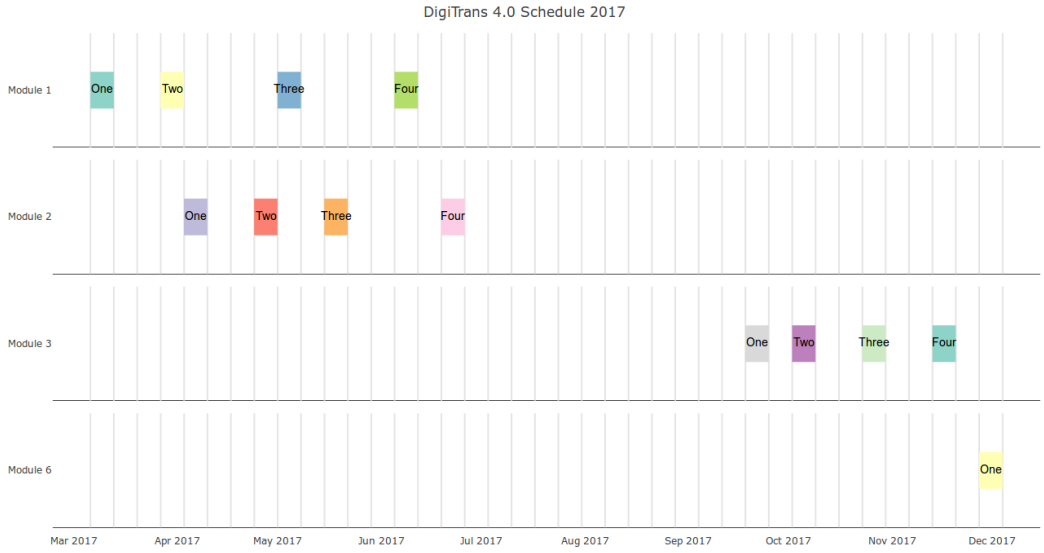
The first two modules are held almost alternating. This means that the first module (Product Life-cycle Management) starts with two theory and two practice units. Then comes the second module (Models and Methods for Digital Transformation) with its first two lectures and exercises parts. Thereafter, a theoretical and practical unit is held alternately by each module. Module one starts again with this pattern. This process takes till June 2017.

During the summer 2017 there is no training for the participants.

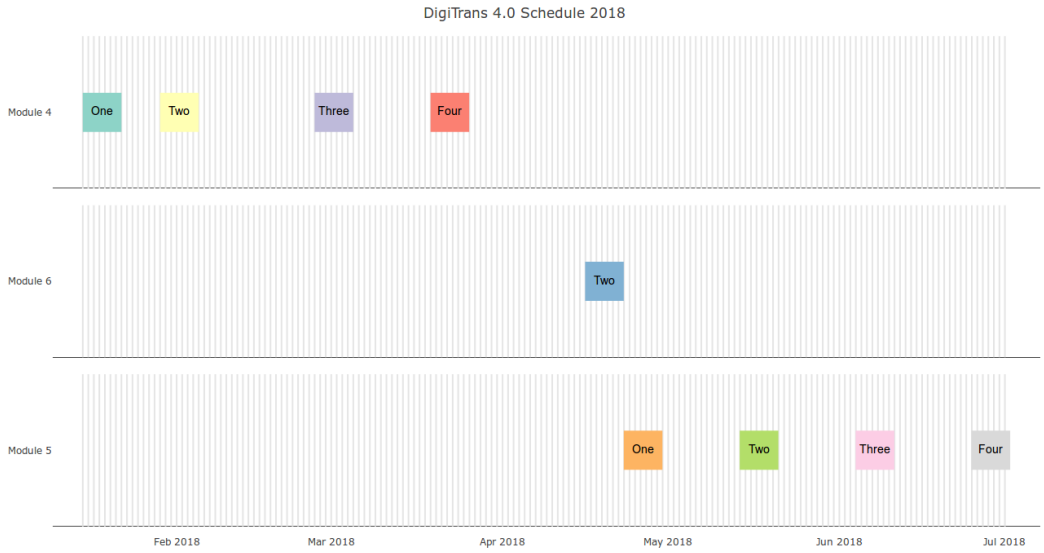
In September 2017, training continues with module three (Automation Technology and Automated Production Systems). It is taught without interruption by other modules. The first part of the module six (Gender and Work Space 4.0) takes place in December. Module four (Value Added Networks) begins after the public holidays. As in module three, there is no interruption by another module in module four and it ends in March 2018. The second and last part of the sixth module is being taught in April 2018. Shortly afterwards, module five (Integration Engineering) takes place till the end of the June 2018.

All three questionnaires where carried out at the same points in each module (Table 5.5) The first questionnaires were completed in the first lesson of each module. No subject matter was taught before sampling. This was done in order not to alter or distort the data of the knowledge that the employees had prior to training in the DigiTrans 4.0 project. The second questionnaire was completed by the employees at the end of the last theoretical unit of each module. This happened because the last practical lesson often took place in places where participants were unable to complete the questionnaire easily or undisturbed. The third questionnaire was issued at least six months after completion of the last unit of the module. To measure the transfer, this time span must have elapsed or the transfer itself could not be measured without manipulating it. This can be traced back to a trade-off between the short and mid or long-term effects, which is explained in detail in the State of the Art chapter.

In the following sections below, questionnaire one might be referred to as Pre-Questionnaire, the second as Post-Questionnaire, and the third as Ultimo-Questionnaire (Table 5.5).



(a) DigiTrans 4.0: Schedule 4.0 of 2017



(b) DigiTrans 4.0: Schedule of 2018

Figure 5.1: DigiTrans 4.0: Schedules grouped by years

CHAPTER 6

Results of the Case Study

This chapter discusses and evaluates the data from the case study collected using the framework. Although the data have not been collected anonymously, it is rendered anonymous in this work. The reason for the anonymisation is to protect the privacy of the participants, but the validity of the data remains unaffected. All data in this chapter have been reduced to five decimal places to ensure legibility. First, we take a look at the results of the questionnaires of the framework itself. These are structured according to the modules, as these are self-contained units that are also considered and analysed as such. Then we discuss the results of the linear regression, in which the transfer was used as a dependent variable. The other transfer parameters that were collected using the questionnaires are used as explanatory variables.

6.1 Knowledge increase in the modules

The results of the questionnaires are divided into the modules of DigiTrans 4.0. This is done because the modules are independent units and should therefore be considered separately. First of all, we look at the data of the questionnaires knowledge section and explain the results found. Since the knowledge part of the different modules differs in the number of questions asked, the data must be normalized to make them comparable with each other. Therefore, relative values are used in the following sections and not absolute values. Afterwards we focus on the topic of linear regression or linear modelling for the transfer.

Module 1

Module one focused on the product life-cycle management. Since many participants deal with this topic in their work, the prior knowledge is the highest of all modules (Figure 6.1a). All of the 23 employees have at least answered one question in prior knowledge test correctly and nine of the participants managed to score half of all possible points or more with the previous knowledge alone. The difference between the level of knowledge in the pre-test and the test at the end of the module is clearly visible. At the end of the module, only six of the 23 participants

had less than half of the points in the knowledge section of the questionnaire. Another way to show this is to evaluate the box plot of the data (Figure 6.1b). The post value is higher than the prior values. Since the notches do not overlap, there is strong evidence that the medians are different [Chambers et al., 1983b].

The difference between the knowledge at the end of the module and at the beginning can also be seen in the statistical values (Table 6.1). The mean of the pre knowledge is 0.37826, whereas the post knowledge equivalent is 0.55217. Therefore, the average improvement of the employees is 17 percents. As can be seen in the box plot, the median is 0.4 for prior knowledge and 0.6 for post-knowledge. Since we have the raw data, which are not anonymous, we can also analyse a further evaluation with the knowledge, namely the personal change of the knowledge due to being taught in the module. This is done by the simple transformation, by subtracting the Pre value from the Post value to get this value. This was done in the percentage improvement figure (Figure 6.1c). Only two of them have a decline in their knowledge, while ten employees or 43% of all participants have improved their knowledge by 20 percent or more.

Questionnaire	Mean	Median	Standard Deviation	IQR	MAD
Pre	0.37826	0.4	0.13127	0.2	0.14826
Post	0.55217	0.6	0.16200	0.15	0.14826

Table 6.1: Module 1: Comparison of statistical values from the Pre and Post knowledge part

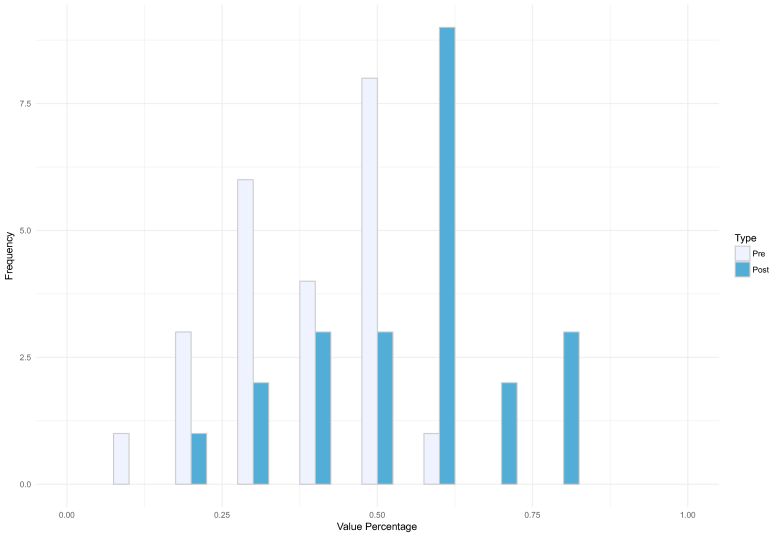
In addition, we compare the Pre and Post data to different means (Table 6.2). Although we only have 22 data points that are not normally distributed, at least both samples are of equal size. To do this, it is necessary to check first whether the variances of the two samples are different. Since the data is not normally distributed we use an Levene test. Since the p-value is 0.26068, we cannot reject the hypothesis that the two variances are equal. The standard procedure would be a t-test. For this, however, the data must be normally distributed, which is why we use a Mann-Whitney test, also known as U test. The p-value is very small with 0.00046. This makes it clear that the two averages differ significantly. Whether alpha is 5, 1 or 0.1 percent, the p value is lower. It is therefore highly unlikely that the means for the Pre and Post values are equal for module one.

Test (Type)	p-value
Levene test (Equality of Variances)	0.26068
Mann-Whitney U test (Equality of Means)	0.00046 (two sided)

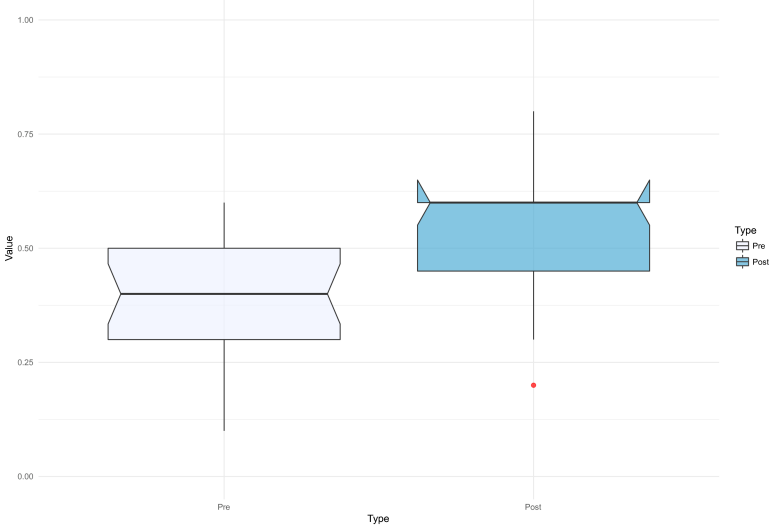
Table 6.2: Module 1: Levene and Mann-Whitney U Test Results

Module 2

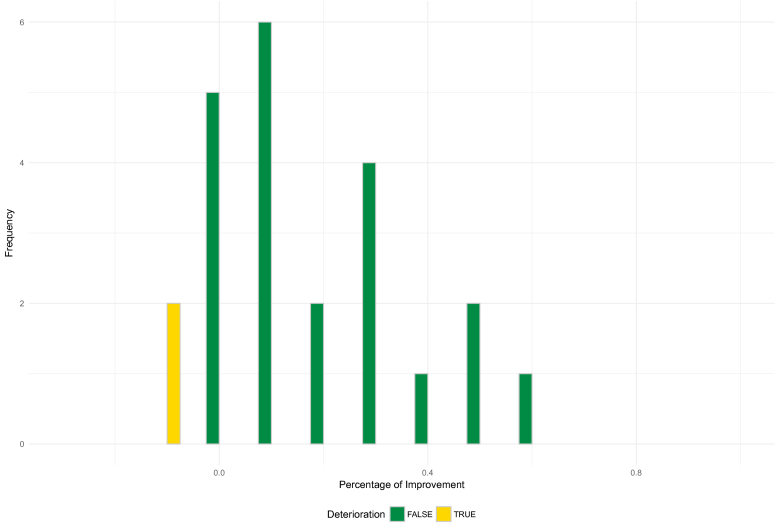
Module two dealt with the modelling and methods for the digital transformation. As most employees do not usually deal with this topic in their daily work routine, their previous knowledge is limited (Figure 6.2a). This is best illustrated by the fact that seven of the participants have



(a) Module 1: Histogram of the Pre and Post knowledge part



(b) Module 1: Box plot of the Pre and Post knowledge part



(c) Module 1: Perceptual Improvement of the knowledge part

Figure 6.1: Module 1: Representation of the data of the knowledge part

not answered a single question correctly. Only one of the 22 participants has reached more than half of the available points. Just as in module one, the increase in knowledge after the end of the module is clearly visible. While in the Pre test only 4 workers, or 18% of all participants, have reached more than a quarter of the possible points, in the Post test 9 persons, or 40% of all those tested, managed to exceed this value. This is also evident in the box plot (Figure 6.2b). As with module one, the notches of the two plots do not overlap, so the median is very likely to be different from each other. The individual improvements are clearly different from module 1 (Figure 6.2c). The whole graph is much more compressed and looks almost normal distributed. Compared to module 1, individual learning success rates are not so high, but there are significantly fewer people who have not improved or even deteriorated.

If you look at the statistic values of the knowledge test, the arithmetic mean is the first data point that stands out, since it is only 13.33 % (Table 6.3). Comparing this value with the average knowledge of the participants at the end of the module, 26.66 percent, one can see that it has doubled. If we use the median, this difference is even bigger, as can be seen in the box plot. According to the median, the average participant at the beginning of the module answered 6.66% of the questions correctly, while the Post Median shows 26.66 percent of the questions properly answered. This means that in the end, an average of 20% more questions were answered correctly than at the beginning.

Questionnaire	Mean	Median	Standard Deviation	IQR	MAD
Pre	$0.1\overline{3}$	$0.0\overline{6}$	0.15118	0.2	0.09884
Post	$0.2\overline{6}$	$0.2\overline{6}$	0.18743	0.2	0.19767

Table 6.3: Module 2: Comparison of statistical values from the Pre and Post knowledge part

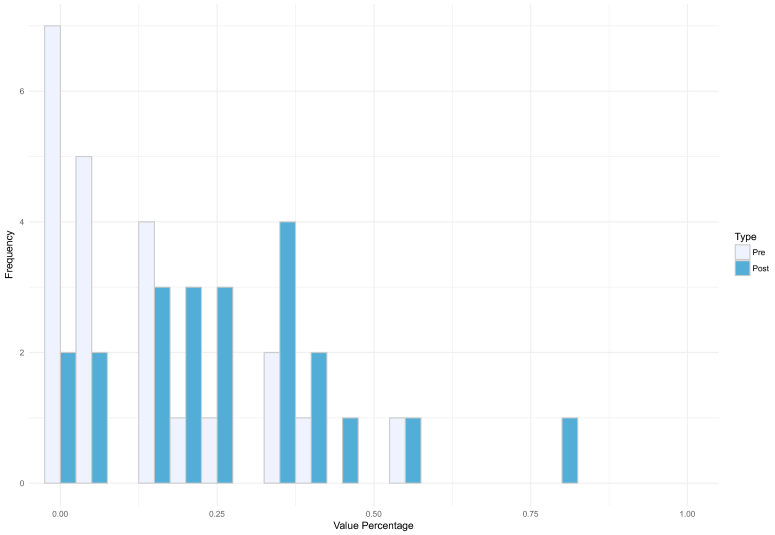
As with module one, we compare the Pre and Post data to see if they might have the same mean (Table 6.4). We have exactly the same number of data points as in module one and the data is not normally distributed. The Levene test is used again to see if the variance of the two samples (Pre and Post) are different. With a p-value of 0.18001 we can not reject the hypothesis that the variances are the same. Again, a Mann-Whitney test must be performed, as the data is not normally distributed. The two sided p-value is 0.01017 and is therefore significant for an alpha value of 5%. So here, too, we can see that the Pre and Post knowledge is different.

Test (Type)	p-value
Levene test (Equality of Variances)	0.18001
Mann-Whitney U test (Equality of Means)	0.01016 (two sided)

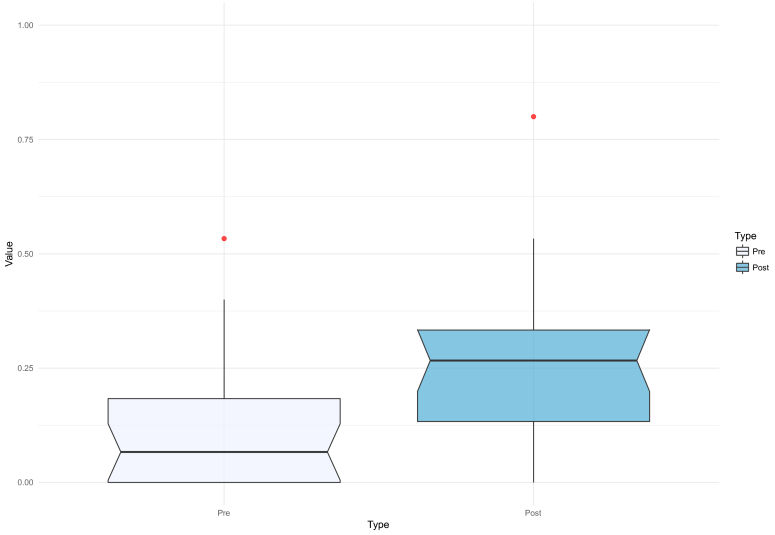
Table 6.4: Module 2: Levene and Mann-Whitney U test Results

Module 3

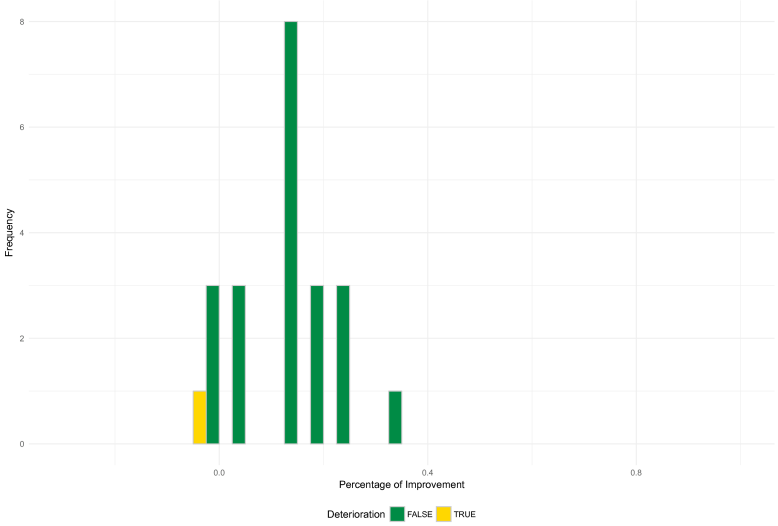
The focus of module three was Automation Technology and Automated Production Systems. Some of the participants have already had experience with this topic in their daily work, but most



(a) Module 2: Histogram of the Pre and Post knowledge part



(b) Module 2: Box plot of the Pre and Post knowledge part



(c) Module 2: Perceptual Improvement of the knowledge part

Figure 6.2: Module 2: Representation of the data of the knowledge part

of them have not. Therefore, the average prior knowledge on this topic is between module one and module two (Figure 6.3a). Four of the participants did not answer a single question correctly in the preliminary knowledge test. As with the previous modules, a growth in knowledge can be identified by the Post data. Each of the employees answered at least one question correctly, which was not the case in the prior data. Some of this can also be observed in the box plot (Figure 6.3b). For the first time, it is not immediately apparent that the averages of the two are significantly different, since the notches of the two box plots overlap. With regard to the data of the individual increase in knowledge (Figure 6.3c), it can be seen that in module three the questionnaire was the longest and most difficult, since the evaluated results are close to each other. Participants had to read these questionnaires very carefully, as traps had been deliberately set and it was not always immediately apparent what exactly was asked for. This is one reason why five of the 20 participants, or 25 percent, have deteriorated in this module and only one person reached half of the possible points.

This is also reflected in the statistical characteristics of the knowledge data (Table 6.5). Although the mean and median data are higher after the end of the module, however, the difference between the pre and post knowledge is also the smallest of all modules. The mean difference amounts to 6.785% and the gap between the two medians is 7.143 percent.

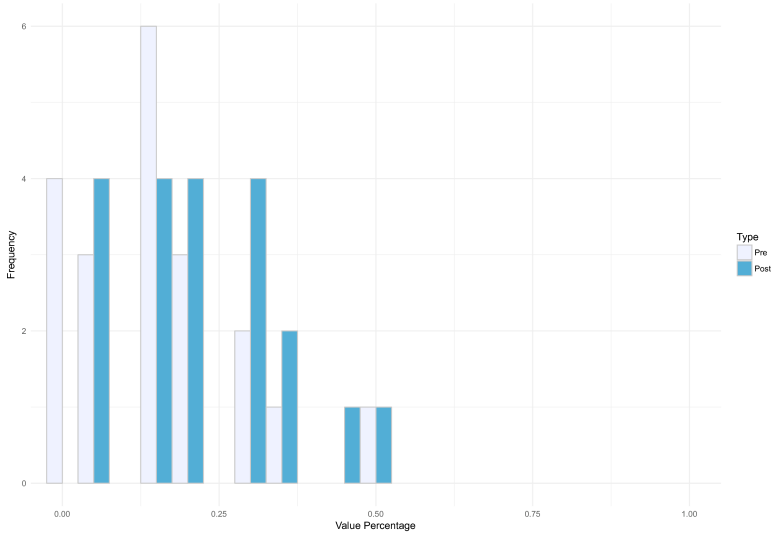
Questionnaire	Mean	Median	Standard Deviation	IQR	MAD
Pre	0.15714	0.14285	0.13027	0.14285	0.10590
Post	0.22499	0.21428	0.12322	0.14285	0.10590

Table 6.5: Module 3: Comparison of statistical values from the Pre and Post knowledge part

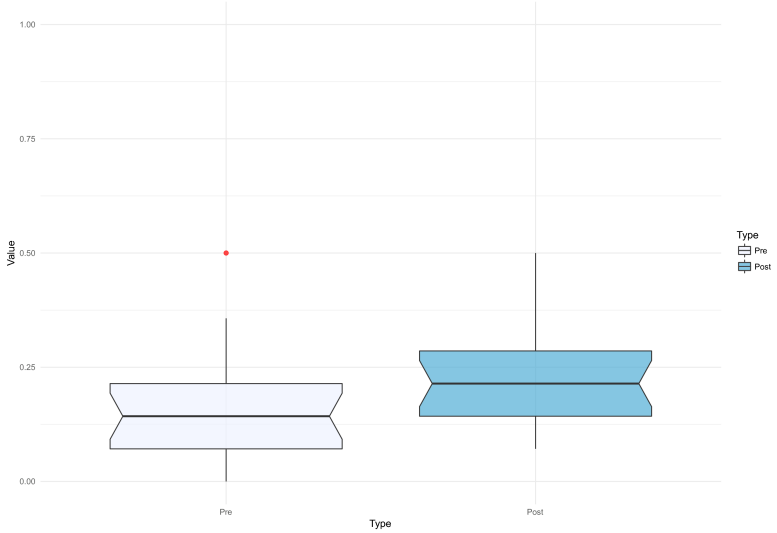
In order to be able to make a statement about the differences in the means of the two samples we use a significance test (Table 6.6). Since we need to know if the variance between the two data sources are different, we do a Levene test. This test is used because we have only 21 observations for each Pre and Post and they are not normally distributed. With a p-value of 0.43553 we can not reject the hypothesis that the variances of the two samples differ. Since the data in module three is not normally distributed, we cannot do a t-test but have to perform a Mann-Whitney test. The two sided p-value of 0.08585 tells us that we can not assume that the means of the two segments are different. This means that the data of the participants are not sufficiently meaningful to show a significant difference between the two measurements or that there is none.

Test (Type)	p-value
Levene test (Equality of Variances)	0.43553
Mann-Whitney U test (Equality of Means)	0.08585 (two sided)

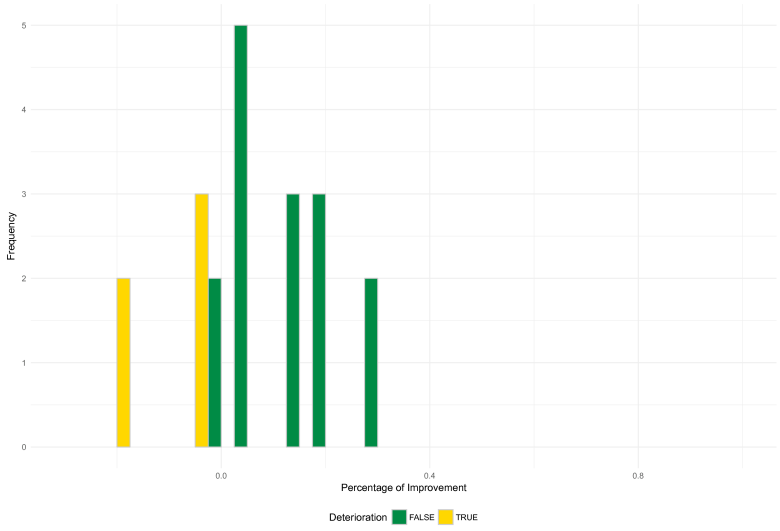
Table 6.6: Module 3: Levene and Mann-Whitney U Test Results



(a) Module 3: Histogram of the Pre and Post knowledge part



(b) Module 3: Box plot of the Pre and Post knowledge part



(c) Module 3: Perceptual Improvement of the knowledge part

Figure 6.3: Module 3: Representation of the data of the knowledge part

Module 4

Module four addressed the value added networks. Since the test was not so difficult in comparison to module three, this can be seen in the previous knowledge of the participants (Figure 6.4a). Only one of them didn't answer any questions correctly. The Pre modus is at 13,3$\overline{3}$%. The Post knowledge values are higher than Pre ones. The modus at the end of the module is 33,3$\overline{3}$ percent. Regarding the box plot it can be seen that the two questionnaires have different characteristics (Figure 6.4b). In module four the notches do not overlap either, so it can be assumed that the median is different from the Pre and Post Questionnaires. Interestingly, there are as many people who have deteriorated as in module three (Figure 6.4c). With this result, it is even more remarkable that the two medians differ statistically.

This is also represented by the statistical values of the data (Table 6.7). The mean of 20.$\overline{06}$ percent is the second highest in the conduced case study, the median is comparatively low with 16.$\overline{16}$%. Including the data collected at the end of the module, there is not much difference from the mean value of almost 28.78 percent. However, an increase to 30% can be observed at the median.

Questionnaire	Mean	Median	Standard Deviation	IQR	MAD
Pre	0.2$\overline{06}$	0.1$\overline{6}$	0.14091	0.1$\overline{3}$	0.09883
Post	0.2$\overline{87}$	0.3	0.12064	0.1$\overline{3}$	0.14826

Table 6.7: Module 4: Comparison of statistical values from the Pre and Post knowledge part

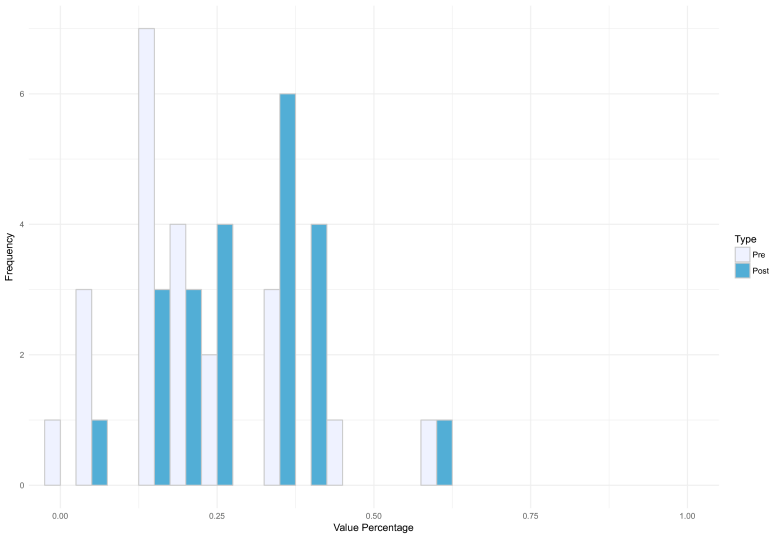
Also in module four we make a statement about the equality or difference of the variances. Since there are 22 participants and no normal distribution as in modules one and two, we used the Levene test (Table 6.8). With a value of 0.20764 we cannot reject the assumption that the variances are the same. Now we compare the means of the two different data. Since these are not normally distributed, we take the Mann-Whitney test. The two-sided p-value is 0.02077 and is thus significant for an alpha value of 5%. So again, Pre and Post-knowledge median is different.

Test (Type)	p-value
Levene test (Equality of Variances)	0.20764
Mann-Whitney U test (Equality of Means)	0.02077 (two sided)

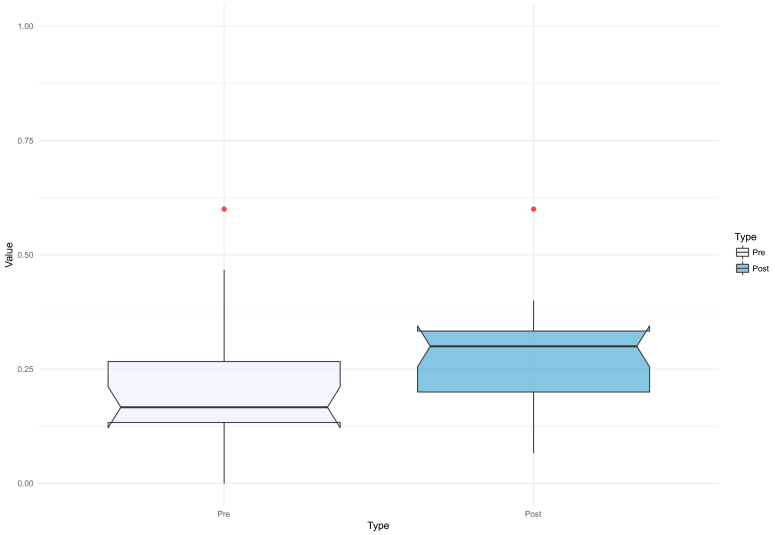
Table 6.8: Module 4: Levene and Mann-Whitney U Test Results

6.2 Transfer Variables

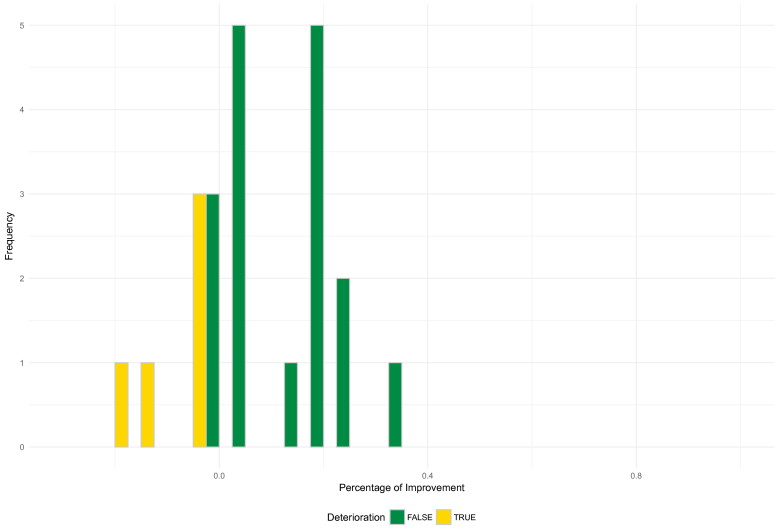
As already described in the framework chapter, the questionnaire collects many transfer variables derived from the literature. The data is now briefly interpreted and later used for linear regression. The exact information can be found in the appendix.



(a) Module 4: Histogram of the Pre and Post knowledge part



(b) Module 4: Box plot of the Pre and Post knowledge part



(c) Module 4: Perceptual Improvement of the knowledge part

Figure 6.4: Module 4: Representation of the data of the knowledge part

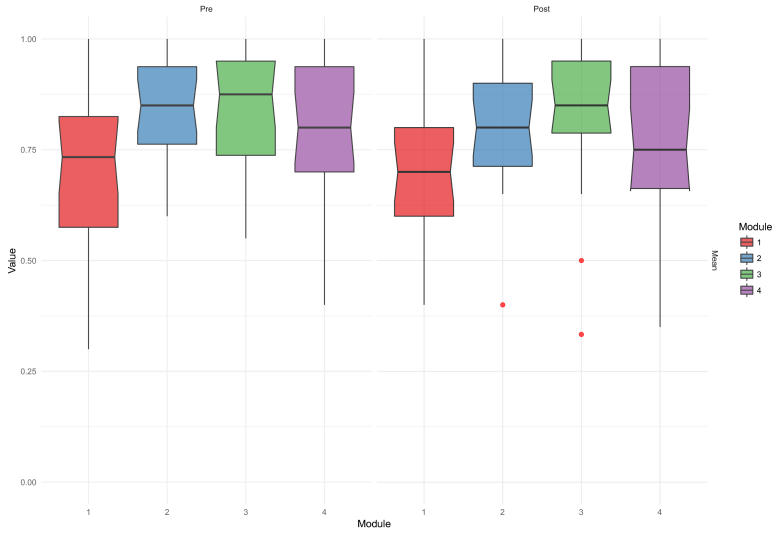


Figure 6.5: All Modules: Transfer Willingness

Module	Type	Mean	Median	Standard Deviation	IQR	MAD
1	Pre	$0.7\overline{3}$	$0.7\overline{3}$	0.20848	0.25	0.19767
2	Pre	$0.79\overline{54}$	0.8	0.13532	0.1875	0.14826
3	Pre	0.68695	0.7	0.17465	0.25	0.19767
4	Pre	$0.784\overline{09}$	0.8	0.16064	0.2375	0.18532
1	Post	0.68695	0.7	0.17465	0.2	0.14826
2	Post	$0.8\overline{03}$	0.8	0.09968	$0.1\overline{3}$	0.09884
3	Post	0.68695	0.7	0.17465	0.2	0.14826
4	Post	0.775	0.75	0.16955	0.2375	0.22239

Table 6.9: All Modules: Comparison of statistical values of Transfer Willingness

Transfer Willingness

The willingness of the participants to transfer was measured in the Pre and Post Questionnaires for each of the four modules (Figure 6.5). If you compare the Pre data, you can see that the box plots are long, which means that the data is very scattered. However, there are no values below 0.3. This can be explained by the fact that the companies have probably sent workers who at least have a little willingness to transfer. Furthermore, it can be seen that the median of willingness to transfer does not differ significantly between the modules. If, on the other hand, the data is taken from the post, you can see that the willingness of the participants has increased, since the boxes and the whiskers have become smaller, except for the possible outliers. For the linear model, we use therefore the Pre values, as these are more diversified and, in our opinion, better describe the initial transfer situation.

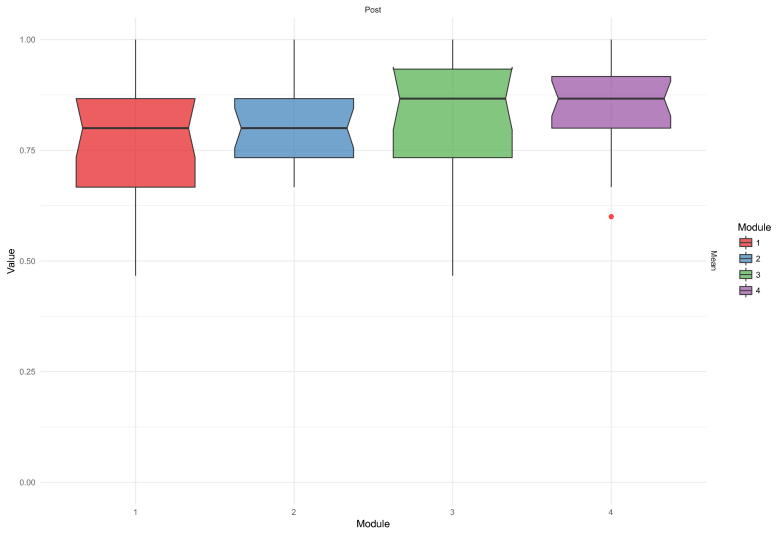


Figure 6.6: All Modules: Transfer Support

Module	Mean	Median	Standard Deviation	IQR	MAD
1	0.75942	0.8	0.12510	0.2	0.09884
2	$0.80\overline{3}$	0.8	0.09968	$0.1\overline{3}$	0.09884
3	$0.83\overline{6}$	$0.8\overline{6}$	0.13416	0.2	0.14825
4	$0.8\overline{36}$	0.8	0.12926	0.1	0.14826

Table 6.10: All Modules: Comparison of statistical values of Transfer Support

Transfer Support

The next variable queried in the questionnaire is transfer support (Figure 6.6). Here, too, the support perceived by the participants across all modules was very high. The median does not differ significantly between all modules. In addition, IQR is smallest in modules two and four. Only two of the measured data points are below 0.5 We assume that one of the reasons for these values is that all questions were answered in the lecture or in the practical units in order to train and inform the participants as well as possible.

This can also be seen in the high means of the individual modules (Table 6.10). Even the lowest value of 0.75942 is quite high for a normalized variable.

Practical Relevance

Just like the perceived transfer support, the practical relevance was also measured at the end of the individual modules (Figure 6.7). Looking at the data, one sees that most participants perceived a very high practical relevance. The boxes are even more crowded than on Transfer

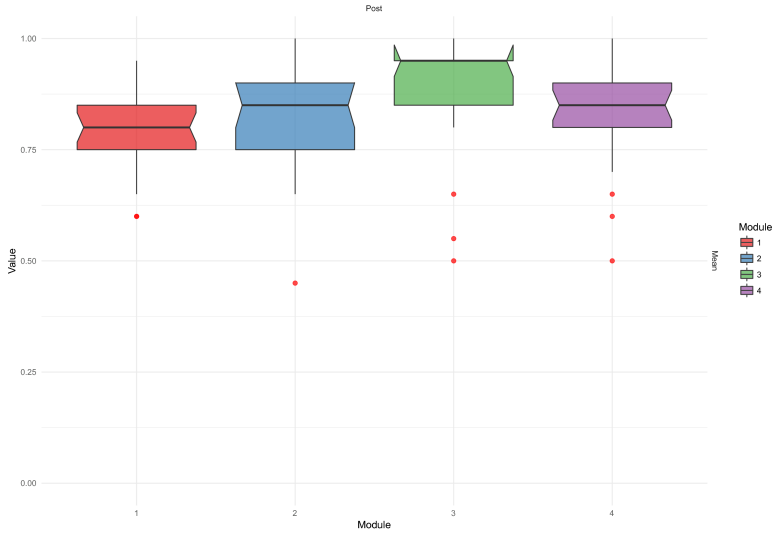


Figure 6.7: All Modules: Practical Relevance

Module	Mean	Median	Standard Deviation	IQR	MAD
1	0.80217	0.8	0.10496	0.1	0.07413
2	0.825	0.85	0.13518	0.15	0.14826
3	0.88	0.95	0.14725	0.1	0.07413
4	$0.83\overline{18}$	0.8	0.15549	0.2	0.07413

Table 6.11: All Modules: Comparison of statistical values of Practical Relevance

Support. What stands out at a glance is that module three differs from the other modules. Due to the high notch, which does not overlap with any of the other module boxes, the median in this module is clearly higher than in the other three.

If you look at the statistical data (Table 6.11) instead of the illustration, it gives a corresponding statement. The mean is clearly higher for module three than for the others. If you look at the median, you see that it differs, because it is not in the eighties, but only 5 percent away from the 100 percent value.

Self-Efficacy

The next variable, self-efficacy, was measured in the Ultimo Questionnaire. Again the box plots show the distribution of the data (Figure 6.8). The boxes are about the same size and the whiskers are also very similar.

The statistical evaluation of the data shows little difference (Table 6.12). Both the mean and medians are very similar, the same applies to the other indicators. A possible explanation for this is that the self-efficacy does not depend on the module but rather on the participants themselves.

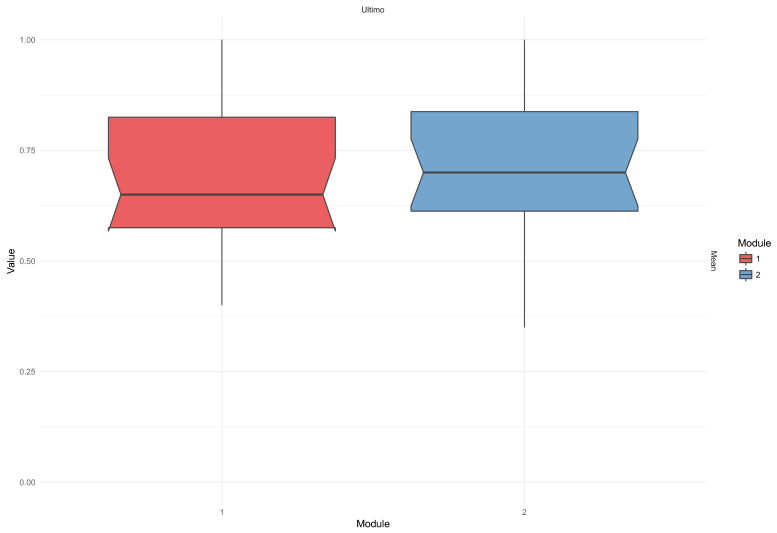


Figure 6.8: Module 1 and 2: Self-Efficacy

Module	Mean	Median	Standard Deviation	IQR	MAD
1	0.69130	0.65	0.17231	0.25	0.14826
2	$0.72\overline{27}$	0.7	0.16236	0.225	0.14826

Table 6.12: Module 1 and 2: Comparison of statistical values of Self-Efficacy

Since most of the employees of the first modules also participated in the second module, there were no major differences between the data to be expected.

Application Possibilities

The application possibilities were also surveyed for the two modules in the Ultimo Questionnaire. In the box plot you can see a difference in this variable between the modules (Figure 6.9). While the application possibilities of module one vary greatly, this is more uniform for module two.

However, looking at the statistical data relating to the mean or to the standard deviation, another picture can be seen (Table 6.13). These metrics are not as different as the median or IQR.

Self-Monitoring

The penultimate value, Self-Monitoring, was measured during the last questionnaire. The box plot shows no big difference between the two data, module one and module two (Figure 6.10). The median is very similar and also the characteristic of the boxing or whiskers are very close.

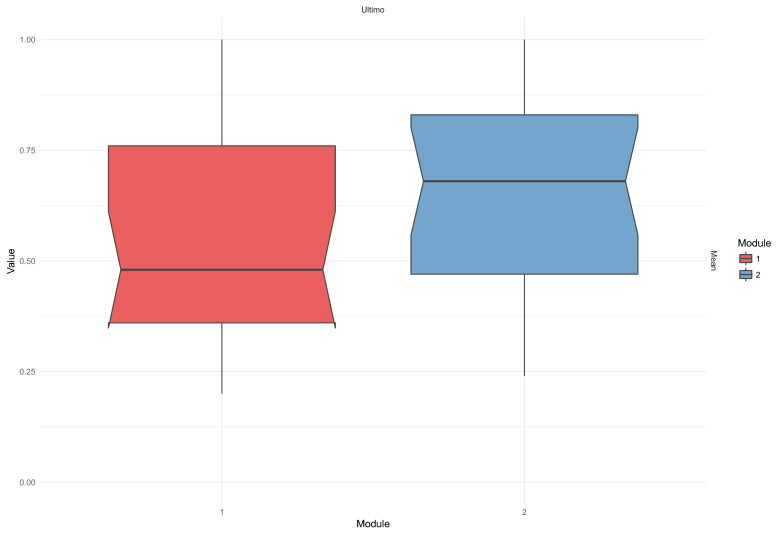


Figure 6.9: Module 1 and 2: Application Possibilities

Module	Mean	Median	Standard Deviation	IQR	MAD
1	0.54260	0.48	0.25062	0.4	0.23721
2	0.64	0.68	0.24126	0.36	0.23721

Table 6.13: Module 1 and 2: Comparison of statistical values of Application Possibilities

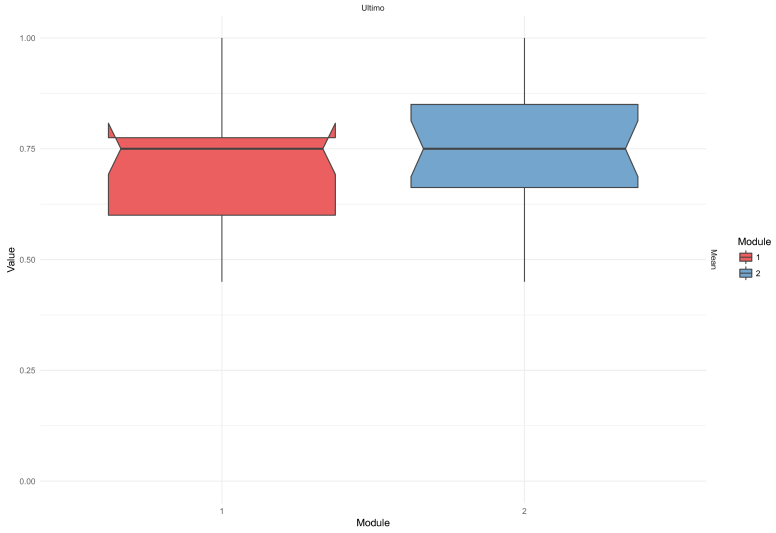


Figure 6.10: Module 1 and 2: Self-Monitoring

Module	Mean	Median	Standard Deviation	IQR	MAD
1	0.71521	0.75	0.12830	0.175	0.14826
2	0.75606	0.75	0.14425	0.1875	0.14826

Table 6.14: Module 1 and 2: Comparison of statistical values of Self-Monitoring

Module	Mean	Median	Standard Deviation	IQR	MAD
1	0.74782	0.8	0.22737	0.4	0.29652
2	$0.77\overline{27}$	0.8	0.16670	0.2	0.29652

Table 6.15: Module 1 and 2: Comparison of statistical values of Transfer

Looking at the most static data, a similar picture can be seen (Table 6.14). Here, too, the differences between the two modules are very small. Had a completely different group of people been interviewed for each module, a different character could have been expected. However, since this is not the case, we do not expect any significant changes in these parameters between the modules, since this value does not depend on the module itself but on the employees.

Transfer

Last but not least, the transfer of the participants was also determined with the help of the Ultimo Questionnaire. The corresponding question is ”Wie beurteilen Sie aus heutiger Sicht den Nutzen von Modul 1 für die Tätigkeit(en) in Ihrem Unternehmen?” (in English: ”From today’s perspective, how do you assess the benefits of Module 1 for the work(s) in your company?”). Although the same question was asked in the Post Questionnaire, we only discuss the data of the Ultimo Questionnaire. The reasons for this are that this Post question was not asked for this thesis but for the organisational management of the DigiTrans course. While this in itself is not a reason for exclusion, the fact that these questionnaires took place at the end of the module and not six months later leads to the final exclusion for the evaluation of this variable. Therefore, we only use the data from the Ultimo Questionnaires. With the corresponding box plot you can see a difference between the two modules (Figures 6.11). The large notch of module one shows that IQR is relatively large while it is smaller in module two. The data of module one is also much more diverse than the corresponding part of module two.

Considering the statistical parameters for the transfer, you can see that these differ very little (Table 6.15). Although the values of the modules appear very similar, the box plot shows that the distribution behind them is different.

After this overview of the measured variables, we now proceed to linear regression. All variables discussed here are used to calculate or explain the transfer.

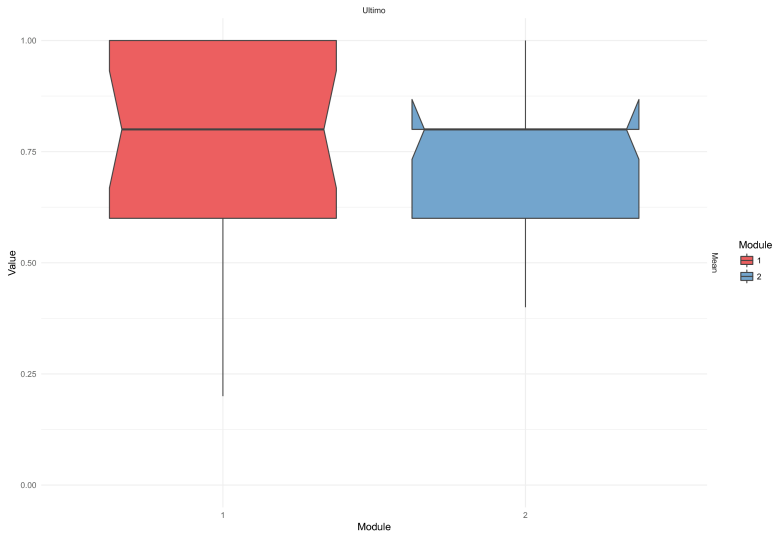


Figure 6.11: Module 1 and 2: Transfer

6.3 Linear Model for the Transfer

As described in the case study section about the questionnaires, there are three different ones. The Pre Questionnaire, which was completed directly before the module. The Post one, which is queried on the last theory day of the unit. Last but not least, the Ultimo Questionnaire was completed six months after the module has ended. Within the questionnaires, various key data relating to the transfer were collected. A brief overview of the data can be found in section transfer variables. The anonymized data can be found in the appendix.

We use linear regression to create a linear model using the ordinary least squares estimator (OLS). In the last questionnaire, Ultimo, the transfer was measured and it is used as the dependent variable. There are four questions that query the variable transfer, but we use only one of them. This relevant item is ”Wie beurteilen Sie aus heutiger Sicht den Nutzen von Modul 1 für die Tätigkeit(en) in Ihrem Unternehmen?” (in English: ”From today’s perspective, how do you assess the benefits of Module 1 for the work(s) in your company?”). The reason for this is that the other three questions also deal with the transfer, but do not deal with its value. For the regression variables, the following parameters are used: The variable Pre Value is the (normalized) state of knowledge before the module. Improvement is the percentage increase in knowledge from the beginning to the end of the module. A hundred percent value means that the participant did not answer a single question correctly at the beginning of the module and was able to answer the knowledge part of the questionnaire correctly throughout. This variable was clearly not measured directly but calculated based on the knowledge of the participants at the end of the module, called Post Value, which is also normalized. From this value, since the questionnaires are not anonymized, the preliminary values were subtracted to represent the improvement of each participant. Transfer willingness is the enthusiasm of the employees to transfer which was measured at the beginning of the module. Although this metric was also measured in the Post

Questionnaire, we use the Pre indicator because it is much more dispersed than the Post variant. Transfer support is the perceived transfer support of the participants, which was measured at the end of the module. The practical relevance of the module was measured in the Post Questionnaire and describes the relevance for the participants' own company work. The Self-Efficacy was measured six months after the end of the module and shows how much the participants' attitude towards their own effectiveness of action is. Furthermore, the possible applications of the individual participants for what they had learned were also asked in this questionnaire. The Self-Monitoring indicator was also surveyed among the participants six months after the end of the module. This variable describes the inner attitude of the participants concerning the transfer.

In addition, the linear models are additionally set up more robust. In this paper we use also an heteroskedasticity corrected linear regression.

Module 1

Using the method described above, we obtain a linear model for module one (Table 6.16).

Looking at the linear model, there are only two significant variables (alpha $\leq 5\%$). One of them is highly significant (alpha $\leq 0.01\%$). We now give a short overview of the parameters resulting from the linear regression. The constant factor has a positive value and a high p-value. It is therefore not that relevant for this model. The knowledge level before the module, Pre Value, is negative and also not significant. This means that participants who start with less previous knowledge in the module have a higher transfer than those who are already better acquainted with the topic. The explanation for this is that there is a higher transfer if the mind being taught does not yet have a prefabricated image about the topic. The knowledge increase, mentioned in the variable description as an improvement, is also negative and not significant. Here one must distinguish between perceived transfer and real transfer. The questionnaires are given to the participants and therefore the perceived transfer is determined. We attribute the negative nature of this variable to the Dunning-Krueger effect [Kruger and Dunning, 1999]. The characteristic of this effect is that people who have little knowledge tend to overestimate themselves and underestimate others. Since the transfer is perceived by the user, this is the reason for the negative sign in front of this variable.

The next variable is transfer willingness, which is significant. Thus, a higher transfer occurs for persons who enter the module with a higher willingness to transfer. This can be explained by the fact that you can do more with a positive attitude than if you approach the matter without motivation [Kaiser, 2003]. Practical relevance is positive and has a high p-value. Our explanation for this is that people who know more about the practical relevance of using the knowledge in the company have a higher transfer therefore than those who are not yet able to classify this. The self-efficacy is negative, but it is just a trend. There are several possible reasons why this variable is negative. The first possible explanation begins with the initial image of people who claim to have low self-efficacy but high transfer. This interpretation declares that the person is insecure, which explains the low self-efficacy, and he or she gets security through the knowledge imparted, which leads to a high transfer. The next possibility is that cause and effect are reversed. The person has brought a lot of knowledge into the company and therefore has a high transfer rate. This made him or her realize that it is difficult to implement everything what has been taught in the training, and that he or she therefore resigns, hence the low self-efficacy.

However, the most significant variable in the linear model by far is the "Application Possibilities". With a p-value of 0.0002, this is highly signifiant and indicates the safest coefficient for the linear model in this module. The linear model for module one is largely based on this variable, since the coefficient of application possibilities is the largest of all in absolute terms.

Last but not least, the self-monitoring variable is also statistically significant. The value of the coefficient is rather low and the p-value rather high. We conclude that this has no great influence on our model and can rather be regarded as background noise. The R^2 value of this model is 0.81467. Thus, the dependent variable transfer can be explained to 81.467% with the help of the other variables.

Variable	Coefficient	Std. Error	p-Value
const	0.56183	0.48933	0.2701
Pre Value	-0.65610	0.46462	0.1797
Improvement	-0.25658	0.17660	0.1683
Transfer Willingness	0.35780	0.16911	0.0528
Transfer Support	-0.26502	0.33824	0.4464
Practical Relevance	0.28571	0.39042	0.4764
Self-Efficiency	-0.57083	0.25924	0.0449
Application Possibilities	0.97126	0.19785	0.0002
Self-Monitoring	0.09726	0.27987	0.3475

Table 6.16: Module 1: Linear Model for the Transfer

When we use a more robust model of module one, also known as an heteroskedasticity corrected linear model, we get slight different data (Table 6.17). When using the heteroskedasticity corrected linear model the general trend of the coefficients stay the same, but the p-value gets even lower, hence more significant. While previously 'only' the variable application possibilities was extremely significant, now the Pre Value, Improvement, Transfer Willingness and Self-Efficiency have also a tiny p-value. Hence, these variables are clearly not background noise but essential components for the model. The R^2 value has likewise increased and now has the value 0,97464. This model thus explains the variable transfer to 97.464% with the eight explanatory variables.

Module 2

For the data of module two, we use the same procedure as for module two. Pre Value, Improvement, Transfer Willingness, Transfer Support, Practical Relevance, Self-Efficiency, Application Possibilities and Self-Monitoring are taken as explanatory variables and Transfer is the dependent variable (Table 6.18). In this model only the constant factor and the Application Possibilities are significant. The standard error for all other variables is too large to be significant. However, this means that all explanatory variables, with the exception of possible applications, cannot be classified as meaningful. The R^2 value is also relatively low at 0.56003, which indicates that this model is not very relevant since only 56.003% of the transfer can be explained by the explanatory variables. This can not be considered a good linear model.

Variable	Coefficient	Std. Error	p-Value
const	0.39970	0.27529	0.1686
Pre Value	-0.81537	0.24614	0.0051
Improvement	-0.31065	0.08369	0.0023
Transfer Willingness	0.48914	0.08769	6,81 e^{-5}
Transfer Support	-0.16254	0.12961	0.2303
Practical Relevance	0.36151	0.27732	0.2134
Self-Efficiency	-0.47467	0.11952	0.0014
Application Possibilities	0.96798	0.08884	3,20 e^{-8}
Self-Monitoring	0.01505	0.15785	0.9254

Table 6.17: Module 1: Linear Model for the Transfer with corrected heteroskedasticity

Variable	Coefficient	Std. Error	p-Value
const	0.87001	0.34180	0.0244
Pre Value	-0.22414	0.27229	0.4253
Improvement	-0.18899	0.44122	0.6754
Transfer Willingness	0.13242	0.30571	0.6720
Transfer Support	-0.61116	0.39754	0.1482
Practical Relevance	-0.06664	0.29426	0.8243
Self-Efficiency	-0.19975	0.36820	0.5966
Application Possibilities	0.64643	0.19321	0.0053
Self-Monitoring	0.16169	0.29549	0.5935

Table 6.18: Module 2: Linear Model for the Transfer

Like for the linear model of module one, we also create an heteroskedasticity corrected model for this module (Table 6.19). The overall tendency changes a bit, but the significance of some of the variables increased dramatically. Now the Pre Value, Improvement, Transfer Willingness, Transfer Support and the Self-Efficiency are significant. While for Improvement, Transfer Willingness and Self-Efficiency the alpha is "only" 5%, the new alpha for Pre Value is 0.0003 and for the Application Possibilities it is 1,61 e^{-7}. While the previous R^2 value for the linear model was okay at best, it rose drastically to 0.95044. This significant improvement shows that 95.044% of the transfer variable for module two can be described by the explanatory variables. Comparing this linear model with that of module one, one realizes that the tendency of the models is very similar. The only difference is that the practical relevance of this module is negative while it is positive for the first one. The same variables are significant for these two models, although the degree of significance varies greatly. While the transfer willingness of the first module is highly significant the corresponding variable of module two is only significant. The main finding, however, is that it looks as if the models from the two modules have a similar formula behind them. This could be explained by the fact that they do not measure the module itself, but rather the parameters that are decisive for the transfer.

Variable	Coefficient	Std. Error	p-Value
const	0.54145	0.23868	0.0410
Pre Value	-0.63744	0.12807	0.0003
Improvement	-0.87427	0.29814	0.0117
Transfer Willingness	0.38060	0.13165	0.0126
Transfer Support	-0.46896	0.21700	0.0499
Practical Relevance	-0.19809	0.13567	0.1680
Self-Efficiency	-0.44543	0.19785	0.0423
Application Possibilities	0.84772	0.08397	1,61 e^{-7}
Self-Monitoring	0.60554	0.18237	0.0055

Table 6.19: Module 2: Linear Model for the Transfer with corrected heteroskedasticity

Module 3 and 4

The transfer measurements are also carried out for Module 3 and 4. However, these measurements and evaluations are carried out after completion of the work. The reason for this is that the Ultimo measurement is only carried out six months after completion of the module and this time has not yet elapsed at the time this thesis is done.

CHAPTER 7

Review of the Framework

In this thesis, a framework that measures the transfer of employees was created using the Design Science approach. Subsequently this framework was used within a case study. The focus of this chapter is on the detailed review of the framework. As described in section Framework Development by the Design Science Approach in the chapter Research Question the framework was subject to certain requirements, so we need to discuss them and their compliance. A short overview for both requirements are:

- The framework must be adaptable
- The collection of data may not take more than half an hour per session.

7.1 Adaptable

Since the framework was used in four of the six modules, it had to be adapted to each of them. We had to choose between different levels of granularity. If we make the questionnaire fully customizable to the respective module, it has better coverage for the module, but it also costs more time and effort to adapt it to another module. Furthermore, there is still the danger that if the framework is designed too fine granular, no framework is created, but only many rules that fit the respective modules. If, however, there is no adaptability for the individual modules, one can not speak of a framework, but should rather refer to a static artefact. That is why we have opted for the middle way. Therefore, we have taken a synthesis on the different approaches described in the State of the Art. We have noticed several places where an adaptability fits well and we selected these passages. Afterwards we integrated them into the framework. This predefined questions clearly refer to a module or the contents contained therein. The questions that have to be adapted to the respective module are listed in the appendix chapter in the respecting subsections.

However, the main question is how best to define if the flexibility of the framework is appropriate. Thus, we have imposed an additional requirement for testing the adaptability of the

framework. The adjustment from one module to another should take between half an hour and one hour. This is to ensure that the adjustments are neither too subtle nor too severe. The questions have also been designed so that they do not directly relate to a module but can also be directed to other similar subjects. This avoids the framework being applicable only in the case study and not in similar environments. The time it took for the adjustments between the modules did not exceed the time span set by us before. Of course we had to consult with the module leaders to get the necessary information regarding the module before the change. We expected this since the four modules are very different and the thought topics was not known to use before. This time is not taken into account, as it does not reflect the adaptability of the framework, but the previous knowledge of the operators of the framework in relation to the topic or context.

The next quality feature of the adaptions is that they are only made available where necessary. This means that if questions concern a person's characteristics, they are not adaptable, as this does not depend on the teaching environment. As can be seen in the chapter appendix, only the questions that refer to a module or its content are customizable. All questions relating to the participant himself or herself have not been designed for this purpose. Hence, this requirement is also fulfilled by our framework.

The third and final requirement regarding adaptability is that it must also be flexible enough to meet the requirements for the case study. Our objective for this was, that with the four modules, which were covered with the help of this framework, no problems arise with regard to adaptability. If it were not possible to adapt the questions to the module, this would be an exclusion reason for this implementation of the framework. Throughout the use of the tool there has not been a single such incident, which is why we consider this requirement to have been met.

Finally, it can be said that the framework is expected to be adaptable for similar courses or in similar environments and meets all related needs.

7.2 Time efficient

If the framework is used, it must be completed by the participants within half an hour in order not to interfere with the case study progress. Due to this requirement, we had to keep the framework short and lean without losing too much substance. We have therefore identified existing approaches and incorporated the commonalities into the framework. Most of this can be traced back to Seidel [Seidel, 2012] and Grossman and Salas [Grossman and Salas, 2011]. The detailed summary can be found in the subsection Selection of existing approaches of the State of the Art chapter.

Our selection criterion for the assessment of this requirement was the observation of the participants with regard to the time taken to complete the questionnaire, as it was created with the help of the framework. The participants concerned should then be approached afterwards and asked what they thought was the problem so that we could improve this in the next iteration.

Each time the framework was used, at least 20 participants used it, which is a sufficiently large sample. For all 87 operations of the questionnaires, the time period of half an hour was not exceeded. Therefore, we could not improve the framework in this respect, as we were always within the desired time frame. Thus, we regard this requirement as fulfilled.

CHAPTER 8

Conclusion

In this chapter we give an overview of our work. We start by recapitulating our research question and methodology. The framework created and the data obtained in the case study are discussed. Afterwards we deal with the limitations of this work. Finally, we discuss interesting possible future work in this area that would result from this work.

8.1 Summary

Our goal was to create a framework that measures the transfer of participants in an innovation course [Pflügl and Pichler-Rohrhofer, 2015]. There are several ways to measure transfer, as shown in the selection of existing approaches section, but none that would have fulfilled the requirements we had to meet. The requirements for this framework are that it provides adjustments for the different applications, but does not interrupt too much when the measurement is performed. Therefore, we had to developed a framework that meets these needs.

Through literature research and applying the Design Science Approach, we have developed a framework that measures the change in knowledge and the participants transfer. Using the framework, we have developed three questionnaires that cover this task. The first questionnaire, Pre, was distributed to the participants on the innovation course by the first unit of the four modules. The aim of this questionnaire is to measure the previous knowledge of the participants as well as the transfer willingness of the individual persons. The name of the second questionnaire is Post and it was obtained at the end of the modules. The knowledge of the participants at the end of the modules, the practical relevance perceived by the participants and the transfer support were measured. In addition, the transfer readiness was measured again. The third and last questionnaire, called Ultimo, was issued to the participants six months after the end of the modules. Only transfer variables such as (i) self-efficacy, (ii) application possibilities and (iii) self-control were asked for. Of course, the transfer itself was also measured.

These questionnaires were then used in the case study, an innovation course called Digi-Trans 4.0. The created artefact was used in four of the six modules. Looking at the knowledge

changes within the first two modules, one can see a clear improvement. This improvement cannot be shown in the third module with the measured data. To describe the transfer we used linear regression. The linear models of module one and two give a similar, though not identical, picture. While in module one the factors such as (i) willingness to transfer, (ii) self-efficiency and (iii) application possibilities stand out significantly, this is different in module two. Only the constant and the application options are relevant for that module. However, if the linear regression is applied with corrected heteroskedasticity, the result get more uniform. In both cases the coefficient of determination R^2 increases, for module two even strongly. Looking at the variables, they become even more important. For module one (i) the previous knowledge, (ii) improvement and (iii) practical relevance become signifiant. The significant variables so far are now even becoming highly significant. For the model of module two the (i) previous knowledge, (ii) improvement and (iii) self-monitoring get significant. As by module one, the application possibilities get highly significant. Comparing these models, it is very clear that there is a similar formula behind both models. However, the exact formula can not be seen, as the two models are still slightly different from each other. However, it can be considered that we measure the real parameters of the transfer, since the results of the model correspond to the data from the literature.

All the requirements placed on the framework were covered. In order to make the framework flexible, certain questions were designed to be adaptable to the context. This is listed in the appendix in the tables for the individual questionnaires. This adaptability means that the framework can also be used in similar environments. In order that the measurement interrupted too much, we have set ourselves a maximum time limit that a participant may need to complete the individual questionnaires. If this would not be met, then there were steps to adapt the framework. However, since none of the measurements exceeded the time, they were not performed.

In summary, the goal of creating a framework that measures the transfer was successful, as was the creation of the linear models about the transfer.

8.2 Limitations

When discussing the results of a work, the limitations must also be mentioned. Some of them are caused by the application environment, others by the goal of the work.

The first limitation comes from the basic orientation of the work itself and should be clearly emphasized. Even though the transfer was measured with the help of the framework, this should not be an attempt to redefine the variables for it. This is not an educational science work that tries to find other variables that are important for the transfer. The aim was to measure the transfer itself and explain it by other variables already known in the literature. No new territory in educational science was explored, as this was not the goal of the work.

The second limitation comes from the environment of the case study. The participants were not selected by us but were fixed. Therefore, a possible restriction can be seen in the participants: All of them were male. Even if the questions are asked without consideration of gender, the absence of women can still restrict the validity of the framework.

Third, the linear regression has only been created for this course and its participants. The aim is not to make a statement about the public or global learning and transfer behaviour. This

is to be especially mentioned, as the ”synthesis” in the transfer is a problem and there are often ”mixed findings” [Blume et al., 2009].

8.3 Future Work

There are also topics in this work that need to be worked on further.

Even if both the framework and the questionnaire were not created for one gender, unfortunately there were only male participants in the case study. It is therefore very interesting whether the results can also be repeated for a more mixed field of participants or whether this is not the case.

Secondly, the framework was deployed in several modules, but only in one innovation course. To further test the adaptability and the framework itself, it takes more than four applications. Even if all the requirements of the case study are met, this does not always have to be the case. Therefore, wider distribution and application of the framework would be very valuable to further review and improve it as needed.

Thirdly, the sample size of the participants should be increased in order to be able to make more precise statements. Even if 25 participants are not a small sample, a repetition with other and more people could lead to new information. As mentioned earlier, a more even ratio of men and women might also provide new details.

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APPENDIX A

Appendix

A.1 Questionnaires

As already mentioned earlier, the questionnaires are published in this thesis. Since the case study took place in Vienna, Austria, and the participants speak German, the questionnaires are also in German. The questions in the questionnaires are asked very precisely and would lose their expressiveness if they were translated into English. That is why we have decided to publish them in German despite the possible language barrier. Furthermore we decided to publish only the questionnaires of Module one, because the others are very similar to these. If one question is module specific, it is adapted to the other module. This is done either by replacing the text 'Modul eins' (in English: Module one) with 'Modul zwei' (in English: Module two) or by adapting the context of the statement to the new module. The exact changes are shown in the corresponding questionnaire table.

Pre Questionnaire

As described in the case study, the Pre Questionnaire was completed shortly before the beginning of the first unit of each module. The questionnaire of module one is displayed below and the changes for the other three modules are shown in the table A.1.

DigiTrans 4.0

Name: ____

	Trifft überhaupt nicht zu	Trifft kaum zu	Trifft eher nicht zu	Trifft eher zu	Trifft überwiegen zu	Trifft voll zu
Ich will neu Gelerntes möglichst schnell im Arbeitsalltag ausprobieren.	◯	◯	◯	◯	◯	◯
Wenn ich an meine zukünftige Arbeit mit Product-Lifecycle-Management (PLM) denke, spüre ich Vorfreude.	◯	◯	◯	◯	◯	◯
Die Arbeit mit PLM macht mir Freude.	◯	◯	◯	◯	◯	◯
Die Arbeit mit PLM ist in meinen Augen eine sehr interessante Aufgabe.	◯	◯	◯	◯	◯	◯

Question	Module	Text
2	1	Wenn ich an meine zukünftige Arbeit mit Product-Lifecycle-Management (PLM) denke, spüre ich Vorfreude.
2	2	Wenn ich an meine zukünftige Arbeit mit Modellen oder Methoden zur digitalen Transformation denke, spüre ich Vorfreude.
2	3	Industrielle Kommunikation und automatisierte Fertigungssysteme sind sehr wichtig für meine(n) Tätigkeitsbereich(e).
2	4	Wertschöpfungsnetzwerke sind sehr wichtig für meine(n) Tätigkeitsbereich(e).
3	1	Die Arbeit mit PLM macht mir Freude.
3	2	Die Arbeit mit Modellen oder Methoden zur digitalen Transformation macht mir Freude.
3	3	Die Arbeit mit Industrieller Kommunikation und automatisierten Fertigungssystemen macht mir Freude.
3	4	Die Arbeit mit Wertschöpfungsnetzwerken macht mir Freude.
4	1	Die Arbeit mit PLM ist in meinen Augen eine sehr interessante Aufgabe.
4	2	Die Arbeit mit Modellen oder Methoden zur digitalen Transformation ist in meinen Augen eine sehr interessante Aufgabe.
4	3	Die Arbeit mit Industrieller Kommunikation und automatisierten Fertigungssystemen ist in meinen Augen eine sehr interessante Aufgabe.
4	4	Die Arbeit mit Wertschöpfungsnetzwerken ist in meinen Augen eine sehr interessante Aufgabe.

Table A.1: Pre Questionnaire: Changes of the module specific statements

Post Questionnaire

The Post Questionnaire was given to the participants at the end of the module. This did not happen on the last day but in the last theory session, the reason is that the practical sessions usually did not allow one to fill the questionnaires. Also here the questionnaire of module one is illustrated and the changes for the other modules are listed in the table A.2.

Name: _____

Sollte Sie eine Frage nicht betreffen so lassen Sie diese bitte aus.

	Trifft überhaupt nicht zu	Trifft kaum zu	Trifft eher nicht zu	Trifft eher zu	Trifft überwiegend zu	Trifft voll zu
Ich will neu Gelerntes möglichst schnell im Arbeitsalltag ausprobieren.	○	○	○	○	○	○
Wir haben im Modul 1 Methoden und Werkzeuge kennengelernt, die uns helfen sollen, auf unvorhergesehene Probleme zu reagieren.	○	○	○	○	○	○
Das Modul 1 hat mich fachlich ein gutes Stück voran gebracht.	○	○	○	○	○	○
Product-Lifecycle-Management (PLM) ist sehr wichtig für meine(n) Tätigkeitsbereich(e).	○	○	○	○	○	○
Wir haben im Modul 1 besprochen, wie verschiedene PLM-Problemstellungen – wie z.B. Varianten- und Konfigurationsmanagement - adressiert werden können.	○	○	○	○	○	○
Die Übungseinheiten haben mir einen guten Eindruck vermittelt, wie man PLM in der Praxis einsetzten kann.	○	○	○	○	○	○
Mir ist der Nutzen, den der richtige Einsatz von PLM-Methoden und –Werkzeugen bringt, klarer geworden.	○	○	○	○	○	○
Der Vortragende hat uns darauf hingewiesen, wo bei der Umsetzung einer PLM-Strategie in Unternehmen häufig Probleme auftreten.	○	○	○	○	○	○
Ich fand das Modul 1 wenig praxistauglich.	○	○	○	○	○	○
Die Arbeit mit PLM ist in meinen Augen eine sehr interessante Aufgabe.	○	○	○	○	○	○
Die Arbeit mit PLM macht mir Freude.	○	○	○	○	○	○

	Gar nicht nützlich	Kaum nützlich	Eher wenig nützlich	Eher nützlich	Überwiegend nützlich	Sehr nützlich
Wie beurteilen Sie aus heutiger Sicht den Nutzen des Modul 1 für die Tätigkeit(en) in Ihrem Bereich(en)?	○	○	○	○	○	○

Question	Module	Text
2	1	Wir haben im Modul 1 Methoden und Werkzeuge kennengelernt, die uns helfen sollen, auf unvorhergesehene Probleme zu reagieren.
2	2	Wir haben im Modul 2 Strategien entwickelt, die uns helfen können, auf unvorhergesehene Probleme zu reagieren.
2	3	Wir haben im Modul 3 Strategien entwickelt, die uns helfen können, auf unvorhergesehene Probleme zu reagieren.
2	4	Wir haben im Modul 4 Strategien entwickelt, die uns helfen können, auf unvorhergesehene Probleme zu reagieren.
3	1	Das Modul 1 hat mich fachlich ein gutes Stück vorangebracht.
3	2	Das Modul 2 hat mich fachlich ein gutes Stück vorangebracht.
3	3	Das Modul 3 hat mich fachlich ein gutes Stück vorangebracht.
3	4	Das Modul 4 hat mich fachlich ein gutes Stück vorangebracht.
4	1	Product-Lifecycle-Management (PLM) ist sehr wichtig für meine(n) Tätigkeitsbereich(e).
4	2	Modelle und Methoden zur digitalen Transformation sind sehr wichtig für meine(n) Tätigkeitsbereich(e).
4	3	Industrielle Kommunikation und automatisierte Fertigungssysteme sind sehr wichtig für meine(n) Tätigkeitsbereich(e).
4	4	Wertschöpfungsnetzwerke und elektronischer Datenaustausch sind sehr wichtig für meine(n) Tätigkeitsbereich(e).
5	1	Wir haben im Modul 1 besprochen, wie verschiedene PLM-Problemstellungen – wie z.B. Varianten- und Konfigurationsmanagement - adressiert werden können.
5	2	Wir haben im Modul 2 besprochen, wie künftige Probleme mit Modellen und Methoden zur digitalen Transformation gelöst werden können.
5	3	Wir haben im Modul 3 besprochen, wie künftige Probleme mit Industrieller Kommunikation und automatisierten Fertigungssystemen gelöst werden können.
5	4	Wir haben im Modul 4 besprochen, wie künftige Probleme mit elektronischen Datenaustausch gelöst werden können.
6	1	Die Übungseinheiten haben mir einen guten Eindruck vermittelt, wie man PLM in der Praxis einsetzten kann.
6	2	Die Übungseinheiten haben mir einen guten Eindruck vermittelt, wie man Modelle und Methoden zur digitalen Transformation in der Praxis einsetzten kann.
6	3	Die Übungseinheiten haben mir einen guten Eindruck vermittelt, wie man Industrielle Kommunikation und automatisierte Fertigungssysteme in der Praxis einsetzten kann.
6	4	Die Übungseinheiten haben mir einen guten Eindruck vermittelt, wie man Wertschöpfungsnetzwerke und elektronischen Datenaustausch in der Praxis einsetzen kann.

Question	Module	Text
7	1	Mir ist der Nutzen, den der richtige Einsatz von PLM-Methoden und –Werkzeugen bringt, klarer geworden.
7	2	Mir ist der Nutzen der einzelnen Anwendungsmöglichkeiten von Metamodellen, Transformationen und Austauschformaten klarer geworden.
7	3	Mir ist der Nutzen von semantischen Schnittstellen insbesondere zur leichteren Integration von Maschinen in der industriellen Fertigung klarer geworden.
7	4	Mir ist der Nutzen von Wertschöpfungsnetzwerken und elektronischem Datenaustausch klarer geworden.
8	1	Der Vortragende hat uns darauf hingewiesen, wo bei der Umsetzung einer PLM-Strategie in Unternehmen häufig Probleme auftreten.
8	2	Der Vortragende hat uns darauf hingewiesen, welche Probleme bei der Anwendung von modellgetriebenen Ansätzen auftreten können.
8	3	Der Vortragende hat uns darauf hingewiesen, dass Informationssicherheit (Security) eines durchgängigen Konzeptes bedarf und nicht auf die Installation einer einzigen Komponente, z.B. einer Firewall, reduziert werden kann.
8	4	Der Vortragende hat uns darauf hingewiesen, welche Probleme bei der Anwendung von elektronischem Datenaustausch auftreten können.
9	1	Ich fand das Modul 1 wenig praxistauglich.
9	2	Ich fand das Modul 2 wenig praxistauglich.
9	3	Ich fand das Modul 3 wenig praxistauglich.
9	4	Ich fand das Modul 4 wenig praxistauglich.
10	1	Die Arbeit mit PLM ist in meinen Augen eine sehr interessante Aufgabe.
10	2	Die Arbeit mit Modellen und Methoden zur digitalen Transformation ist in meinen Augen eine sehr interessante Aufgabe.
10	3	Die Arbeit mit Industrieller Kommunikation und automatisierten Fertigungssystemen ist in meinen Augen eine sehr interessante Aufgabe.
10	4	Die Arbeit mit Wertschöpfungsnetzwerken und elektronischem Datenaustausch ist in meinen Augen eine sehr interessante Aufgabe.
11	1	Die Arbeit mit PLM macht mir Freude.
11	2	Die Arbeit mit Modellen und Methoden zur digitalen Transformation macht mir Freude.
11	3	Die Arbeit mit Industrieller Kommunikation und automatisierten Fertigungssystemen macht mir Freude.
11	4	Die Arbeit mit Wertschöpfungsnetzwerken und elektronischem Datenaustausch macht mir Freude.
12	1	Wie beurteilen Sie aus heutiger Sicht den Nutzen des Modul 1 für die Tätigkeit(en) in Ihrem Bereich(en)?
12	2	Wie beurteilen Sie aus heutiger Sicht den Nutzen des Modul 2 für die Tätigkeit(en) in Ihrem Bereich(en)?

Question	Module	Text
12	3	Wie beurteilen Sie aus heutiger Sicht den Nutzen des Modul 3 für die Tätigkeit(en) in Ihrem Bereich(en)?
12	4	Wie beurteilen Sie aus heutiger Sicht den Nutzen des Modul 4 für die Tätigkeit(en) in Ihrem Bereich(en)?

Table A.2: Post Questionnaire: Changes of the module specific statements

Ultimo Questionnaire

Six months after the completion of a module, the final questionnaire was surveyed. The participants were reminded of the module with the help of the module title, the name of the module leader and the discussed and taught topics, so that they could answer the questions more precisely. The two page questionnaire of module one is displayed and the differences between the statements of the Likert scale are referenced in table A.3.

Name: _____

Sollte Sie eine Frage nicht betreffen so lassen Sie diese bitte aus.

Bildungscontrolling	Trifft überhaupt nicht zu	Trifft kaum zu	Trifft eher nicht zu	Trifft eher zu	Trifft überwiegend zu	Trifft voll zu
Ich traue mir jetzt fachlich zu, komplexere Product-Lifecycle-Management (PLM)-Aufgaben zu übernehmen oder umzusetzen.	○	○	○	○	○	○
Ich setze das im Kurs Gelernte bereits in meinem Arbeitsalltag ein.	○	○	○	○	○	○
Mit vielem aus den Lehreinheiten von Modul 1 wurde ich in der Praxis bereits konfrontiert.	○	○	○	○	○	○
Um selbstständig komplexe Aufgaben mit PLM durchführen zu können bräuchte ich noch detaillierteres Wissen.	○	○	○	○	○	○
Ich traue mir zu, das Gelernte am Arbeitsplatz selbstständig anzuwenden.	○	○	○	○	○	○
Ich weiß oft nicht, wie ich mit auftretenden Schwierigkeiten bei der Anwendung des Gelernten umgehen soll.	○	○	○	○	○	○
Ich fühle mich noch nicht bereit, komplizierte PLM-Aufgaben ohne Unterstützung durchzuführen.	○	○	○	○	○	○
Ich habe einen Weg gefunden mit dem ich Barrieren, die die Anwendung des Gelernten verhindern, aus dem Weg räumen kann.	○	○	○	○	○	○
Ich bin seit Sommer 2017 mit verschiedenen PLM Aufgaben beschäftigt.	○	○	○	○	○	○
Es gibt immer eine Möglichkeit, Hindernisse zu überwinden, die die Anwendung des Gelernten blockieren.	○	○	○	○	○	○
Ich habe Aufgaben übertragen bekommen, die mit dem Gelernten aus Modul 1 zu tun haben.	○	○	○	○	○	○
Wenn sich Barrieren auftun, die eine Anwendung des Gelernten am Arbeitsplatz blockieren, kann ich es nicht verhindern.	○	○	○	○	○	○
Ich habe nach dem Kurs im betrieblichen Umfeld Anwendungsmöglichkeiten gefunden, in denen ich das Gelernte einsetzten kann.	○	○	○	○	○	○

Transfer	Gar nicht	Kaum	Eher wenig	Eher ja	Überwiegend ja	Ja
Haben Sie versucht, das Wissen und die erlernten Vorgehensweisen aus Modul 1 in Ihre Arbeitstätigkeit einzubinden?	◯	◯	◯	◯	◯	◯
In wie weit ist Ihnen eine Anwendung des Gelernten gelungen?	◯	◯	◯	◯	◯	◯

Bitte schätzen Sie: Wie viel Prozent des Gelernten haben Sie bereits angewendet?	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

	Gar nicht nützlich	Kaum nützlich	Eher wenig nützlich	Eher nützlich	Überwiegend nützlich	Sehr nützlich
Wie beurteilen Sie aus heutiger Sicht den Nutzen von Modul 1 für die Tätigkeit(en) in Ihrem Unternehmen?	◯	◯	◯	◯	◯	◯

Beschreiben Sie mit Stichworten Ihre bisherigen **Verwertungsaktivitäten** hinsichtlich der Themen aus Moduls 1: (z.B. Qualifizierungsmaßnahmen im Unternehmen)

Beschreiben Sie mit Stichworten Ihre bisherigen **Weiterverbreitungsaktivitäten** hinsichtlich der Themen aus Moduls 1: (z.B. Kunden, Events)

Question	Module	Text
1	1	Ich traue mir jetzt fachlich zu, komplexere Product-Lifecycle-Management (PLM)-Aufgaben zu übernehmen oder umzusetzen.
1	2	Ich traue mir jetzt fachlich zu, komplexere Aufgaben zu übernehmen, die sich mit den Themeninhalten aus Modul 2 beschäftigen.
3	1	Mit vielem aus den Lehreinheiten von Modul 1 wurde ich in der Praxis bereits konfrontiert.
3	2	Mit vielem aus den Lehreinheiten von Modul 2 wurde ich in der Praxis bereits konfrontiert.
4	1	Um selbstständig komplexe Aufgaben mit PLM durchführen zu können bräuchte ich noch detaillierteres Wissen.
4	2	Um selbstständig Aufgaben im Themenbereich "Modelle und Methoden zur digitalen Transformation" durchführen zu können, bräuchte ich noch detaillierteres Wissen.
7	1	Ich fühle mich noch nicht bereit, komplizierte PLM-Aufgaben ohne Unterstützung durchzuführen.
7	2	Ich fühle mich noch nicht bereit, die im Modul 2 gelernten Methodiken ohne fachliche Unterstützung durchzuführen.
9	1	Ich bin seit Sommer 2017 mit verschiedenen PLM Aufgaben beschäftigt.
9	2	Ich bin seit Sommer 2017 mit verschiedenen Aufgaben betraut, die sich mit Modellen, Modellgetriebener Entwicklung, Modelltransformationen oder Methoden zur digitalen Transformation befassen.
11	1	Ich habe Aufgaben übertragen bekommen, die mit dem Gelernten aus Modul 1 zu tun haben.
11	2	Ich habe Aufgaben übertragen bekommen, die mit dem Gelernten aus Modul 2 zu tun haben.
13	1	Haben Sie versucht, das Wissen und die erlernten Vorgehensweisen aus Modul 1 in Ihre Arbeitstätigkeit einzubinden?
13	2	Haben Sie versucht, das Wissen und die erlernten Vorgehensweisen aus Modul 2 in Ihre Arbeitstätigkeit einzubinden?
16	1	Wie beurteilen Sie aus heutiger Sicht den Nutzen von Modul 1 für die Tätigkeit(en) in Ihrem Unternehmen?
16	2	Wie beurteilen Sie aus heutiger Sicht den Nutzen von Modul 2 für die Tätigkeit(en) in Ihrem Unternehmen?
17	1	Beschreiben Sie mit Stichworten Ihre bisherigen Verwertungsaktivitäten hinsichtlich der Themen aus Moduls 1: (z.B. Qualifizierungsmaßnahmen im Unternehmen)
17	2	Beschreiben Sie mit Stichworten Ihre bisherigen Verwertungsaktivitäten hinsichtlich der Themen aus Moduls 2: (z.B. Qualifizierungsmaßnahmen im Unternehmen)
18	1	Beschreiben Sie mit Stichworten Ihre bisherigen Weiterverbreitungsaktivitäten hinsichtlich der Themen aus Moduls 1: (z.B. Kunden, Events)

Question	Module	Text
18	2	Beschreiben Sie mit Stichworten Ihre bisherigen Weiterverbreitungsaktivitäten hinsichtlich der Themen aus Moduls 2: (z.B. Kunden, Events)

Table A.3: Ultimo Questionnaire: Changes of the module specific statements

A.2 Data of the Questionnaires

The data of the questionnaires are discussed and presented in this section. The users are made anonymous due to the publication of the results. The individual questions of the questionnaires are converted into different variables. The mapping is described in the table A.4.

The following steps were taken to convert the data from the questionnaires into the data provided (Table A.5, A.6): The individual Likert scales were normalized and an equal distance was assumed between the response options. If more than one question was asked for a variable, the mean value was used as an indicator for this parameter. Questions that were not answered in the questionnaire were interpreted as not available and were not used for averaging. It was very rare that a question was not answered and when it occurred, only one of the questions in a questionnaire was not answered by any participant.

Questionnaire	Variable	Question Numbers
Pre	Transfer Willingness	1, 2, 3, 4
Post	Transfer Willingness	1, 4, 10, 11
Post	Transfer Support	2, 5, 8
Post	Practical Relevance	3, 6, 7, 9
Post	Transfer	12
Ultimo	Self-Efficiency	1, 4, 5, 6
Ultimo	Application Possibilities	2, 3, 9, 11, 13
Ultimo	Self-Monitoring	6, 8, 10, 12
Ultimo	Transfer Attempted	14
Ultimo	Transfer Succeeded	15
Ultimo	Transfer Percentage	16
Ultimo	Transfer	17

Table A.4: All Questionnaires: Mapping of Questions to Variables

Name	Module	Pre Value	Post Value	Pre Transfer Willingness	Post Transfer Willingness	Post Transfer Support	Post Practical Relevance	Post Transfer	Ultimo Transfer	Ultimo Self-Efficacy	Ultimo Application Possibilities	Ultimo Self-Monitoring	Ultimo Transfer Attempted	Ultimo Transfer Succeeded	Ultimo Transfer Percentage
User 01	1	0.5	0.5	0.4	0.5	0.6	0.6	0.6	0.6	0.65	0.36	0.75	0.6	0.4	0.2
User 02	1	0.6	0.6	1	0.95	$0.8\overline{6}$	0.8	0.8	1	0.7	0.88	0.7	0.8	0.6	0.7
User 03	1	0.5	0.6	0.3	0.4	0.6	0.8	0.4	0.6	0.55	0.6	0.65	0.6	0.6	0.5
User 04	1	0.3	0.3	0.8	0.75	$0.8\overline{6}$	0.95	0.8	1	0.75	0.48	0.6	0.8	0.8	0.3
User 05	1	0.1	0.6	0.65	0.65	0.8	0.85	0.8	0.8	0.55	0.4	0.8	0.4	0.6	0.4
User 06	1	0.3	0.2	0.8	0.7	$0.9\overline{3}$	0.95	0.8	1	0.85	0.76	0.75	0.8	0.6	0.5
User 08	1	0.5	0.8	0.95	0.6	$0.4\overline{6}$	0.8	0.6	0.4	0.85	0.24	0.6	0.6	0.2	0.3
User 09	1	0.2	0.8	0.7	0.55	$0.8\overline{6}$	0.95	0.4	0.6	0.65	0.4	0.75	0.6	0.6	0.2
User 10	1	0.5	0.6	0.4	0.65	0.6	0.6	0.6	0.8	0.5	0.56	0.8	0.6	0.6	0.5
User 11	1	0.3	0.4	0.8	0.65	0.8	0.85	0.8	0.6	0.75	0.28	0.55	0.2	0	0
User 12	1	0.3	0.4	0.55	0.4	$0.7\overline{3}$	0.75	0.4	0.2	0.65	0.24	0.7	0.4	0.2	0.2
User 13	1	0.2	0.7	0.6	0.7	0.8	0.75	0.6	0.6	0.45	0.2	0.6	0.4	0.6	0.2
User 14	1	0.5	0.6	0.45	0.7	$0.6\overline{6}$	0.65	0.8	0.8	0.4	0.6	0.45	0.6	0.4	0.2
User 15	1	0.5	0.6	0.95	1	$0.8\overline{6}$	0.8	1	1	1	1	0.75	1	1	1
User 16	1	0.5	0.5	0.65	0.7	$0.7\overline{3}$	0.75	0.8	0.8	0.95	0.84	0.85	0.8	1	0.9
User 17	1	0.2	0.6	0.4	0.4	0.8	0.85	0.8	0.6	0.6	0.4	0.65	0.8	0.4	0.2
User 18	1	0.4	0.4	0.75	0.7	$0.6\overline{6}$	0.7	0.8	0.6	0.6	0.4	0.6	0.6	0.4	0.3
User 19	1	0.4	0.6	$0.7\overline{3}$	0.6	$0.6\overline{6}$	0.95	0.8	1	0.9	0.76	0.9	1	0.8	0.6
User 20	1	0.4	0.7	0.85	0.85	0.8	0.8	0.8	1	0.75	0.84	0.75	0.8	0.8	0.8
User 21	1	0.3	0.6	$0.9\overline{3}$	0.85	$0.7\overline{3}$	0.8	0.8	1	0.45	0.56	0.75	0.6	1	0.6

Name	Module	Pre Value	Post Value	Pre Transfer Willingness	Post Transfer Willingness	Post Transfer Support	Post Practical Relevance	Post Transfer	Ultimo Transfer	Ultimo Self-Efficacy	Ultimo Application Possibilities	Ultimo Self-Monitoring	Ultimo Transfer Attempted	Ultimo Transfer Succeeded	Ultimo Transfer Percentage
User 22	1	0.5	0.8	1	1	1	0.75	1	1	0.95	1	1	1	1	1
User 23	1	0.4	0.3	$0.7\overline{3}$	0.65	$0.7\overline{3}$	0.8	0.8	0.6	0.8	0.36	0.9	0.8	0.6	0.3
User 24	1	0.3	0.5	0.6	0.85	$0.8\overline{6}$	0.95	0.8	0.6	0.6	0.32	0.6	0.4	0.4	0.3
User 25	2	$0.1\overline{3}$	$0.2\overline{6}$	0.75	0.9	$0.9\overline{3}$	0.95	1	1	0.95	0.92	0.95	1	0.8	0.7
User 26	2	0	$0.2\overline{6}$	0.6	0.4	$0.6\overline{6}$	0.95	0.6	0.6	0.35	0.24	0.9	0.4	0.2	0.2
User 27	2	0.4	$0.5\overline{3}$	0.8	0.9	$0.8\overline{6}$	0.9	1	0.8	0.7	0.92	0.9	0.8	0.6	0.8
User 28	2	$0.2\overline{6}$	$0.2\overline{6}$	0.95	0.8	$0.6\overline{6}$	0.85	0.8	0.8	0.85	0.72	0.85	0.8	0.8	0.3
User 29	2	0	$0.1\overline{3}$	0.8	0.9	$0.7\overline{3}$	0.75	1	0.8	0.6	0.6	0.7	0.8	0.6	0.5
User 30	2	0	$0.0\overline{6}$	0.9	0.9	$0.7\overline{3}$	0.65	0.8	1	0.55	0.56	0.6	0.6	0.6	0.5
User 31	2	0	$0.\overline{3}$	1	0.75	$0.9\overline{3}$	0.9	0.8	0.6	0.6	0.76	0.5	0.6	0.6	0.4
User 32	2	0	$0.1\overline{3}$	0.65	0.65	0.8	0.8	0.6	0.8	0.7	0.6	0.75	0.8	0.8	0.3
User 33	2	$0.1\overline{3}$	0.2	1	0.95	1	1	1	1	0.95	1	0.85	1	1	0.8
User 34	2	$0.0\overline{6}$	0.2	0.7	0.75	$0.8\overline{6}$	0.8	0.8	0.8	0.65	0.76	0.6	0.8	0.8	0.6
User 35	2	0.2	0.4	0.85	0.8	$0.7\overline{3}$	0.75	0.8	1	0.9	0.92	0.9	1	0.8	0.9
User 36	2	$0.1\overline{3}$	$0.\overline{3}$	0.9	0.75	0.8	0.95	0.6	0.8	0.7	0.84	0.75	0.8	0.8	0.5
User 37	2	$0.\overline{3}$	$0.4\overline{6}$	0.9	0.85	0.8	0.9	0.8	0.8	0.7	0.44	0.75	0.4	0.6	0.8
User 38	2	$0.\overline{3}$	0.4	0.7	0.85	$0.7\overline{3}$	0.7	0.8	0.8	0.75	0.8	0.65	0.8	0.8	0.8
User 39	2	$0.0\overline{6}$	0.2	0.95	1	$0.7\overline{3}$	0.9	1	1	0.8	0.64	$0.7\overline{3}$	0.8	0.8	0.7
User 40	2	0	0	0.75	0.7	0.8	0.85	0.2	0.4	0.9	0.28	0.75	0.8	0.8	0.3

Name	Module	Pre Value	Post Value	Pre Transfer Willingness	Post Transfer Willingness	Post Transfer Support	Post Practical Relevance	Post Transfer	Ultimo Transfer	Ultimo Self-Efficacy	Ultimo Application Possibilities	Ultimo Self-Monitoring	Ultimo Transfer Attempted	Ultimo Transfer Succeeded	Ultimo Transfer Percentage
User 41	2	$0.0\overline{6}$	0	0.85	0.7	$0.7\overline{3}$	0.85	0.8	0.6	0.7	0.32	0.45	0.4	0.2	0.1
User 42	2	0	$0.1\overline{3}$	0.8	0.65	0.8	0.65	0.6	0.6	0.5	0.28	0.6	0.4	0.6	0.2
User 43	2	$0.0\overline{6}$	$0.\overline{3}$	0.85	0.7	$0.8\overline{6}$	0.9	0.6	0.6	0.55	0.28	0.8	0.6	0.4	0.2
User 44	2	$0.5\overline{3}$	0.8	1	0.95	0.8	0.45	1	0.8	0.75	0.84	0.85	0.8	0.8	0.6
User 45	2	$0.1\overline{3}$	$0.\overline{3}$	0.9	0.75	$0.6\overline{6}$	0.7	0.6	0.8	0.75	0.6	0.8	0.8	0.6	0.5
User 46	2	$0.0\overline{6}$	$0.0\overline{6}$	1	0.9	1	1	1	0.6	1	0.76	1	1	1	0.7

Table A.5: Module 1 and 2: Anonymised questionnaire data

Name	Module	Pre Value	Post Value	Pre Transfer Willingness	Post Transfer Willingness	Post Transfer Support	Post Practical Relevance	Post Transfer
User 47	3	0.071428571	0.142857143	0.55	$0.\overline{3}$	$0.4\overline{6}$	0.65	0.6
User 48	3	0.142857143	0.142857143	0.9	0.95	$0.9\overline{3}$	0.9	1
User 49	3	0.357142857	0.285714286	0.65	0.85	$0.8\overline{6}$	1	0.6
User 50	3	0.142857143	0.071428571	0.8	0.85	$0.8\overline{6}$	1	0.8
User 51	3	0	0.285714286	0.9	0.85	$0.9\overline{3}$	0.95	1
User 52	3	0	0.142857143	0.95	0.85	1	0.95	0.8
User 53	3	0	0.214285714	0.95	1	$0.8\overline{6}$	0.95	1
User 54	3	0.142857143	0.214285714	0.9	0.95	$0.9\overline{3}$	1	1
User 55	3	0	0.071428571	0.85	0.75	$0.7\overline{3}$	0.9	0.8
User 56	3	0.142857143	0.357142857	1	0.95	$0.8\overline{6}$	0.95	0.8
User 57	3	0.285714286	0.071428571	0.65	0.75	$0.7\overline{3}$	0.5	0.8
User 58	3	0.071428571	0.214285714	0.7	0.65	$0.7\overline{3}$	0.85	0.6
User 59	3	0.214285714	0.357142857	0.8	0.8	$0.9\overline{3}$	0.85	0.8
User 60	3	0.5	0.285714286	0.75	0.8	$0.7\overline{3}$	0.95	0.8
User 61	3	0.142857143	0.214285714	0.65	0.5	$0.6\overline{6}$	0.55	0.4
User 62	3	0.214285714	0.428571429	0.95	0.9	1	0.95	1
User 63	3	0.285714286	0.285714286	0.95	1	1	1	1
User 64	3	0.142857143	0.071428571	1	0.8	$0.7\overline{3}$	0.8	0.8
User 65	3	0.071428571	0.142857143	0.8	0.95	$0.8\overline{6}$	0.95	1
User 66	3	0.214285714	0.5	0.95	0.9	$0.8\overline{6}$	0.95	0.8
User 67	4	$0.1\overline{3}$	0.2	0.95	0.9	$0.8\overline{6}$	0.95	0.8
User 68	4	$0.1\overline{3}$	0.2	0.75	0.95	$0.6\overline{6}$	0.85	1

Name	Module	Pre Value	Post Value	Pre Transfer Willingness	Post Transfer Willingness	Post Transfer Support	Post Practical Relevance	Post Transfer
User 69	4	0.2	$0.2\overline{6}$	0.85	0.65	$0.8\overline{6}$	0.8	0.8
User 70	4	$0.0\overline{6}$	$0.2\overline{6}$	0.8	0.95	1	0.95	1
User 71	4	$0.1\overline{3}$	$0.\overline{3}$	0.7	0.75	1	0.95	0.8
User 72	4	$0.1\overline{3}$	$0.\overline{3}$	0.6	0.9	$0.7\overline{3}$	0.85	0.8
User 73	4	$0.1\overline{3}$	$0.\overline{3}$	0.8	0.7	$0.8\overline{6}$	0.65	1
User 74	4	$0.\overline{3}$	$0.2\overline{6}$	0.6	0.65	$0.9\overline{3}$	0.9	0.8
User 75	4	0.2	$0.\overline{3}$	1	1	$0.8\overline{6}$	0.5	1
User 76	4	0.6	0.6	0.9	1	$0.9\overline{3}$	0.9	1
User 77	4	0.2	0.4	0.7	0.5	0.8	0.85	0.6
User 78	4	$0.0\overline{6}$	$0.1\overline{3}$	0.6	0.8	0.8	0.95	0.6
User 79	4	0.2	0.2	1	1	1	1	1
User 80	4	$0.4\overline{6}$	0.4	1	0.95	$0.8\overline{6}$	0.9	1
User 81	4	$0.\overline{3}$	$0.\overline{3}$	0.65	0.9	0.8	0.8	1
User 82	4	0	$0.2\overline{6}$	0.4	0.7	$0.7\overline{3}$	0.7	0.8
User 83	4	$0.2\overline{6}$	$0.1\overline{3}$	0.7	0.65	$0.8\overline{6}$	0.85	0.8
User 84	4	$0.2\overline{6}$	$0.\overline{3}$	0.85	0.75	$0.9\overline{3}$	0.8	0.8
User 85	4	$0.1\overline{3}$	$0.0\overline{6}$	0.8	0.35	$0.6\overline{6}$	0.6	0.4
User 86	4	$0.\overline{3}$	$0.1\overline{3}$	0.95	0.75	$0.8\overline{6}$	0.85	0.8
User 87	4	$0.1\overline{3}$	0.4	0.7	0.6	$0.8\overline{6}$	0.85	0.8
User 88	4	$0.0\overline{6}$	0.4	0.95	0.75	0.6	0.8	0.8

Table A.6: Module 3 and 4: Anonymised questionnaire data