THESIS

IDENTIFYING REQUIRED TACIT KNOWLEDGE AND INFLUENCING FACTORS OF TECHNOLOGY TRANSFERS

A CASE STUDY OF A BIOTECH MANUFACTURING PROCESS TRANSFER FROM GERMANY TO THE US

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ABSTRACT

Expert knowledge is a valuable asset in the Biopharmaceutical Industry (BI) as the growing market of biopharmaceuticals increases the need for company specific competitive advantage. Hence, knowledge dissemination is required to maintain expert knowledge in the company. Especially in the technology transfer (TT) field it is important due to the organisation's need to be fast, agile and flexible in switching manufacturing schedules to serve project timelines or market needs. Another relevant purpose of a TT is the scaling up of manufacturing capacities for the biopharmaceuticals to be the first on the market with a sufficient amount of drug product. During these transfers, the knowledge transfer is often biased toward codified or explicit knowledge. The tacit component, however, needs more attention, because both types of knowledge are required for a successful technology transfer. Incomplete knowledge transfers, in which only one type of knowledge is provided, are a consistent problem and may lead to delays in timelines of biopharmaceutical projects.

Hence, in order to make TTs more robust, the visibility of tacit knowledge in the BI needs to be strengthened. This is in line with the call in the literature to contextualize tacit knowledge more. In addition, research on how tacit knowledge can be transferred and measured should be conducted. The known practices to disseminate knowledge are influenced by a variety of factors like e.g. trust between the different parties or power relations in the group. Different authors suggest to explore these context dependent influencing factors for the tacit knowledge transfer and the knowledge transfer in general in more detail.

Therefore, the research study "Identifying required tacit knowledge and influencing factors of technology transfers - A case study of a biotech manufacturing process transfer from Germany to the US" aimed to explore and identify the types of tacit knowledge used during a TT in the BI, as well as the influences and corresponding mechanisms and practices to support the tacit knowledge dissemination and knowledge sharing during a TT in general. The types of tacit knowledge were explored by conducting semi-structured expert interviews. In order to identify influencing factors for the knowledge dissemination in general, the data from the semi-structured interviews was used. Influences on the tacit knowledge dissemination have been discovered during the analysis of the focus group discussions. Practices and mechanisms to disseminate knowledge were derived from the semi-structured interviews and focus group

discussions as well. The data analysis for both interview-based method types was chosen according to answer the research questions. Hence, content analysis, thematic analysis and causal mapping were used to address the objectives of this study.

When analysing the types of tacit knowledge used during a TT in the BI, 63 types of tacit knowledge in line with the epitomes of tacit knowledge (ETK) list from Haldin-Herrgard (2003) could be identified. Additional 7 types of tacit knowledge specific to the BI were found and were used to enlarge the list provided by Haldin-Herrgard (2003). With the same data set also synonyms used in the BI for different ETKs were added. This helped to contextualize the ETKs for the BI. To understand how these types of tacit knowledge and knowledge in general are transferred in order to strengthen the TT, the study looked for influences that support the dissemination. 32 groups of influences and single influences had been identified during the analysis of the semi-structured interviews, as well as the focus group discussions. Influences in the areas of team structure and characteristic, company structure and motivation to disseminate knowledge, as well as culture, were found. Having worked out the types of tacit knowledge and influences on knowledge dissemination, the study also carved out practices and tools supporting the dissemination of knowledge. After having analysed the data from the semi-structured interviews, focus group discussions and the literature review, 30 practices and methods could be identified that can be used to support the knowledge transfer during a TT. Overall, the gained insights from this study helped to broaden the understanding of tacit knowledge used and the influences for the knowledge transfer during a TT in the Biopharmaceutical Industry in order to help make TTs more robust. In addition, they set a basis for future research.

ABBREVIATIONS

BI	Biopharmaceutical Industry
CMO	Contract manufacturing organisation
CoP	Communities of Practice
E.coli	*Escherichia coli*
e.g.	*exempli gratia* (for example)
EMA	European Medicines Agency
et al.	*et alii* (and others)
etc.	*et cetera*
ETK	Epitomes of tacit knowledge
GMP	Good Manufacturing Practice
i.e.	*id est*
ICH	International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use
IT	Information technology
KM	Knowledge Management
K-O	Knowledge used as an object
KS	Knowledge Sharing
K-SCC	Knowledge as a subjective contextual construction
KT	Knowledge Transfer
mAb	Monoclonal antibody
p.	Page
QbD	Quality by design
RQ	Research question
RU	Receiving unit
SU	Sending unit
TA	Thematic analysis
TT	Technology transfer
TTL	Technology Transfer Lead
US	United States

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"Writing a thesis is a journey of self-discovery, where words become your guideposts." – John Smith

It's been four years now since my DBA journey had started. It had been interesting, exciting and exhausting years in which I learned a lot about knowledge, new methods for data generation and about myself. Of course, it had not been always an easy way, but I don't regret it as I grew a lot by taking it. A lot of people accompanied me on this path, whom I would like to thank.

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1 INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Due to the rapidly growing biopharmaceutical market, there is an increasing pressure on biopharmaceutical companies to gain competitive advantage (Tsumoto *et al.*, 2019). Competitive advantage can be achieved by quick manufacturing, and being agile and efficient while keeping product quality standards and cost ranges for products constant (Calnan *et al.*, 2017; Tsumoto *et al.*, 2019). Hence, the manufacturing knowledge as well as the knowledge base are valuable assets (Williams, 2020), which have to be managed and transferred robustly. A praxis-oriented system in which different forms of knowledge are managed is described as knowledge management (KM) (Williams, 2020).

The technology transfer (TT), which is needed for an organisation to be agile and flexible in switching manufacturing schedules and for scaling up manufacturing capacities, can be considered one example where knowledge management and knowledge dissemination is key. The economic importance as well as the sustainable development in a company driven by effective technology transfers hence, led to a considerable attention on TTs (Bengoa *et al.*, 2021). Each technology transfer has the objective to run the manufacturing process at the receiving unit “with no or minimal changes from the original process” and without failure (Ahamed, Ternbach and Ives, 2011, p.52). The transfer can only be successful when the quality of the process itself and the communication between both parties is adequate (Ahamed, Ternbach and Ives, 2011) and hence, knowledge can be disseminated. A lot of knowledge is captured in documents and in data format and therefore, is already monitored quite well. This knowledge is called explicit knowledge (Nonaka and von Krogh, 2009; Joia and Lemos, 2010; Esfandyarpour *et al.*, 2024). Specific examples for the Biopharmaceutical Industry (BI) in this regard are “blueprints, copyrights, patents and trademarks” (Williams, 2020, p.446), but also process descriptions, process parameter and measured data. In addition, technical elements like know-how and skills etc. need to be transferred, which are referred to as tacit knowledge (Joia and Lemos, 2010; Schmidt, Bell and Warren, 2021). In an initial study in the BI, Lipa, Kane and Greene (2019) found out, that the effectiveness of the tacit knowledge transfer needs to be improved and understood better compared to the explicit knowledge transfer, which is

already managed well (Lipa, Kane and Greene, 2019). This research forms a starting point for further evaluation of the topic.

Therefore, the research study "Identifying required tacit knowledge and influencing factors of technology transfers - A case study of a biotech manufacturing process transfer from Germany to the US" is intended to find out more about exactly this topic during a specific project transfer, which had been started in 2021. The manufacturing process of a biopharmaceutical asset had been developed in the company's development department in Germany and has been transferred to the manufacturing department in the US due to capacity reasons. The goal of this transfer was to perform the manufacturing process according to the original process to ensure the same product quality. As described, this can be achieved by effectively transferring explicit and tacit knowledge. Special product knowledge, as well as platform and process knowledge, are captured in protocols and standard procedures and are already well monitored. The tacit knowledge transfer including skills and decision making, however, needs more attention. The role of the tacit knowledge transfer and its influences needs to be further explored. The next section describes the context as well as the purpose of the research study in more detail.

1.2 Context of the Study

1.2.1 Development in the Biopharmaceutical Industry

Biopharmaceuticals are becoming increasingly important for the modern healthcare system due to the need of complex and specific biomolecules that can offer treatments for various disorders (Lalor *et al.*, 2019). Hence, the industry is growing and the biopharmaceutical market is expected to reach more than 380 billion dollars in 2024 (Tsumoto *et al.*, 2019).

Biopharmaceuticals are a diverse class of products, that reach from recombinant protein therapeutics and monoclonal antibodies to vaccines to cell and gene therapies (Kedia *et al.*, 2022; Szkodny and Lee, 2022). The first biopharmaceutical products have been discovered more than a century ago. Examples are transfusions that have been developed in the late 19th century. In the early 20th century, the discovery of animal derived insulin and the industrialized manufacturing of penicillin have been important milestones (Lalor *et al.*, 2019). A breakthrough for this industry has been the first regulatory approval of a biopharmaceutical product in 1982, which was recombinant human insulin produced in *E.coli* by Eli Lilly & Co

(Lalor *et al.*, 2019; Szkodny and Lee, 2022). Since then, over 300 biopharmaceutical products have been approved with a wide range of applications like cancer, genetic disorders or infectious diseases (Szkodny and Lee, 2022). Monoclonal antibodies (mAbs), as well as recombinant proteins, are the main products manufactured and approved as they are highly specific to their targets and more efficacious compared to small molecules (Goswami *et al.*, 2013; Tsumoto *et al.*, 2019; Szkodny and Lee, 2022). In 2019, 9 out of the 20 top-selling therapeutics have been mAbs, with a collective earning of around $75 billion (Szkodny and Lee, 2022). In 2024 the expected sales for mAbs are projected to reach $200 billion (Higgins *et al.*, 2023). Besides classical naked antibodies, other formats like bispecific antibodies, antibody-drug conjugates and low molecular weight antibodies, are being considered next-generation products (Tsumoto *et al.*, 2019). This study, however, will focus on the transfer of a classical mAb and hence, describes the development process of such a product in more detail.

The development of a mAb product is differentiated into a discovery phase or product development phase and a process development phase. Product development covers all activities related to the design or the discovery of new products by screening top candidates for their efficacy, whereas process development is intended to optimize the manufacturing conditions for the target molecules (Lorenz, Raven and Blind, 2019; Szkodny and Lee, 2022). Most of the literature available focusses on product development, but only a few articles refer to process development and its complexity (Lu and Botha, 2006). Manufacturing processes for mAbs compared to small molecules are difficult to perform and complex to scale up (Goswami *et al.*, 2013). A typical mAb manufacturing process is depicted in Figure 1.

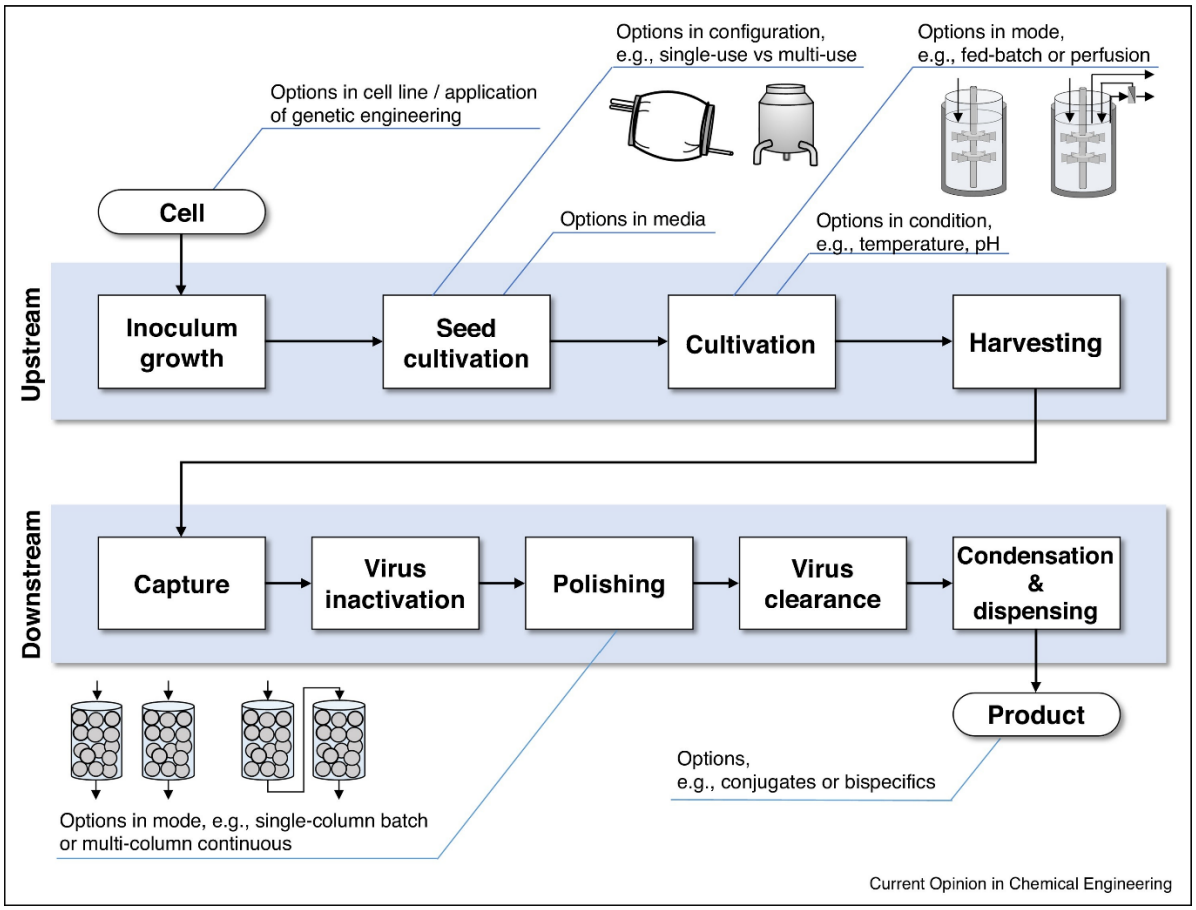

Figure 1: Mammalian cell culture derived mAb manufacturing process (Badr and Sugiyama, 2020).

Figure 1 shows a generic mAb manufacturing process consisting "of several upstream and downstream unit operations, starting from cell culture, followed by chromatographic purification, viral clearance, and formulation" (Rathore, Thakur and Kateja, 2023, p.334). Hence, a variety of unit operations with different options are needed to successfully manufacture a mAb, which shows the complexity of these processes. The first part of the process is indicated with the label "upstream". In this phase of the process the cells are expanded to express the mAb. Inoculum and seed cultivation generate the cell amount to start the main cultivation step in which the mAb is produced. During the harvest step the cells are separated from the mAb product, which can be found in the supernatant. The whole upstream process is optimized to increase product quantity and quality (Badr and Sugiyama, 2020). The following unit operations are summarized as "downstream activities". The first step is intended to capture the mAb from the harvested supernatant as other host cell derived molecules are present in the supernatant like DNA and proteins. Afterwards, a virus inactivation step, a polishing step and a virus clearance step are applied to further decrease impurities from the product. In the last step the product is concentrated. Downstream

purification processes are designed to achieve the defined product profile (Badr and Sugiyama, 2020). Overall, experts from upstream and downstream processing are required to develop a process with a sufficient yield and good product quality. In addition, during all unit operations, analytics are performed to monitor the process and the product quality, which involve experts from this field as well.

It is important that the mAb manufacturing process is robust and, hence, always leads to the same outcome. This is essential as the process is determining the product quality. If the product quality gets negatively affected due to deviations in the process there is the chance of a delay in timelines and higher costs for the product as these batches might not be released for treatments. The assessment of which parameters are crucial for the quality of the drug is done in a risk-based analysis, evaluating their impact on patient safety as well on efficacy (Eon-Duval, Broly and Gleixner, 2012). This evaluation is done by the process experts together with a quality assurance manager.

Depending on the mode of action of the mAb, many mAb therapies require a relatively high dose for efficacy (Goswami *et al.*, 2013). Therefore, it is important that the mAb manufacturing process provides a constantly high yield. It needs to be developed so that it can be robustly transferred with no impact on the product quality to other sites if needed for capacity expansion, in order to be able to provide sufficient material for clinical studies and launch. To ensure sufficient supply, companies built up their own capabilities to be flexible in switching around the production schedules for their products to lower the risks, time and costs for developing new biologic therapeutics or use contract manufacturing organisations (CMOs) to perform the manufacturing (Langer, 2009). Hence, structured and robust approaches to transfer the process and the knowledge required to manufacture a mAb are needed to avoid issues and failure during a process transfer. The importance, as well as the structured approach of the technology transfer, is discussed in the next section.

1.2.2 Technology Transfers in the Biopharmaceutical Industry

The term “technology transfer” itself is hard to define. Manu and Gupta (2016) describe it as a “collection of techniques, methods or processes used in the production of goods” (p.7). This includes all knowledge needed to transfer a technology from one site or unit to another. “Technology”, however, can be understood differently by the sending (SU) and receiving unit (RU). The issue might derive from the fact that the terms “technology” and “knowledge” are

often used interchangeably in research (Esfandyarpour *et al.*, 2024). In some cases, the SU is ready for the "technology "know-how" transfer (type of transfer in which complete knowledge including documentation, diagram, demonstration of process, sample, raw material detail, training, etc.)" plus the "show-how" by documentation (Kundu, Bhar and Pandurangan, 2015, p.80). The RU, however, needs to know also underlaying principles and backgrounds, which is considered the dissemination of tacit knowledge (Kundu, Bhar and Pandurangan, 2015). Hence, the knowledge transfer cannot be separated from the technology transfer "as knowledge is key to control technology as a whole" (Kundu, Bhar and Pandurangan, 2015, p.81). In general, the TT can be considered successful, when the receiving unit can fully utilize the transferred techniques, methods and processes for the required application (Manu and Gupta, 2016). Knowledge transfer processes can be structured and unstructured. Structured processes are planned and formal, whereas unstructured processes are the entire opposite (Chen, Sun and McQueen, 2010). Knowledge transfers during TTs are structured processes that are described in this section.

The knowledge transfer of explicit and tacit knowledge consists of different stages. In the first stage, the transfer is initiated (World Health Organization, 2022). In this phase, the business case is defined and the kick-off meeting for the technology transfer team is scheduled (McIntyre and Sumen, 2015). In this meeting, the roles and responsibilities, as well as the timeline, need to be clarified. After the responsibilities are set, the transfer planning phase begins. At this time of the transfer, the transfer master plan is established and the initial risk assessment and gap analysis is performed (World Health Organization, 2022). During the phase of transfer execution, the details of the analytical methods and about the process are exchanged to plan for trainings and to write the Master Batch Records (MBRs) for the receiving unit (McIntyre and Sumen, 2015). Explicit knowledge is mainly captured in documents and detailed data and hence, in most companies already monitored well. The tacit knowledge transfer makes around 80% of the generated knowledge during process development (Calnan *et al.*, 2017). This type of knowledge is not easy to capture in written format. Still, it is expected by agencies as well as the transfer experts that tacit knowledge is transferred and used during a technology transfer (Lipa, Kane and Greene, 2020). The last phase of the transfer is the project review and close-out (World Health Organization, 2022). In this phase compliance with the procedures and protocols should be verified and the successful completion of the technology transfer should be assessed (World Health Organization, 2022). As mentioned

before, the application and hence, the goal for a TT in the BI is often an expansion of manufacturing capacity to supply the clinical trials with material or the market in general. For this purpose, the TT takes place from an internal sending unit to a receiving unit with the objective of running the manufacturing process at the receiving unit "with no or minimal changes from the original process" and without failure (Ahamed, Ternbach and Ives, 2011, p.52) as the process is determining the different attributes of the product quality. During all knowledge transfer phases, experts from the sending and the receiving unit are in close contact and exchange information in both directions. In many cases, the TT does not take part in one country but involves parties from different countries with different cultural background. Hence, the next section describes the influence of multinationalism for a TT.

1.2.3 Technology transfers within Multinational Companies

The technology transfer considered in this study is an intra-company transfer, that took part from a German development department to a manufacturing department in the US. This shows that team members from more than one country are involved in the activity. Per definition this can be considered as a multinational business (Miroshnik, 2002). In this case, the company, in which the transfer is executed in, is working globally. In general, a company is regarded as a social community, "where individual, social and collective expertise can be transformed into economically useful products" (Park, Vertinsky and Becerra, 2015, p.90). For this process it is important to understand how the environment of this multinational business effects the social community. Hence, especially the cultural aspect plays a big role with regards to the influence on the TT as different cultures might need different project management skills (Miroshnik, 2002). Culture covers the belief systems that are embedded in a society (Chen, Sun and McQueen, 2010). It is about how to communicate, anticipate, and create standards about what is right or wrong, as well as having the knowledge and skills to know what is needed in certain situations and to identify others with similar background (Miroshnik, 2002). It is important to acknowledge that there are cultural differences for multinational companies. International business, however, leads to additional types of distances, which include the institutional distance, linguistic distance, economic distance and geographic distance (Srivastava, Singh and Dhir, 2020). Hence, the technology transfer needs to be tailor-made and "requires lots of understanding and respect towards each other for successful implementation" (Kundu, Bhar and Pandurangan, 2015, p.84). German and American management styles for handling these differences are different due to the country culture.

This needs to be considered when starting a transfer. Importantly, “people, not papers, transfer technology” (Foley, 1996, p.30). Therefore, also the set-up of the team and the individuals need to be considered. Teams are defined as two or more employees that interact with each other and work towards a common goal for a relevant task in a company (Kozlowski, 2018). They have different roles and responsibilities in one organisational structure (Kozlowski, 2018). The easiest way to interact in a multinational company or when geographically distributed is via virtual tools e.g. Microsoft Teams, Zoom or Skype. These teams are also called virtual teams or remote teams and like for co-located teams the interaction and communication are crucial to achieve joint goals (Morrison-Smith and Ruiz, 2020). This can be done through formal and informal meetings in a virtual setting. The advantage of virtual teams is that experts are always available and the need for travelling is decreased (Morrison-Smith and Ruiz, 2020). Due to the distance, the disadvantages are that building trust is not as easy as for co-located teams and that only small windows for meetings are available due to the different working hours of the teams. In summary, cultural aspects, as well as remote working aspects, have to be considered and managed for the TT.

This thesis is intended to help create a broader understanding of the types of tacit knowledge used during the technology transfer and how the dissemination of the knowledge is influenced. This also includes the multinational, as well as the remote aspects. Hence, it should find out if teams involved from different countries value different factors with regard to the technology transfer. More detailed information about the purpose of this study is provided in the next section.

1.3 Purpose of this Research

1.3.1 Problem of the study and gap identified in the literature

As mentioned before, in the competitive biopharmaceutical industry, the technology transfer, which is needed for an organisation to be agile and flexible in switching manufacturing schedules and for scaling up manufacturing capacities, can be considered one example where knowledge dissemination is key. Technology transfer capabilities had additionally been critical during the Covid-19 pandemic, where new drugs were quickly needed. “Prominent drug product development and rollout campaigns have struggled due to slow scale-up and technology transfer challenges (…)” (Thomas, 2021, p.21), which indicates the need for a

robust transfer process to overcome these challenges. In general, an intra-company technology transfers takes place internally from a sending unit to a receiving unit (Ahamed, Ternbach and Ives, 2011). Inter-company transfers are also possible but not in focus of this thesis. To transfer the manufacturing process "with no or minimal changes from the original process" (Ahamed, Ternbach and Ives, 2011, p.52) both explicit and tacit knowledge has to be transferred. An initial research study indicates that there is only limited understanding with regards to the tacit knowledge used during technology transfers in the biopharmaceutical industry available (Kane, Greene and Lipa, 2019). This study was based on a literature review, a survey with participants of a regulatory seminar and expert interviews with international industry and regulatory authority experts. This indicates that a special group of experts in the BI was consulted for this study. However, this study can be a good starting point for researching other groups related to the tech transfer in the BI and to assess their understanding of tacit knowledge. One of the reasons for the found limited understanding of tacit knowledge can be rooted in the general consideration of knowledge in natural science. Studies in this field are mainly based on general laws rather than individual perspectives (Abettan, 2016). This is also confirmed by the widely used Good Manufacturing Practice (GMP) mantra "if it isn't written down, it didn't happen" (Lipa, Kane and Greene, 2020, p.4). Still, it was found out by Lipa, Kane and Greene (2019) that both explicit and tacit knowledge and hence, also individual perspectives and know-how, are important for the TT in the BI. This has also been confirmed by Adams, Kane and Greene (2022). Yet, the difference between both forms of knowledge used during a TT is, that only explicit knowledge is managed effectively already (Lipa, Kane and Greene, 2019). One reason for this is, that "tacit knowledge transfer is frequently undervalued and underestimated by the technical teams managing the technology transfer project and (…) a frequent cause of failure and of on-going process-related problems post-transfer" (Kane and Lipa, 2020, p.25). Incomplete knowledge transfers, however, in which only parts of the required information are provided, are a consistent problem and lead to delays in timelines (Shanley, 2018). In addition, "(…) the simple reason that regulatory approval typically requires the extensive codification of tacit manufacturing knowledge" leads to the need "to explore and share tacit knowledge" (Nicholson Prince II, Rai and Minssen, 2020, p.913). This also shows that there is room for further research to be able to understand the used tacit knowledge better, in order to make TTs more robust and to strenghten the visibility of tacit knowledge in the BI. According to Ipe (2003), success in an

organisation is enhanced when a common understanding is established about what constitutes as knowledge within the specific organisation. Hence, creating an in-depth understanding about the types of tacit knowledge used during a TT will also help to widen the common awareness in this regard. In addition, tacit knowledge sharing is associated with organizational growth and development and hence, companys should become more aware of its importance (Oranga, 2023). This is in line with the call in the literature from Hadjimichael and Tsoukas (2019) to contextualize tacit knowledge more. Nakano, Muniz and Batista (2013) also highlighted that more insight into tacit knowledge associated with technology transfer and in particular with shop floor workers is needed. This additionally indicates that the practical component of tacit knowledge needs to be evaluated further and leads to the first research question (RQ) of this study:

RQ1: Which types of tacit knowledge are used during a technology transfer between a German development department and the US manufacturing department in the BI?

In addition, it is known that the dissemination of knowledge is influenced by a variety of factors like e.g. trust between the different parties or power relations in the group (Ipe, 2003). These influencing factors can occur on the individual, organisational or group level (Ipe, 2003). In the literature, there is a call for further research in the direction on critical success factors during virtual technology transfers in the BI (Lipa, 2021), as well as influencing factors of the tacit knowledge transfer in non-state-owned companies (Joia and Lemos, 2010). Additionally, Borges, Bernardi and Petrin (2019), Venkitachalam and Busch (2012) and Visvalingam and Manjit (2011) suggest to explore context dependent influencing factors for the tacit knowledge transfer in more detail. As knowlegde sharing in general is associated with organizational growth, additonal case studies should be conducted to identify nuances of the influencing factors of knowledge sharing (Ipe, 2003). Therefore, studying the influencing factors of the tacit knowledge as well as the general knowledge transfer during a TT will contribute to widening the literature and will help to close the identified gaps. Hence, the second research question for this study is:

RQ2: What influences the knowledge transfer between the German development department and the US manufacturing department in the BI?

Next to certain influences, different practices can help to make the knowledge dissemination more robust. In the literature different methods and technologies are known for knowledge

sharing. Zamiri and Esmaeili (2024), evaluated different methods to support knowledge sharing within learning communities (Zamiri and Esmaeili, 2024). They state that the selection of methods and technologies has to be aligned with among others the contextual-characteristics. This means methods and practices for knowledge sharing have to be tailor-made for the technology transfer in the BI. Lipa et al. (2020) did some research in this direction and conducted a case study to assess the practices for tacit knowledge transfer in the BI. They came to the conclusion, that open-ended questions enable the communication between the sending unit and receiving unit teams and hence, have shown to be beneficial for the tacit knowledge transfer. This is only one example of practices that can help to facilitate the technology transfer. Still, additional research on how tacit knowledge can be transferred and measured should be conducted (Kane, Greene and Lipa, 2019). Hadjimichael and Tsoukas (2019) highlighted that additional studies for methods to transfer tacit knowledge in the digital environment are required. Therefore, this research also aims to provide more insight into the topic of tacit knowledge transfer mechanisms and knowledge sharing methods for a TT in the BI in general by answering the third research question:

RQ3 - Which practices can be applied during a technology transfer to support the dissemination of knowledge in the BI?

Additional information about the research aim and the methods to answer the RQs, as well as the research objectives of this this study are provided in the next section.

1.3.2 Aim and Research Questions

Due to the identified gaps in the literature, the aim of this study is to explore and identify types of tacit knowledge that are used during a TT in the Biopharmaceutical Industry and to find influences and methods supporting the success of the knowledge transfer.

The listed research questions and objectives in Table 1 will be investigated in this study. To address these, different methods will be applied. The planned methods in order to answer the research questions and objectives are provided in Table 1. More information regarding the applied methods is provided in chapter 3.

Table 1: List of methods in order to answer the RQs of this study.

Research questions	**Corresponding objective**	**Methods**
RQ1 - Which types of tacit knowledge are used during a technology transfer between a German development department and an US manufacturing department in the BI?	To gain a better understanding of the types of tacit knowledge used during a biopharmaceutical technology transfer.	Semi-structured interviews
RQ2 - What influences the knowledge transfer between the German development department and the US manufacturing department in the BI?	To identify the influencing factors for the knowledge dissemination for a specific transfer from a German development department to a US manufacturing department in the BI and compare them to the influences found identified during the literature review.	Semi-structured interviews Focus groups
RQ3 - Which practices can be applied during a technology transfer to support the dissemination of knowledge in the BI?	To make recommendations on how to support the knowledge transfer for upcoming technology transfers in the BI by e.g., developing a roadmap or listing practices to use during a technology transfer.	Semi-structured interviews Focus groups

The shown methods are used for exploring and identifying the types of tacit knowledge used during a technology transfer in the BI, as well as influences for the knowledge dissemination and hence, will contribute to closing the gap on a theoretical level. In addition, identifying practices and methods to support the knowledge dissemination will add practical suggestions for future technology transfers in the BI. More detailed information about the contribution is provided in the next section.

1.3.3 Contribution of this study to knowledge and practice

This study aims to add value on the theoretical, as well as practical level. It will add context-specific understanding regarding the tacit knowledge used during a technology transfer in the Biopharmaceutical Industry. This is in line with the request from Hadjimichael and Tsoukas (2019) to contextualize tacit knowledge. This means, this research will contribute to theoretical work as it addresses gaps around tacit knowledge especially in the Biopharmaceutical Industry. These gaps are elaborated in more detail in section 1.3.1. Additionally, this study will highlight influences of the knowledge transfer in the specific context of the BI, which will add theoretical value as it has not been explored yet. This is in

line with the calls from Borges, Bernardi and Petrin (2019), Venkitachalam and Busch (2012) and Visvalingam and Manjit (2011) to explore context dependent influencing factors for the knowledge transfer, which includes the tacit knowledge transfer, in more detail. The results from answering the research questions will help to guide future theoretical work in this direction.

In terms of practical contribution, the study will add value as it will widen the awareness of tacit knowledge in the explicit knowledge driven scientific sector. This is crucial as the "tacit knowledge transfer is frequently undervalued and underestimated by the technical teams managing the technology transfer project and (…) a frequent cause of failure and of on-going process-related problems post-transfer" (Kane and Lipa, 2020, p.25). The study aims to show how using tacit knowledge more consciously will help to transfer knowledge in a robust way. This is especially important as incomplete knowledge transfers during technology transfers can lead to delays in timelines (Shanley, 2018). The criticality has also been seen during the Covid-19 pandemic, where new drugs were quickly needed. In this case different campaigns have failed due to technology transfer issues (Thomas, 2021). Additionally, issues in the technology transfer can affect drugs and patients (Lipa, Kane and Greene, 2019). These issues can be overcome by gaining awareness of the tacit knowledge transferred and how is applied in the organisation. Knowing the types of tacit knowledge used during technology transfers in the BI has the potential to also simplify regulatory approval of drugs, as "regulatory approval typically requires the extensive codification of tacit manufacturing knowledge" (Nicholson Prince II, Rai and Minssen, 2020, p.913). Therefore, this research will help the employees to focus on tacit knowledge that contributes to a successful technology transfer. The use of context specific methods and measures to transfer knowledge during a TT is another crucial aspect to explore to make TTs more robust (Hadjimichael and Tsoukas, 2019; Kane, Greene and Lipa, 2019). In addition, more specifically, critical success factors during virtual technology transfers in the BI should be evaluated (Lipa, 2021). The study will, hence, provide practical suggestions to support future transfers by suggesting practices to transfer tacit knowledge. This offers the opportunity for other companies to adjust the results for their needs.

Overall, the study will add new understanding and insight for the academic and practical application in terms of context-specific tacit knowledge for the BI and its specific influences.

1.3.4 Structure of this thesis

As mentioned before, this study is intended to generate a deeper understanding of the types of tacit knowledge used during a TT in the BI and to find influences and methods supporting the success of the tacit knowledge transfer. Hence, the next section provides more insight into the theoretical background for knowledge, knowledge dissemination, tacit knowledge and technology transfers. It also lists the identified gaps during the literature review in more detail. Afterwards, the used methodology and methods are elaborated in chapter 3. This also includes the data collection and sampling strategies applied in this study, as well as the ethical considerations. The corresponding results for answering RQ1, RQ2 and RQ3 are listed in chapter 4 and discussed in chapter 5. The last chapter concludes the findings of this research and lists the achievements of the study. Furthermore, limitations of the study and ideas for future research are presented.

2 THEORETICAL BACKGROUND

2.1 CONSTITUTION OF KNOWLEDGE AND KNOWLEDGE MANAGEMENT

In order to underpin this research, it is important to have a clear understanding of what constitutes knowledge as well as how to manage knowledge. Therefore, in the following sections, different definitions of knowledge are considered and the different types of knowledge are described in more detail. As knowledge has become a primary production factor and is treated as a valuable asset nowadays (Ismail Al-Alawi, Yousif Al-Marzooqi and Fraidoon Mohammed, 2007; Joia and Lemos, 2010), the subsequent section assesses this aspect.

2.1.1 Definition of Knowledge

The literature offers several definitions of knowledge. This arises from the impression, that the term itself is well-known, but unthinking and diffuse (Schreyögg and Geiger, 2002). Authors like Roberts (2000) state that knowledge is synonymous with information that is gained by data (Roberts, 2000). Nonaka (1994), however argues that the two concepts should not be used interchangeably. He describes information as the flow of messages and knowledge as the flow of information, which means for knowledge there is an influencing human component (Nonaka, 1994). Davenport and Prusak (1998), Ismail Al-Alawi, Yousif Al-Marzooqi and Fraidoon Mohammed (2007), Antonio and Bernardo (2010), among others, agree with the importance of the influencing human component and therefore, believe that knowledge does not only exist in documents, but that the human mind plays an essential role. Knowledge is determining the human's actions and behaviours (Nonaka, 1994; Gammelgaard and Ritter, 2005; Ismail Al-Alawi, Yousif Al-Marzooqi and Fraidoon Mohammed, 2007; Joia and Lemos, 2010). This implies that knowledge is dependent on context, experience, beliefs, values, insights and the corresponding reflection and personal learning (Davenport, De Long and Beers, 1998; Gammelgaard and Ritter, 2005; Joia and Lemos, 2010; Schmidt, Bell and Warren, 2021). Gammelgaard and Ritter (2005) explain, that it can be interpreted by the minds of the knowledge senders. When applied in an organisation, it is a result of the rules and procedures of a company and becomes embedded in documents, processes, routines and practices (Gammelgaard and Ritter, 2005; Schmidt, Bell and Warren, 2021). It is important that the knowledge from these repositories is then implemented in the people's minds and

their actions (Ismail Al-Alawi, Yousif Al-Marzooqi and Fraidoon Mohammed, 2007). This results in the difficulty to manage knowledge (Joia and Lemos, 2010).

In addition to managing knowledge, it is important to understand that knowledge can be separated into different levels, depending on how it is used. Ford (2001), describes the possibilities to have knowledge as an object, individual knowledge, knowledge within a group, collective knowledge, and public knowledge (Ford, 2001). For companies, it is most important to magange their collective knowledge and to watch the public knowledge (Ford, 2001). Ipe (2003), however, argues that in organisations knowledge is created between individuals. This knowledge needs to be shared with other individuals to have an impact on the effectiveness of organisations (Ipe, 2003). This is in line with the spiral organizational knowledge creation model established by Nonaka (Esfandyarpour *et al.*, 2024). As this thesis is about the knowledge transfer in companies, it will bring the collective as well as the individual knowledge into focus as these levels are the most relevant to the topic.

Even though knowledge can be described as a mixture of elements and there is not one distinctive description, some key components of understanding knowledge are established (Gammelgaard and Ritter, 2005). The first thing is that knowledge cannot be confused with data, as data are raw facts and knowledge is the understanding of those facts triggered by one's understanding (Ismail Al-Alawi, Yousif Al-Marzooqi and Fraidoon Mohammed, 2007). That means knowledge results from the integration of data and information (Gray, 2000). This has also been stated by Nonaka (1994), as mentioned before. Another important thing is that knowledge can be distinguished into tacit and explicit knowledge (Nonaka and von Krogh, 2009; Duan *et al.*, 2022; Esfandyarpour *et al.*, 2024). A more detailed description of the types of knowledge is provided in the next section.

2.1.2 Types of knowledge

As mentioned above, knowledge can be conceptually differentiated into explicit and tacit knowledge. The classification of knowledge is dependent on its ability to be structured and codified (Joia and Lemos, 2010). Ipe (2003), subdivides the knowledges' ability to be structured into the "mechanism for transfer, methods for acquisition and accumulation, and the potential to be collected and distributed" (Ipe, 2003, p.344).

Explicit knowledge can be captured in writings and documents as well as in language and drawings (Nonaka and von Krogh, 2009; Joia and Lemos, 2010; Morshedi, Nezafati and Shokouhyar, 2023) and represents the knowing about or the objective knowledge (Ambrosini and Bowman, 2001; Williams, 2020). Therefore, this type of knowledge can be verbalized and can be stored in databases and documents (Joia and Lemos, 2010; Schmidt, Bell and Warren, 2021). This leads to the fact that it can be shared via codification e.g. in the company's data networks (Joia and Lemos, 2010). This aspect makes it, in general, robust to transfer. However, Ipe (2003) discusses the subdivision of explicit knowledge into rationalized and embedded knowledge. Rationalized knowledge is independent of context and individuals and standardized as well as available to the public (Ipe, 2003). This means it is easy to share. Embedded knowledge, in contrast, is dependent on context and individuals and is only applicable in a narrow context (Ipe, 2003). As it can be sensitive in a professional and personal way, it is not likely to be shared with others (Ipe, 2003). This means not all explicit knowledge can be transferred in the same way. In the considered case study for this thesis, the knowledge transfer for explicit knowledge and embedded knowledge in the professional context is already well structured and measures are in place to track the state of the transfer.

These measures are not as easy to implement for tacit knowledge. Nonaka and von Krogh (2009) describe tacit knowledge as "unarticulated and tied to the senses". It can also be classified as knowing how or subjective knowledge (Williams, 2020). This means that this type of knowledge is gained through experience and is difficult to express and difficult to formalize (Joia and Lemos, 2010; Schmidt, Bell and Warren, 2021; Esfandyarpour *et al.*, 2024). Influencing factors are the context, beliefs, values and perceptions of individuals (Haldin-Herrgard, 2000; Joia and Lemos, 2010; Schmidt, Bell and Warren, 2021). A way to share tacit knowledge is by learning through collaboration and shared experiences (Foos, Schum and Rothenberg, 2006). This way of sharing is influenced by different factors e.g. corporate culture, trust and communication, which makes the transfer less robust and reliable compared to a data based transfer (Foos, Schum and Rothenberg, 2006; Joia and Lemos, 2010; Visvalingam and Manjit, 2011).

The topic of this thesis is located in the science driven Biopharmaceutical sector. In this sector, knowledge is generally specified as verified statements (Schreyögg and Geiger, 2002). Hence, historically, a lot of knowledge in science is gained by information through literature and

experimental data, but as in other industries, it is important to enable knowledge creation from individual and tacit knowledge to stay innovative. All forms of knowledge are valuable for companies, because they are a strategic asset resource and can lead to competitive advantage (Ismail Al-Alawi, Yousif Al-Marzooqi and Fraidoon Mohammed, 2007; Joia and Lemos, 2010). However, the industry determines certain types of knowledge that are valued more than others. In the Biopharmaceutical industry, this is true for knowledge related to research and development (Ipe, 2003), which includes the knowledge transferred during a technology transfer. This knowledge can appear in form of "blueprints, copyrights, patents and trademarks" (Williams, 2020, p.446), and also as process descriptions, process parameter and measured data and hence, is mainly explicit. Still, technical elements like know-how and skills are known to be valuable either (Joia and Lemos, 2010). Therefore, the next section describes the value of knowledge as an asset.

2.1.3 Knowledge as an asset

In traditional economies, capital, land and other tangible assets have been important factors for growth and competitive advantage. Today, these factors have been replaced or supplemented by knowledge as a primary production factor (Ismail Al-Alawi, Yousif Al-Marzooqi and Fraidoon Mohammed, 2007; Joia and Lemos, 2010). Knowledge itself can be characterized by its uniqueness and originality and is defined as intellectual capital and strategic resource (Ismail Al-Alawi, Yousif Al-Marzooqi and Fraidoon Mohammed, 2007; Harlow, 2008; Nonaka and von Krogh, 2009; Rinaldo, 2018). Harlow (2008), discusses the different meanings of intellectual capital, which are: "knowledge that can be converted into value; (…) knowledge and knowing capability of a social collectively; packaged useful knowledge; and Intellectual capital = competence × commitment" (Harlow, 2008, p.149).

One special property of knowledge is that it cannot be imitated or substituted once created and it develops by being used and managed (Ismail Al-Alawi, Yousif Al-Marzooqi and Fraidoon Mohammed, 2007; Nonaka and von Krogh, 2009). These characteristics make it special and valuable for all businesses as it fosters innovation (Duan *et al.*, 2022). In addition, this makes knowledge an intangible asset, which can only be captured by complex cognitive processes like learning and communication (Gao, Chai and Liu, 2018). Anyhow, to be accessed and stored, knowledge assets have to be treated like objective things (Mandják *et al.*, 2021). Companies with unstructured approaches to manage their knowledge, therefore, have issues

competing in their fields or new environments (Davenport, De Long and Beers, 1998; Joia and Lemos, 2010). An important factor here is also the involvement of the employees. Some employees might not want to share their knowledge as they assume that knowledge is their strength and by sharing they are not irreplaceable anymore (Rinaldo, 2018). This shows that people have to be convinced to share both their tacit and explicit knowledge as knowledge is one of the most important strategic resource for companies. The next section provides a summary of knowledge in context of this research.

2.1.4 Summary of knowledge and knowledge management in context of this research

In the literature there are a variety of definitions for knowledge. However, within this research, the definition of Davenport and Prusak (1998), is regarded as the most important because it summarizes knowledge as the flow of information and brings it together with the human component: “A fluid mix of framed experience, values, contextual information, and expert insight that provide a framework for evaluating and incorporating new experiences and information. Knowledge originates and prospers in the minds of experts. In organisations, it often becomes embedded not only in documents of repositories but also in organisational routine, process, practices, and norms” (Davenport and Prusak, 1998; p.5). Therefore, this definition is used to describe the knowledge needed to fulfil the task of the technology transfer. This knowledge can be either codified or tacit. In general, knowledge will be regarded as a collective asset in this context, that needs to be managed. As explicit knowledge is already valued and managed well in the Biopharmaceutical Industry, this study emphasizes the tacit knowledge used. The next chapter describes tacit knowledge more in detail.

2.2 TACIT KNOWLEDGE

This chapter provides a deeper description of different attributes of tacit knowledge to foster understanding of why tacit knowledge has been chosen as the focus topic for this thesis. When thinking about explicit and tacit knowledge, the first thought may be that explicit knowledge can provide more benefits (Alavi and Leidner, 2001). This is true when assessing the need of codified knowledge for certain tasks. However, tacit knowledge has the advantage, that it cannot be easily transferred to competitors and can avoid the variance in outcomes that might occur by only transferring explicit knowledge (Chilton and Bloodgood, 2008). This is especially relevant for the technology transfer. Therefore, in this chapter the different dimensions of tacit knowledge and its role are described. Afterwards, mechanisms and practices known to

enhance the tacit knowledge transfer are summarized. This is important to set the basis to foster the understanding of relevant influencing factors of knowledge sharing. Before concluding this chapter, the more specific literature for tacit knowledge in the BI and during technology transfers is considered.

2.2.1 Dimensions of tacit knowledge

As mentioned before, the most common dimensions of knowledge, in general, are tacit and explicit knowledge. These dimensions were mainly shaped by authors like Polanyi (1962) and Nonaka (1994). In the last decade, the research on these dimensions has increased and they were studied more closely. This section will elaborate on the dimensions of tacit knowledge in more detail, as this is the focus of the study due to its crucial impact on competitiveness and robustness of knowledge transfers. This is due to the assumption that tacit knowledge forms the backbone structure to interpret and develop explicit knowledge (Alavi and Leidner, 2001).

According to the literature, tacit knowledge consists of two dimensions: the cognitive and technical dimension (Nonaka, 1994; Alavi and Leidner, 2001; Haldin-Herrgard, 2004; Ferretti and Afonso, 2017). The technical element refers to know-how, expertise and skills and a specific context, whereas the cognitive dimension is more about individual beliefs, mental models, paradigms, thinking-pattern and points of view (Alavi and Leidner, 2001; Liu and Cui, 2012). All of these are relevant to the focus topic of this study. Lui and Cui, 2012, add three more elements to cognitive and technical dimension. For them, there is also experience, emotion and faith element in tacit knowledge (Liu and Cui, 2012). The experience dimension accumulates in the cognitive, physical and mental internal and external experience (Liu and Cui, 2012). Here, the internal experience refers to the individual experience in the organisation whereas the external experience includes all social connection and networking activities in an organisation (Liu and Cui, 2012). The emotional part of tacit knowledge is the most variable. It involves emotions like passion, likeliness, hatred and intuition, which are inherent and related to the degree of education (Liu and Cui, 2012). The last element mentioned is the faith dimension. It covers the belief in the values of the organisation, which includes the assessment of values and behaviour in organisational activities (Liu and Cui, 2012). This element is influenced by learning and experience. When looking at especially the technical and cognitive dimension of tacit knowledge, the more practical, technical element is defined as implicit

knowledge in some publications (e.g. Frappaolo, 2008). The author will use the overall definition of tacit knowledge in this thesis and will not differentiate between knowledge that could be classified as implicit or tacit knowledge to cover the whole scale from practically used know-how and skills for a knowledge transfer to individual beliefs about the process. The possible distinction between tacit and implicit knowledge, however, should be kept in mind.

Another way of classifying tacit knowledge has been done by Kikoski and Kiskoski (2004). They differentiate tacit knowledge into a fast and a slow type. For the fast type, implicit cognitive processes and reflexes are used, whereas the slow type is mental and intellectual (Kabir, 2012). Even with this differentiation, overall tacit knowledge is automatic and is rooted in the subconscious mind. This also means that the challenging aspect of tacit knowledge is how to code it, because due to its characteristics it cannot be easily listed. This results in tacit knowledge from bypassing the consciousness of an individual by using the knowledge from the environment (Chilton and Bloodgood, 2008). This decreased conscious awareness and inability to fully describe the behaviour is described in detail in the cognitive load theory and elaborates the brain functions (Chilton and Bloodgood, 2008). The theory is also about forming the long term memory by creating automated schemata while learning, which can lead to the handling of tasks without thinking about it (Chilton and Bloodgood, 2008). Chilton and Bloodgood (2008) developed a scale to measure the degree of tacitness of knowledge based on its characteristics. They assess to which degree the holder is consciously aware, if the knowledge is expressible in oral or written form, if it can be demonstrated to others and if it is applied in a formal or informal manner (Chilton and Bloodgood, 2008). Chennamaneni and Teng (2011) suggest a similar classification and divide tacit knowledge into skills with a low degree, medium degree and high degree of tacitness (Chennamaneni and Teng, 2011).

From the different ways of classifying tacit knowledge, it can be seen that there are different approaches of defining tacit knowledge. Some authors like Polanyi see tacit knowledge as a part of human actions, which means tacit knowledge can be hardly described or measured (Asher and Popper, 2019). Other authors believe that tacit knowledge can be elicited (Asher and Popper, 2019), which indicates that tacit knowledge can be expressed to a certain level. Either way, it is important to know why tacit knowledge should be evaluated further. Hence, the next section explores the role of tacit knowledge in a company.

2.2.2 Role of tacit knowledge

Knowledge in an organisation can be depicted as an iceberg. In this metaphor, the visible part is explicit knowledge, and the part under the surface is tacit knowledge. That goes along well with the Polanyi's (1966, p.4) statement "We can know more than we can tell". Tacit knowledge in an organisation makes up around 80 to 90% of the knowledge in a company (Smith, 2001; Liu and Cui, 2012; Calnan *et al.*, 2017). All the existing explicit knowledge in a company that can be expressed through language or documents is rooted in the existence of tacit knowledge (Liu and Cui, 2012). According to Harlow (2008), sharing and creating tacit knowledge, however, is the most difficult.

As described before, tacit knowledge is context-dependent, praxis-oriented, individual, and learnt by experience. Therefore, the tacit part of a company's knowledge is crucial to be sustainable competitive (Johannessen, Olaisen and Olsen, 2001) but also to maintain existing processes at high quality and to be able to decide on smart strategies for the company. However, tacit knowledge "has been overlooked or toned down in terms of competitive importance" until the 1990s (Johannessen, Olaisen and Olsen, 2001, p.7), but is become of more and more importance since then. The interest increases as tacit knowledge is connected not only to competitive advantage and strategy in a company, but also to innovation, learning and product development (Haldin-Herrgard, 2004) and manufacturing operations (Nakano, Muniz and Batista, 2013). The two latter are in the focus of this work. Liu and Cui (2012) confirm that tacit knowledge plays a big role in innovation. They also bring it together with creativity. Venkitachalam and Busch (2012), add financial growth and industry performance. In general, the mentioned recognition has also been partly described by the knowledge theory and the dynamic capability approach, but still only fractions about tacit knowledge are known (Johannessen, Olaisen and Olsen, 2001).

Anyhow, some facts about tacit knowledge are established. It is developed through organisational processes, which include procedures and internal communication (Johannessen, Olaisen and Olsen, 2001). In contrast, what is not known is why it is important in certain internal processes like the technology transfer and how it can be transferred and measured (Kane, Greene and Lipa, 2019). This is especially true for the Biopharmaceutical Industry, where the topic of this thesis is located. To overcome the lack of knowledge, different concepts have been developed to describe tacit knowledge in more detail. Haldin-

Herrgard, 2003, developed epitomes of tacit knowledge (ETKs) to use them as symbols for tacit knowledge and to assess the tacitness of different parts of knowledge (Haldin-Herrgard, 2004). These ETKs are derived from a literature review (Haldin-Herrgard, 2003) and are also used in this study to set the basis for analysing the types of tacit knowledge used during a technology transfer. The whole list of ETKs identified by Haldin-Herrgard (2003) can be found in the appendices in section 8.1. The most often mentioned epitomes for tacit knowledge, according to her research, are intuition, skills, insight, know-how, beliefs, mental models and practical intelligence (Haldin-Herrgard, 2003), which can be personal, group knowledge or even collective. Liu and Cui (2012) add wisdom, inspiration and experience to this list. It is important to understand, that tacit knowledge is less personal and abstract, then perceived, because this view offers the opportunity to enable methods of tacit knowledge transfer in a company (Haldin-Herrgard, 2004). On the other hand, authors like Hager (2000), challenge the importance of tacit knowledge and know-how in an organisation. He states that it is a "very limited concept for understanding the learning that results from an appropriate sequence of workplace practice" (Hager, 2000, p.285). Farrell (2003) agrees with this point of view (Farrell, 2003). Both authors belong to the field of Education where the tacit part of knowledge might be of less importance compared to business research, where most of the other authors are located. In terms of business, Venkitachalam and Busch (2012), describe tacit knowledge including "experiences, education, technical know-how and cultural values" as the intellectualcapital of a company (Venkitachalam and Busch, 2012, p.361), which is important in decision making processes (Smith, 2001). The term "interlectual capital" was introduced in the 1990s to show the value of the intangible asset knowledge and its relationship to value creation and the company's performance (Harlow, 2008).

2.2.3 Tacit knowledge in the Biopharmaceutical Industry

In this research, it will be important to reveal the role of tacit knowledge in a technology transfer context in the Biopharmaceutical Industry. In the ICH10 guideline the knowledge transfer during the technology transfer is defined as follows: "The goal of technology transfer activities is to transfer product and process knowledge between development and manufacturing, and within or between manufacturing sites to achieve product realisation. This knowledge forms the basis for the manufacturing process, control strategy, process validation approach and ongoing continual improvement (European Medicines Agency (EMA), 2015)". This definition does not distinguish between tacit and explicit knowledge, however.

The first time the role of tacit knowledge during a technology transfer was introduced has been in the Good Practice Guide: Technology Transfer in 2014 (Kane, Greene and Lipa, 2019) which shows that the importance of tacit knowledge in this regard has only been acknowledged recently.

Technology transfers are needed throughout the whole value chain from research over development to market access of a product (Dennett, 2015). As the technological uncertainty is higher in earlier stages of the development of biopharmaceutical assess, the need to transfer tacit knowledge during these stages is even more important (Samant and Kim, 2023). Hence, the commitment to disseminate tacit knowledge has a great impact on innovative outcomes (Samant and Kim, 2023). In combination with complementary inputs like on-site visits, the transfer of tacit knowledge can be smoothened as most of the tacit knowledge is disseminated through socialization processes (Samant and Kim, 2023). However, the entire role of tacit knowledge during a technology transfer is still not clear and fully recognized (Kane, Greene and Lipa, 2019). A detailed list of e.g. epitomes of tacit knowledge developed by Haldin-Herrgard (2003) have not been tested for the BI yet. This means context-specific research in this regard is required. The approach to make the “familiar appear novel” is described by Tsui, (2004) as one possibility to apply contextualization in context specific-research (Tsui, 2004). The context in this case is the Biopharmaceutical Industry, in which the familiar (epitomes of tacit knowledge by Haldin-Herrgard (2003)) should be assessed. In addition, due to the inductive approach of this study also new context-specific types of tacit knowledge for the BI should be identified that have not been explored yet.

Before summarizing the gaps for the tacit knowledge research in the Biopharmaceutical Industry even more, possible mechanisms and practices for a tacit knowledge transfer in general will be discussed in the next section.

2.2.4 Transfer mechanisms and practices of tacit knowledge

Most tacit knowledge in an organisation occurs in know-how and best practices (Joia and Lemos, 2010). These attributes are individual and acquired through experience, reflection, and talent. Therefore, the personal component is important to transfer this type of knowledge (Joia and Lemos, 2010). In addition, organisational structures like trust and interaction structures can support the dissemination of tacit knowledge (Joia and Lemos, 2010; Lipa, Kane and Greene, 2020).

As mentioned in section 2.1.2, tacit knowledge is difficult to express, and therefore, the communication range is limited. In addition, it is harder to find robust knowledge storing systems compared to systems for explicit knowledge (Joia and Lemos, 2010). Anyhow, there are knowledge transfer mechanisms and practices known, that can be useful for the tacit knowledge dissemination. These approaches found in the literature are summarized in the Appendices in section 8.1 and discussed further in the following. Some of these practices are document based (best practices, decision trackers, subject matter expert listing), others focus more on group or network discussions and hence use a bi-directional sharing method (collaboration and social networks, CoPs, employee and management meetings, lessons learnt / after action review). Further practices are based on a more unidirectional way of sharing (knowledge-fairs, retention of critical knowledge, shadowing of experts / apprenticeships, short- and long-term visits (in parts), storytelling). The remaining practices include individual and self-controlled learning (hands-on-practice, mentoring/coaching, in parts short- and long-term visits, trial and error). The used practice needs to be chosen according to the need. For technology transfers, tacit knowledge transfer mostly happens in an ad hoc manner (Lipa, Kane and Greene, 2020). Anyhow, implementing practices can have a strong input on the management of knowledge (Lipa, Kane and Greene, 2020). Especially “Lessons learnt”, “Shadowing of experts”, “Mentoring” and “Collaborations” are important for the technology transfer. Therefore, to know about the mentioned methods will be of importance for this study to suggest a list of mechanisms for future technology transfers. The majority of the mentioned methods are based on personal contact, to be able to discuss occurring challenges directly to learn for the next time. Especially this personal contact requires individual and company support to be successful, but a lot of organisation only focus on IT based solutions when it comes to knowledge dissemination practices (Abdelwhab Ali *et al.*, 2019). This is also important as one metaphor for tacit knowledge is the stage light perspective. Everybody in the audience sees something different and is focussing on different aspects (Spero *et al.*, 2012). Hence, different perspectives have to be assumed, and individual experiences have to be taken into account (Spero *et al.*, 2012) to get the whole picture. A recent systematic literature review about methods and technologies for knowledge sharing within learning communities (Zamiri and Esmaeili, 2024) identified similar transfer mechanisms for knowledge sharing in general. They added E-newsletters and FAQs to the list as well as detailed aspects about IT solutions like learning management systems, collaboration

platforms, wikis and video conferencing tools. Still, this study encompasses both the explicit and tacit aspects of knowledge sharing. This shows that it is hard to differentiate the transfer methods for either tacit or explicit knowledge sharing. The literature indicates that most of the general methods for knowledge sharing facilitate tacit knowledge sharing as well. As this study aims to support the robustness of technology transfers in the BI, all knowledge sharing practices will be captured in order to answer RQ3. The next section summarizes the findings of the literature for tacit knowledge and the transfer mechanisms again in brief.

2.2.5 Summary of the important aspects of tacit knowledge for this research

Tacit knowledge in general is a very complex construct as it covers many dimensions. The author will use the definition of the cognitive and technical dimension of tacit knowledge. No distinction between tacit and implicit knowledge will be applied. The context-dependent and praxis-oriented tacit knowledge in a company is not only important for strategy, innovation and competitiveness, but also for product development and manufacturing operations. During the earlier stages of the development of biopharmaceutical assets, the need to transfer tacit knowledge is very important and a lot of biological processes are transferred to clinical manufacturing at this stage to be able to supply clinical studies. Hence, the commitment to disseminate tacit knowledge has a great impact on the positive outcome of the transfer. This shows the importance of increasing the understanding of the role of tacit knowledge and its transfer in this regard. Even though some research has been done in terms of tacit knowledge, there is a call in the literature to widen the understanding of context-specific tacit knowledge for the BI. To transfer knowledge, different practices are known, that should be applied context-dependent. For the technology transfer, these would include lessons learnt, shadowing of experts, mentoring and collaboration among others. Additional mechanisms will be evaluated when answering RQ3: Which practices can be applied with a technology transfer in the BI to support the dissemination of knowledge? Most of these practices require personal contact to disseminate knowledge. The dissemination of knowledge and corresponding influences are hence, described in the next section.

2.3 Knowledge Dissemination and its Influences

To understand the importance of knowledge dissemination, the concepts of knowledge sharing (KS) and knowledge transfer (KT) are discussed in this chapter. Promoting KS and KT is one of the major challenge in managing knowledge (Gao, Chai and Liu, 2018). However, in the

literature these two terms are often used interchangeably (Paulin and Suneson, 2011), which makes it harder to assign certain literature to either KS or KT. Jonsson, 2008, noted that “it is not clear if there is a difference” between KS and KT, and therefore both will be used (Jonsson, 2008, p.39). To overcome the lack of clarity, some authors like Tangaraja et al (2016), and Paulin and Suneson (2011), provide guidance on how to use both terms. This is especially important, when discussing the borders of KS and KT. In addition, KS and KT are key processes to enable knowledge transmission between employees (Tangaraja *et al.*, 2016) which is the focus area of this work. Therefore, in this chapter, the concepts of KS and KT as well as their interconnection, are discussed. Afterwards, the special case of knowledge dissemination during a technology transfer and the influencing areas of knowledge dissemination are described.

2.3.1 Key concepts of Knowledge Sharing (KS)

Knowledge sharing (KS) is embedded in a social and individual context and focuses on knowledge dissemination in a context specific way (Paulin and Suneson, 2011). This knowledge cannot be separated from the context or the individual and is therefore described as “knowledge as a subjective contextual construction, K-SCC” (Paulin and Suneson, 2011, p.87). Gao, Chai and Liu (2018), define KS in general as “the exchange of knowledge between and among individuals” (Gao, Chai and Liu, 2018, p.47). This exchange, however, can be further separated into unidirectional and bidirectional ways of sharing (Tangaraja *et al.*, 2016). Unidirectional sharing describes the dissemination of knowledge from provider to recipient in only one direction (knowledge provision), whereas bidirectional sharing is specified by knowledge collection and donation between individuals (knowledge exchange) (Tangaraja *et al.*, 2016).

Tangaraja et al. (2016), found three elements from a literature review which construct KS:

1) The characteristic as a behavioural attribute, which involves unidirectional and bidirectional sharing
2) The people-to-people process, which can either happen on the individual level (unidirectional) or beyond the individual level (bidirectional)
3) The involved actions like only donating or giving knowledge (unidirectional) or both donating and collecting knowledge (bidirectional)

The success of KS is dependent on the degree to which the knowledge is absorbed by the recipient (Gao, Chai and Liu, 2018). That also implies that the knowledge is presented by the sender in a way that it can be understood by the recipient (Ipe, 2003). It is intended to be a voluntary act that distinguishes it from reporting (Ipe, 2003; Zamiri and Esmaeili, 2024). Hence, KS is highly dependent on human components like attitude, experience, communication and personal contact (Morshedi, Nezafati and Shokouhyar, 2023).

In this thesis it will be important to consider the knowledge transmission beyond the individual level as in the technology transfer larger teams are involved. The whole team needs to receive the required knowledge to successfully manufacture the product in a robust way. Therefore, it is important to note that the knowledge acquisition process is not part of KS. This happens via sense-making over time and is part of the Knowledge Transfer (KT), that is described in the next section.

2.3.2 Key concepts of Knowledge Transfer (KT)

Knowledge transfer (KT) has often been used to describe intra-firm organisational and group knowledge dissemination (Paulin and Suneson, 2011) which also includes the knowledge dissemination during a technology transfer. Its purpose is to facilitate the knowledge flow in a company or to an external partner (McNichols, 2010). Knowledge in this case is used like an object (K-O) (Paulin and Suneson, 2011).

KT can be distinguished into two strategies: personalization and codification (Gammelgaard and Ritter, 2005; Joia and Lemos, 2010; Venkitachalam and Busch, 2012; Tangaraja *et al.*, 2016). Both strategies can be accomplished with or without the involvement of technology. Yet, it is more intuitive to involve technology for the codification strategy due to its attributes as codification describes the storage, standardisation and structuring of explicit knowledge. Personalization on the other hand, is the strategy to mainly transfer tacit knowledge like know-how and best practices from one employee to another (Joia and Lemos, 2010; Tangaraja *et al.*, 2016). This means, mainly the technical dimension of tacit knowledge can be transferred with this strategy. The cognitive dimension, however, is harder to recognize and hence, harder to share. Still, making the technical elements of tacit knowledge independent of persons, offers the opportunity to reuse it for many purposes (Hansen, Nohria and Tierney, 1999). The personalization strategy can easily be confused with KS because KS is a critical part that is involved in the personalization strategy. This also means that there is some overlapping

content. The challenge for most companies is to decide on a focus on either the codification or personalization strategy (Venkitachalam and Busch, 2012). Organisations specialized on standardised products should adopt codification strategies to be able to use the existing explicit knowledge, whereas companies associated with customized products should rather focus on a personalization approach (Hansen, Nohria and Tierney, 1999; Venkitachalam and Busch, 2012). When looking at the Biopharmaceutical Industry where this thesis is located, there is a wide range of the nature of products depending on whether to look at a research and development department or rather product supply driven departments. The focus of this research is the knowledge transfer during a technology transfer between a development department and a manufacturing unit. It is the first time that this process has been transferred. Therefore, this knowledge dissemination is "customized" and personalization strategy should be the strategy of choice. Still, due to the nomothetic nature of the BI, most knowledge transfer focusses on explicit knowledge and hence, the codification strategy.

KT, in general, can occur on the individual level as well as higher levels such as groups, organisations and departments (Tangaraja *et al.*, 2016). As mentioned before, this study is particularly interested in the higher-level knowledge transfer.

Tangaraja et al. (2016), found three elements from a literature review which construct KT:

1) The process involved: For KT the personalization or codification strategy can be used depending on the type of knowledge that needs to be transferred

Table 2: Core process flow elements of the different KT strategies (adapted from Tangaraja *et al.*, 2016).

Strategy	**Codification**	**Personalization**
Main type of knowledge transferred	explicit	tacit
# of core processes	5	6
Process flow	Knowledge Identification	Knowledge Identification
	Recognition	Recognition
		Sharing
	Acquiring / Absorbing	Acquiring / Absorbing
	Assimilation	Assimilation
	Application	Application

2) The characteristics of KT: KT involves both behavioural and non-behavioural features, both are non-visible and occur through sense-making
3) Occurrence level: individual or higher, depending on the strategy used

As shown in Table 2, the main difference between the codification and personalization strategy is the involvement of knowledge sharing in the personalization strategy core processes. This strategy is mainly used for tacit knowledge transfer, whereas the codification strategy is intended for the transfer of explicit knowledge. There is some critique, that both strategies should be combined in every KT to use the benefit of explicit and tacit knowledge (Venkitachalam and Busch, 2012). The author agrees that both strategies are essential to indicate the full picture of the dissemination of explicit and tacit knowledge during a transfer. As discussed above this research will focus on the KT during a technology transfer with a focus on tacit knowledge. Therefore, KS and the personalization part of KT will be in focus of this thesis. Still, this does not exclude the explicit knowledge transfer of a TT as both types of knowledge are crucial for a successful TT. Hence, the next section describes this topic.

2.3.3 A special type of knowledge dissemination: Technology transfers

A relevant example of knowledge dissemination for this research is the special case of technology transfer (TT). According to Bengoa et al, 2021, technology transfer is a highly debated topic, which has no clear definition due to its complexity. One possible description of a TT is that it is a "goal-oriented process of interaction between two or more social entities during which the technology and the knowledge related to it is transferred" (Bengoa *et al.*, 2021, p.1515). Manu and Gupta, 2016, describe TTs as a "collection of techniques, methods or processes used in the production of goods" (Manu and Gupta, 2016, p.7). This includes all explicit and tacit knowledge needed to transfer a technology from one site or unit to another. This means, a technology transfer can only be considered successful, when the receiving unit can fully utilize the transferred techniques, methods and processes for the required application (Manu and Gupta, 2016).

Interestingly, most pre-historic human technology transfers were based on tacit knowledge as no written languages were available until 3000 BC and hence, evolutionary tacit knowledge was there prior to explicit (Gorman, 2002). For superior agriculture technology, technology was transferred through apprenticeship across generations (Gorman, 2002). Literal societies, however, started to rely more on explicit knowledge dissemination (Gorman, 2002). Still, even these societies knew that a document-based transfer would not lead to the desired outcome in most of the cases and therefore, experienced workers had to be hired (Gorman, 2002). These experts had knowledge that had not been or could not be written down. This means

technology transfers require both the explicit knowledge transfer by document, textbooks and briefings, and the tacit knowledge transfer that can only be done by person-to-person sharing.

To be successful in a TT, also the robustness of the process itself and the communication between both parties are decisive (Ahamed, Ternbach and Ives, 2011). Due to potential different infrastructures and technical challenges, there needs to be a vital way of exchanging knowledge during the TT (Langer, 2009; McBeath and Ball, 2012). Therefore, the TT is a very specific example for which the sharing of knowledge is of great importance. The information and knowledge flow during a generic technology transfer is described in a framework by McBeath and Ball (2012).

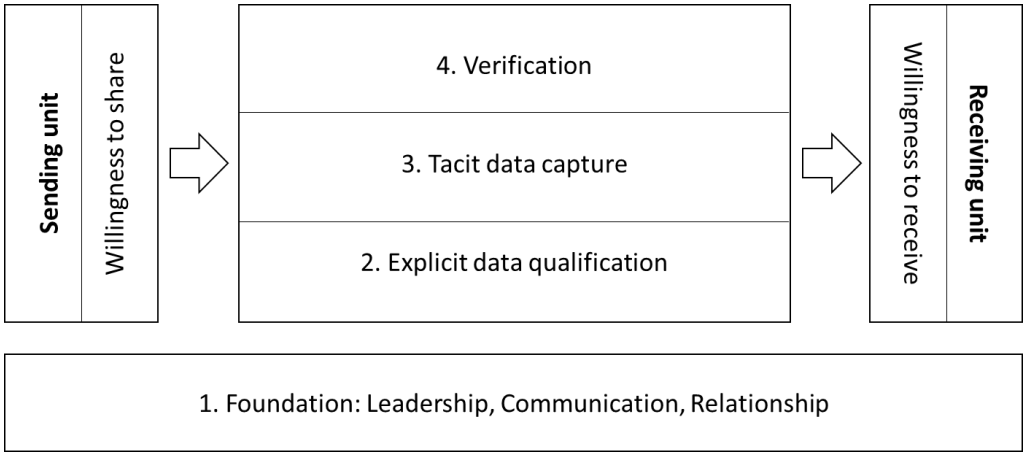

Figure 2: Framework for information and knowledge flow during a technology transfer (adapted from McBeath and Ball, 2012).

As shown in Figure 2 the TT involves a sending and a receiving unit. Both units need to have experts from all required functions involved. The sending unit has all information about the process that needs to be transferred to the receiving unit. These units can be located closely to each other or at both ends of the world. In multinational companies the technology transfer often includes two units in different countries. This means cross-cultural teams are working together as a goal-oriented and task-oriented group (Zhou *et al.*, 2023). In general, international, cross-cultural teams are more complex to handle compared to domestic projects. This is due to the fact that these teams are temporary and team members are distributed all over the world and hence, have different cultural backgrounds (Zhou *et al.*, 2023). Hence, good communication between both parties is crucial to conduct the TT successfully. This communication is fostered by a positive relationship between the team

members and a seminal leadership. Good leadership can influence the transfer in a way, that it can motivate people to strive for success (McBeath and Ball, 2012). Next to the motivation, the willingness to share knowledge is influenced by different influences like trust, perception, expectation, and ability. These influencing factors are crucial for the transfer as they determine the outcome. The explicit knowledge transfer, as well as the tacit knowledge transfer, occurs in the subsequent phases of the knowledge flow. They are transferred by exchanging relevant explicit data and manuscripts as well as trainings and face-to-face meeting. The tacit knowledge transfer intends to capture also hidden know-how (McBeath and Ball, 2012) and know-why. After transferring both types of knowledge in the last phase the transferred process is checked by verification.

To assess the importance of technology transfers more in detail, a review about studies conducted on technology transfers is provided in the next section.

2.3.3.1 Studies about knowledge dissemination in technology transfers

With regard to technology transfers and knowledge dissemination some literature reviews have been conducted to assess the knowledge available about this topic. Bengoa *et al.*, 2021, found out, that more than 3200 articles with the keyword “technology transfer“ had been published until 2018. They noticed a rapid growth of the number of studies in the recent years and state, that “TT is a contemporary discipline with great dynamism and continuous growth” (Bengoa *et al.*, 2021, p.1520).

Barros *et al.*, 2020, conducted a literture review with the keywords “technology transfer” and “knowledge management” and identified 50 relevant articles published between 2013 and 2018. These 50 articles could be grouped into case studies, literature reviews, as well as studies intended for model development (Barros *et al.*, 2020). “Most recent studies (2016–2018) are focused on the study of the industries, through applied case studies, innovation generation (Brescia et al. 2016) and partnerships between companies and universities (Duffield and Whitty 2016; Gerbin and Drnovsek, 2016; Dahlborg et al. 2017). In previous periods (2013–2014), barriers, intellectual property rights, science, groups and other topics were the most visited terms” (Barros *et al.*, 2020, p. 1596).

This study is intended to research the context of a TT in the Biopharmceutical Industry. When looking at the studies identified by Barros et al., 2020, that focus on industries, the research

by Golembiewski, B., Sick, N., & Bröring, S. (2015) as well as Speck et al. (2017) go into a related direction. Golembiewski, B., Sick, N., & Bröring, S. (2015) look at linking the knowledge-based bioeconomy to technology and innovation management research. Speck et al. (2017) discuss about bio-derived developments with regard to sustainability by considering descriptive, normative and emotional aspects.

This means in the literature studies about knowledge management during technology transfers can be found. Still, no study is explicitly looking at technology transfers in the Biopharmaceutical Industry and researching the required types of tacit knowledge and the relevant influencing factors. Hence, context-specific research in this regard is needed. Tsui, 2004, states that one approach for context-specific research is to make the familiar appear novel (Tsui, 2004). In this case this would be to describe the required types of tacit knowledge in the technology transfer context as well as the relevant influencing factors for knowledge dissemination. More details about the context can be found in the next section.

2.3.3.2 Technology transfers in the Biopharmaceutical Industry

The purpose of a process technology transfer in the BI "is to transfer all of the necessary process information, documentation, equipment, materials, and tools in order to implement the manufacturing process at a specific facility and obtain regulatory approval" (Li *et al.*, 2010, p.475). This indicated that compared to other industries the equipment knowledge transfer is not the main part of this transfer, but rather it is built around the knowledge of the manufacturing process of a biologics asset. This manufacturing process consist of upstream activities to expand the cells and produce the desired antibody and of downstream activities to purify the mAb to achieve the defined product profile as described in section 1.2.1. These processes are complex and require the involvement of experts from different areas. As already mentioned, technology transfers in the Biopharmaceutical Industry are conducted to be flexible in scheduling and locating manufacturing slots as well as to serve product demands (Langer, 2009). This can be realized internally or with an external partner, but infrastructure and technical issues must be overcome, and knowledge has to be exchanged in a robust and vital way (Langer, 2009; McBeath and Ball, 2012). The main objective of a technology transfer in the BI is to manufacture a biologic asset at the receiving site with no product quality effecting changes compared to the transmitting site (Ahamed, Ternbach and Ives, 2011). Therefore, explicit and tacit knowledge have to be disseminated in a robust way and the

codification, as well as the personalization strategy to transfer knowledge has to be applied. Otherwise, incomplete transfers could occur that have a negative effect on project timelines (Shanley, 2018) or can affect drugs and patients (Lipa, Kane and Greene, 2019). The whole transfer is dependent on the willingness to share and receive knowledge. This shows that the individual contribution to a transfer is crucial.

When comparing the manufacturing processes of Biologics to small molecule processes, the Biologics' processes are more complex and harder to scale up (Goswami et al., 2013). This is due to the fact that the biopharmaceutical process consists of upstream and downstream operations that are determining the product quality as described in section 1.2.1. The success of a transfer, hence, depends on the quality of the process, as well as on the knowledge dissemination between the involved parties (Ahamed, Ternbach and Ives, 2011). This knowledge dissemination includes both tacit and explicit knowledge, whereas tacit knowledge makes approximately 80% of the generated knowledge during a process development (Calnan et al., 2017). The transfer of both tacit and explicit knowledge has to provide all the information and knowledge needed to perform the process robustly at the receiving site. Hence, it is important to understand the influencing factors to enable a vital knowledge dissemination culture. These factors are discussed in more detail in the next section.

2.3.4 General influencing factors of knowledge dissemination

Ipe (2003), identified four different areas as important for knowledge sharing which includes the tacit and explicit knowledge sharing. Ipe's influencing areas are assumed to be relevant also for the personalization strategy of KT as this includes knowledge sharing. The author, therefore, relates to them as influencing factors of knowledge dissemination. These include "the nature of knowledge, motivation to share, opportunities to share, and the culture of the work environment" (Ipe, 2003, p.343). These areas are shaped by the company, but as stated before the individual component has great influence on tacit knowledge. Hence, it is important to note that due to inability to be stored in external repositories, tacit knowledge sharing needs active participation and cooperation of the knowledge provider (Visvalingam and Manjit, 2011). This means both the individual and the company have to contribute to make knowledge dissemination possible.

The first area of influence that has been identified is the nature of knowledge, which can either be tacit or explicit, as described earlier. The two types of knowledge can be valued differently

in organisations, which has an impact on the way the knowledge is shared (Ipe, 2003). When employees consider their knowledge valuable, they start a process of deciding what knowledge to share with whom and when (Ipe, 2003; Joia and Lemos, 2010). For valued knowledge employees tend to claim emotional ownership, which is due to the fact, that knowledge is linked to status, career development and reputation (Ipe, 2003). One type of knowledge that is considered of high value is knowledge related to research and development activities (Ipe, 2003). This is important to know, especially for this project, as it is assigned to the Development Department of the company. The observed technology transfer will take part from the Development Department to the Manufacturing Unit. That means the knowledge is important to manufacture a high-quality product and is therefore commercially valuable. The dilemma of contradictory incentives to share and withhold knowledge needs to be closely watched (Ipe, 2003).

The second area to enhance knowledge dissemination according to Ipe (2003), is the "motivation to share". This motivation can either be internal or external. Internal motivation is based on the power attached to knowledge and knowledge sharing. When employees see knowledge as a tool to control and defend, this can lead to politics of information, which means these employees might also hoard their knowledge to protect it (Ipe, 2003; Joia and Lemos, 2010; Duan *et al.*, 2022). To share their knowledge, employees must understand that it is a give and take process (reciprocity) (Abdelwhab Ali *et al.*, 2019). When sharing knowledge individuals expect to benefit from their involvement in created value (Ipe, 2003; Abdelwhab Ali *et al.*, 2019). External motivation, on the other hand, is more related to relationships and rewards (Ipe, 2003; Visvalingam and Manjit, 2011). The two levels in relationship that influence the KS are trust and the power of the recipient (Ipe, 2003; Joia and Lemos, 2010). Trust is based on how much individuals contribute to the community as well as how much cooperation is valued by the recipient (Ipe, 2003). In terms of power relations, employees tend to share their knowledge with employees with a higher status and power compared to themselves or on their peer level when they already have a certain status (Ipe, 2003). When communicating knowledge upwards, unfavourable or vulnerable information is withheld (Ipe, 2003). To overcome this, rewards for knowledge sharing can be implemented. These can either be positively related with incentives or negatively by penalties that are related to knowledge sharing (Ipe, 2003). Different types of rewards, monetary or intangible rewards like recognition are needed to keep up the motivation of individuals (Ipe, 2003; Rese, Kopplin

and Nielebock, 2020). Gao, Chai and Liu, 2018, also agree to this. In addition, they suggest to add joy and social capital to the motivation factors (Gao, Chai and Liu, 2018).

There are formal and informal opportunities to disseminate knowledge in a working environment, which relate to the third mentioned influencing area for the knowledge dissemination process. Formal actions include training programmes, working teams, and IT solutions that enable knowledge dissemination (Ipe, 2003). This means the knowledge exchange process is structured, and the necessary tools are available. Most knowledge that is disseminated through this channel, however, tends to be explicit, as mentioned in section 2.3.2. Informal exchange is fostered by relationships and social networks (Ipe, 2003; Joia and Lemos, 2010; Nakano, Muniz and Batista, 2013). Many of these opportunities take place face-to-face enabling trust, which is important for knowledge sharing in general (Ipe, 2003).

All the factors described above are influenced by the organisational culture, which is essential for knowledge creation, sharing and use (Ipe, 2003; Visvalingam and Manjit, 2011). Culture is reflected in values, norms and practices in the company, as culture is a collection of assumptions on how to approach problems and how to work together (Ipe, 2003). These aspects shape which knowledge is important and it creates the forum for social interaction and, therefore, also has an influence on the different levels where knowledge is used (individual, organisational or group level) (Ipe, 2003). Norms greatly influence how knowledge is shared, because they determine how and when knowledge is communicated and processed (Ipe, 2003). Organisational values that are created by a corporate vision influence KS as well. Important values are the involvement of employees, trust, and openness (Ipe, 2003). As described in section 1.2.3, this is an interesting point for multinational technology transfers, because the country culture for the team members might be different. Hence, corporate culture needs to bring values and mindsets of employees from different countries together.

The mentioned areas of influence are summarized in Figure 3 to show their interconnection.

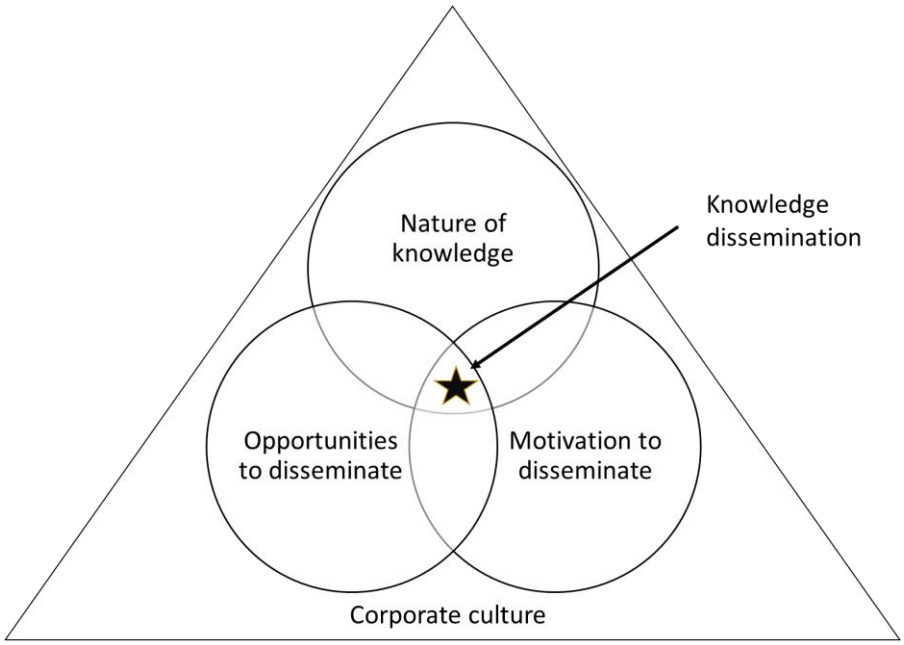

Figure 3: Influencing areas of knowledge dissemination (adapted from Ipe, 2003).

Figure 3 shows that only when all puzzle pieces come together (nature of knowledge, opportunities to disseminate, motivation to disseminate, and corporate culture), knowledge is effectively disseminated. This sweet spot is indicated by the star in the figure. The sweet spot area is rather small, which suggests it is hard to achieve a "perfect" dissemination atmosphere. One aspect why this is the case could be that companies focus more on one area compared to another.

Anyhow, authors like Ipe (2003) and Joia and Lemos (2010), approach the influencing areas of knowledge dissemination in a positive way. They mention the factors that can enhance the process. When looking into additional literature, some authors approach it the other way around and discuss the knowledge barriers. Gammelgaard and Ritter (2005), for example, identified barriers for KT, which include "fragmentation, overload and de-contextualization" of knowledge (Gammelgaard and Ritter, 2005, p.133). Paulin and Suneson (2011) add factors like "lack of absorptive capacity, [..] uncertainty how aspects of the knowledge interact and respond to factors in the environment [.. and] an ardous relationship between source and receipient" (Paulin and Suneson, 2011, p.86). In addition, they mention three areas where knowledge barriers might occure, namely in the fields of economic, organisational and behavioral contexts (Paulin and Suneson, 2011). McNichols (2010), adds ignorance, no absorptive capacity, lack of preexisting relationships and lack of motiviation (McNichols, 2010). This shows that knowledge dissemination cannot only be influenced in a positive way,

but there can also be barriers that decrease the chance of knowledge dissemination in a company.

This section offers a high-level description of influencing areas for knowledge dissemination in general. However, these areas can be broken down into single factors. In the literature various factors can be found that influence or facilitate especially the tacit knowledge transfer. Joia and Lemos, 2010, did a literature review for the most relevant factors associated with the KT of tacit knowledge. The factors and their importance are shown in the appendices in section 8.3. They are supplemented with additional factors found in the literature by the researcher of this thesis. All identified factors have been categorized into the influencing areas according to Ipe (2003). This assignment has been done by the researcher.

To do so, the researcher used the description of the areas “nature of knowledge”, “opportunities to disseminate” and “motivation to disseminate” to categorize the single factors. The result can be found in Figure 4.

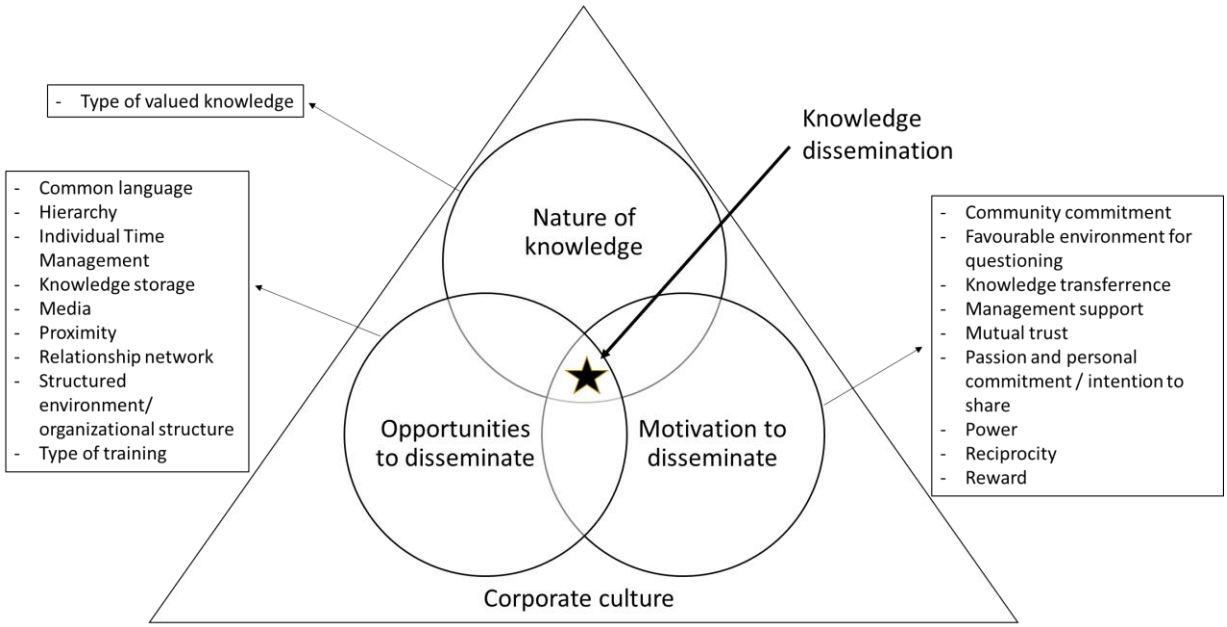

Figure 4: Assignment of single influencing factors to Ipe's (2003) influencing area model.

The assignment of the influencing areas show that the majority of the single factors are located in the areas of opportunity and motivation to disseminate. Anyhow, for all these factors it is important to note, that the underlaying structure is the corporate culture. Corporate or organisational culture is referred to as the combination of language, symbols, rituals, and myths of a company (Abdelwhab Ali *et al.*, 2019). To successfully disseminate

knowledge, influencing factors of the different areas have to fit together so that there is an overlapping region (indicated by the star in the figure) where knowledge dissemination is effective.

In fact, 19 factors were identified from the literature. Joia and Lemos (2010), identified 13 indicators to enhance the tacit knowledge transfer already by a literature review. This means additional 6 factors were found that will be used for this research to build on what Joia and Lemos (2010) already evaluated for a major state-owned Brazilian oil company. They call for further research on these influencing factors in other devisions as well as on "how tacit knowledge is used within an organisation (…)" (Joia and Lemos, 2010, p.423). In addition, even though some influencing factors of tacit knowledge dissemination are known, there is still the call in literature to further investigate their influence and importance. Venkitachalam and Busch, 2012, suggest to explore the relationship between context-dependent factors like values, culture, strategy etc. and the tacit knowledge flow in more detail. To close this gap, research question 2: "What influences the knowledge transfer between the German development department and the US manufacturing department in the BI?" will evalute the influencing factors in a context specific manner. It will explore whether the mentioned factors are relevant in this sector and if there are additional factors that should be monitored.

The next section summarized the section of knowledge dissemination in context of this research.

2.3.5 Summary of knowledge dissemination in context of this research

To decide on the right methodology for this research, it is important to understand the underlaying theories of the topic to approach it. As this thesis is focussing on the tacit knowledge required for technology transfers, it is crucial to have clear definitions for the terms KT and KS. In the literature this definition is unclear in some publications, but authors like Tangaraja et al, 2016, and Paulin and Suneson, 2011, provide good guidance on how to differentiate both concepts. As outlined in this chapter, the research will be focussing on an intra-company knowledge transfer during a technology transfer. A technology transfer is a "goal-oriented process of interaction between two or more social entities during which the technology and the knowledge related to it is transferred" (Bengoa *et al.*, 2021, p.1515). At the same time, a "collection of techniques, methods or processes used in the production of goods" (Manu and Gupta, 2016, p.7) is transferred. The purpose of a process technology

transfer in the BI “is to transfer all of the necessary process information, documentation, equipment, materials, and tools in order to implement the manufacturing process at a specific facility and obtain regulatory approval (Li *et al.*, 2010, p.475)”. This includes all explicit and tacit knowledge needed to transfer a technology from one site or unit to another. To capture the tacit portion of this process, the personalization strategy will be of importance. As this strategy also includes knowledge sharing also aspects of this concept will be considered. Both the personalization strategy, as well as knowledge sharing is based on the willingness of employees to disseminate both their tacit and explicit knowledge. Hence, the corporate culture, which influences the motivation to disseminate knowledge, offers opportunities to disseminate knowledge and influences the type of valued knowledge has to fit the company’s or departments focus of work.

To bring the findings from the literature review together, the next section concludes the theoretical background of this study.

2.4 Conclusion of the Literature Review

Knowledge is the flow of information in a company, which is dependent on context and individual assumptions. It can be either codified or tacit. To make knowledge available to all members of the company, it has to be disseminated. Knowledge dissemination can be distinguished between KS and KT, whereas KT describes the intra-firm organisational and group knowledge dissemination (Paulin and Suneson, 2011) which is also relevant for the technology transfer, the focus area of this thesis. A technology transfer is a “goal-oriented process of interaction between the sending and receiving unit during which the technology and the knowledge related to it is transferred” (Bengoa *et al.*, 2021, p.1515). In the Biopharmaceutical Industry, the purpose of a process technology transfer “is to transfer all of the necessary process information, documentation, equipment, materials, and tools in order to implement the manufacturing process at a specific facility and obtain regulatory approval (Li *et al.*, 2010, p.475)”. This includes all explicit and tacit knowledge needed to transfer a technology from one site or unit to another. The context-dependent and praxis-oriented tacit knowledge in a company is not only important for strategy, innovation and competitiveness, but also for product development and manufacturing operations. During the earlier stages of the development of biopharmaceutical asset, the need to transfer tacit knowledge is very important and a lot of biological processes are transferred to clinical manufacturing at this

stage to be able to supply clinical studies. A detailed list of e.g. epitomes of tacit knowledge developed by Haldin-Herrgard (2003) have not been tested for the BI yet. This means context-specific research in this regard is required using the “familiar appear novel” described by Tsui, (2004) as one possibility to apply contextualization in context specific-research (Tsui, 2004). This is done when answering RQ1: Which types of tacit knowledge are used during a technology transfer between a German development department and the US manufacturing department in the BI?. Anyhow, different methods are known to enhance the knowledge sharing, which are contextualized during this study by answering RQ3: Which practices can be applied with a technology transfer to support the dissemination of knowledge? The effectiveness of these practices can be enhanced by fostering influencing factors in a company. These factors are important to be able to identify set screws for upcoming transfers and are assessed during answering RQ2: What influences the knowledge transfer between the German development department and the US manufacturing department in the BI?. In addition, during the comprehensive literature review specific gaps have been identified that were used to develop the aim of the study as well as the research questions. These gaps are presented in the next section.

2.4.1 Summary of identified gaps in the literature about tacit knowledge applied in technology transfers in the Biopharmaceutical Industry

The literature review reveals that transferred knowledge during technology transfers in the BI is often biased toward codified or explicit knowledge (Lipa, Kane and Greene, 2019). This is not entirely surprising as this industry relies on nomothetic science (general laws which concern generality) rather than individual perspectives (idiographic) (Abettan, 2016). This is also confirmed by the Good Manufacturing Practice (GMP) mantra “if it isn’t written down, it didn’t happen” (Lipa, Kane and Greene, 2020, p.4). However, Lipa, Kane and Greene (2019) found out, that both explicit and tacit knowledge are important for the technology transfer and the BI, but only explicit knowledge is managed effectively. Incomplete knowledge transfers, with a tendency towards the explicit knowledge transfer, are a consistent problem and lead to delays in timelines (Shanley, 2018). Lipa, Kane and Greene (2019) did some pioneering research for tacit knowledge in the BI and identified tacit knowlegde associated with technology transfers as the part of the transfer where only limited understanding is available. They also state, that it is not widely recognized and call for further research in this direction (Lipa, Kane and Greene, 2019). One reason for this is, that “tacit knowledge transfer

is frequently undervalued and underestimated by the technical teams managing the technology transfer project and (…) a frequent cause of failure and of on-going process-related problems post-transfer" (Kane and Lipa, 2020, p.25). Another aspect why exploring and sharing tacit knowledge in the BI is important, is "(…) the simple reason that regulatory approval typically requires the extensive codification of tacit manufacturing knowledge" (Nicholson Prince II, Rai and Minssen, 2020, p.913). Hence, more research with regards to the types of tacit knowledge used during TTs in the BI is needed. This also shows that there is room for further research to be able to understand the used tacit knowledge better, in order to make TTs more robust and to strenghten the visibility of tacit knowledge in the BI. This is in line with the call in the literature from Hadjimichael and Tsoukas (2019) to contextualize tacit knowledge more. Nakano, Muniz and Batista (2013) also highlighted that more insight into tacit knowledge associated with technology transfer and in particular with shop floor workers is needed. This indicates that the practical component of tacit knowledge needs to be evaluated further. To foster the dialogue about practical knowledge between the sending and receiving unit, Lipa, Kane and Greene (2019) identified open-ended questions a benficial mechanism. Hadjimichael and Tsoukas (2019) highlighted that additional studies for methods to transfer tacit knowledge in the digital environment are required. Zamiri and Esmaeili (2024), evaluated different methods to support both tacit and explicit knowledge sharing within learning communities (Zamiri and Esmaeili, 2024). They state that the selection of methods and technologies has to be aligned with the contextual-characteristics. This means methods and practices for knowledge sharing have to be tailor-made for the technology transfer in the BI. Hence, a study to contextualize knowledge sharing methods in this regard would help to widen the literature. These practices, however, are influenced by individual and organisational factors. These influencing factors can occur on the individual, organisational or group level (Ipe, 2003). Joia and Lemos (2010) call for further research on how tacit knowledge is used in an organisation, after they did some research on influencing factors of the tacit knowledge transfer in an oil company. Their research was limited to a specific department in this state-owned company and so they also call to do research in the private sector, which the study for this thesis will imply. In terms of the influencing factors, it will also help to widen the literature as there is a call from Borges, Bernardi and Petrin (2019) and Venkitachalam and Busch (2012) to explore the dependency of context dependent factors and the tacit knowledge transfer in more detail. Visvalingam and Manjit (2011) suggest a study

in the same direction and ask for more research on complementary predictors of tacit knowledge sharing. Knowlegde sharing in general is associated with organizational growth, and therefore, additonal case studies should be conducted to identify nuances of the influences of knowledge sharing (Ipe, 2003). Hence, the aim of the study to explore and identify tacit knowledge that is needed during a technology transfer in the BI and to find influencing factors improving the success of the knowledge sharing in general and more specific the tacit knowledge dissemination will widen the limited literature on this topic and will contribute to closing some of the gaps found during the literature review in the specific context of the Biopharmaceutical Industry. To do so, a tailor-made methodology and methods has to be used for the study, which is presented in the next chapter.

3 METHODOLOGY AND METHODS

3.1 THE RESEARCHER

3.1.1 Context and background

The researcher is part of the company the research is conducted in. Hence, it is important to understand the researcher's background and working context to give transparency on the interdependencies of the researcher's position and this study.

Before being employed in the company, the researcher studied Molecular Biotechnology. Already during her Master's studies, she started her career in the company in the division responsible for the development of pharmaceuticals with an internship that led to a project for her Master's thesis. After successful completion of her degree, she continued working in the Biological Development unit as a scientist responsible for the implementation of state-of-the-art technologies. Later, she was given the opportunity to laterally lead a laboratory team. At the same time, she also started to technically lead the CMC development team of an asset in the pipeline of the company and had been able to get insights into project management. The author tightened these project management skills by project management trainings. In the lifecycle of such a pipeline asset, she got in contact with technology transfers which form the focus area of this research project. In both of her roles, the lateral team lead and the project manager, the researcher also gained experience in leadership. Two years later, the researcher became a laboratory head with direct reports. Her lab is responsible for the development of manufacturing processes. Having more responsibility in the leadership area, the researcher wanted to increase her knowledge in this regard even more. Hence, she again conducted trainings but also got more interested in the tacit knowledge that is available in the company. This led to the idea of this research and brought together the technology transfer aspect with the leadership topic to maintain tacit knowledge in the company.

During her eight years in the company, when starting this thesis, the researcher has had different positions with different responsibilities, which shows the commitment and experience she gained. This also means that conducting research in the organisation she works in has some implications as she will be an insider researcher. This topic is elaborated more in the next section.

3.1.2 Being an Insider Researcher

When conducting work-based research, the organisational structures and culture, as well as the actions of colleagues, will affect the study (Costley, Elliott and Gibbs, 2010). In this kind of research, it is important to understand the situatedness of the study, which is defined as the interplay between agent (researcher), situation (circumstances and position) and context (where, when, background) (Costley, Elliott and Gibbs, 2010). To be transparent about the situatedness, the agent and situation are described in section 3.1.1. As mentioned, the researcher had different roles in the company already and is currently in a laboratory head position, responsible for direct reports. The context of the study is elaborated further in the introduction (section 1.2). In a nutshell, this study will investigate the knowledge transfer during the first technology transfer from Germany into a brand-new facility in the US. The transfer was scheduled to start in 2021 and involved colleagues from Germany and the US.

As mentioned before, when individuals conduct research in the organisation they are part of, these individuals are called insider researcher (Coghlan, 2007; Humphrey, 2012; Saunders, 2019). Insider research has the advantage that it leads to specific individual and organisational learning (Milano, Lawless and Eades, 2015) and critically reflect on the status quo in an organisation (Costley, Elliott and Gibbs, 2010). This can lead to change a practice situation. This study is intended to increase the understanding of the tacit knowledge used during a technology transfer in the company and to deepen the understanding of protentional influences on the knowledge transfers. Overall, being an insider researcher means the researcher has access to insider knowledge, which could not be used by an outside researcher. However, conducting insider research, on the other hand, can cause dilemma in the fields of ethics, profession and politics (Costley, Elliott and Gibbs, 2010; Humphrey, 2012) as well as power and privilege (Costley, Elliott and Gibbs, 2010). These dilemmas have to be prevented by considering them before starting work-based research. In terms of the ethical dilemma, honesty, privacy and fair share have to be regarded (Unluer, 2012). These aspects have been discussed in an ethical application at the Ethical Committee at the University of Worcester, as well as with HR and the worker's council in the organisation. Dilemmas with regards to ethics include that informed consent of the participants must be given, that the participation is voluntary, that confidentiality is ensured and that any harm to the participants is avoided (Worcester, 2018). The researcher is aware that she will potentially recruited colleagues that she shares a professional past with, which has also been experienced in other research studies

(Poulton, 2023). Hence, being transparent about the research and speaking about potential risks with regards to confidentiality is important. For this reason, information sheets and consents forms have been established, which can be found in the appendices in section 8.4 (information sheet) and 8.5 (consent form). Another aspect to watch as mentioned before, is to protect the anonymity and confidentiality of close colleagues (Poulton, 2023). The participants of this study knew each other as they were working in the same technology transfer team. Hence, anonymizing the data had to be carefully done to avoid identification of individual participants by other team members. Therefore, no position of the individual team members was mentioned during the data analysis. Only the membership of the sending unit or receiving unit was mentioned. When considering the professional dilemma, different roles in the professional life can collide (Humphrey, 2012). This means the role duality (being a member of the organisation and the role as a researcher) has to be combined with organisational politics (Coghlan, 2007). Hence, all stakeholders have been regularly updated to avoid conflicts. In terms of power, the researcher did not interview direct reports to avoid issues that might occur due to higher-ranked positions (Mercer, 2007). In general, insider research has, as mentioned, advantaged and disadvantages. Whether it leads to different results compared to outsider research is debated in literature and not clear yet (Mercer, 2007). Overall, the researcher sees great advantage in conducting this study as an insider researcher. Knowing the status quo and the individual needs of technology transfers in the BI is beneficial to generate data that can support the knowledge dissemination in this regard. Dilemmas going along with this role have to be watched and openly discussed with the participants. Knowing that the participants are the researcher's colleagues, implies a respectful and transparent communication that should be given anyway.

The author's insider researcher perspective supports the qualitative orientation of the study. As the research philosophy has to support these assumptions, the next section discusses the philosophical spectrum for this research.

3.2 Methodology

In order to justify and organize the methodological approach for a research study, the philosophy, the approach to theory development, as well as the strategy and the methodological choice have to be linked (Saunders, 2019). Figure 5 shows a short overview of the chosen research design.

Philosophy	• Constructivism
Reasoning	• Induction
Methodology	• Multi-method
Strategy	• Single Case Study
Data	• Qualitative
Data collection	• Interviews and focus groups

Figure 5: Chosen research design for the study.

The following sections provide a short description of the topics and describe their application for the proposed research.

3.2.1 Research philosophy – use of constructivism to get an insight into human perspectives

Research in the area of knowledge management, in general, and more specific for tacit knowledge, can be based on different paradigms (Turyahikayo, 2021). There is no defined paradigm that has to be used for these studies, but it should be chosen according to the needs of the study. The complex aim of this study requires flexible research methods to address the fact that the tacit knowledge transfer during a technology transfer involves different people from different countries. This means methods must be respondent to the context as well as the formal aspects of a TT. As mentioned in section 2.2, tacit knowledge is regarded differently in terms of its ability to be expressed by different authors. Hence, different authors will pursue different goals with their studies and use different philosophies.

Studies based on positivism most often focus on explicit knowledge (Turyahikayo, 2021) or see tacit knowledge as something that is possible to elicit (Asher and Popper, 2019) as this philosophy is searching for a single and objective reality (Thomson, Petty and Scholes, 2014). The study outcome is intended to be generalizable and value-free. Studies on tacit knowledge with this philosophy most often appear in the two disciplines of practical intelligence and organisational learning and focus on the practical contribution of the tacit part of knowledge (Asher and Popper, 2019). However, these studies can be criticised in a way that they do not take into account that tacit knowledge can be unconscious and how it is acquired. These studies adapt quantitative methods to model tacit knowledge (Buunk, Hall and Smith, 2016). Quantitative methods like surveys with Likert scale (e.g. in Joia and Lemos, 2010; Borges,

2013; Salleh *et al.*, 2013; Tsai, 2014) are initially designed for studies of explicit knowledge and hence, lack in the ability to capture the multidimensional nature of tacit knowledge (Buunk, Hall and Smith, 2016). Another aspect that is criticised in these studies is that most of the resulting models remain untested (Buunk, Hall and Smith, 2016). As mentioned before these studies lack in researching the unconscious part of tacit knowledge, which also means that they do not recognize socially constructed and embedded knowledge as well as know-how received from experience and working practice. The increase of understanding of these forms of knowledge however is the focus of this study. Due to the lack of information regarding the unconscious part of tacit knowledge, positivist studies are at risk of meeting the requirements for research validity as they do not research tacit knowledge itself, but rather resulting forms of information derived from tacit knowledge (Buunk, Hall and Smith, 2016).

Interpretivism, on the other hand, assumes that there are multiple realities as they are created by individuals (Thomson, Petty and Scholes, 2014) and accepts that these cannot be studied objectively (Buunk, Hall and Smith, 2016; Pham, 2018). Studies using this philosophy apply qualitative methods like interviews, focus groups and surveys (e.g. in Puusa and Eerikäinen, 2010; Nakano, Muniz and Batista, 2013) which do not lead to model generation but rather provide understanding of questions that are related to tacit knowledge (Buunk, Hall and Smith, 2016). These studies are criticised in a way that they cannot be generalized as they are focussing on a certain topic in a specific setting. Therefore, studies based on this philosophy leave a gap in verifying the results. However, interpretivist studies often use a case study setting, which generate new or broadened understanding by deeply analysing data (Buunk, Hall and Smith, 2016).

The deep analysis of the data is one goal of this study. However, due to her background and her ontology, the researcher prefers a philosophy that seeks to use a more objective truth for the study. Constructivism is a philosophy derived from interpretivism and, therefore, can also be used as a "sensitizing concept" to answer specific research questions (Schwandt, 1994). Like interpretivism, constructivism offers the opportunity to provide understanding of a complex world with multiple individuals. Its aim is to create understanding rather than general findings. Hence, it also uses the same sets of methods as interpretivism. However, constructivism differs from interpretivism in the way it sees realities are created. For constructivists, reality is subjectively formulated in the individual's mind and do not consider

the reality as an outward entity. This means there is not one single truth, but realities shaped by the participant's history, environment, and culture. The individuals are hence, actively involved in the knowledge-creation process (Ültanır, 2012). This shows that constructivists believe that new knowledge is built on prior knowledge, which also implies that the existence of actual truth is hard to explain. Hence, the assumption can be created that relativism is in vain (Krahenbuhl, 2016). In contrast to interpretivists, constructivists seek to use "objectivism, empirical realism, objective truth, and essentialism" for their research (Schwandt 1994). Hence, constructivists distinguish between natural and social phenomena and see them both as linguistically constructed. "For (Constructivists), the natural sciences are just another realm of social life" (Gorski 2013, p.660). Constructivists are "observing reality being formed in daily life or in science" (Ültanır 2012).

This study seeks to generate an understanding of tacit knowledge used during the technology transfer and the influences and practices supporting a technology transfer in the BI. The tacit knowledge used, and the influences are subjective and hence, dependent on the participants involved. This means the research needs to provide an understanding of the world of individuals, which indicates the application of a philosophy located at the interpretivist end of the philosophical spectrum. The need to generate understanding rather than generalization is because the technology transfer is dependent on human behaviour. During the study, the knowledge will be provided by the individuals involved, which will lead to an enhanced understanding of the specific phenomenon. Thus, the constructed realities are subjective outcomes within boundaries. The researcher's task in this study will be to collect and organize the participants data. This clearly points to the use of the constructivist's paradigm as it is suitable to research knowledge that is dependent on the knower, as well as a specific context (Ambrosini and Bowman, 2001). To avoid bias due to the construction of knowledge by the researcher, a feedback cycle will be implemented after the first data collection and construction, to ensure that the data is not interpreted wrongly, but purely taken from the participants.

The chosen philosophy has to be aligned with the study design, which is presented in the next section.

3.2.2 Approach to theory development – use of an inductive approach to address the research needs

Depending on the ability to be expressed, tacit knowledge can appear in different facets. Some types of tacit knowledge can be hardly described, others can be elicited (Asher and Popper, 2019). Tacit knowledge appears in forms of know-how and expertise but also in individual beliefs and thinking-patterns (Alavi and Leidner, 2001; Liu and Cui, 2012). Hence, capturing embedded and difficult to express tacit knowledge located in, for example, individual beliefs or thinking patterns, will be a challenge in this study. The literature review indicates, that there is only limited understanding about tacit knowledge during a technology transfer available (Lipa, Kane and Greene, 2019). In addition, as some general influencing factors for tacit knowledge and knowledge sharing in general are known from the literature, it needs to be clarified which of them are relevant in the context of technology transfers in the BI. Hence, this study will use the generated data and observe patterns in the data set to form a theory based on interpretation (Thomson, Petty and Scholes, 2014). Collected data on tacit knowledge that is used during a technology transfer will be thematically analysed to form patterns. This implies the use of an inductive approach. To support the analysis of the types of tacit knowledge, in a first step epitomes of tacit knowledge developed by Haldin-Herrgard (2003) will be evaluated from the data set. This supporting content analysis hence, uses an abductive approach. Still, as the main part of the analysis is based on an inductive approach, this study is considered inductive. Also, this research is intended to construct relationships between variables identified during data analysis which goes well along with the inductive approach. To form patterns, a suitable strategy, methodological choice and data collection method are needed. Hence, this is described in more detail subsequently.

3.3 Methods and Data collection

3.3.1 Strategy – Case study research to broaden the understanding of the tacit knowledge used during technology transfers

The strategy is considered the link between the choice of methods and the research philosophy. Different strategies have been developed that are associated with qualitative, quantitative or mixed-methods approaches (Saunders, 2019). A few examples for strategies are experiments, surveys, archival and documentary research, case study, action research, grounded theory and narrative inquiry. In this research, a case study will be the strategy of

choice due to its inductive nature and the empirical approach that uses different kinds of information to collect context-dependent data (Boiral, 2002). In addition, the case study approach is often used to conduct research on tacit knowledge as it provides understanding on situational details about its nature and about the dissemination (Kucharska and Erickson, 2023). These aspects are important to study the human and tacit aspects during a technology transfer.

A case study explores a contemporary phenomenon that is rooted in a real life context and can involve one system (single case) or multiple systems (multiple cases) (Eisenhardt, 1989; Gustafsson, 2017; Warren and Bell, 2022). It is intended for an in-depth analysis to develop an understanding of a real-world phenomenon within the borders of the case (Guetterman and Fetters, 2018). Case studies can be differentiated by the study purpose, the number of cases and the units of analysis used (Guetterman and Fetters, 2018). Despite these differences, all case studies have in common that they collect and analyse multiple sources of data, they aim to clarify and understand theoretical propositions and they provide a report of the case description and themes (Guetterman and Fetters, 2018).

Whether only one case or multiple cases are selected depends on the purpose of the study. They can either be selected because they represent a phenomenon of interest (instrumental case study) or a unique or important situation, where the case itself is of interest (intrinsic case study). As mentioned before, case studies also differ in the number of cases they are looking at. For multiple case studies, the researcher evaluates different cases to understand differences and similarities and will be able to analyse data of different cases simultaneously or one after another (Gustafsson, 2017; Guetterman and Fetters, 2018). This also means that the researcher will be able to create strong and reliable data that can be used for theory development and a broad exploration of the research questions (Gustafsson, 2017). The downside of multiple case studies is that these studies are expensive and time consuming. If the researcher only wants to research a single phenomenon a single case study can be chosen and hence, the researcher gets a deeper understanding of a subject by taking more time to explore relationships in the study (Gustafsson, 2017). This in-depth understanding is gained by implementing a variety of perspectives (Ozcan, Han and Graebner, 2017). In a single case study it is also possible to look at different subunits in one case and do cross-analysis (Gustafsson, 2017). It is supported when the case is representative and typical for the problem

(Joia and Lemos, 2010). In addition, single cases allow research in areas that are not easily accessible for outsiders (Ozcan, Han and Graebner, 2017). The last attribute that differentiates case studies are the units of analysis. Holistic case studies use a global analysis of e.g. a program, whereas the embedded case study design analyses the data on different levels e.g. participants in the program and from different sites (Guetterman and Fetters, 2018). In this study the researcher will look at one specific technology transfer in the BI in the researchers employing company. Hence, the context is relevant for the phenomenon, which makes the case study an appropriate choice (Warren and Bell, 2022). The transfer took place in 2021 from a German development unit to an US manufacturing unit. The purpose of this transfer was to enable robust clinical manufacturing at the US manufacturing unit for one specific biologics asset product. This kind of technology transfer is representative for other transfers in the BI that are done due to capacity reasons or for clinical manufacturing. This makes this case a great opportunity to study the tacit knowledge used during this transfer in-depth and to ask for different perspectives on what influences the knowledge dissemination in a TT. Contextualized understanding of the phenomenon hence, will be provided. Still, this case has the unique occurrence that it took place during the Covid-19 pandemic. In addition to this special situation it was performed in, the fact that it was the first transfer with an entirely new team setting at the US site made it special. The knowledge gained by studying this transfer can only be assessed by an insider researcher as an outsider would not have access to the information. Hence, the study can be considered an extreme case and therefore is worth studying (Warren and Bell, 2022). The study will cover the subjective realities of the involved participants and will deepen the understanding with regards to types of tacit knowledge used during a technology transfer, influencing factors of the knowledge transfer and used practices and mechanisms to disseminate the knowledge. Hence, it will look at a contemporary phenomenon rooted in a real-life context for one single case and will use an embedded design for analysis. Therefore, according to Eisenhardt (1989) this study can be considered a (single) case study (Eisenhardt, 1989). This single case study will look at different subunits involved in the transfer (sending unit and receiving unit). Data will be gathered by individual interviews, as well as focus group discussions. The data analysis for both interview-based method types will be different due to the purpose of the methods. As mentioned in section 3.2.1, the use of case studies is one advantage of interpretivism and constructivism, as it offers the opportunity to perform deep data analysis and hence, broaden the understanding of a specific

phenomenon. As constructivism is chosen for this research study, the strategy is aligned with the philosophy. In addition, the methodology and methods need to be in line with the strategy. Hence, the next sections discuss these aspects.

3.3.2 Methodological choice – qualitative approach to capture opinions and subjective understanding

Research studies are often distinguished into qualitative and quantitative approaches by assessing whether the used data collection method results in numeric or non-numeric data. Qualitative research has the objective to capture opinions and subjective understanding, which means it is used to obtain insights on a research question in an exploratory way (Almeida, 2018). Hence, non-numeric data is generated (Saunders, 2019). Quantitative research on the other hand, intends to measure behaviour with a subsequent statistical data analysis (Almeida, 2018). It generates numeric data (Saunders, 2019). Another possible option is to combine both methods if more flexibility and the advantages of both approaches are needed to answer the research question (Bell and Warren, 2023). This approach is called mixed methods. This combination allows the use of inductive, deductive or abductive approaches (Saunders, 2019).

When using one single data collection technique, the study is considered a mono method study. If more than one method to either collect qualitative or quantitative data is used, the study is called a multi method study. If qualitative and quantitative research are combined, the study is referred to as a mixed method study as mentioned above.

This research study will use qualitative research methods embedded in a case study design. This also indicates the insider researcher role of the author. In addition, qualitative research is well aligned with the inductive approach that is needed to answer the research questions. It also goes well together with the chosen paradigm of constructivism as it takes subjective opinions and realities into consideration to create a broader understanding. Subjective data can only be gathered by qualitative approaches. In addition, qualitative research offers the opportunity for in-depth study. In this case more than one qualitative method is used to avoid bias due to the interpretation of the data. In a first step semi-structured expert interviews are conducted. The results of the data analysis of the semi-structured interviews set the basis for the focus group discussions. The focus group discussions are intended to extend and confirm

the results from the interviews. Hence, a sequential multi method approach is chosen for this study.

As there are different ways to generate qualitative data, the next section discusses the methods used in this research.

3.3.3 Data collection methods – literature review of published studies on tacit knowledge

Publication numbers about tacit knowledge in general increased during the last years (Puusa and Eerikäinen, 2010) and hence, studies with different methodological background can be found in the literature. Research studies can be grouped into qualitative research (Ambrosini and Bowman, 2001; Dinur, 2011; Nakano, Muniz and Batista, 2013), quantitative research (Chilton and Bloodgood, 2008; Borges, 2013; Salleh *et al.*, 2013; Borges, Bernardi and Petrin, 2019; Rese, Kopplin and Nielebock, 2020) or mixed method studies (Haldin-Herrgard, 2003; Foos, Schum and Rothenberg, 2006; Lipa, Kane and Greene, 2019). As tacit knowledge research is context dependant, different methods need to be used to achieve the study's aim. In the appendices in section 8.6, different relevant publications with their corresponding used methods are presented.

Questionnaires, interviews, and bibliographic reviews are the most common methods used. When using a questionnaire, all participants receive the same set of questions that is answered in a predefined order (Saunders, 2019). This allows the comparison of participants responses. Questionnaires that are self-completed by the participants are also referred to as surveys (Saunders, 2019). These surveys can be distributed electronically via email, but other options like postal, SMS or via telephone are possible as well. This means these surveys can reach a large group of participants, who can be "profiled" (Rowley, 2014). Due to the large number of participants, generated data can be used for generalization (Rowley, 2014).

The second mentioned method to study tacit knowledge is interviews. Interviews are most often used as a qualitative research method to "learn about the world of others" (Qu and Dumay, 2011, p. 239). Interviews are frequently used for tacit knowledge research and are defined as conversation with a purpose (Roberts, 2014). These interviews can be conducted with one person (One-to-one interviews) or with a small number of participants (One-to-many interviews or focus group discussion). When interviewing a group of participants in some cases it might even be useful to have two interviewers (Two-to-many interviews) (Saunders, 2019).

There are three broad categories of interviews that are differentiated by their level of standardisation used: structured, semi-structured and unstructured interviews. Structured interviews are based on a fixed set of questions and are used to collect quantifiable data (Saunders, 2019). They are intended to minimize the interviewers bias and to increase the generalizability of the findings, hence there is also little flexibility in this type of interview method (Qu and Dumay, 2011). By comparison, non-standardized interviews can be semi-structured or unstructured and are used for qualitative data collection. Semi-structured interviews start with a list of topics or key questions, but remains flexible to react on what the participant says. This still allows comparison of participants responses (Saunders, 2019). The style of questioning can be adjusted to get the fullest response of the participants (Qu and Dumay, 2011). For unstructured interviews, on the other hand, the necessary questions are not known prior to the interview and are able to adjusted and generated according to the purpose of the research (Qu and Dumay, 2011). Hence, this type of interviews is the most unstandardised method of interviews.

Another possible method to study tacit knowledge is documentary research. It is defined as the analysis of documents containing information regarding the conducted research (Ahmed, 2010). Qualitative or quantitative analysis can be applied, but it has to be noted that most documents used must be considered secondary data as they have been generated for a different purpose (Saunders, 2019). This might also lead to the fact that data might be missing or cannot be presented in a sufficient way due to the availability of the number of documents (Saunders, 2019). Hence, it can be useful to combine this method with one of the other methods used in tacit knowledge research.

All mentioned methods are fitted into their corresponding research designs. As described in section 3.3.1, this study will use a single case study strategy to link methods and philosophy. Hence, the next sections discuss the methods selected for this research to fit the strategy.

3.3.4 Methods selected to answer the research questions of this study

As described before, tacit knowledge compared to explicit or objective knowledge is generally not easy to articulate neither easy to share. Hence, the researcher has to carefully think about ways to getting the required information in order to answer the research questions. As mentioned in section 3.3.3, the most often used method for data generation for studies on tacit knowledge are interviews, questionnaires, and documentary research. This study will not

use all the three methods, as the BI is a science driven sector and some employees might not be fully aware of the definition of tacit knowledge. Therefore, direct questioning with questionnaires without the option to ask comprehension questions is not regarded feasible. In addition, it needs to be acknowledged that probably merely tacit knowledge that can be expressed or at least partly articulated will be unravelled during the study. Tacit knowledge that is deeply ingrained will be hardly discovered. Hence, the researcher decided to choose the interview approach for this study as it allows to flexibly react on the participants answers. In addition, it is possible to directly discuss questions or concerns of the participants. Both expert interviews, as well as group interviews in the form of focus groups, are valuable for this study. The assignment of the method and their justification can be found in Table 3. A more detailed description of the methods used will be provided in the following sections.

Table 3: Methods used to answer the research questions.

Research questions	**Methods**	**Justification for the use of method**	**Type of data**
RQ1 - Which types of tacit knowledge are used during a technology transfer between a German development department and an US manufacturing department in the BI?	Semi-structured interview	In-depth interview with participants to gain more insight into the types of tacit knowledge used during a technology transfer	Quali-tative
RQ2 - What influences the knowledge transfer between the German development department and the US manufacturing department in the BI?	Semi-structured interview Focus groups	Storytelling approach to reveal general influences of a successful TT in order to start to causal mapping process Generation of deep understanding of certain influences for the tacit knowledge transfer; participants will be asked for examples and stories to get from the general influences to the specific tacit influences	Quali-tative Quali-tative
RQ3 - Which practices can be applied during a technology transfer in the BI to support the dissemination of knowledge?	Semi-structured interviews Focus groups	Storytelling approach to reveal practices and methods to disseminate knowledge Generation of deep understanding of practices for the knowledge dissemination; participants will be asked for examples and stories	Quali-tative Quali-tative

In Table 3 it can be seen that for finding the answer for RQ1, semi-structured interviews are applied. To answer RQ2, semi-structured interviews set the basis to start the causal mapping process. With this data influences for the general knowledge sharing during a TT are identified.

Additional in-depth data is generated through the causal mapping discussion in the subsequent focus group discussions to reveal influences for especially the tacit knowledge sharing. To answer RQ3, a storytelling approach is used to identify practices, methods and tools used during a TT in the semi-structured interviews. Additional data is generated through causal mapping during the focus group discussions.

Appropriate data to answer the research questions can only be gathered when including the right participants into the study. Therefore, the next section describes the sampling for the study.

3.3.5 Sampling – involving suitable participants to get important input to answer the research questions

As this research wants to study the influences supporting TTs and types of tacit knowledge used during a TT in-depth, it is important to choose the right participants to get information that helps to answer the research questions. To do so, purposeful sampling is applied to select the participants of this study. Purposeful sampling is a strategy to select participants for qualitative research. It can be applied when information-rich cases are available to generate in depth-understanding of a subject (Patton, 2015). It is also applicable for single cases, which is true for this study as it is looking at one specific technology transfer as discussed in section 3.3.1. The selected sample is dependent on the research questions and needs to be in alignment with the purpose of the study. In this case, only individuals involved in this transfer can provide the needed information. Therefore, an a priori judgement by the researcher has been conducted to select participants, who are important and justifiable (Czernek-Marszałek and McCabe, 2024). The developed sampling criteria are presented in Table 4.

Table 4: Sample criteria to join the study

Inclusion criteria
Involved in meetings and tasks to accomplish the technology transfer for the project
Role in project: subject matter expert, project management
Reporting line: no direct reporting line with the author
Concrete membership of the sending or receiving unit or project management

As mentioned in Table 4 it is important to select participants that are involved in critical activities for the TT. Participants need to be either members of the sending or receiving unit to generate the opportunity to cluster data also on this level. No direct report of the author is

involved in the study due to ethical constraints. The core technology transfer team consists of around 28 people and it is planned to involve all willing members into the study. The participants are either from different departments of the SU or the RU, or are part of the extended team. The main functions are depicted in Figure 6. Additional technicians and process experts are important to perform the process on-site, but as these team members are not part in the technology transfer meetings, they are not in focus of this study.

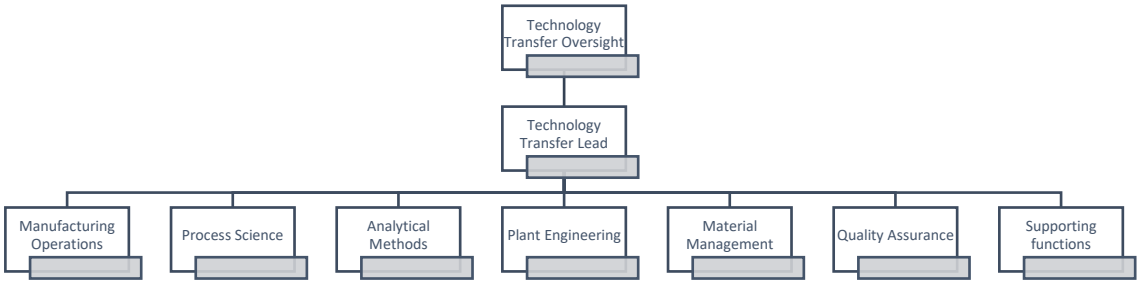

Figure 6: High level structure of the Technology Transfer Team.

As shown in Figure 6, the team members of the TT core team are categorized into eight different roles. Each role is at least filled with one employee from the sending unit and one from the receiving unit. The Technology Transfer Lead (TTL) has the overall responsibility for the knowledge transfer. He or she ensures the communication between the SU and RU and provides updates to the management (e.g. the TT Oversight and higher management) and stakeholders about the status of the transfer. The TT team consists of subject matter experts from manufacturing operations, process science, analytical methods, plant engineering, material management, quality assurance and other supporting functions. They provide their expertise and contribute to the knowledge dissemination during the transfer. These team members play a big role in the success of the transfer. In total, scientists, managers and lab personnel from three different departments are involved in the transfer, who can provide valuable information for the study.

The participants are contacted via email and can volunteer to join the study. They can opt themselves, if they suit the study by looking at the criteria. If they suggest an additional participant not involved in the researcher's list, the fit of the inclusion criteria is checked and this individual is contacted. This means snowball sampling is allowed. The details listed in Table 5 are captured and used for data analysis. In addition, this list is used to generate a rich

and thick description of the participants. This helps the reader to decide whether the results are transferrable to other settings due to their characteristics (Erlandson *et al.*, 1993). This is one important validation strategy in this research study to ensure rigor of the results. More details about the validation strategies for this research can be found in section 3.6.

Table 5: Participant details.

Category	**Details**
Participant number:	
Member of RU/SU/Ext:	
Time in company:	
Time involved in the project:	
Involved in more than 2 TTs before:	

Table 5 shows the details that are requested prior to starting the interviews. The participant number is anonymous and unique to each participant. It is randomly assigned by the researcher. The location is an important point to be able to distinguish between participants from the Sending Unit (SU), Receiving Unit (RU) and the extended Team (Ext). Consultants are additionally labelled with a C behind the location. This attribute is used during the analysis for comparison of the answers. The additionally listed attributes show the participants' experience and might be used for further analysis as well. When involving these participants into the study, it is important to follow ethical guidelines to avoid any harm to the individuals. These guidelines are described in the next section.

3.3.6 Ethical considerations for the study – how to contact and interact with participants

As mentioned before, in this research study, interviews and focus group discussions are conducted. This implies that participants are actively involved in the research. Hence, research ethics, which examines the behaviour of the researcher in relation to the rights of the participants have to be closely followed (Saunders, 2019). These ethics have to be assigned to the context of the study (Bell and Bryman, 2007). As the study involves participants from Germany and the US, codes of ethics in this regard must be considered in addition to the ethics guideline provided by the University of Worcester. Particular ethical considerations are valid for all studies. These include that the research has to be justified and adds new knowledge. Another important point is that every research study needs informed consent from the participants. This means the participants need to have all required information of "any potential benefits, risks, obligations or inconvenience associated with the research before they choose to participate" (Worcester, 2018, p.3). The participants can freely decide whether

they want to join the study. In addition, confidentiality and anonymity must be ensured all the time. It is the author's goal to minimize the risk of harm to any participant arising from the research, which includes negative impacts in social or working environments. No vulnerable groups, "such as: children (and) persons lacking mental capacity" (Worcester, 2018, p.3) are included into the study. To make all the information available to all participants, interviews conducted with German employees are conducted in German, whereas interviews with the US employees are performed in English.

In the following, interaction with the participants is described in more detail: The author asked the participants via email to join the study. Participants were selected by the purposeful sampling strategy, as explained in section 3.3.5. The sample criteria mentioned in Table 4 were explained in this email, as well as the purpose of the study. In addition, the email contained the consent form as well as the participant information sheet. After having volunteered for the interviews, each participant was assigned a specific participant number to be able to randomize and anonymize participation. The first two randomized samples were used for pilot testing of the interviews. At the beginning of all interviews the researcher did a short briefing to check whether there are questions or uncertainties (Sim and Waterfield, 2019). Afterwards, the participants were asked for their signed written consent form. The author also asked for the permission to record the interview. The interviews were about to last approximately 30-45 minutes and were conducted via Microsoft Teams video meetings. Interviews were conducted in the participants' language at work (GER: German; US: English). After the interviews, the author did a debriefing and addressed raised concerns and questions.

The same experts involved in the initial interviews were asked to join the focus group discussions. Hence, the sample criteria remained the same as described in section 3.3.5. Before starting the focus group discussions, the author did a short briefing to check whether there are questions or uncertainties (Sim and Waterfield, 2019) or additional information was required after the initial interviews. Like in the interviews, participants were free to withdraw, whenever they wanted to. Focus group discussions lasted around 1,5 to 2 hours and were also conducted via Microsoft Teams.

The researcher decided to use Microsoft Teams as the default medium for the study due to the Covid-19 pandemic and to create the same conditions for participants from Germany and

the United States for the interview and focus group settings. More details about the interviews, as well as the focus groups, are provided in the next sections.

3.4 Method Description, practical Preparation and Analysis of the Semi-Structured Interviews

3.4.1 Preparational work for the analysis of the Semi-Structured Interviews

As mentioned before, semi-structured interviews and focus group discussions are the methods of choice for this study. Hence, the semi-structured interviews are an important source of data. They were used to answer RQ1 and helped to start answering RQ2 and RQ3. Different methods were applied to extract the relevant data. As the process of setting up the interviews to analysing the data was complex, the activity flow is depicted in Figure 7 to guide the reader through the different steps.

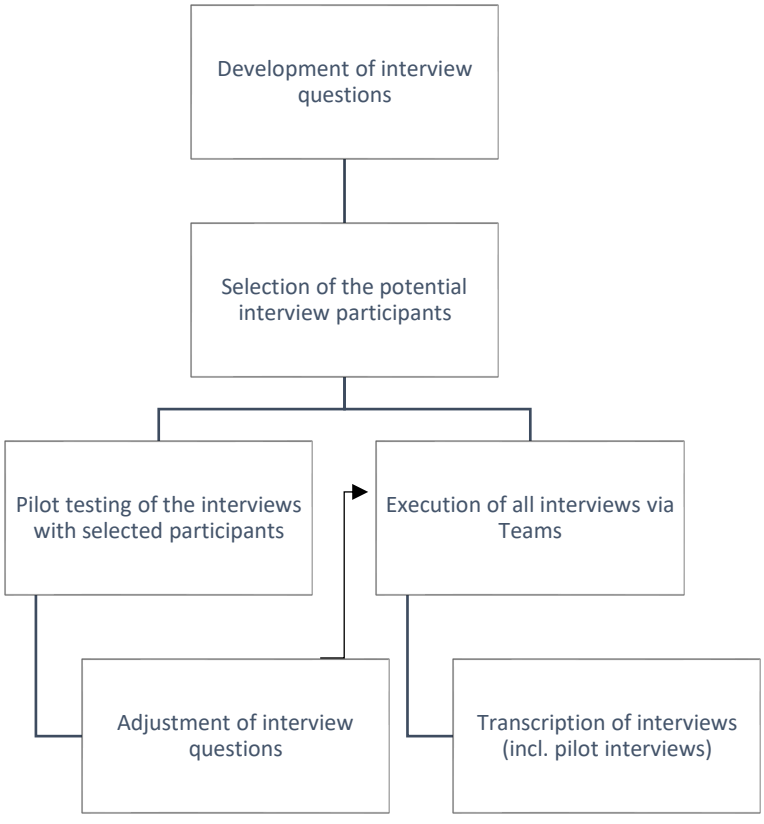

Figure 7: Processes used to identify relevant data to answer RQ1 to RQ3 from the semi-structured interviews.

The detailed description of each mentioned process step in Figure 7 can be found in the following sections.

3.4.2 Development of the questions for the semi-structured interviews

As mentioned above, the first method to generate data was semi-structured qualitative interviews. These interviews were structured in the way that their purpose and key questions were pre-determined (Ambrosini and Bowman, 2001). Experts of the TT were selected to explore their perspectives on the types of tacit knowledge transferred. In addition, the semi-structured interviews were intended to reveal the first general influencing factors and mechanisms of the knowledge dissemination to start up the causal mapping process for the focus group discussions. The leading interview questions are listed in Table 6. The interview guide, in this case, was highly scripted in order to allow comparability of the participants and to be consistent and systematic in questioning. Anyhow, as a semi-structured interview format was chosen, the researcher was able to react on participants answers and could add additional participant-tailored questions during the interview.

With the first two purposely selected participants, a pilot testing of the interviews was conducted. During this pilot test, the flow of the questions, as well as the intelligibility of the questions, were checked. If necessary, the flow and the questions were reworked according to the outcome of the pilot testing.

Table 6: Leading interview questions for the semi-structured interviews.

Research question	**Question #**	**Leading interview questions**	**Aim of the question**
Introducing questions	Q1	Can you tell me about your role in the project? What is your contribution to the TT?	Get the participant into the mood of the interview / scientific discussion
RQ1 - Which types of tacit knowledge are used during a technology transfer between a German development department and an US manufacturing department in the BI?	Q2	In your view, what counts as knowledge?	Identify the participants view on knowledge; generate understanding whether the difference between explicit and tacit knowledge is obvious to the participants; assess site or role specific differences and similarities
	Q3	What knowledge is most important to you and why?	Generate understanding of the types of knowledge relevant to the participants; check why participants consider certain types of knowledge as important; get a feeling for which types of knowledge are valued in the organisation

	Q4	What knowledge is needed in your view to robustly manufacture a biologics asset?	Generate an understanding of important types of knowledge for the manufacturing in general to be able to compare this to the knowledge needed during a TT
	Q5	How important is knowledge during a technology transfer and why?	Identify the relevance of knowledge during the TT from the participants point of view; also assess why it is important; assess site or role specific differences and similarities
RQ1 and RQ3	Q6	How is the knowledge needed for manufacturing in general transferred? Can you please provide examples on easy to transfer parts and hard to transfer parts?	Identify practices used and get first insights into explicit and tacit knowledge used
RQ1 - Which types of tacit knowledge are used during a technology transfer between a German development department and an US manufacturing department in the BI?	Q7	At which stages of the TT do you exchange knowledge? And how is it used? Can you please give an example?	Generate an understanding at which stages of the transfer most of the knowledge is exchanged; generate an understanding of the applicability of the disseminated knowledge
	Q8	Are there different types of the knowledge used or needed by the sending and receiving unit? Can you please provide one example each?	Generate an understanding whether different types of knowledge are required and / or requested by the different groups involved in the TT; identify whether sense of self and awareness of others fit together
	Q9	What are the main challenges in a TT to transfer knowledge?	Identify challenges of the knowledge transfer related to the different positions of the participants; assess whether challenges are rather individual or structural.
	Q10	How would you rate the current knowledge dissemination process during a TT and why?	Assess the status quo; compare differences between the answers of participants
RQ3 - Which practices can be applied during a technology transfer in the BI to support the dissemination of knowledge?	Q11	Which practices sharing knowledge do you know and did you use during technology transfers? Can you please provide some examples?	Identify used practices to disseminate knowledge during a TT; assess whether more explicit practices are used or if also practices to enable tacit knowledge dissemination are actively used; assess whether practical guidance on additional practices might be possible.

RQ1 - Which types of tacit knowledge are used during a technology transfer between a German development department and an US manufacturing department in the BI?	Q12	What is special in this knowledge transfer due to the current Covid-19 situation? How is it influencing the knowledge dissemination?	Understand the impact of the Covid-19 pandemic on the knowledge dissemination during the TT
RQ2 - What influences the knowledge transfer between the German development department and the US manufacturing department in the BI?	Q13	Can you tell me an example of what has caused knowledge transfer failure during a technology transfer?	Start up the causal mapping process; identify first general influencing factors of the knowledge transfer
	Q14	Can you tell me an example of what has caused knowledge transfer success during a technology transfer?	

Table 6 shows the key questions to ask during the semi-structured interviews. The interviews started with an introducing question to get the participant ready for the interview. Afterwards questions to answer RQ1, RQ2 and RQ3 were asked. According to the answers of the participants, the author asked follow-up and probing questions to deepen the data and hence, the understanding. This was done by active listening and through rephrasing statements from the participants and asking for the right understanding. According to the background of the participants also specifying questions were asked to achieve more precise descriptions of a topic that was touched broadly. To maintain a positive relationship with the participants, the researcher did not offer opinions about responses and avoided indications of surprise and shock (Qu and Dumay, 2011). One criticism of using semi-structured interviews is the reliability of data due to the lack of standardisation. In this study, the highly scripted interview guide helped to overcome this risk. It provided a solid structure for all conducted interviews and led to data that could be used for thematic analysis. The data for RQ1, RQ2 and RQ3 was used differently after the interview as they have different purposes. The analysing process is described in brief below.

Answering RQ1: Which types of tacit knowledge are used during a technology transfer between a German development department and an US manufacturing department in the BI?

After transcription and the analysis of the interview results, the data was checked for accuracy. German data stayed in German for the analysis process and English data stayed in English. The next step was organizing the data to make it accessible for the data analysis. During this process the data was also made anonymous. The first step of the analysis was a content analysis, which identified codes and words within the qualitative data set. In this case the transcripts were searched for the epitomes of tacit knowledge developed by Haldin-Herrgard (2003). This process is described in more detail in section 3.4.6. In a second step the thematic analysis was applied to the transcripts. The process included a labelling and thematic coding process. The thematic coding process is independent of a theory and hence, very flexible (Braun and Clarke, 2006), but also requires conceptual and design thinking (Braun and Clarke, 2021). In the researcher's opinion it hence, fitted well with the constructivist paradigm as it emphasizes the context and it helped to deepen the understanding of the different perspectives of the participants about the knowledge used during TTs. Thematic analysis was used to identify patterns in the data to be able to identify concepts. Hence, first codes and categories were created. Similar themes were searched and reviewed. Afterwards, these themes were named and captured in the results of the analysis. Data analysis was done via NVivo.

Answering RQ2: What influences the knowledge transfer between the German development department and the US manufacturing department in the BI?

In order to answer this research question, also a thematic analysis process was applied. The obtained overarching influencing factors were then be used to start up the causal mapping process conducted during the focus group discussions. Most influences derived from answering Q13 and Q14, which cover the influences for both explicit and tacit knowledge sharing.

Answering RQ3: Which practices can be applied during a technology transfer in the BI to support the dissemination of knowledge?

Similar to answering RQ2, for answering RQ3, also the thematic analysis was performed. It was supplemented with the data derived from the focus group discussions in a subsequent step to achieve a full picture.

The next section elaborates more about the participants who joined the semi-structured interviews.

3.4.3 Participant information for the semi-structured interviews

In total, 28 team members and 6 extended team members were contacted via email to take part in the study. These team members had different roles in the tech transfer and were assigned to either the sending or receiving unit, as described before. The researcher got the information about the most current team composition from the technology transfer lead. Because of some changes during the transfer process with regards to personnel that happened during the course of the study, 9 more participants were suggested by the contacted persons as they were deemed to be more suitable for the study. Hence, in total, 43 participants were asked to join the study. 17 contacted team members did not reply to the invitation and were hence, not included in the interview process. Additional 5 team members declined, as they felt a lack of fit to join the study because they had not been part of the tech transfer meetings and suggested substitutes, as mentioned before. 21 participants accepted the invitation and conducted the interview process. The average duration of the interviews was 50.4 minutes.

One important aspect to ensure all views were covered in the semi-structured interviews with regard to expertise was to involve at least one Subject Matter Expert from each function in the interviews. For the semi-structured interviews in this study, this could be achieved, as shown in Figure 8.

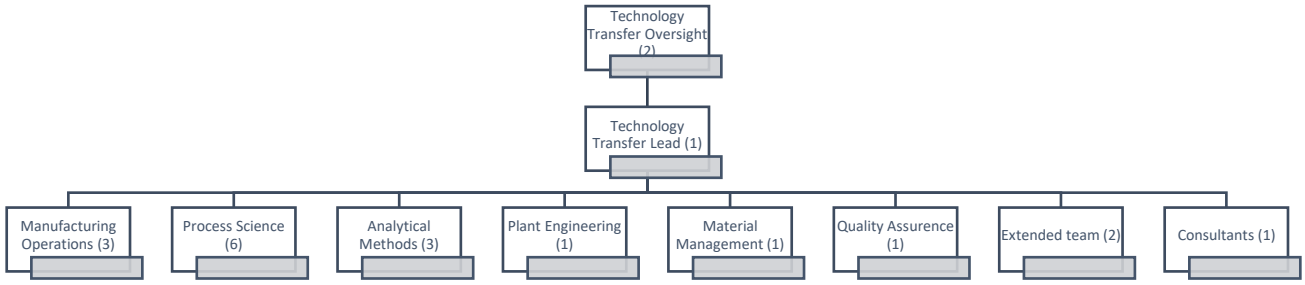

Figure 8: Number of participants per role in the semi-structured interviews (numbers indicated in brackets).

Figure 8 shows that at least one participant per role accepted the invite to join this study. Manufacturing Operations, Process Science and Analytical Methods are represented in a technology transfer team by more members compared to the other functions. Hence, it is not remarkable that these functions led to most responses. In total, the distribution of the participants fitted well to the normal distribution in the technology transfer team. Overall, 12 participants from the receiving unit, 7 participants from the sending unit and 2 extended team members joined the study. In general, all participants except for two had been involved in two or more technology transfers in the past. This shows that the majority of the participants were experienced in technology transfers. In addition, all of the participants had been working on the project for more than a year at the time of the interview. Hence, all of them were familiar with the project, the team and the recent development in the technology transfer.

3.4.4 Pilot testing of the semi-structured interviews

To adequately formulate the questions for the interviews, pilot testing was conducted to explore the flow as well as the intelligibility of the questions. Testing of the questions and the interview technique also helped the researcher to gain practice in interviewing (Majid *et al.*, 2017). Pilot studies are associated with qualitative studies and help to test out questions to strengthen the interview (Majid *et al.*, 2017). Findings during the piloting were used to make necessary modifications to the flow of questions as well as the wording.

The process for piloting of the interviews has been designed according to the suggestions from Majid et al. (2017) and is depicted in Figure 9.

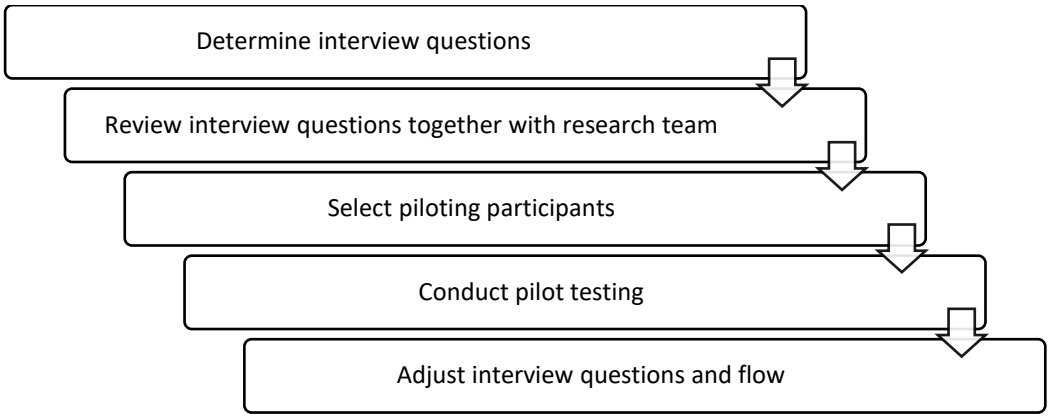

Figure 9: Process for pilot testing of the interview questions.

The first step in the piloting process as shown in Figure 9 is the determination of the interview questions. Hence, interview questions had been drafted with the intention to answer RQ1 and to start the discussions in the focus groups for RQ2 and RQ3. The questions were open-ended to allow to get insights of the participant's perspective of types of tacit knowledge used during technology transfers as well as influencing factors. In-depth interviewing was done by a storytelling approach. Subsequent to drafting the interview guide, it was sent to the supervisory team for review to assess the wording and relevance of the suggested questions. After the discussion with the supervisory team some questions had been amended resulting in the interview guide shown in section 3.4.2. These questions had been used for the pilot testing.

Participants for the pilot testing had been selected purposely by the researcher. One German-speaking participant and one English-speaking participant had been selected. Both participants were considered honest and patient and were known to the researcher. As the aim of the pilot study was to test the flow of the questions, as well as the intelligibility of the questions, both participants were deemed good candidates to give feedback.

The pilot study had been conducted in Q2/2022. Prior to starting the interviews, participant numbers had been generated. Participant numbers were generated with the Google random number generator (1-1000). The participant number had been added to the consent form, which had been discussed prior to starting the interviews. It was also good to see that the digital signature of the consent forms worked well. Participants were used to this kind of authorization and hence, this procedure was kept as an option during the whole interview process. The interviews themselves had been held in a Teams based format. After an

introduction, the interviews had been recorded via audio and video. The two pilot study interviews lasted around 45 mins to one hour, which was longer than the expected 30-45 mins. Therefore, in the invitation for the rest of the participants, the time had been adjusted. Both participants have been very open and positive with regards to the study and the topic from the beginning on.

The first learning from the pilot studies had been a technical one. The transcription function in MS Teams had to be adjusted to the right language, because the system did not recognize the language itself. It used English as the default language. As some interviews had been conducted in German, the language needed to be set in the beginning to simplify the subsequent transcription of the interviews.

Starting the interview with the participants role in the transfer went well. It helped to start up the discussion. The second question, around what counts as knowledge for the participants, needed adjustment as it was not entirely clear to the participants. Hence, it was altered to be less general and more focussed on the working environment. The adjusted questions can be found in Table 7. The full table is additionally shown in the attachment in section 8.7.

Table 7: Adjustment of interview questions after the pilot study (changes indicated in bold).

Research question	**Question #**	**Initial interview question**	**Adjustment**
RQ1 - Which types of tacit knowledge are used during a technology transfer between a German development department and an US manufacturing department in the BI?	Q2	In your view, what counts as knowledge?	**If you think about your daily work, what counts as knowledge for you?**
	Q3	What knowledge is needed in your view to robustly manufacture a biologics asset?	Position of question adjusted to enhance flow of interview **(position has been Q4; now Q3). Connection to the general knowledge question felt more natural during the interview.**
RQ2 - What influences the knowledge transfer between the German development department and the US manufacturing department in the BI?	**Q9**	Can you tell me an example of what has caused knowledge transfer failure during a technology transfer?	Position of question adjusted to enhance flow of interview **(position has been Q13; now Q9). As participants were already talking about the TT, it was easier to put this question into context.**
	Q10	Can you tell me an example of what has caused knowledge transfer success during a technology transfer?	Position of question adjusted to enhance flow of interview **(position has been Q14; now Q10). As participants were already talking**

			about the TT, it was easier to put this question into context.
RQ1 - Which types of tacit knowledge are used during a technology transfer between a German development department and an US manufacturing department in the BI?	**Q14**	How would you rate the current knowledge dissemination process during a TT and why?	As the wording "rate" indicated a more quantitative use of this question, it was changed to: **What is your overall summary of the transfer? Would you approach anything different for your next TT?** As this question was considered a good closing question it was moved to the end of the interview **(position has been Q10; now Q14).**

In Table 7, it can be seen, that the position of Q4 had been switched to Q3. It had been experienced during the pilot study, that it feels more natural to connect the general question about knowledge with the question about the types of knowledge used during the TT. Also, the position of questions Q13 and Q14 needed to be adjusted. They felt out of context at the end of the interview and hence, the researcher decided to ask them earlier in the interview phase. They were fitted directly after Q8 as the TT is discussed in detail in this phase of the interview. In addition, having a rating question (Q10) in the qualitative interview seems to be difficult. Hence the question has been changed to a more qualitative wording: "What is your overall summary of the transfer? Would you approach anything different for your next TT?". The summary question was considered a good question for closing the interview. Hence, it was moved to the end of the interview guide.

After 6 conducted interviews, the researcher identified two additional questions, that have been answered during the first interviews as side-topics of other questions. As these answers had been helpful in answering the research questions the researcher decided to have them as additional questions within the interview guide to ensure the input from the rest of the participants is also captured. The additional questions are listed in Table 8.

Table 8: Additional identified questions for the semi-structured interviews.

Position of question	**Question**
Q6a	How do you decide what knowledge is needed for the transfer?
Q7a	How do you make sure, the transferred knowledge is understood correctly?

Overall, the piloting interviews were a great chance to improve the author's interviewing skills and to sort out the technical difficulties of the interview process. It was also important to understand that every interview is different and that questioning had to be adjusted individually. The interview guide, in general, was a good tool during the interview but needed to be used in a way that it fits the participant's answers. The researcher experienced during the two piloting interviews already that the different personalities of the participants, as well as their roles, needed to be considered to ask the questions in a way that the best depth is achieved. The first collected data sets were used to familiarize with the coding and evaluation in NVivo. That has also been applied to the rest of the semi-structured interviews. As for the pilot study, the same topics compared to the following interviews have been assessed, all data sets were used to answer the research questions.

3.4.5 Transcription of the Semi-structured Interviews

While conducting the Microsoft Teams based pilot interviews, as well as the following interviews with the participants mentioned in section 3.4.3, the transcription function in Microsoft Teams had been activated. In addition, the semi-structured interviews were audio and video recorded to be able to adjust the transcripts where ever necessary. In general, the Microsoft Teams transcription turned out to be very helpful to transcribe most of the interviews. Each transcript was downloaded first and the corresponding video and audio file has been opened. The identifying name of the participant had been replaced by the participant number to deidentify the data (Stuckey, 2014). In addition, synonyms were used for specific names or projects mentioned. To transcribe interviews, two dominant modes are known, that need be chosen according to the goal of the study (Oliver, Serovich and Mason, 2005). According to Oliver, Serovich and Mason (2005), the first one is naturalism, which is correlated with transcribing every spoken word in much detail. The second one is denaturalism, which means pauses, stutters etc. are removed from the transcript. This is due to the fact that denaturalism sees speech as "meanings and perceptions that construct our reality" (Oliver, Serovich and Mason, 2005, p.1274). As the study's philosophy is constructivism, the denaturalism approach is the method of choice. Still, it is important to also assess whether the transcription mode also works with the applied methods to analyse the data. The first method to be applied was content analysis. This method was intended to check for ETKs present in the transcribed text, hence no transcribed stutters or filling words are needed. The second method for data analysis was thematic analysis. In this case codes from

the transcript were identified, which means for this method filling words etc. were also not relevant. Therefore, the researcher decided to use the denaturalism approach to transcribe the interviews. Following this mode, the researcher adjusted the wording in the automatically generated transcripts according to the recorded files and also deleted words that had been mentioned double, as well as pauses and stutters. Most of the filling words had been deleted in addition. Each transcription process took around three to four times the length of the interview and the final document had been sent back to the participants for member checking. Two participants had suggested additional corrections and comments, that the researcher worked into the transcripts. The rest of the participants did not add any comments.

In the next step the transcribed interviews were used for the data analysis phase. As mentioned before, content analysis and thematic analysis were used to analyse the data. These methods are described in the next sections.

3.4.6 Content analysis

Content analysis is a systematic research tool developed in the 1950s (White and Marsh, 2006). It is also often referred to as textual analysis and is used to determine certain words, or codes within qualitative data that is durable in nature (Stemler, 2001). It has mainly been used in communication research, but is also applied in “maintaining collaborative work groups” (Potter and Levine-Donnerstein, 1999), which is comparable to technology transfer teams. While some researchers argue that it can only be used in a quantitative context, others also state that it can be either qualitative or quantitative. In general content analysis uses coding units to analyse the data.

In this study, in the first step, a quantitative content analysis was used by applying the ETK concept developed by Haldin-Herrgard (2003) to the data derived from the semi-structured interviews. Hence, this part of the analysis uses an abductive approach. The analysis was intended to identify the clearly defined terms in the interviews to see if they occur, which means the ETKs formed the coding units. This form of analysis is called manifest content analysis and can be applied using any research theory (Potter and Levine-Donnerstein, 1999). Hence, it is also in line with the constructivism paradigm used in this study. As the ETKs could already be considered coding units, no additional classification approach was needed for this study. Hence, the coding units are already validated and do not need additional concepts for validation.

As mentioned before, in this study the data derived from the semi-structured interviews was used to analyse the presence of the ETKs. In this case, no quantitative counting of the EKTs per document was applied, but only the presence in the document of the specific ETK was noted down. No quantitative analysis was needed for this step as the intention was to build a basis for the thematic analysis in the next step of the data analysis. This is due to the fact that the researcher was more interested in exploring how many participants mentioned a certain ETK rather than knowing how often the word was used in general.

3.4.6.1 Goal and limitations – Content analysis

In this case, the content analysis for the semi-structured interview data was intended to identify the known epitomes of tacit knowledge developed by Haldin-Herrgard (2003) to get a first hint of the tacit knowledge used during a technology transfer. Therefore, the ETKs were used as coding units for the manifest content analysis that had been applied to the data. One limitation of manifest content analysis is, that it does not allow additional interpretation of the content (Potter and Levine-Donnerstein, 1999). For this study, this was not a problem as the second step of data analysis was thematic analysis to identify patterns, as well as interconnections between the data. Another aspect that is deemed critical for the content analysis is the validity and reliability of the method (Potter and Levine-Donnerstein, 1999). In this case, this can be overcome by using the established ETKs from Haldin-Herrgard (2003). In general, this first step of data analysis built the basis to answer RQ1 – "Which types of tacit knowledge are used during a technology transfer between a German development department and an US manufacturing department in the BI?". In the subsequent step it was brought together with the results from the thematic analysis to form a comprehensive picture on which types of tacit knowledge are used in a technology transfer. The following section show the different steps undertaken to generate the results from the content analysis.

3.4.6.2 Translation of the epitomes of tacit knowledge - Preparation for the Content Analysis

As the semi-structured interviews were conducted in both English and German, the English concept of ETKs from Haldin-Herrgard (2003) needed to be translated to German to be applied to all interviews. The ETKs were used as coding units and hence, needed to be precise and without any translational errors. This led to the fact that in cross-cultural research the process of translation becomes a quality criterion to develop multilingual research instruments for the study (Genkova, 2015; Colina *et al.*, 2017). The used research instruments needed to be

reliable and valid to ensure the quality of the study. In this case, back-translation is a commonly used tool to assess the translated material (Colina *et al.*, 2017). For the ETKs, this back translation from English into German and vice versa had already been conducted by Schmidt (2020). In the mentioned study (Schmidt, 2020) the back-translation process involved two English native speaking translators with experience in the German language. The first translator translated the ETKs into German and the second one re-translated them back into the source language (Schmidt, 2020). As this back-translation followed a clear logic and the researcher of this study double-checked the outcome in addition, for this study the same translated list of ETKs has been used. The translated list of epitomes can be found in the Attachment in section 8.1. It has to be noted, that for some of the English epitomes more than one German term had been discovered. The reason for this is that the single epitomes are not put into context in a full sentence and hence, could have different meanings in the German language.

The pilot testing, as well as the execution of the content analysis for the semi-structured interview data can be found in the appendices in section 8.8. As mentioned before, the subsequent method to assess the data for the types of tacit knowledge was thematic analysis. This type of analysis is described in more detail in the next section.

3.4.7 Thematic analysis

Data derived from the content analysis is not deemed to reveal all the tacit knowledge used during a technology transfer. Hence, an additional approach was needed to go into additional detail within the data set. The researcher chose the thematic analysis approach to get a deeper understanding of the data. The thematic analysis is also used to identify influencing factors and possible practices for the knowledge dissemination mentioned by the participants.

Thematic analysis (TA) is a data analysis technique to identify and analyse patterns in qualitative data. The aim is to interpret and identify features of data rather than just summarizing it. It can follow inductive or deductive approaches. When using a deductive approach, a framework or theory is needed to classify the data (Braun and Clarke, 2006, 2021), TA, however, does not necessarily rely on any pre-existing framework (Braun and Clarke, 2006) and hence, can be used for inductive approaches as well, as it is a very flexible method. It is a “systematic procedure[…] for generating codes and themes” (Clarke and Braun, 2017, p.297). The thematic analysis in this thesis used a mixed approach as some codes and themes

for the ETKs were known from Haldin-Herrgard (2003) and for the influencing factors by conducting a literature review. These frameworks were used as a basis, but the researcher added additional and new upcoming codes and themes that are specific to the Biopharmaceutical Industry. Hence, the approach is considered inductive. Codes are small unites depicting interesting features of the data. They are relevant for themes, which are larger units of analysis and provide frameworks for organizing and discussing the results (Clarke and Braun, 2017). When using it with the constructivist philosophy, it can examine realities, meanings, and experiences of participants.

To conduct a thematic analysis, a 6-step guideline has been developed by Braun and Clarke (2006). The process is depicted in a high-level format in Figure 10.

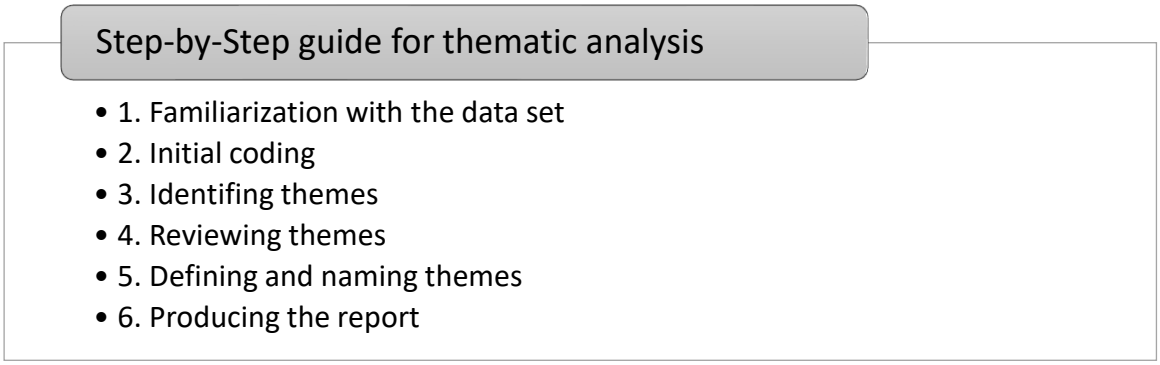

Figure 10: Step-by-step guide for performing a thematic analysis by Braun and Clarke (2006).

Figure 10 provides an overview of the step-by-step guide for performing a TA by Braun and Clarke (2006). In the first phase, the researcher needed to immerse with the data in-depth. Hence, the first step to familiarize with the data set was transcribing it. TA requires an orthographic transcript of the data received from the interviews (Braun and Clarke, 2006). Each transcript was sent to the specific participant for member checking to ensure rigor of the data. While repeatedly reading and checking the transcript during this phase, capturing notes and ideas was important. In the next phase, the initial codes in the data set were identified. These codes are general features of the data and depict a basic element of information. Coding in this case was data driven, which means that themes depended on the data. Coding was done with the help a computer software (NVivo) to add tags and names to sections. In the subsequent phase, the identified codes were used to select broader themes in the data. Mind-maps were used to combine different codes to one theme. Stage 4 of the TA process covers the reviewing of the themes. This stage is again important to ensure rigor in the data

analysis. Hence, TA has a built in two-stage review process (Clarke and Braun, 2017). During the first level, the collated extracts were checked whether they were able to be harmonized to one pattern. If this was not the case, themes had to be reworked. After checking and reworking, the next level involved reviewing the whole data set. This phase involved looking for codes that had been missed during the first round of coding and checking the existing codes again for their applicability. In stage 5 of the TA process, for each theme, a detailed analysis was done to be able to define and name it. By doing this, sub-themes might also occur that provide structure for large themes. After having named the themes, the next and last step of the TA was to do a final analysis and discussion, which is provided in the subsequent chapters.

TA was used in this study for the data derived from the semi-structured expert interviews. It was intended to provide insight into which types of knowledge are used during the TT. This data was needed to answer RQ1. In addition, influencing factors for transferring knowledge were assessed with TA. These factors were used to start the causal mapping process and helped to answer RQ2. Furthermore, methods, mechanisms and practices to disseminate knowledge during a TT were captured in order to answer RQ3.

3.4.7.1 Goals and limitations

From this part of the analysis of the semi-structured interviews, deep insights into the data sets should be gained. The complex data set had been analysed according to the study's needs. In this case, the perspectives on the types of tacit knowledge used during a technology transfer, as well as the influencing factors and mechanisms and practices of knowledge dissemination in general, should be assessed and the large data set should be summarized in an easy way. This is something that could be achieved by using this approach according to Nowell et al. (2017). For this approach it was important that the reader transparently understands the data analysis conducted as this crucial to determine whether the process is credible (Nowell *et al.*, 2017) to overcome any limitations of the method in this regard. Hence, the steps of the analysis done are described in appendices in section 8.9.

As also data derived from the focus group discussions was used to answer the research questions, this method is described in more detail in the next section.

3.5 Method Description and practical Preparation of the Focus Groups

3.5.1 Focus groups – feeding the causal maps to answer RQ2 and RQ3

Focus groups are a form of in-depth group interviews (Slovák, Daněk and Daněk, 2023). During the last decades, it has been predominantly used in a variety of settings and different disciplines (Then, Rankin and Ali, 2014). Focus groups are used to gather in-depth knowledge about beliefs, opinions and perceptions regarding a specific topic (Then, Rankin and Ali, 2014; Slovák, Daněk and Daněk, 2023). The method combines individual interviews and observation to collect data from the groups interaction (Freitas *et al.*, 1998). The group interaction is used to develop participants' ideas and also to capture non-verbal communication (Then, Rankin and Ali, 2014). During the focus group discussion, the researcher is responsible for moderating the discussion to encourage open communication.

As mentioned before, the same experts involved in the initial interviews were asked to join the focus group. People were split up into a SU group and a RU group. This means the maximum number of participants per group for this study was 14. This is in line with literature that proposes three to 21 participants (O.Nyumba *et al.*, 2018). Focus groups with the SU were performed in German, whereas focus group discussion with participants from the RU were performed in English. These focus groups were assumed to take around 1,5 to 2 hours and were guided by the questioning structure presented in Table 9. These guiding questions were based on the results from the initial interviews and used the identified influencing factors as a starting point for the focus groups. They enabled the causal mapping process described in the following. The causal mapping was done live during the focus groups. This also indicates that direct member checking was applied to ensure rigor of the analysis directly.

Table 9: Moderators guide for focus groups discussions.

Phase of the causal mapping onion	**Example questions**
Initial questioning	Why is … influencing the TT? What causes this?
Deeper questioning	How is this done? How did this happen? Who is influencing this?
Asking for an example	Can you tell us an example about …?
Asking for a story	Can you tell us a story about the occurrence of …?

The questions presented in Table 9 were applied to each general influence discovered in the first phase of the semi-structured interviews, which were team structure, company structure, motivational influences, culture and environment. This means the question sequence was

repeated during the process. Hence, this led to a deeper understanding of the influencing factors of a knowledge transfer, which helped to answer RQ2*: What influences the knowledge transfer between the German development department and the US manufacturing department in the BI?*

This method was focussed on finding influences of especially the tacit knowledge sharing. This was done by asking specifically what influences the dissemination of e.g. individual knowledge like skills and know-how. It was assumed that some of the specific influences for the tacit knowledge transfer could only be revealed by stories and metaphors as these influences, like the tacit knowledge itself, might be hard to express. Hence, some of these influences could only be found in the outer layers of the causal mapping onion. During the process, the author especially took care that these layers were closely watched. After the mapping process had been finalized, the discovered influences were compared to the influences found during the literature review and the data from the semi-structured interviews.

Answering RQ3 - Which practices can be applied during a technology transfer in the BI to support the dissemination of knowledge?

When answering the question of "how" certain things were done, it was assumed that practices and methods would come up during the focus group discussions that support the knowledge dissemination. These methods hence, were captured during the causal mapping process.

To get a more detailed description on how the focus group discussions were conducted, the next section describes the preparational activities for this method.

3.5.2 Preparational activities for the focus group discussions

As no pilot study or extensive testing had been done for the focus group discussions beforehand, the researcher created a short workflow to prepare herself for the activity. The plan is depicted in Table 10.

Table 10: Planned workflow for the focus group discussions.

Intro	**Body**	**Wrap up**
- What is this discussion about? - Explanation of the consent form - Explanation about video recording - Ask for open questions before starting	- Start recording - Explanation of the process - Ask questions according to the onion model - Foster interaction and reactions of the participants - Allow different opinions - Find consent with regards to different views - Provide thought-provoking impulses if necessary	- Ask for open questions - Remind about the consent form - Inform about next steps - Thank participants for joining the discussion - Stop recording

The workflow shown in Table 10 was used as a guideline for the focus group discussions. The discussions were intended to keep their natural flow to not interrupt fruitful exchange. The researcher had a clear moderating role and provided though-provoking impulses whenever necessary. In addition, she fostered the interaction between participants by allowing different opinions and asking directly related questions. The discussion was recorded via Microsoft Teams video and the transcript was automatically generated.

To start up the discussion, a Whiteboard was created in addition to guide the questions and to help as a memory aid for the researcher. The Whiteboard was based on the results from the interviews. Figure 11 shows one example of the used structure.

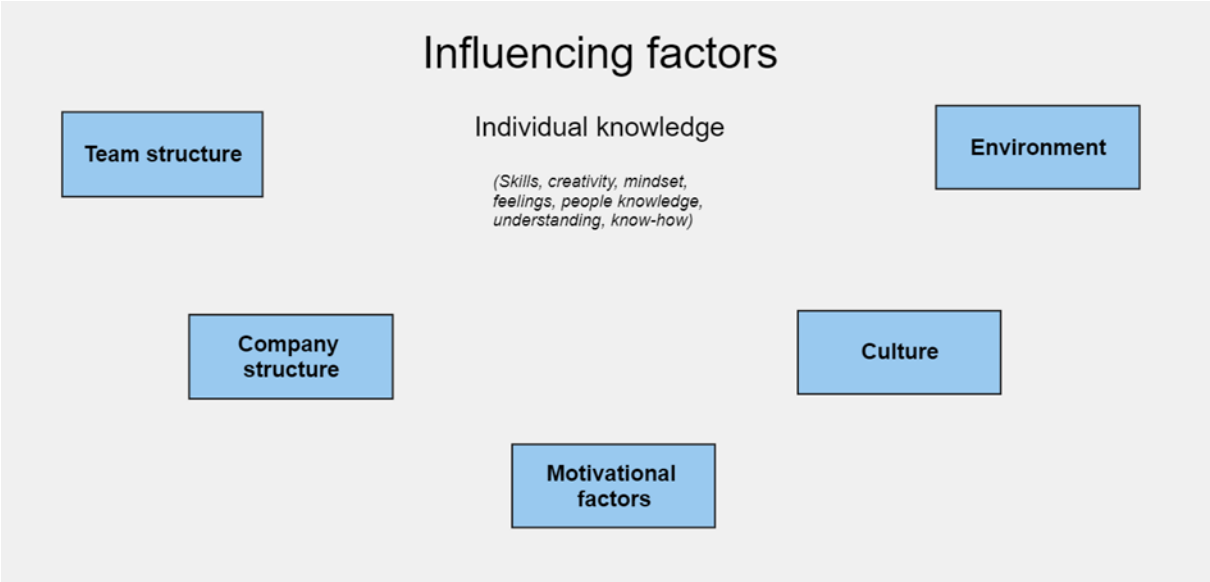

Figure 11: Example for the Whiteboard used during the focus group discussions.

In Figure 11 it can be seen, that the identified themes for the influencing factors from the interviews had been used as the first discovered influences for the tacit knowledge dissemination of e.g. skills, mindset and know-how and hence, the first layer of the onion. With these, the conversation was started after a short introduction. The participants were asked to provide their input and experience for each item. One example was to ask for the influence of the team structure for the dissemination of individual knowledge like e.g., understanding of specific process steps. First results were directly captured within the Whiteboard function on notes. A more detailed description of the causal mapping process can be found in section 3.5.5.

3.5.3 Participant information for the focus group discussions

The focus group discussions in this study were intended to gain insight into what the participants view as influencing factors for a successful technology transfer influenced. Hence, only participants were involved who had been part of the respective TT and who also had experience from former technology transfers. In total, 21 participants were contacted who also took part in the semi-structured interviews. This included 7 participants from the sending unit, 12 participants from the receiving unit and two extended team members.

The focus group discussions were intended to be split up into a sending unit and a receiving unit discussion to be able to assess similarities and differences between the two groups. From the sending unit seven participants volunteered to join the focus groups discussion. These

participants were invited via email for a MS Teams call. One person had to cancel on short notice due to a personal meeting conflict, so that in the end six participants took part in the discussion. From the receiving unit, six participants volunteered to take part in the discussions. For this group, three persons had to cancel on short notice, which meant the discussion was conducted with three participants in this case.

When looking at the literature, the reported range for the number of participants per focus groups varies from 3 to 21 participants (O.Nyumba *et al.*, 2018). As for the focus groups performed in this study individuals with high level of expertise are needed, only a small pool of participants was available. In this case also mini focus groups can be conducted which have a small group size of around two to five participants (O.Nyumba *et al.*, 2018). This means participant numbers for the focus group discussions with participants from the SU, as well as the RU are in line with the suggestions from the literature. Overall, the most important aspect of the focus groups was to bring in different points of view and fruitful discussions with regards to the influencing factors and the methods used for tacit knowledge dissemination that the experts experienced during the technology transfer. This could be achieved by both groups. Both discussions were recorded via video to again capture the interaction, but also to be able to fine-tune the generated transcripts when required. This process is described in the next section.

3.5.4 Transcription of the focus group discussions

Similar to the translation of the individual semi-structured interviews, the transcription function in Microsoft Teams was used to capture the discussion within the focus groups. Hence, Microsoft Word documents were generated directly after the discussion by the system. In addition, the focus group interviews were audio and video recorded to be able to adjust the transcripts when needed. To de-identify the participants, their names had been replaced by the participant numbers. Participant numbers stayed the same compared to the semi-structured interview process. Specific names and projects were again exchanged by synonyms. Like in the semi-structured interviews, the denaturalism transcribing mode was used, which means pauses, stutters, filling words and repeats had been removed by the researcher from the transcript as these were not needed to analyse the data from the causal mapping approach for the focus group discussions. The transcription process took around two and a half to three times as long as the discussion themselves. The transcripts were used to

confirm the causal maps established during the focus group discussions and to feed them with additional data if required. The causal mapping process is described in the next section.

3.5.5 Causal mapping during the Focus Group Discussions

Causal mapping is a kind of cognitive map to capture realities of participants tied together by causal relations (Ambrosini and Bowman, 2001). These maps represent the participants realities and knowledge and are used to facilitate the exploration of the participants beliefs and value system (Ambrosini and Bowman, 2001). They are a visual presentation of the participants ideas and issues raised regarding the discussed topics (MacLennan and Markides, 2021). Through this graphical representation by nodes (important constructs) and arrows (relationship between the constructs) the participants subjective insights can be shown (Ackermann and Alexander, 2016). As RQ2 and RQ3 are by their nature causal questions, the author beliefs that this analysis tool is suitable to answer them. “Furthermore, causal maps can be particularly useful for eliciting factors that are context dependent” (Ambrosini and Bowman, 2001, p.818) which is also true for RQ2 and RQ3. Causal maps can provide different explanations for research objects and can show relationships between factors and challenges. As the constructivists philosophy wants to bring together realities of different participants, this study used collective or group maps. Due to the pandemic, it was not be possible to bring all participants from Germany and the US together to discuss the topics face-to-face in a focus group. This led to using online settings via Microsoft Teams rather than performing individual interviews and mapping processes. This had the advantage that the participants were able to react and reflect on other opinions.

To start up a causal map, two general questions regarding the success of a technology transfer were asked during the semi-structured interviews (see section 3.3.5). This also assured that no external influence by e.g., literature etc. influenced the start of the map. Only context dependent factors were added. A storytelling approach was used during the interviews because tacit knowledge as well as the influencing factors of its dissemination, could be wrapped in stories. Participants could tell what is important during a technology transfer and by doing that, tacit elements could be unravelled. One important vehicle to do so were metaphors. These metaphors are images that can be used instead of explicit words for describing processes and experiences. As mentioned in section 3.3.5, the participants were asked about examples when the technology transfer had been successful or had failed. Hence,

obvious and less obvious influences could be collected before the focus group discussion. The mapping process is depicted in Figure 12.

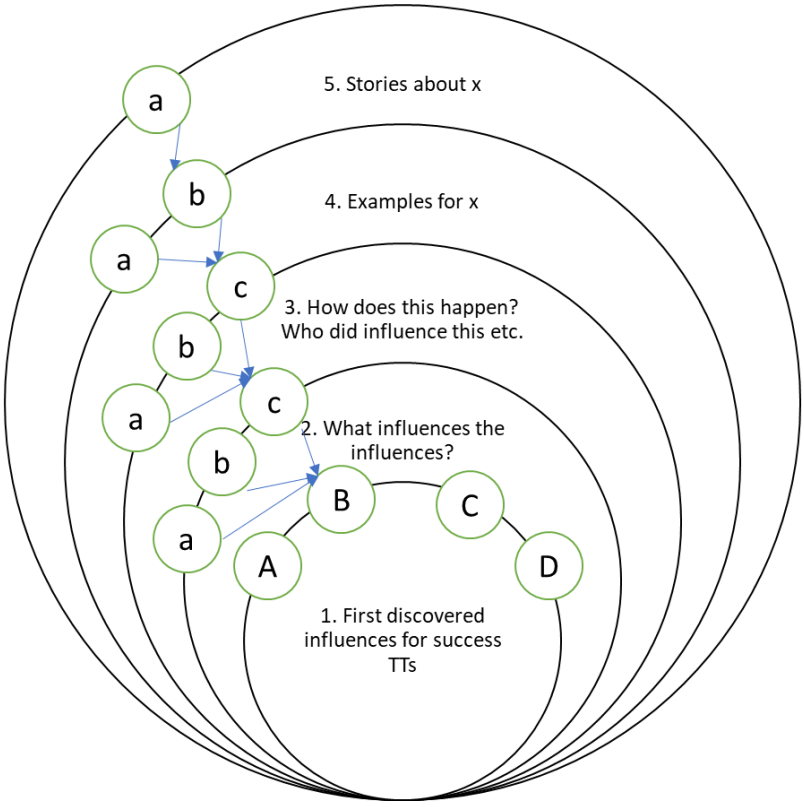

Figure 12: Onion model for causal mapping.

Ambrosini and Bowman (2001) describe this as the first layer of an onion process, after which new layers follow. These are built by asking for the influences of the influences discovered in the semi-structured interviews. This could be done by asking questions like “How does this happen”, “What causes that” etc. With each layer, the onion got more and more precise. When the process slowed down, the participants were again asked to tell stories about certain influences. The process was stopped when participants could not add examples or stories anymore.

In case of the causal mapping, the maps were developed together with the participants during the focus group discussions. This offered the advantage that participants could directly check whether their input had been added correctly. This member checking was one procedure used for ensuring rigor in this qualitative research.

3.5.5.1 Goals and limitations of the causal mapping within the focus group discussions

The goal of the causal mapping exercise within the focus groups was to get an aligned, in-depth understanding of the influencing factors of the tacit knowledge dissemination. In addition, it should reveal practices and methods used to get knowledge transferred. This part should help to find feasible techniques and practices that can be applied in future technology transfers. These results were used to confirm and complement the results from the thematic analysis for the data derived from the semi-structured interviews. The results for the causal mapping emerged from the questions from the onion model described above. Hence, the format of the results was not the same compared to the results from the semi-structured interviews. Still, the results were brought together in the discussion chapter. Discussing about influencing factors, as well as practices in a focus group was intended to lead to an interaction of the people involved within the group and to social interaction which is able to reveal attitudes, feelings and believes (Gibbs, 1997). This also led to the fact that the moderator had to give up parts of the control for the interview structure to foster this interaction. In addition, another limitation could be that participants express a groups based view rather than their individual view, which might make it harder for the researcher to filter out individual views (Gibbs, 1997). Hence, good planning and asking in-depth questions for a better understanding were key. As mentioned before, the tools used for the planning of the focus groups were workflows and Whiteboard notes to guide the discussion. The next section describes the execution of the focus group discussions.

3.5.5.2 Execution of the focus group discussions

The execution of the focus group discussions took part in 01/2023 via Teams and was scheduled for two hours. In the first 10-15 minutes, the introduction took place and afterwards, the main part of the discussion was conducted. For the sending unit's (SU) discussion, the main part took around 110 minutes, whereas for the receiving units discussion around 90 minutes of discussion were recorded. In both interviews, a good climate and polite interactions were visible. The team members knew each other and discussed openly. When collecting the answers, it became clear that the participants discussed the topics from different points of views and offered examples when opinions deviated. Still, at the end, the participants found consent on what was important for the group per topic. While having the discussion, the Whiteboard was used to capture notes from the discussion and to directly do a first member checking if the captured topics reflect the discussion. Interestingly, both teams

found it hard to distinguish influences for the individual, team and organisational knowledge. Hence, only one of the prepared Whiteboards was used during the focus group interviews. The analysis process for the causal mapping during the focus groups is shown in the appendices in section 8.10.

For the resulting data sets rigor has to be shown. Hence, the next section shows the procedures chosen for this study to show validity.

3.6 RIGOR – ENSURING VALIDITY IN QUALITATIVE WORK

The vast majority of data used in this study is qualitative data derived from the semi-structured interviews and focus group discussions. When performing qualitative research studies, it is essential to ensure credibility. Therefore, several concepts to show validity have been developed, as stated by Creswell and Miller (2000). The issue here is that there is not one general strategy that has to be used. Therefore, Creswell and Miller (2000) suggest to base the choice of procedures on the used paradigm as well as different inquirers viewpoints to validate the study (researcher, participants, externals like reviewers and readers) (Creswell, J.W., & Miller, 2000). Commonly used procedures are for example triangulation, disconfirming evidence, researchers reflexivity, member checking, prolonged engagement in the field, collaboration, audit trails, trick rich descriptions and peer debriefing (Creswell, J.W., & Miller, 2000).

Creswell and Miller (2000) provided guidance on which procedures to follow, dependent on the chosen paradigm. As in this study, the used paradigm is constructivism, the following validation procedures are suggested by Creswell and Miller (2000) for the study:

Table 11: Validity procedures assumptions for constructivism-based studies by Creswell and Miller (2000).

Lens	**Researcher**	**Participants**	**People external to the study (reviewers, readers)**
Procedure	Disconfirmation evidence	Prolonged engagement in the field	Thick, rich description

It can be seen in Table 11 that using “disconfirmation evidence” is suggested as the procedure of choice to cover the researcher’s lens in the process. In this process, the researcher checks

for disconfirming or negative evidence in the data set (Creswell, J.W., & Miller, 2000). This was done by defining preliminary themes that are confirmed or disconfirmed during the data evaluation. This process is used during thematic analysis of the data. Researchers have to rely on their own view during this procedure and need to check multiple perspectives on one theme. This is well aligned with the constructivist paradigm. For constructivists, credibility for multiple and complex realities are important. This was confirmed with this approach.

In addition, for this study, different data sources (semi-structured interviews and focus group discussions) were used to answer the research questions. This means triangulation is applied as a validity procedure for the researcher's lens as well. Triangulation aims to find similarities and differences in the data sets by using a systematic process (Creswell, J.W., & Miller, 2000). This was done by applying content analysis, thematic analysis and causal mapping to analyse the data. For the content analysis, the reliability of the data had been tested by the percentage agreement method additionally.

Another important lens to show validity is the participant's lens. As participants provide the data and their reality is socially constructed, they need to check the analysed data on whether it has been interpreted right. The suggested practice to do so is "prolonged engagement in the field". This process is especially valid for ethnographic studies (Creswell, J.W., & Miller, 2000). For this validation procedure, the researcher stays with the participants for a longer time period and builds trust. This also leads to getting more information about the case and the researcher can combine interview and observation data. In this study, this procedure is hardly possible as the participants are located at two different sites of the company, on two different continents. Hence, for the researcher, it was not possible to stay at both sites next to her normal working hours. In addition, due to the Covid-19 pandemic, travel restrictions were advised. To still acknowledge the participants perspectives in a procedure, the author decided to include "member checking" into this study. The researcher took data and interpretations back to the participants to let them confirm credibility. Participants were asked to check the transcribed raw data and identified themes for its accuracy. The participants' comments were worked into the results. This also implied that the participants could comment during the analysis process, as well as to the final narrative. In addition, during the focus group discussions, the causal maps were created together with the participants.

Hence, they could directly check the identified influences for accuracy. After the analysis of the data, the summarized findings were sent to the participants in addition.

A third perspective that helps the validation process is that of external individuals. External individuals are not affiliated with the research and hence, can help establish credibility as well. The procedure proposed by Creswell and Miller (2000) is thick, rich description. This should be done to give the reader the feeling that they have experienced the methods used in the study. They can then transport the narrative into another setting or situation (Creswell, J.W., & Miller, 2000). To do so, different perspectives are contextualized, which is well aligned with the constructivist paradigm. The narrative has to be as detailed as possible to bring persons as well as relationships "alive". This detailed description helps the reader to make decisions on whether the findings can be applied to other contexts. Detailed descriptions are provided for the narratives of the data analysis methods and corresponding quotes of identified themes during the TA among others. These can be found in chapter 4 and 5.

The selected validation procedures for this study described above are presented in Table 12.

Table 12: Validation procedures used for this research study.

<table>
<tr><th>Lens</th><th>Researcher</th><th>Participants</th><th>People external to the study (reviewers, readers)</th></tr>
<tr><td rowspan="2">Procedure</td><td>Disconfirmation evidence

Triangulation</td><td rowspan="2">Member checking</td><td rowspan="2">Thick, rich description</td></tr>
<tr><td>Reliability of the data from the content analysis</td></tr>
</table>

As presented in Table 12, all three lenses of importance for the study were covered by at least one procedure. With this, the author wanted to acknowledge all viewpoints available to ensure the credibility of this research study. In addition, the reliability of the content analysis had been tested and shown. All used procedures and their outcomes, are described in more detail in the following sections.

3.6.1 Content analysis – reliability of the coding data

To ensure the reliability of the data from the content analysis, the output of the coding process needed to be consistent (Stemler, 2001). It was important to develop a coding instruction that was explicit and did not lead to shared or hidden meaning of the coding (Stemler, 2001).

Reliability of the data is shown, when the stability and the reproducibility of the coding is proven. To ensure stability of the data, the researcher performed the coding of the transcripts a second time and got exactly the same results as before. This shows that when trying to code multiple times, the result was constant. Therefore, stability of the data could be shown in this regard.

For the reproducibility, it had to be shown that different coders come to the same results when coding the text. Hence, to be able to calculate the percentage agreement, a second coder was needed. Due to ethical constrains, the researcher decided to have a script for coding of the data, instead of a second, not-involved coder. Therefore, the script shown in Figure 13 had been written.

```
1  #!/bin/bash
2
3  #$1 interview
4  #$2 etk-list
5
6  cat $2 | while read line
7  do
8      source=`echo $line in $1`
9      count=`grep -w -i "$line" $1 -c`
10     if [ $count -ne 0 ]
11     then
12         echo "$source:$count"
13     fi
14 done
15
```

Figure 13: Script for the coding exercise (Unix code).

Figure 13 describes that the Unix script takes the transcript converted in a .txt file and compares it to the list of ETKs (also transferred into a .txt file). Each ETK was represented in one line of the table and the programme searched for exactly this term in the transcript file. To only analyse the participant's answers, the interview questions were removed from the transcripts in the .txt format as the script cannot distinguish between the questions and answers. The function cat $2 read the ETK list line by line. The exact wording of each line was compared to transcripts (indicated by the -w). For the search, it was irrelevant whether large or lower case was used (indicated by the -i). If the code was found, it was counted

(represented by -c). A code that was detected one or more times was written in a generated report. After running through each document, the script created an output file with all the terms that had been found in the document. This output file had been compared to the researcher's results of the content analysis and the percentage agreement (PA) had been calculated. The advantage of having a script for the codification of the data is that the assessment is more objective compared to human coding. The disadvantage is that the script cannot put the terms into context. Hence, some deviations from the researcher's coding were expected, which could be explained. These deviations needed to be assessed in an objective way to see how reproducible the results are.

A common way to calculate the reliability is Cohen's Kappa (Stemler, 2001). Cohen's Kappa is defined as:

$$\kappa = \frac{P_A - P_C}{1 - P_C}$$

P_A = proportion of units on which the raters agree

P_C = proportion of units for which agreements is expected by chance

The difficulty with Cohen's Kappa for this study is that 79 units were used to code the transcripts. Hence, Cohen's Kappa was not a feasible and easy-to-use tool. Therefore, a different method was needed to calculate the reproducibility for the 79 codes used in this study. Another way to calculate the inter-rater reliability is the percentage agreement (Saunders, 2019), which is more applicable to the data set. It is calculated by the following formular:

$$PA = \frac{A}{n} \times 100$$

PA = percentage agreement

A = number of agreements between the two coders

n = number of segments coded

By calculating the percentage agreement, the question arises, which values were sufficient to show reproducibility. Even though there is no clear recommendation, percentage scores above 80% are considered acceptable (Saunders, 2019).

In the first round of running the script, the percentage agreement was 79%, which was slightly below the acceptable value of 80%. The most common deviation from the coding were the terms “opinion”, “culture”, “perspective” and “value”. This was due to the fact, that the set phrases “in my opinion” and “from my perspective” are often used in the interviews. In the specific case of the technology transfer in the Biopharmaceutical Industry “values” for “cell culture” parameter, like pH, temperature, flow velocities etc. were transferred. Hence, these words were also mentioned often by the participants. When coded by the researcher, these set phrases and words were excluded from the coding as they had different meanings than described by Haldin-Herrgard (2003). When only excluding these 4 phrases from the coding, the percentage agreement increases to 89%, which led to an acceptable result.

Testing the content analysis with the script, helped the researcher getting even more familiar with the data. The analysis showed, that a pure manifest content analysis, which was performed by the script, only has limited value for the analysis and data assessment. This is due to the fact that certain words have doubled or underlaying meanings, which need to be interpreted. By manually elimination the most currently used double meaning set phrases (“opinion”, “culture”, “perspective” and “value”), reliability of the data could be shown. This also indicates, that a script-based search can be optimized to fit the content analysis needs, which might reduce the future workload for such studies. Still, a verification by a researcher is needed.

After coding 12 of the 21 interviews, the researcher recognized that not many new codes were found during the analysis anymore. To get the whole picture, the researcher decided to code all of the interviews anyways. After analysing 6 further interview transcripts, only in one additional transcript ETKs could be identified. The last coded transcripts did not lead to the identification of additional ETKs. This shows that the data had been saturated.

3.6.2 Disconfirmation evidence

To get rid of the confirmation bias in the data interpretation, themes for the thematic analysis were adjusted in an iterative way. The complex information from the semi-structured interviews led in a first attempt to interpreting the data in the easiest way. Still, when having the codes clustered, it became clear sometimes that the most obvious first interpretation had not been feasible for the majority of the codes and hence, had to be reworked. The reworking process of the themes is described in more detail in the appendices in section.

3.6.3 Triangulation

Triangulation is described of the use of different methods to create a comprehensive understanding of a certain phenomenon (Carter *et al.*, 2014). Carter et al. (2014) summarizes four types of triangulations used:

- Method triangulation
- Investigator triangulation
- Theory triangulation
- Data source triangulation

In this study data, source triangulation was used to answer RQ2 and RQ3, as the data sets from both, the semi-structured interviews, as well as the focus groups are used to provide insights to answer the questions. In this case, the two data sources are used to confirm and complement each other. The results were compared to each other in the following results and discussion chapters.

In order to answer RQ1 method triangulation was used. Both content analysis as well as thematic analysis had been applied to the same data set derived from the semi-structured interviews.

Overall, triangulation had been used to answer the three research questions as using more than one method or data source helped the researcher to create a better and in-depth understanding. This led to comprehensive results to provide solutions for the research questions.

3.6.4 Member checking

To enhance the trustworthiness of the data, the analysed data had been sent to the participants to check if the generated data from the semi-structured interviews are valid. This step has been also important to decrease the researchers bias from the data set.

All participants had been included in this member checking activity to review the data, as well as the transcripts and to provide their opinion. Participants were asked to send back their feedback in a timeframe of 14 days via email.

The first step for the member checking was to send the final documents of the transcription of the semi-structured interviews, as well as the focus group discussions to the participants.

Two participants had suggested additional corrections and comments, that the researcher worked into the transcripts. The rest of the participants did not add any comments.

Additionally, the analysed results were also sent to the participants for member checking. In this case, one participant added a comment that was implemented into the results section.

3.6.5 Thick, rich description

The thick and rich description for the results and their interpretation goes beyond just describing and recording the methods used. In addition, the researcher provided information about the participants, quotes from the interviews and the participants behaviour in the focus group discussions (chapters 4 and 5).

The descriptions of the results were put into context and tried to create a better understanding of the situations they were collected in. Quotes and additional description can be found in the result chapter.

In summary, it can be stated that the three lenses of importance (researcher, participants and people external to the study) were covered by at least one procedure that was described in this chapter. The next section concludes this chapter and summarizes the used methodology for this study.

3.7 Conclusion of the Methodology and Methods used for this study

The aim of this study was to increase the understanding of the tacit knowledge used during the technology transfer and to find out more about influences and practices supporting the knowledge dissemination during a TT. The tacit knowledge used, and the influences are subjective and hence, dependent on the participants involved. Therefore, an understanding of the world of individuals was needed. During the study, the knowledge was provided by the individuals involved, which led to subjective outcomes within boundaries. This is well aligned with the use of the constructivist's paradigm. The collected data from this study was thematically analysed to form patterns to find the relevant types of tacit knowledge and the influences of the knowledge dissemination during a TT. This leads to an inductive approach. To form patterns, a suitable strategy, methodological choice and data collection method are needed. In this case the case study approach had been chosen as the context was relevant for the studied phenomenon and the chosen transfer was representative for other transfers in

the BI within boundaries. Hence, the required tacit knowledge and the influences of the knowledge dissemination could be studied in depth. Still, this case had the unique occurrence that it took place during the Covid-19 pandemic and it was the first transfer with an entirely new team setting at the US site. Hence, the study can be considered an extreme case and therefore was worth studying. Data was collected by individual interviews, as well as focus group discussions to capture the perspectives of the involved team members. This means a qualitative approach was used during this study as this type of approach can assess subjective data. In addition, qualitative research offers the opportunity for in-depth study. This in-depth understanding was generated by analysing, describing and discussing the data in detail, which is shown in the next chapters.

4 RESULTS

4.1 INTRODUCTION

This chapter provides the results for answering the research questions (RQs) of this study. Hence, it allows more insight into the data generated for RQ1 to RQ3:

> RQ1: Which types of tacit knowledge are used during a technology transfer between a German development department and the US manufacturing department in the BI?
>
> RQ2: What influences the knowledge transfer between the German development department and the US manufacturing department in the BI?
>
> RQ3: Which practices can be applied during a technology transfer in the BI to support the effective dissemination of knowledge?

The first step for answering RQ1 was to conduct the content analysis which formed the basis for the more in-depth thematic analysis to identify further codes and themes within the transcripts of the interviews. The epitomes listed by Haldin-Herrgard (2003) were used as a baseline for the content analysis, but as not all participants used the same vocabulary compared to the list, synonyms and different wordings used for certain epitomes were only identified during the thematic analysis.

RQ2 was also answered by the data derived from the semi-structured interviews by thematic analysis. It helped to identify general influences for the dissemination of tacit and explicit knowledge during a TT. In addition, the results for the identified influencing factors from the focus group discussions were used to confirm and complement the data. This method focussed on getting deeper insights into the influences of especially the tacit knowledge dissemination during a TT. The compiled data was compared to the influencing factors identified during the literature review to generate a supplemented list of influences from both the literature and this study.

In order to answer RQ3 practices, techniques and methods were extracted from the semi-structured interviews by thematic analysis. These results were compared to the findings from the focus group discussions. Both methods were used to confirm and complement each other.

The detailed results per research question are described in the next sections.

4.2 Results for Answering RQ1: Which types of tacit knowledge are used during a technology transfer between a German development department and an US manufacturing department in the BI?

As described before, in order to answer RQ1, a content analysis, as well as a thematic analysis were conducted, to find relevant types of tacit knowledge for a technology transfer. The results from the analysis are shown in the next sections.

4.2.1 Findings of the Content analysis– a first step to identify the types of tacit knowledge used

To answer RQ1, the content analysis was intended to set the basis to identify the types of tacit knowledge used during the considered knowledge transfer. Still, looking for the existing epitomes within the interviews forms the "bones" of the types of tacit knowledge skeleton to which more specific "flesh" was added later on during the thematic analysis. The ETKs established by Haldin-Herrgard (2003) formed the framework for this analysis. This was also intended to add additional rigor to the data derived from the content analysis as the found ETKs during the content analysis were assumed to show up in the thematic analysis as well. Hence, for the content analysis all interviews have been transcribed and analysed. More details with regards to execution of the data analysis for the content analysis can be found in the appendices in section 8.8. During the analysis of the data, the terms epitomes of tacit knowledge (ETKs) and types of tacit knowledge are used redundantly.

In the first step of the analysis the ETKs found per transcript were listed and compared by dividing the participants according to their membership to a specific unit. This means participants that were taking part from the sending unit were clustered. The same was done for participants from the receiving unit and the extended team. If participants mentioned a certain ETK more than once, this was not considered in the counting. The average usage of the ETK in the interviews is listed in Table 13.

Table 13: Average number of ETKs mentioned by the participants from the different units.

Sending unit	Receiving unit	Extended team
5,6	3,9	4,0

In Table 13, it can be seen, that the number of different ETKs used per interview for the sending unit participants is the highest with a value of 5,6 ETKs mentioned on average.

Interestingly, only these participants were German speaking. Hence, the translated list of ETKs was used to analyse the documents. In comparison to the original English ETKs, the translated list contains different synonyms per ETK due to the translation. This also shows that the probability is higher for the German speaking participants to use a wording from the list in the interviews. When looking at the English-speaking participants from the receiving unit and the extended team, the number of ETKs used per interview is comparable (3,9 and 4,0 ETKs used per transcript on average). Still, the average used number of ETKs is very low with values of 3,9 to 5,6 of 79. This shows again that the ETKs are very specific terms, that might be too specific to use a pure manifest content analysis for the interview's evaluation for the purpose of this study. Still, using it as an initial step, helped to get a feeling for frequently used ETKs during the interviews.

As the number of ETKs per interview is not the primary interest of this analysis, the different ETKs found during the coding exercise are depicted in Figure 14.

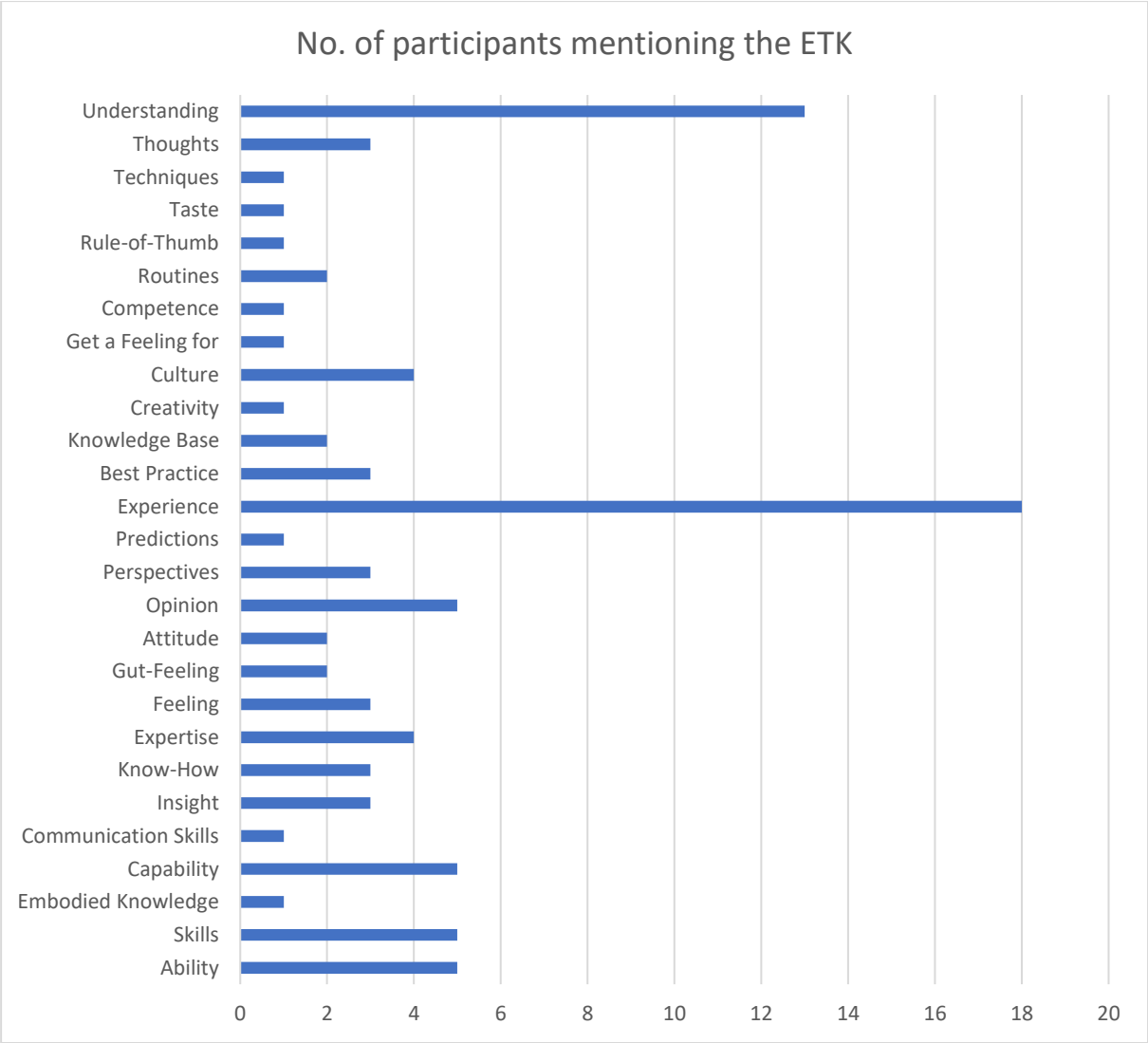

Figure 14: Types of tacit knowledge used mentioned by the participants in the interviews analysed by content analysis in order to answer RQ1.

In Figure 14, it can be seen that 27 out of 79 ETKs could be found during the content analysis. The most frequently mentioned type of tacit knowledge mentioned was “experience”. 18 participants refer to this ETK in the context of hands-on knowledge, device and process experience. Another commonly mentioned type of tacit knowledge is “understanding” (13 participants), which is connected to “experience”. Employees have to understand what and why they are doing certain process steps to be able to take decisions independently if needed. “Insight” (3 times mentioned) and “get a feeling for” (1 time mentioned) share a common line. The next cluster found in 5 interviews each is “capability”, “skills” and “ability”. All of these ETKs are needed to perform a successful manufacturing process. “Techniques” (1 entry), “routines” (2 entries), “knowledge base” (2 entries), “best practice” (3 entries), “expertise” (4 entries), “know-how” (3 entries) and “embodied knowledge” (1 entry) are heading into the

same direction. ETKs that are rather related to pragmatic and fast solutions that are also sometimes needed during a technology transfer are “rule-of-thumb” (1x), “prediction” (1x) and “creativity” (1x). ETKs mentioned with regard to communication and the team’s relationship are “culture” (3x), “opinion” (5), “attitude” (2x), “perspectives” (3x) and “communication skills” (1x).

The researcher acknowledges that the epitomes listed by Haldin-Herrgard (2003) are comprehensive, but not all participants use the same vocabulary, which means some synonyms and different wordings used for certain epitomes will not be identified by the content analysis. In addition, as the epitomes have not been developed specifically for the Biopharmaceutical Industry, the researcher assumed additional types of tacit knowledge that might be identified by deeper analysis of the data. Hence, the results derived from the thematic analysis, as shown in the next section, were used to create a more complete picture of the tacit knowledge used during a technology transfer in the Biopharmaceutical Industry.

In summary, the content analysis was an effective exercise to gain a better understanding of the interview data. Reliability of the data had been shown during the testing for it in section 3.6. This led to robust results that could be used to discuss the data. 27 out of 79 ETKs had been found during the analysis, which could all be reasonably connected to the technology transfer. These are summarized in the appendices in section 8.11. Having completed the content analysis, formed the basis to build up further insight about the types of tacit knowledge used during the technology transfer with the thematic analysis. It was supposed that the same ETKs found during the content analysis would also be identified during the thematic analysis. Further interpretation of the data was assumed to extract all types of tacit knowledge used from the data set. This was done during the thematic analysis, which is described in the next section.

4.2.2 Findings of the thematic analysis for the types of tacit knowledge used during a technology transfer

The second step of the analysis of the types of tacit knowledge used had been the thematic analysis of the data set to also identify BI-specific types of tacit knowledge. This means this step is extending and contextualising the results of the content analysis and by going beyond analysing the existing ETKs from Haldin-Herrgard (2003) by further contextualizing the epitomes for the BI. This section provides insights into the themes and subthemes found

during the analysis and compares the found types of knowledge in the end to the content analysis to ensure rigor in the data set.

During the thematic analysis of the data to identify the types of tacit knowledge used from the semi-structured interviews, two themes with five sub-themes were established. The detailed process of the data analysis can be found in the appendices in section 8.9.2. The generated mind map is depicted below. The map shows additional codes identified during the thematic analysis compared to the content analysis. Codes already mentioned in the content analysis sections are not being depicted in this section again.

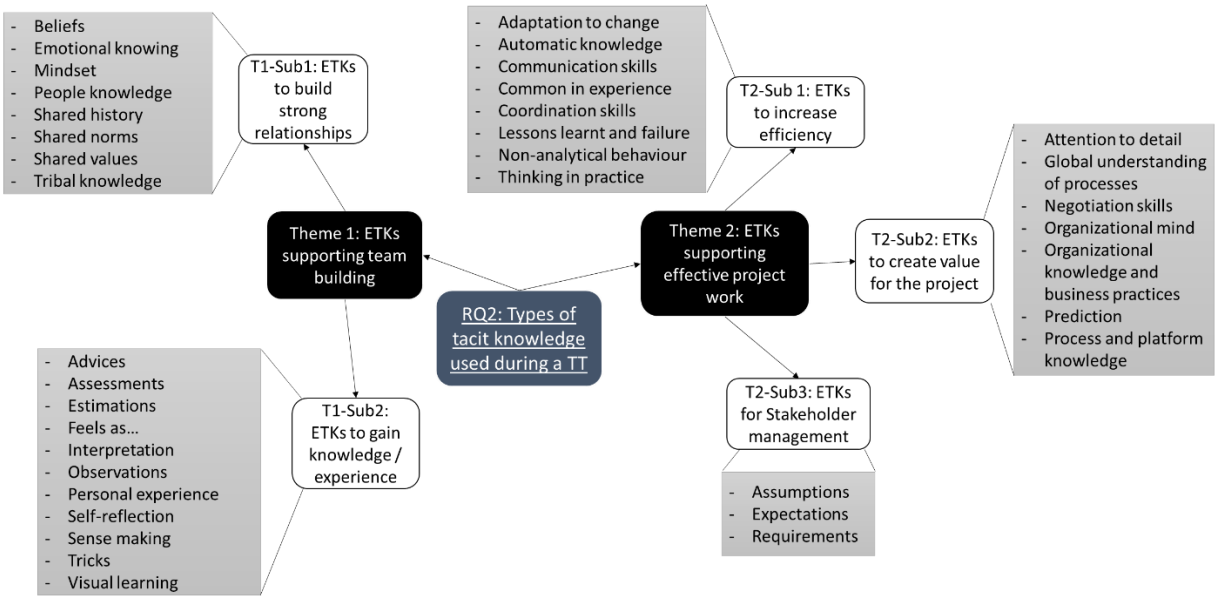

Figure 15: Themes and subthemes allocated to the codes identified through the thematic analysis (only additional ETKs compared to the content analysis shown).

The single codes had been grouped into themes, in this step of the analysis, to be able to discuss them first in a more holistic fashion. The single codes are still important to answer RQ1 and hence, will also be used for discussion in the next chapter. A general overview of the themes and sub-themes developed during the thematic analysis is provided in Figure 16.

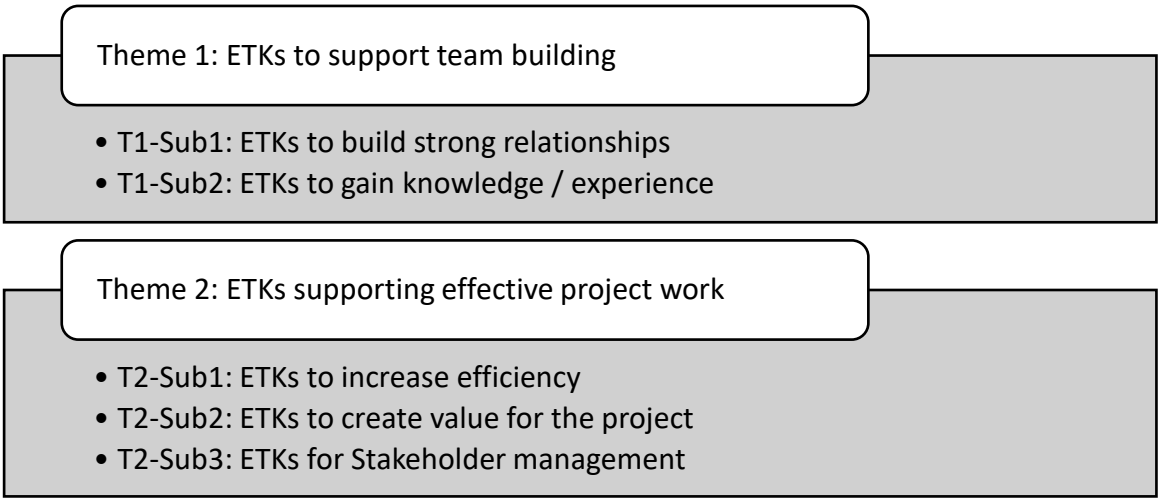

Figure 16: Themes and sub-themes identified for the types of tacit knowledge used during a TT by thematic analysis of the semi-structured interviews.

A more detailed description of the themes is provided in the next two subsections. The identified types of tacit knowledge specify the knowledge that is needed to enable the knowledge dissemination process during a technology transfer and to transfer the required process knowledge. They do not describe the tacit knowledge needed to conduct process development for mAb manufacturing processes. All mentioned ETKs during the interviews are listed in the results chapter. The alignment and comparison to the applied definition of knowledge for this study is done in the discussion chapter.

4.2.2.1 Types of tacit knowledge theme 1: ETKs to support team building

The first theme "ETKs to support team building" is a holistic cluster of codes and hence, types of tacit knowledge, that are used during a technology transfer. It includes the interpersonal, as well as the practical level that is important to achieve a successful transfer.

4.2.2.1.1 Types of tacit knowledge subtheme 1-1: ETKs to build strong relationships

To grow together as a team, it is important to build a strong relationship, which is indicated as subtheme 1. This is especially true due to the multinational team, the transfer is conducted with. The participants in this study mentioned types of tacit knowledge that are used for team building by implementing social and emotional intelligence. One example is "emotional knowing" or "empathy" which is important to create an atmosphere that fosters learning and communication:

> *"(…) empathy is another topic, asking the right questions without looking annoyed (…)" (Participant 730-SU)*

> *"(…) tone is a huge part of communication, (…) like, what's the verbal versus body language versus the actual syntax of speech?" (Participant 297-RU)*

This is especially important as within a team, the members are taking decisions together and need to be able to understand each other. This also goes beyond only practical skills, which are also important for the transfer. From experience, the researcher knows that most scientists involved in the specific transfer had a pure nomothetic education. Hence, character as well as experience and previous trainings and learnings in this direction are very valuable. With regards to the social aspect of team building, a shared history and tribal knowledge has to be taken into consideration by the team members. The following quote summarizes this well:

> *"(…) it doesn't matter how systemic or how good your standard work is, there's always this word of mouth, this sort of legend and lore that you just have to (…) know." (Participant 362-RU)*

Getting to know these "legends and lore" can be a difficult task for new team members. These members have to rely on their people knowledge and a mindset that allows them to see the big picture. They also need to be open and ask questions to be able to understand how things have been done in the past according to the participants answers. Team members should not only rely on their assumptions how things are done:

> *"(…) you need also to move into that sort of mindset of not assuming that everybody does [it] the same way you do because again, assumptions are, in my experience, the big enemies in tech transfer" (Participant 161-Ext).*

Overall, to build strong relationships, different types of tacit knowledge are used. These include emotional and people knowledge but also beliefs, mindsets and the knowledge about shared history and tribal knowledge. They have to be combined with practical types of tacit knowledge, to bring all the knowledge required into the team. These more practical types of tacit knowledge are clustered within subtopic 2 "ETKs to gain knowledge/experience".

4.2.2.1.2 Types of tacit knowledge subtheme 1-2: ETKs to gain knowledge/experience

Important factors that came up during the interviews both for gaining experience but also for increasing the efficiency were lessons-learnt and self-reflection. These are sometimes connected to negative feelings at first, but help the team to grow. The following examples had been mentioned during the interviews by the participants:

> *“(…) So it kind of came off as a negative, as if I'm attacking them, which then I had to clarify that, (…) I wanna make it easier for us to run the process with minimum amount of issues observed.” (Participant 671-RU)*

> *“(…) They need to have tried and failed (…). I want a subject matter expert that has done this a lot, but have seen things go wrong so they have that kind of knowledge that can say: we've seen this or you know X might happen and this is how we handled it.” (Participant 297-RU)*

> *“(…) But in addition to that, all those previous, (…) the failure, the bad experience those particular for analytical transfer, are also very important for us to help us to, (…), either not have to reinvent the wheel or prevent us to step into the same challenge as the sending unit.” (Participant 517-RU)*

Learning and gaining experience together is an important process when growing together as one team as well within an organisation. With regards to tacit knowledge used for learning and gaining experience together in the team, observations and interpretations can also help to gain more knowledge during the process, because these could be discussed with the group to come to an aligned opinion as mentioned by the participants:

> *“(…) The engineering run helped a lot and whenever we were running the engineering run, we started having daily meetings for 30 minutes where we tell [the SU] what we're observing (...)” (Participant 671-RU)*

> *"(…) it was of course very enlightening to experience how other people who didn't know anything about a process beforehand took it up, i.e. how do other people actually approach such a process? How do they interpret certain data that we take for granted by the sending unit?" (Participant 273-SU)*

Talking about process details together strengthens the team spirit and the common understanding. It is important that all team members are included in discussions and also details and changes are understood correctly and make sense to the different team members. The understanding has to be combined with tricks to be able to implement the process at the receiving unit.

> *“(…) and then make a determination of what makes sense for the process and have a dialogue with the receiving unit if that is even acceptable.” (Participant 122-RU)”*

> *“(...) that one site is offering tips to the other site and vice versa (…)” (Participant 273-SU)*

> *“(…) I've been doing a fair number of tech transfer in the past and I started to realize that you've got, let's say, classic pitfalls where you have to fall once and then it sticks with you and you're like, (…) I know that this is not clear and this*

> *needs to be changed, or it would be when you could see something, don't look detailed enough or don't make sense one with the other and you're like, if I read that and I was an operator I don't see the link between there, so there's something missing or there's something that needs to be addressed.“ (Participant 161-Ext)*

Next to growing together as a team, it is, of course, the main goal during a technology transfer to run the manufacturing process at the receiving unit with a similar setting compared to the sending unit as discussed before. This has to be done in an effective way. Hence, the second theme “effective project work” looks at types of tacit knowledge that are required especially for this purpose. This is described in more detail in the next subsection.

4.2.2.2 Types of tacit knowledge theme 2: ETKs supporting effective project work

The cluster “ETKs to support effective project work” contains ETKs which are important to increase efficiency (subtheme 1), create value for the project (subtheme 2) and for stakeholder management (subtheme 3).

4.2.2.2.1 Types of tacit knowledge subtheme 2-1: ETKs to increase efficiency

According to the participants, for increasing the efficiency, an important aspect next to a good communication and coordination is the use of automatic knowledge that is already available in the team members minds. This automatic knowledge can, in some cases, already be directly connected to the platform and process knowledge, but it can also be independent of the modality that is used in the concrete technology transfer. Participants describe it as the following:

> *“(…) Right now, (…) in the industry whether you are in an antibody or you are in cell therapy or gene therapy world, (…) I think that everybody has a good idea of what a platform looks like, what a unit operation, what needs to be there. Nobody needs to reinvent it, (…)“ (Participant 500-RUC)*

> *“(…) i.e. the technology platforms how to perform an antibody manufacturing. There is a lot of prior knowledge and also separate technology projects that have harmonized this platform within the receiving and sending unit, so that we could all assume a common knowledge base." (Participant 273-SU)*

Platform processes consist of different unit operations and functions involved, like subject matter experts from Upstream Development, Downstream Development, Analytics, Quality Assurance etc. Therefore, respecting and accepting that all team members are experts in their fields is important to trust their decisions concerning process changes and hands-on activities

were important points for the participants. These aspects can lead to quicker technology transfers and shorter team meetings and hence, increase the efficiency. During the respective transfer, the team members trusted each other and valued this thinking in practice a lot. This led to a quickly accepted dissemination of knowledge, which can also be verified with the following quotes:

> *"(…) people who really know the details of their process, they've done hands on (Participant 343-RU)"*
>
> *"(…) the general experience of being on the production floor is helpful… (Participant 579-RU)"*

In addition to these more general types of knowledge to increase the efficiency, another key cluster of types of knowledge needed is around the project knowledge and how to create value for the respective project by knowing how the surrounding of the project works. These aspects are included in subtheme 2 "ETKs to create value for the project".

4.2.2.2.2 Types of tacit knowledge subtheme 2-2: ETKs to create value for the project

One specific example for this, that was mentioned during the interviews, is knowing about organisational knowledge and business practices as well as organisational mind and the global understanding of processes within the company. Examples from the semi-structured interviews around this topic are:

> *"(…) So it's an experimentation thing, but it's also the understanding how the functions relate to one another and really setting up the processes that will be successful for us long term." (Participant 330-RU)*
>
> *"(…) I mean, you could even say that there's tacit knowledge around business practices too and kind of a group responsibilities." (Participant 343-RU)*
>
> *"(...) and of course this information was very, very important for us and we had to get to know every specific player on the other side and what is the role of everyone in the team on the other side?" (Participant 523-SU)*
>
> *"(…) but I think you should at least have general idea of something outside of (…) your subject matter expert knowledge, right?" (Participant 72-RU)*

Knowing how this communication routes and the placement of the respective TT in the value chain works, helps to understand priorities and urgencies. This of course is also dependent on the involved stakeholder, who's needs are covered in the third subtheme "ETKs for stakeholder management".

4.2.2.2.3 Types of tacit knowledge subtheme 2-3: ETKs for Stakeholder management

Stakeholders are groups or individuals with an interest in the outcome of the project. To manage this interface, knowing expectations and requirements from the internal and external involved parties is indispensable. This might also be different at the sending and receiving unit. The participant phrased it in the following way:

> *"(…) And then on the receiving unit, they will have some different regulatory requirement to do that as well, right?" (Participant 537-Ext)*
>
> *"(…) so we had meetings and I was able to visit their labs, where they were manufacturing the product and see how they were doing it and what the expectations are." (Participant 671-RU)*

Overall, it can be stated that soft skills, as well as practical types of tacit knowledge, are needed to conduct a successful technology transfer. Growing together as a team is equally important as knowing how the surrounding works and how to communicate with team members and stakeholders. The whole technology transfer is very complex and hence, a variety of single ETKs have been found that are required.

4.2.3 Bringing together the results from the content analysis and the thematic analysis

When comparing the found ETKs to the content analysis, all 27 types of tacit knowledge had also been identified in the thematic analysis. For doing this analysis only the codes used during the thematic analysis have been added to the table for comparison as they are equal to the definition of the ETKs. No themes or subthemes are mentioned here, as they are used to summarize the groups of ETKs used during a technology transfer. The comparison of the single ETKs provides a more detailed insight into the types of tacit knowledge used. Hence, Table 14 shows a summary of the found ETKs during the content and thematic analysis. Additional quotes for the new identified ETKs during the thematic analysis can be found for completeness in the appendices in section 8.12.

Table 14: Comparison of the ETKs found during the content analysis and thematic analysis.

Mentioned (content analysis)	**mentioned (thematic analysis)**	**Type of tacit knowledge identified**
x	x	ability
	x	adaptation to change
	x	advices
	x	assessment
	x	assumptions
	x	attention to detail

x	x	attitude
	x	automatic knowledge
	x	beliefs
x	x	best practice
x	x	capability
	x	common in experience
x	x	communication skills
	x	coordination skills
x	x	creativity
x	x	culture
x	x	embodied knowledge
	x	emotional knowing / empathy
	x	estimations
x	x	expertise
	x	expectations
x	x	feeling
	x	feels as…
x	x	get a feeling for
	x	group's sense
x	x	gut-feeling
	x	hands-on skills
x	x	insight
	x	interpretation
x	x	know-how
x	x	knowledge base
	x	lessons learnt and failure
	x	mindset
	x	negotiation (skills)
	x	non-analytical behaviour
	x	observations
x	x	opinion
	x	organisational mind / global understanding of processes / organizational knowledge and business practices
	x	pattern of experience / process and platform knowledge
	x	people knowledge
x	x	personal competence
x	x	personal experience
x	x	perspectives
x	x	predictions
	x	project management skills
	x	requirements
x	x	routines
x	x	rule-of-thumb
	x	self-reflection

	x	sense making
	x	shared history
	x	shared norms
	x	shared values
x	x	skills
	x	team spirit
x	x	taste
x	x	techniques
	x	thinking in practice / hands-on
x	x	thoughts
	x	tribal knowledge
	x	tricks
x	x	understanding

All ETKs mentioned in Table 14 were specific to the respective transfer. In addition to these ETKs, it has to be noted that there are more explicit types of knowledge like process parameter or instructions that have not been the focus of this analysis. As different aspects influence the dissemination of knowledge during a technology transfer, the mentioned influencing factors for the TT in the BI are listed in the next section in order to answer RQ2.

4.3 Results for Answering RQ2: What influences the knowledge transfer between the German development department and the US manufacturing department in the BI?

RQ2 wants to identify the influencing factors of a TT. Hence, it uses the data derived from the semi-structured interviews as well as the analysis from the focus group discussions to identify relevant influences for the specific transfer looked at in this study. During the thematic analysis for the semi-structured interviews, general influences for the knowledge dissemination are determined. The focus groups, however focussed on the tacit knowledge dissemination influences and are hence, used to complement the data from the semi-structured interviews. The terms “influences” and “influencing factors” are used redundantly during this evaluation. They do not indicate whether qualitative or quantitative methods are used to identify them, as the results are purely based on qualitative data analysis.

4.3.1 Findings of the thematic analysis for the influences of tacit knowledge dissemination

Like in the analysis of the types of tacit knowledge used during a TT, the thematic analysis of the semi-structured interview data had been the method of choice to identify the relevant

influences to enable knowledge dissemination. During the thematic analysis, four themes and six sub-themes were identified, which are depicted in Figure 17Figure 20.

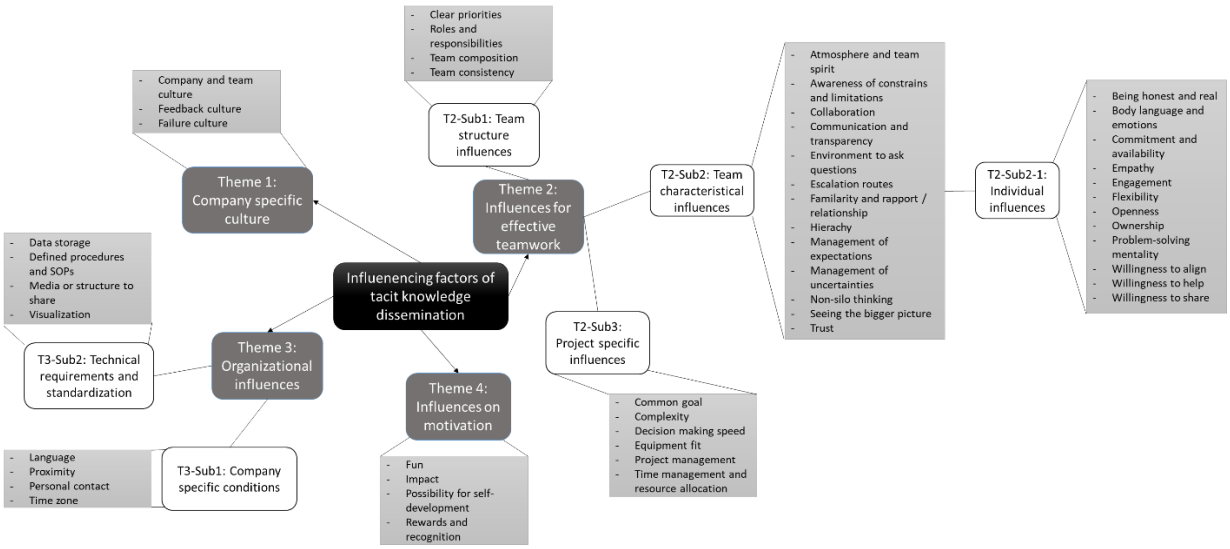

Figure 17: Themes for the influences of tacit knowledge dissemination.

As a lot of influences had been identified during the thematic analysis. Hence, the order of the discussions of the themes and sub-themes is shown in Figure 18.

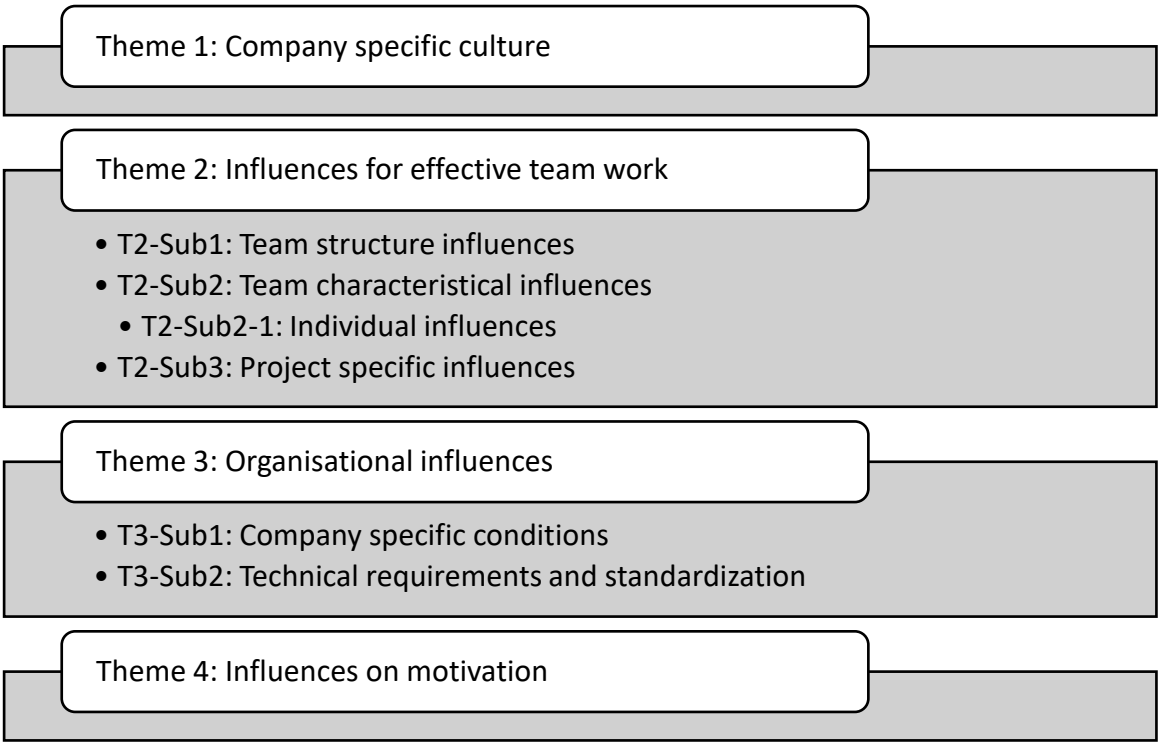

Figure 18: Themes and sub-themes identified for the influences of tacit knowledge dissemination during a TT by thematic analysis of the semi-structured interviews.

A more detailed description of the themes and sub-themes is provided in the following sections as mentioned before.

4.3.1.1 Influences of the tacit knowledge dissemination theme 1: Company specific culture

The first theme identified as an influencing factor is culture. For the technology transfer especially, the culture embedded in the company and the team is of relevance. This is due to the fact that the company culture forms the basis of how people work together in teams. Knowledge should not be seen as something that should be kept, so that one person gains power through this knowledge, but it should rather be shared so that the whole team can grow. Trust in the team and the company needs to become a basic pillar in the team and company culture. During the semi-structured interviews, examples for this aspect had been mentioned.

> *"(…) And then you were mentioning another very important and interesting thing like people having the confidence that they are allowed to share something. How do you increase this?" (Researcher's question)*
> *"It's part of it. I think it's a company culture. It's a team culture. (…) sometimes it can be complicated when you have legal matter that are coming through, because when you're acting on behalf of another party, it's always hard to say, you know, I'm not at liberty to share some of the data. I'm not at liberty to share some of the comments. That sometimes is a big problem, but definitely on each side having inside the team that understanding that everything is an opportunity to learn, to accumulate knowledge and to share the knowledge." (Participant 161-Ext)*

So having the confidence to share knowledge is important to grow. Team members need to have a clear understanding about what is expected and allowed when disseminating knowledge. It needs to be considered, in addition, that not everything is going to work at the first attempt and that not all the knowledge disseminated might be understood correctly. Hence, failure culture needs to be established in the teams and in the management. This leads to less pressure during the project and increases the probability of better results.

> *"(…) I've seen also before that one thing which can be very important is to have at least one test which is not an official run. It's more of a fitting test. So, you try once and you're like I'm allowing myself to fail. I'm allowing my results to not be good, but I'm doing this to learn." (Participant 161-Ext)*

Learning in general is an important aspect for TTs. It not only takes place when failing, but also when getting feedback from others. Companies know that and a lot of them have implemented a feedback culture as one important pillar for their company culture. To be able

to provide feedback, team members e.g. have to be open and trust each other. This behaviour helps the team to become more effective. These influences are discussed in more detail in the "Influences for effective team work" section. Hence, formal and informal routes of feedback should be established during a TT. Seeing feedback as positive tool is important to grow. Participants in the semi-structured interviews were phrasing it in the following way:

> *"(…) So whenever we have that conversation, it was open and candid, I'm like: I'm not challenging you. I just wanna make sure that we have an easy transfer once we have that and we understood that we are not attacking each other, we're working together to make it happen and it's positive feedback that we're providing like the feedback that is gonna help us, constructive feedback for the process. Once we understood that this is where we are, then it shifted." (Participant 671-RU)*

By having a feedback culture implemented, team members understand the basic rules of feedback and know that they should not take suggestions personally. Feedback can help the project to become a success.

Culture in general can be considered the underlaying structure for all other influences. These cultural guidelines influence other intrinsic factors that are listed in the next sections which are more individual.

4.3.1.2 Influences of the tacit knowledge dissemination theme 2: Influences for effective team work

As mentioned in the previous section, culture forms the backbone for effective team work and individual influences in general. Team work itself is influenced by the team structure, team characteristics including individual factors and project specific factors. An aspect that very often comes up when considering team work is trust. Hence, trust is also the central topic when looking at the different influences for effective team work.

4.3.1.2.1 Influences of the tacit knowledge dissemination sub-theme 2-1: Team structure influences

For a technology transfer it is essential to have a dedicated and skilled team available. Therefore, the team structure is important to look at. Experts from all involved areas need to be part of the team and counterparts at the SU and RU need to be available and also the participants in this study stressed this point:

> *"(…) I think one of the big the reason that you can have a failure or you can have huge challenges in tech transfer [is that] all the key players need to be involved.*

> *And the responsibilities need to be clearly laid out (…). I think the documentation (…) flows really well if the key players are involved and the responsibilities are clear, (…)" (Participant 500-RUC)*

> *"(...) Of course, this is always a basic prerequisite, how is the team composed. Yes, from the receiving unit and from the sending unit, that's a very important thing that you think about it carefully at the beginning and (…) that's what [the two project managers] did, they did it very, very well. That they immediately have the responsibilities laid out. Who does what,… who would be responsible,… clear agreements … and that was very good." (Participant 149-SU)*

These team members need to be available and need to prioritize the TT activities over other tasks. This has to be supported by the management. Participants describe their experience from the transfer in the following way:

> *"(…) The sending unit has made themselves available just about all day any day, so having immediate access to biological development has been really good and helped us succeed now from the receiving unit. The fact that we had people whose job was to make sure that [the RU] was successful. That also helped, because we had people that were dedicated just to this, and this was the priority for them." (Participant 72-RU)*

Still, even with clear priorities, team members can change during the TT for different reasons. They might retire or leave the company or receive different tasks. By member changes additional transfer effort is required, which was also mentioned by the participants:

> *"(…) In the meantime, the teams have already changed, which was also a longer process in terms of time, which means that the contact persons have changed again on the Berkeley side. The knowledge would then also have to be transferred again to the new colleague." (Participant 523-SU)*

The more structured and consistent a TT team is the easier the transfer as this also influences the characteristics of a TT team. Hence, these characteristics are described in the next section.

4.3.1.2.2 Influences of the tacit knowledge dissemination theme 2-2: Team characteristical influences

Consistent teams know each other well and create a certain team spirit. For a successful TT the atmosphere should be good and trustful. SU and RU need to collaborate to achieve the joint goal, which makes a good team spirit essential. The participants phrased it in the following way:

> *"(…) A good atmosphere is very important in any case, so I always think it's one of the most important things ever." (Participant 295-SU)*

> *"(…) Yes, exactly, it was in no way the case that any bad words were said in a single meeting. No accusations were made, even if something went wrong. So, it was really constructive. And that was really very positive, I can't say otherwise." (Participant 273-SU)*

> *"(…) I think the flexibility and the willingness of everybody to just raise issues. I think we have an extremely cohesive team." (Participant 330-RU)*

Collaboration and a good team spirit can only be established and maintained when having a trustful relationship between the team members. Interpersonal trust, which is one facet of trust in addition to team trust, has also been labelled as rapport and familiarity during the semi-structured interviews.

> *"(…) Yes, it's easy to imagine if it hadn't been for these travel restrictions, maybe there would have been an on-site team visit that all employees involved in the team really meet in person, get to know each other personally, which of course makes communication much easier when you talk to someone you know from a meeting face-to-face than if it were now in the worst case even without a picture, only by phone. This simplifies communication if you know each other and have already built up a small relationship of trust. As a result, you are simply more open, I think everyone is aware of that in everyday life." (Participant 647-SU)*

> *"(…) Familiarity with everything from the equipment itself, to the automation, to the person standing next to you and what you're going to do versus what they are going to do." (Participant 362-RU)*

> *"(…) So you have a good communication and rapport with those people to ask questions is crucial." (Participant 544-RU)*

When knowing a lot about the other unit's team members and when exchanging also informally, team members get a better awareness of the constraints and limitations. Respecting these constraints and limitations helps to understand why some processes have been developed in a certain way and again foster trust. It is important to enable a non-silo thinking atmosphere.

> *"(…) I think, the one thing that I would say was unique, this was a later stage project, right? So, there were more requirements that we will not see for early stage. So, then you have to be aware of it." (Participant 500-RUC)*

> *"(…) I think the most critical thing that we need to do is we need to understand the processes and how all the linkages work. And I think that's where we get caught up in silos and we need to really not do that." (Participant 330-RU)*

Team trust, compared to interpersonal trust, can be influenced by different aspects. Consistent team composition, good leadership and a vital team spirit had been mentioned during the semi-structured interviews as influencing factors. All of these aspects create a good team spirit and an environment to ask questions.

> *"(…) So, I think that the challenges can be there in terms of roles and responsibilities and the commitment from the different groups, I think is very important. Commitment on a regular basis because if you are working towards timelines, then you don't want to lose any time. Because, if somebody is not coming to the meetings or some group is not represented and then later on, they say "ohh I don't approve this or this is not we can't do it this way" then that makes things very challenging." (Participant 500-RUC)*

> *"(…) I would actually say, you know, as I'm talking through this there is a very strong sense of ownership on the side of the sending unit and on the side of the receiving unit, (…)" (Participant 343-RU)*

This is important as the team has the same goal to achieve a successful transfer. Hence, the team members should have the bigger picture in mind and use this as a joint motivation. Participants in this study stated that particularly the thought of helping patients is key, but also all steps to attain need to be considered. The process itself needs to be robust to be used for the different stages of the clinical development until launch of the project. Hence, this was also mentioned during the semi-structured interviews:

> *"(…), actually in my opinion it starts with the development organisation keeping the future in mind that the process needs to be developed such that it is robust and repeatable. (…) You don't wanna do that every single time. So that one-on-one communication and how is that knowledge transferred that's important but you always have to be thinking longer term in the back of your head. It's really easy to get swept up in the moment. And get excited about this thing because it's right in front of you and it's a wonderful thing. It's gonna help a lot of people and so on. But you've gotta think about the next thing as well." (Participant 362-RU)*

In addition to the mentioned aspects, the organisational structure has some influence on how trust is built in a team and how the team members disseminate information. This includes the hierarchy within a company, the decision-making speed as well as the escalation routes.

Especially decision making and escalation routes were also mentioned by the participants for the TT in this study.

> *"(…) we were supposed to do everything in timely fashion and then you have certain things that need to be escalated and you escalate them and the timely input if you don't have it, then you kind of stuck. And then you have to wait for that resolution, so I would say that is also very important, because the tech transfer team does not have all the information or it cannot make all the decisions sometime and those decision has to be made by somebody else and the faster the input is received the easier it is to keep moving forward, (…)." (Participant 500-RUC)*

> *"(…) in [another project] we definitely had a good escalation channel. In order to resolve problems quickly. So that ensured, I mean timely, (…) delivery. Otherwise, I mean, I would say just, (…) we tend to go a little bit slower on decision making and so decision making was sped up by having this process." (Participant 122-RU)*

With the participants' input, it can be seen, that the timely decision making is crucial for keeping the project timelines. This means sometimes decisions have to be taken even though not everything is known yet. The participants phrased it in the following way:

> *"(…) I think that just having a platform or process description is always the foundation required for good tech transfer. Reoccurring meetings. Site visits. Quick ability to adapt to uncertainty. Alignment, I think would just be the most important things." (Participant 544-RU)*

> *"(…) I think we have a very knowledgeable team and I think that as issues have come up, the ability to shift on the fly and mitigate situations and come up with creative solutions have been very good, because this has been a challenge for the site." (Participant 330-RU)*

> *"(…) And I think this is probably where the management of expectation is coming from and the definition of success is, you know, the success should not be: Everything is perfect. It should be: I understand why things that fail, fail." (Participant 161-Ext)*

Having a trustful, cohesive and flexible team is also dependent on the single team members. Therefore, individual factors can influence the feeling of collectivism in a group. This is due to the fact that trust is built by being real and honest. When having empathic people in a team that foster a safe environment, the appreciation and team spirit is assumed to be better. This again leads to more effectiveness as the team members exchange thoughts and knowledge.

> *“(…) It helped us get to know better the receiving unit, but between all the different communications that we had, we got to know them a lot more and they got to know us a lot more. We were put under pressure and they saw us under pressure and we saw them under pressure. You see how people react then. But I do believe that for future tech transfers it should be a lot easier, a lot more streamlined given that we have taken care of a lot of the bugs earlier on.” (Participant 671-RU)*

> *"(…) Well, the basic characteristic of the people who were involved in this process transfer was that everyone can communicate relatively well and speak precisely, for example, it's not only about creating trust, so empathy is also an issue, asking the right questions and not appearing annoyed, even though you may be. And to ask the questions precisely, that was a basic prerequisite, where I had the feeling that the team had already internalized it very well and these were, as I said, these basic characteristics of everyone involved." (Participant 730-SU)*

Empathy also plays an important role for working in digital environments, which was the communication media of choice during the Covid-19 pandemic as well as for multinational teams. Participants mentioned that virtual communication becomes easier when everyone agrees on switching on cameras during team meetings.

> *“(…) I think, especially in a big meeting where you don't have a camera on, (…) there could be certain body language cues that you're missing. Something as subtle as a slight nod of the head or a lean back or things like that, that add depth to communication, that you missed this way.” (Participant 297-RU)*

> *"(…) That's when I learned a little bit that it's very, very good to do it with a camera for situations like that. It's not just the other language, it's also that the facial expressions support it, so that you can convey it better. Being able to package the information better than if you just do it orally." (Participant 523-SU)*

When thinking about trust, other factors that are influencing the transfer are commitment and ownership. The whole team needs to show commitment for the project to not lose track to keep the timeline for the project. This leads to a joint will to achieve the project goals and hence, fosters a positive problem-solving mentality in the team.

> *"(…) So it went well and what led to a success in this respect was really the willingness of everyone, i.e. the Berkeley colleagues, to really take their samples very early in the morning, to have the data available. During the engineering run and then also here in Germany also the willingness to just sit down at the computer at 9pm or so in the evening and then just chat and just again*

> *sometimes it was only 10 minutes if you didn't have much. Sometimes we sat together for over an hour and we offered comfort (...)." (Participant 295-SU)*
>
> *“(…) And when there's that sense of ownership. There's a push to kind of go above and beyond to make sure that things are working well there's a problem. Guess what. They see it as their problem. You know, we need to solve this. That's a very positive phenomenon.” (Participant 343-RU)*

This also means that the willingness of both parties to achieve a successful TT is crucial. To adapt learnings and changes into the transferred process, willingness to align, to help and to share the learnings and knowledge need to be available and established within the team, which the participants described in the following ways:

> *"(…) To a certain extent, I think it stands and falls with the people. So both you are always sender and receiver, (…), so that's like what goes around, comes around, that's one thing, the other is, if you just think expediently and say, actually the most uncomplicated thing is to adopt the method, even though I would like to take my method." (Participant 846-SU)*
>
> *“(…), so for all my trustful experience with our sending unit colleagues all of them are very open. Very helpful. Willing to, you know, provide the help as much as they can.” (Participant 517-RU)*
>
> *“(…) And now people are things were much more lean and agile and everybody's openly collaborating and sharing ideas. And it's exciting. I think it's the right way to go.” (Participant 297-RU)*
>
> *“(…) So, communication and I think that's overall is the experience of the sending unit, especially like the subject matter experts, the lead of the sending unit that really define the most of the success of the transfer and also the like the willingness to share.” (Participant 517-RU)*

The implementation of changes of course also can cause trouble during a TT due to the ownership mentality of the SU for their invented technology. To overcome this thinking, the team members need to stay flexible and open for suggestions and need to see the bigger picture for the project.

> *“(…) And I think just everybody being flexible, you know, I think a credit to [the colleagues from the SU], they're not, understandably, you spent ten years of your life working on something. It's your baby. They are not set in their ways, so to say they are more than open to suggestions or changes to the process which I think is critical, especially because you know, like I said, this is different equipment and different building at a different scale potentially so there might be a couple necessary changes and they're very flexible and open to exploring other possibilities.” (Participant 297-RU)*

> *"(…) I would say that people are very open minded and to changes and not being rigid, if there is something that it's not going to work, then people were very flexible in suggesting a solution. Sometimes you don't like this solution, right? You say that. OK, well, this is gonna be painful because it's not being done like this before, but I think everybody, whether it's sending unit or receiving unit, they were both open to solutions, both open to changes and evaluate those changes to make the transfer successful." (Participant 500-RUC)*

Overall, it can be stated that the individual influences during a technology transfer are essential. They are the prerequisite for other huge important aspects like communication and trust within a group. That shows again that picking the right people for a transfer determines the success or failure of a TT.

4.3.1.2.3 Influences of the tacit knowledge dissemination theme 2-3: Project specific influences

Next to the mentioned team related and individual aspects also project specific factors can influence the success of a TT. The developed technology or process for a certain project is a valuable possession for a company as it may be patented. Therefore, the right experts need to be allocated to the team and these members need to have sufficient time to accomplish the transfer. Time and resources have to be provided by the management. This means the higher management must facilitate these efforts.

> *"(…) Of course, the colleagues also had to understand the differences and why has it been done in that way. Doesn't create enthusiasm at first, because it's complex. And that was very difficult, because again the transfer of knowledge, why is that? And also to find acceptance and I got a lot of support [from a colleague], he saw it very pragmatically and I always communicated very clearly why and that we simply support this uncertainty at a certain point in time." (Participant 523-SU)*

> *Researcher's question: (…) would you approach anything different for your next tech transfer?*
> *Participant 544-RU: "I guess it's a little bit of resources for me. I wish I had more resources to get more involvement in tech transfer."*
> *Participant 72-RU: "No, I probably would have asked for a lot more resources, right? Because resources were stripped thin, but I don't think I would ask for anything different, though outside of that."*

Resources especially in remote teams are a big topic. Team members might be assigned to other projects and their time allocation for the TT can be different. Hence, transparency and open communication about these topics are required.

In addition to the sufficient resources, the TT team needs a good project management to help to guide the process of transference. The project management also needs to foster discussions about open topics and issues raised and track action items. The project management has to provide a joint goal that the team can work to.

> *"(…) I think it started being efficient when looking at the processes themselves, where we sat down together every day and talked about this project - our common baby, let's say now - and then we really pulled together. Of course, everyone had the same goal and that is of course particularly memorable." (Participant 730-SU)*

> *"(…) So as long as everybody has the same understanding on a priority that went very well. People will really react fast and then give you answers in a very timely manner and then all the communication, even sometimes, is wrong people. They will also trying to help you out to find the right one to answer the questions as well. (…) So this kind of same goal, same understanding of the priority also went very well on one of the tech transfers." (Participant 537-Ext)*

> *"(…) So the most important thing is, if there were ambiguities, that this was also clearly addressed and they did that well, because they had a lead (...), who did that, she made the appointments. So she wrote protocols, action items and she tracked actions that were not delivered. So that was good, you always knew where their lack of understanding was. (Participant 149-SU)*

Another project specific aspect is the management of new technologies and the acquisition of new equipment. This influence, however, is not people related compared to the ones mentioned before. Still, the facility and the equipment fit for the project is crucial to smoothen the transfer. This is due to the fact that working with the same equipment helps to adopt procedure 1:1 from the SU. In addition, troubleshooting is faster as issues can be discussed with experts from both sites.

> *"(…) And there may be other things because it's a new technology that you need to keep in mind, but since it's not in the transfer process then you may overlook it and that can cause failure, right? So I think that's one example that it can happen, but I would say the facility fit the equipment. Like to like equipment or changes can have a huge effect on the impact on to the product." (Participant 500-RUC)*

In summary, it can be said that effective team work including the team characteristics and the individual influences, plays a big role for the TT. Building trust and trying to smoothen the communication is essential to be fostered by the team and the management. This means the

organisation needs to fit the purpose of team building. The correlated influences are discussed in the next section.

4.3.1.3 Influences of the tacit knowledge dissemination theme 3: Organisational influences

Intra-company transfers are influenced by the conditions within the organisation. This includes company specific conditions like the location of the sites, but also the technical situation the company can offer.

4.3.1.3.1 Influences of the tacit knowledge dissemination sub-theme 3-1: Company specific conditions

Of course, each company that conducts a technology transfer has its own specifics. This starts with the location of the sites that are involved in the TT. Their proximity determines how often the team members can meet face-to-face.

> *"(…) We also notice that it is easier the closer you are to each other, we also have transfers in Wuppertal from GMP operation to GMP. The colleagues are across the street, so to speak, and you know each other. You have a lot of trust in each other." (Participant 730-SU)*

> *"(…) So certainly, then also cross-border local separation. If you don't know each other personally, I think then this local separation is definitely very crucial." (Participant 295-SU)*

Interestingly, in the transfer looked at in this study also the time zone came up as an essential influence. This might be due to far distance between the two sites with a time difference of 9 hours. This leaves only a short window for exchange and meetings in the working hours of the two teams. In this case it is especially important as the transfer was conducted during the Covid-19 pandemic. This means site visits were not possible and kick-off meetings etc. had been switched to an online working mode. Hence, personal contact had been limited, which the participants described in the following way:

> *“(…) I think the real barrier to the international stuff is the time zones. Like there's a very small window where we can meet that's reasonable for both parties.” (Participant 297-RU)*

> *"(…) Due to the fact that it was in a different time zone, which had a time difference of 9 hours, only very short meetings were possible and that dragged it out incredibly long, so due to travel was restricted, Corona and general austerity constraints a trip was just not possible and that complicated it." (Participant 273-SU)*

Another key aspect to keep in mind for a multinational technology transfer is that due to different countries that are involved, the team members have different mother tongues. This can lead to difficulties in communication when team members are not fluently speaking English and are limited in technical terms. Speaking the same language can simplify the TT.

> *"(…) By the way, what is happening right now, when you have to explain technical things in detail, definitely still make the whole thing difficult, is also clearly the language barrier, so you can certainly follow a conversation in English and I have to say that my colleagues are really trying hard…" (Participant 295-SU)*

> *"(…) Yes, and whatever happened: at some points there are of course also language comprehension problems as I said, but that can be fixed, (...)" (Participant 149-SU)*

Overall, company specific influences like location or the language spoken in the teams are important for technology transfers. Still, it has to be kept in mind that these are external conditions that cannot be influenced by the management or the project team. This means they need to be considered but cannot be easily changed.

4.3.1.3.2 Influences of the tacit knowledge dissemination sub-theme 3-2: Technical requirements and standardization

Another organisational aspect that comes into play, when thinking about TTs are the technological situations as well as the status of standardization within the company. A lot of data is shared during a technology transfer. Hence, sufficient technical tools, data storage and structure to share has to be established within the company. One tool used during the respective transfer in this study had been Microsoft Teams as mentioned by the participants:

> *"(…) On the one hand, we have a Teams folder, (...), in which (…) all relevant documents are stored." (Participant 846-SU)*

> *“(…) So that there was a lot of utilization of Teams for sharing of documents, things like batch records or campaign reports or things like that” (Participant 297-RU)*

Next to the communication channels and data storage options, standardized documents to disseminate knowledge are required. To be able to have a joint understanding about procedures, global standard operating procedures and reports need to be in place and available for all team members.

> *"(…) that's one thing, another thing is historical data or those things will help us really for [the] transfer, we have a global SOP (…)." (Participant 517-RU)*

Overall, influences specific for the company are related to site-specific conditions as well as the technical and standardization status. Most of the site-specific influences are fixed and hence, cannot be changed. The technical and standardization status, however, is more flexible and should be as up to date as possible. Outdated procedures can de-motivate team members and hence, need to be avoided. Instead, positive motivators should be used to support the success of a project. Motivational influences are described in the next section.

4.3.1.4 Influences of the tacit knowledge dissemination theme 4: Influences on motivation

Influences on motivation can be divided into intrinsic and extrinsic motivation. Intrinsic motivation promotes a team spirit that involves all team members in the communication. Due to the intrinsic motivation, people feel more committed to the company, team and project. They have more fun working in the group. This had also been reflected in the participants answers:

> *"(…) And to ask the questions precisely, that was a basic prerequisite, where I had the feeling that the team had already internalized it very well and that were these, as I said, these basic characteristics of everyone involved. That's why it was always a lot of fun to meet people from the beginning and talk about everything." (Participant 730-SU)*

> *"(…), I also found it quite nice that before we went to the technical topics, we were asked about such personal sensitivities in the meeting. What you like to eat most, how often you would cook, whether you would have already ridden a bike today or what kind of car do you actually have? And everyone had to make a little bit of their contribution. This has also changed the mood immensely. That it became more personal, more open and you had more fun at work." (Participant 523-SU)*

Again, these quotes also address individual influences mentioned before like empathy. These influences the creation of trust that again helps to enhance the employee's commitment to the task as well as the willingness to learn, which was also valued by the participants:

> *"(…) The most positive is really the communication. And also to learn a lot from very good, very experienced colleagues. And then also learn how to deal with some really stressed situation to develop myself." (Participant 517-RU)*

Next to the self-development it is important that the team members know about the impact of the project for the patients. This is in line with the participants experience:

> *“(…) And I will say I've used this understanding in a previous life: it wasn't so much about how new or novel or strange or exciting the process that was about to be executed. That wasn't what people got excited about. They got excited about the new medicine. And they wanted to go fast. They wanted to do it for patients. And I would argue as a technician if that's what motivates me, and, I'll speak for myself, that's the part that motivates me.” (Participant 362-RU)*

All the mentioned motivators so far were intrinsic ones. In addition, recognition as an extrinsic motivator needs to be available and transparent as mentioned during the semi-structured interviews:

> *"(…) And what I have also used as a tool, is I have tried to give the groups such valuable feedback, not always in the large group, but that I have the opportunity for one-on-one conversations, which there were quite a few times or which you can also have a little bit, that you come to the one-on-one conversation, that you really praise it again personally. The fact that you really talk through what you particularly liked, (…) and that finally led to the fact that the function in Berkeley then also asked me to tender recommendations for special payments (…) which have been particularly excellent and that also supports this evaluation process and that is a good tool to support this overall process, because there is a certain appreciation behind it through this process that you go through. This is often forgotten. You say good, yes, thank you very much, that's great, but really appreciation comes more often, perhaps through an additional personal conversation, of course, means more and more time." (Participant 523-SU)*

Interestingly, a lot more intrinsic motivational influences have been mentioned than extrinsic ones. Extrinsic motivators, however, can help to enhance the success of a transfer, as well as they show appreciation for accomplished tasks. Hence, the visibility of certain team members is increased which builds a good reputation that can be important for future promotions and further expert exchange in the field. Overall, both intrinsic and extrinsic motivation needs to be watched to achieve a successful TT.

In summary, during the analysis of the data derived from the semi-structured interviews, a large number of influences could be identified. The next section discussed the influences identified during the focus group discussions. The focus groups were intended to extend the views of the participant by asking questions directly related to the influences of the tacit knowledge dissemination according to the onion model for causal mapping. Examples and stories should reveal additional influences that were not easy to express. In addition,

consensus should be achieved and hence, differences and similarities were evaluated when comparing the results.

4.3.2 Findings of the focus groups for the influences of tacit knowledge dissemination

To assess whether similar influences are mentioned in a group setting compared to the single expert interviews, the results from the semi-structured interviews analysed by thematic analysis are compared to the results from the focus group discussions analysed by causal mapping in this section. In addition, similarities and differences of the results from the SU and RU focus groups are discussed.

The influences found during both types of analysis are listed in Table 15. Additionally, the table holds influences identified during a literature search. These influences are discussed in chapter 5. All influences had been categorized into cultural (indicated in green), team (indicated in white), organisational (indicated in blue) or motivational aspects (indicated in orange). These categories match the themes identified during the thematic analysis in order to compare the results.

Table 15: Comparison of the influences identified during the focus group discussions and the semi-structured interviews.

Influence identified	Influence identified during focus group discussion	Influence identified during the semi-structured interviews	Influence identified during literature review	Category
(Country specific) Culture (SU/RU)	x			Culture
Accessibility, commitment and availability (SU/RU)	x	x	x	Team
Atmosphere and team spirit (SU/RU)	x	x	x	Team
Awareness of constrains and limitations		x		Organisation
Backing (SU)	x			Motivation
Being honest and real		x		Team
Body language and emotions (SU)	x	x		Team
Capturing aha-moments / tribal knowledge (RU)	x			Team
Celebrate success (SU)	x			Motivation
Clear priorities (SU)	x	x		Team
Collaboration		x		Team
Common goal / defined milestones (SU / RU)	x	x		Motivation

Communication and transparency (SU/RU)	x	x		Motivation
Company and team culture (SU/RU)	x	x	x	Culture
Competency (RU)	x			Team
Complexity (RU)	x	x		Team
Connectivity between teams (RU)	x			Organisation
Consistent platforms (RU)	x			Organisation
Data storage (SU)	x	x	x	Organisation
Decision making speed (RU)	x	x		Team
Defined procedures and SOPs (SU)	x	x		Organisation
Department culture (SU)	x			Culture
Empathy		x		Team
Empowerment and autonomy (SU/RU)	x			Motivation
Engagement (RU)	x	x		Team
Environment to ask questions (SU)	x	x	x	Team
Equipment fit / facility fit (SU/RU)	x	x		Organisation
Escalation routes (SU)	x	x		Organisation
Exchange on the right level (RU)	x			Organisation
Experience (SU/RU)	x			Team
Facility readiness (RU)	x			Organisation
Failure culture (SU)	x	x		Culture
Familiarity and rapport (SU/RU)	x	x	x	Team
Feedback culture (SU)	x	x		Culture
Flexibility		x		Team
Fun (RU)	x	x		Motivation
Hierarchy (SU)	x	x	x	Organisation
Interfaces between functions (RU)	x			Team
Joint culture (SU)	x			Culture
Joint history (SU)	x			Team
Joint will to succeed (SU)	x			Motivation
Knowledge storage			x	Organisation
Knowledge transference			x	Team
Language (SU)	x	x	x	Organisation
Management of expectation (SU)	x	x		Team
Management of uncertainties		x		Team
Media or structure to share (SU)	x	x	x	Organisation

Motivation (intrinsic) and impact (SU)	x	x	x	Motivation
Mutual understanding (SU)	x			Team
Non-competitive environment (SU)	x			Team
Non-silo thinking		x		Team
Openness (SU)	x	x		Team
Opportunity to share (SU)	x	x	x	Organisation
Ownership (SU/RU)	x	x		Motivation
Passion and personal commitment / intention to share			x	Motivation
Personal contact / face-to-face contact (SU/RU)	x	x		Team
Possibility for self-development (SU)	x	x		Motivation
Power and politics (SU)	x		x	Motivation
Pragmatism (RU)	x			Team
Problem-solving mentality / Pioneering character (SU)	x	x		Motivation
Professionality (SU)	x			Team
Project management (SU)	x	x		Team
Proximity (SU/RU)	x	x	x	Organisation
Relationship (RU)	x	x	x	Team
Required training available (SU)	x		x	Organisation
Responsiveness (RU)	x			Team
Rewards and recognition (SU/RU)	x	x	x	Motivation
Roles and responsibilities (SU/RU)	x	x		Team
Seeing the bigger picture / understanding the rational (SU)	x	x		Motivation
Stakeholder (SU)	x			Organisation
Standardisation (SU)	x	x		Organisation
Structure (SU)	x	x	x	Organisation
Support from management (SU)	x		x	Motivation
Taxonomy (SU)	x			Organisation
Team composition / sufficient resources (SU)	x	x		Team
Team consistency		x		Team
Technical tools and visualization (SU)	x	x		Organisation
Time management and resource allocation (SU)	x	x	x	Team
Time zone (SU)	x	x		Organisation
Trust (SU)	x	x	x	Team

Type of valued knowledge			x	Organisation
Virtual culture / environment (SU/RU)	x			Culture
Willingness to align		x		Team
Willingness to help (SU)	x	x		Team
Willingness to share		x		Team

In Table 15, it can be seen that overall, 81 influences were identified during the thematic analysis and the causal mapping. 71 influences were found during focus groups discussions and 54 influences could be extracted during the semi-structured interviews. Only 9 influences had been found during the semi-structured interviews that did not come up during the focus group discussions. This means that most influences from the semi-structured interviews could be confirmed during the focus group discussions even though the discussion was focussed on the tacit knowledge dissemination. All influences elaborated for the semi-structured interviews are not repeated in this section. Only influences identified in addition are described in more detail below.

4.3.2.1 Influencing facets of culture found during the focus group discussions compared to the results from the semi-structured interviews

When looking at the cultural influences (indicated in green), this topic has been discussed in more granularity within the focus groups compared to the semi-structured interviews. Next to the company and team culture, as well as the failure and feedback culture, also country specific culture, virtual culture, joint culture and department culture had been mentioned during the focus group discussions. Country specific culture plays a role in a lot of TTs as multinational teams are involved. The joint culture and department culture are extensions to the already mentioned team and company culture. Team culture for TTs should always be based on a joint understanding of values. The department culture is derived from the company culture and might have some different characteristics, but the basic pillars should be similar. Virtual culture is a really important point, as TT teams work in remote settings to an increased degree. Hence, an overarching company initiative for a virtual culture or at least etiquette, like switching a camera on during the meeting, would be required.

> *"(…) maybe that's one of those things, that you [should] have: this virtual culture, that it should perhaps be cross-location. Sure, if there are 20 people in the meeting, and then everyone else has the camera on, it's also difficult, but at least when someone is talking, that you have the camera on and see: Who is it anyway? And what does he or she even look like? And at least the facial*

expressions can be seen, which is reasonably better via the cameras than if you just talk on the phone." (Participant 647-SU)

Cultural aspects as influences for the TT had been mentioned in both the SU and RU focus group discussion. During the SUs discussion it was even more engrossed and topics like the virtual, feedback and failure culture came up. Still, both groups valued culture a lot and expressed how important it is for the TT. The researcher's impression is that there are no differences due to country cultural reasons how culture at work is seen at the SU and RU. The company, in general, focusses a lot on living a joint culture and making transparent what the pillars of the culture are. Hence, culture is something that is always in the team members mind as they are reminded to take it seriously during townhall meetings or department meeting for example.

4.3.2.2 Influences on motivation found during the focus group discussions compared to the semi-structured interviews

When looking at the motivational influences indicated in yellow, it can be seen that there is a great conformity of the results derived from the semi-structured interviews and the focus group discussions. Anyhow, five additional influences had been identified during the focus group discussions. The SU focus group stressed the importance of backing and the support from management as it helped to feel safe and to be able to represent group decisions. The higher the commitment to the company and project, the more likely the team members disseminate all the important knowledge. This is especially important as the SU has the initial knowledge for the process to be transferred as they invented it. For the semi-structured interviews, the ownership and not-invented-here influence has already been described. In the focus group discussion also the pioneering character of the researchers came up as an influence in this regard. This means team members share their knowledge, because they are proud of what they invented.

"(…) Yes, so as a motivating factor I can only confirm everything that is said before, but subliminally I think we can also say that we are all developers. And every developer is proud of this development. This technically works, and we had the opportunity to redevelop the latest process with a new cell line, to transfer it here and also to set it up in the plant, and that was also one of the drivers, which was very much managed in the team, which is a good thing. We have this task, we love the technology and have achieved it and were also very proud to be able to do it." (Participant 523-SU) (...)

"I just wanted to ask, is that some kind of pioneering character?" (Participant 846-SU)

"For technologists like us, yes." (Participant 523-SU)

In addition, to being proud, the autonomy and empowerment to decide how to transfer knowledge and which knowledge to start with, as well as decision making had been mentioned in both the SU and RU focus group discussion. When having reached defined milestones and after finalization of the transfer, the successes should be celebrated together. This also fosters the joint will to succeed. Overall, the mentioned intrinsic motivators again support the team spirit and trust within the TT team.

Like for the cultural aspects, some motivational influences had been mentioned in both the SUs and RUs focus group discussion (four in total). Eight additional influences had been mentioned by the SU, where as one additional influence had been mentioned by the RU team. This was due to the fact that the discussion in the SU team about these kinds of influences lasted longer and had more focus on this topic compared to the RU focus group. As only one focus group with the SU team and one focus group with the RU team took place, it cannot be stated that this is due to the department management focus or cultural influences. Still, it is something that should be watched further.

4.3.2.3 Organisational influences found during the focus group discussions compared to the semi-structured interviews

With regards to the organisational or company structure influences, five additional aspects came up during the focus group discussions. The first one is a language related aspect, namely taxonomy. For researchers, speaking the same language regarding specific terms for the BI is important. When not having the same taxonomy in place at the two sites this can easily cause misunderstandings and can in the worst-case lead to failure of the TT. It can also cause relationship issues as one site could think that they do not get the required information by purpose, even though it is only a misunderstanding due to differently used taxonomy. Another aspect that helps to smoothen a transfer is when consistent platforms in terms of devices and consumables etc. are used. Hence, no switch in equipment is required which lowers the risk of the transfer. When performing the transfer to a new facility or a facility that is newly equipped, the facility readiness is of importance. Otherwise, team members are still involved in the build-up of the facility and cannot fully concentrate on the pure transfer activities.

During the focus groups also exchange related topics came up that are influenced by the organisation. Team members stressed that exchange has to take place at the right level.

> *"(…) And here we had subject matter expert level exchanges where it's you just have a higher quality exchange when you have subject matter experts talking to each other. I think it's an interesting question, right? How you can you have a high-level exchange and then just have like a level of detail or some sort of matrix that makes it so you absolutely cannot miss anything and maybe that's the Holy Grail for a tech transfer." (Participant 343-RU)*

It is important that the connectivity of the teams is fostered by the management and the organisation in general. All needed functions should be involved from the beginning on in the transfer.

Two organisational influences had been mentioned in both the SUs and RUs focus group discussion (equipment fit and proximity). 14 additional points came up during the SUs discussion and four during the RUs discussion. Again, as influences from this category had been mentioned in both focus group, it cannot be stated that the SU or RU value these aspects more compared to the other unit.

4.3.2.4 Influences for effective team work found during the focus group discussions compared to the semi-structured interviews

The last category of clustered influences is the team structure and characteristic indicated in white. A lot of influences for this category had already been found during the analysis of the semi-structured interviews. Next to the mentioned aspects, also individual aspects like experience, competency, pragmatism and professionality came up. The joint history of the team members can influence the TT as an established trustful relationship between the team members can be reactivated, which was also mentioned during the focus group discussions. A joint history can form a basis for the trustful relationship in the team in addition to other factors. Responsiveness and mutual understanding are two added influences in this regard from the focus group discussions. Experiences made together and learnings from the TT should be kept as aha-moments and tribal knowledge. For technical purposes it was essential to the team to have the required training available. This is also important to keep the knowledge in the company. To enable a viable exchange, a non-competitive environment has to be fostered. This can be done by joint goals, the celebration of milestones, as well as transparency and clear roles and responsibilities. Also, the reporting has to be transparent

and clear. When discussing about different reporting lines in general, stakeholder management and the management of interfaces between function was mentioned.

Six influences regarding the team had been identified during both the RUs und SUs focus group discussion. 15 additional influences came up during the SU focus group discussion and nine additional influences during the RU focus group discussion. Interestingly, this category holds most influences identified. This is due to the fact that the team identifies itself most with the category and has strong feelings about what helped to become successful. On the other hand, it is also interesting that most of the influences mentioned for the team are different when comparing the discussion from SU and RU. The RU discussed a lot of aspects related to the project management and project work like pragmatism, competency and complexity. One reason for this is the composition of the focus group. Two managers and one consultant took part in the discussion. The SU discussion, on the other hand, was a lot about the relationship (non-competitive environment, joint history, environment to ask questions and body language and emotions). Here the participants were mainly subject matter experts for the project. Like for the other categories this difference during the discussion is hence, rather due to the involved participants and their current focus then a manifested cultural difference.

Overall, aspects from all categories of influences had been mentioned during both the SUs discussion as well as the RUs discussion. From the pure number of influences mentioned, the SUs focus group came up with more influences. Still, it has to be kept in mind, that the group itself was larger, which might have led to longer discussions. In general, the mentioned influences match the results from the semi-structured interviews well and complement the categories with additional influences.

As also practices had been mentioned to disseminate knowledge during the TT, the next section describes this aspect in more detail.

4.4 Results for Answering RQ3: Which practices can be applied with a technology transfer in the BI to support the dissemination of knowledge?

In order to answer RQ3 in a first step, mentioned practices, methods and tools identified during the semi-structured interviews were analysed and used as codes. These codes were then structured into themes to be able to discuss them in a holistic way. However, to establish a roadmap or practice guide the single codes were needed. In addition, to the results from the

semi-structured interviews, also practices mentioned during the focus groups were captured. Both methods were used to complement each other and to build consensus on the practices and mechanisms used. The findings were in a subsequent step compared to practices known from the literature to establish a proposal list of practices, methods and tools to use during a technology transfer.

4.4.1 Findings of the thematic analysis for the practices, methods and tools of tacit knowledge dissemination during a technology transfer

As mentioned before, the first step to capture practices for an effective knowledge transfer had been the analysis of the semi-structured interviews. During the thematic analysis of these semi-structured interviews, practices, methods and tools used for knowledge dissemination during a technology transfer were coded and clustered into three themes and in total four subthemes.

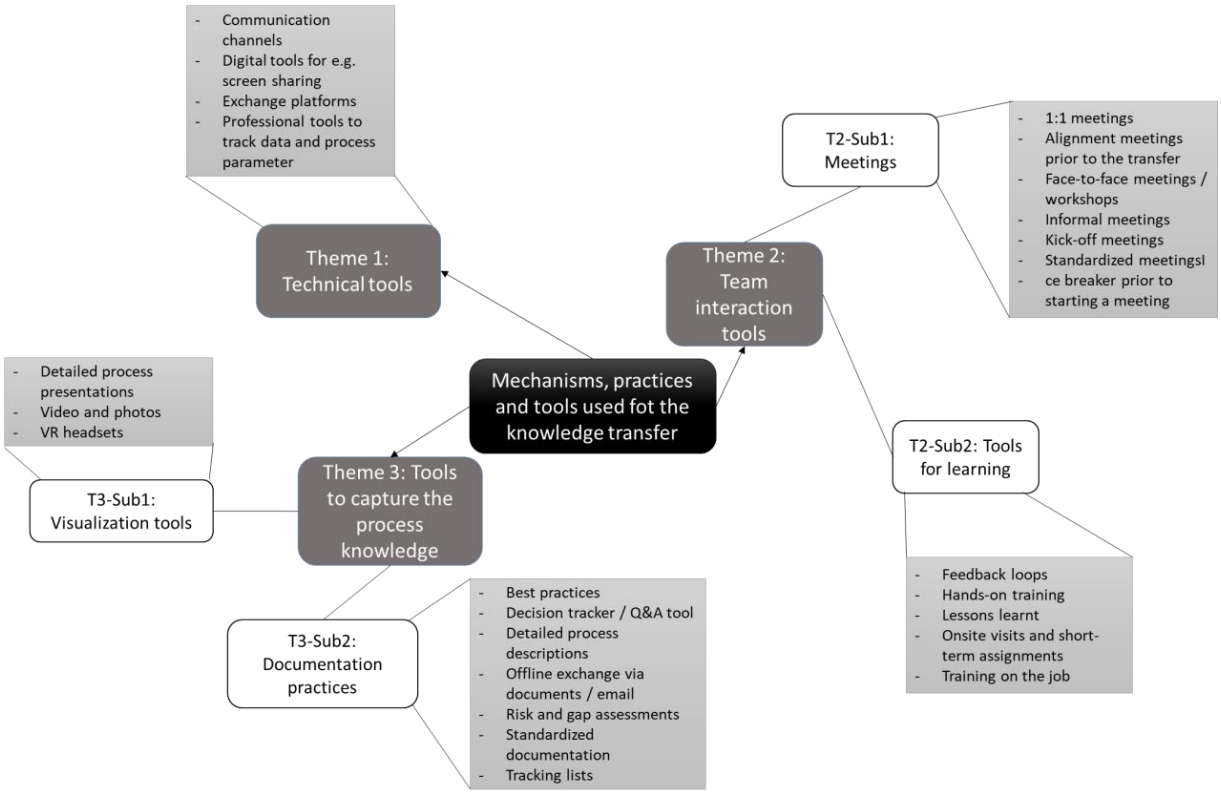

Figure 19: Themes to capture the practices mentioned during the semi-structured interviews.

It can be seen, that in total, three themes were used to cluster the subthemes and codes found during the analysis. A summary of the themes and subthemes is provided in Figure 20.

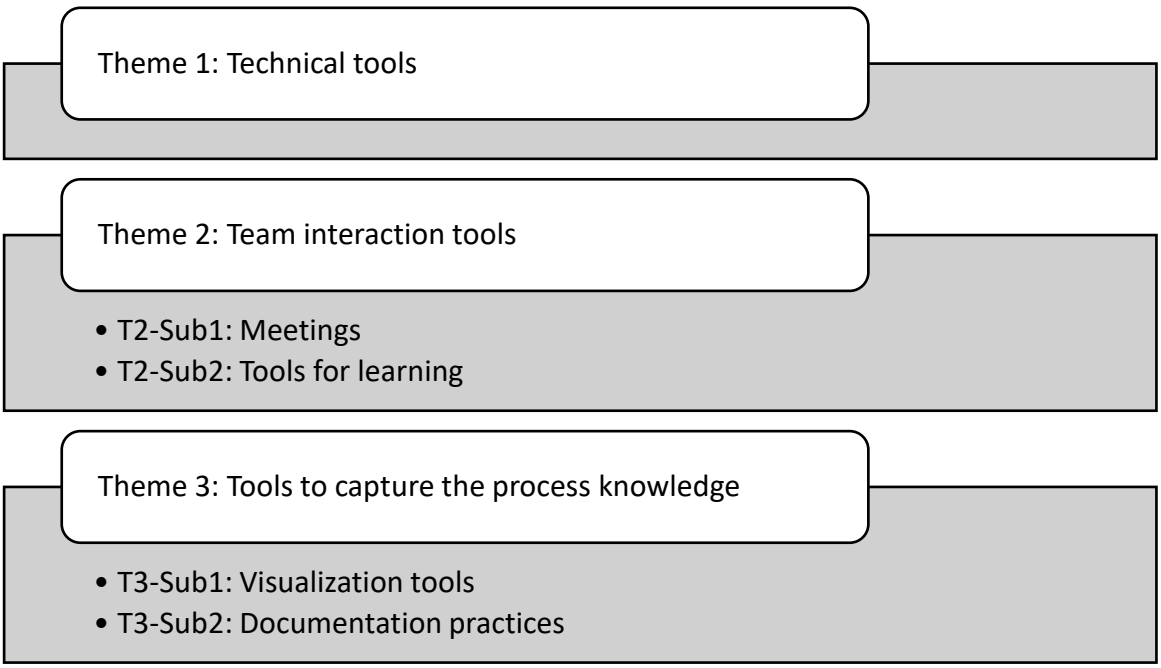

Figure 20: Themes and sub-themes for the practices, methods and tools for the knowledge dissemination used during a TT by thematic analysis of the semi-structured interviews.

In general, the topic technical tools, team interaction tools and tools to capture the process knowledge had been mentioned by the participants. A detailed description of the different themes in provided in the following subsections of this section.

4.4.1.1 Practices, methods and tools to disseminate knowledge theme 1: Technical tools

Theme 1: "Technical tools" consists of exchange possibilities for the team like communication channels and sharing tools, as well as data and parameter exchange tools. Technical tools are important during a TT to be able to store data and communicate when geographically distributed. In this case the transfer took part from Germany to the US and hence, used a lot of technical and digital tools to connect the teams. In addition, the respective transfer looked at in this study took part during the pandemic, which made the tools even more valuable.

Software solutions like Microsoft Teams or SharePoint were used to store data and to exchange documents in a user-friendly way. They had been used prior to the pandemic as well, but the teams got even more used and experienced to use Microsoft Teams for meetings and file transfers. This had also been confirmed during the semi-structured interviews:

> *"(…) What I haven't mentioned before, what we have also used, are of course file transfers, i.e. Teams. There were of course Teams structures, folders, where a lot of documents, i.e. auxiliary documents, were stored." (Participant 273-SU)*

> *„(…) Yes, the communication method is relatively simple: Teams, logically, and then we all sit in front of the computers with headphones.“ (Participant 295-SU)*

Only when everybody is able to use the software tools, communication and interaction works in the required way. Hence, sufficient time and training is required as mentioned by the participants:

> *„(…) So, if you're in the meeting now and sharing screens, then of course you have several options. You can also request the control for example and then you can log into the system. Our databases are just separate, that means I can't dive directly into the raw data without this being shared, but if someone allows access to his/her computer, then of course I can see for myself how I can do the […. data analysis] by requesting the control, i.e. not only sharing, but also really allowing someone access to their own data somehow.” (Participant 846-SU)*

In addition to Microsoft Teams, some team members have mentioned other tools from their previous experience that were not used in the respective transfer looked at in this study. These professional tools are e.g. QbD Vision or software solutions generated by IDBS. This kind of software can be used in a powerful way to transfer and harmonize data. Participants described it in the following way:

> *„(…) Other tools that I can think of, which would of course also be feasible, but which we have not used, are harmonized or professional tools to record and transfer process parameters, data, etc.” (Participant 273-SU)*

Next to the pure technical tools, it is also important, that the team has possibilities to interact in a sufficient way. This does not necessarily mean a pure digital collaboration, but also includes face-to-face interactions. These practices are described in the next subsection.

4.4.1.2 Practices, methods and tools to disseminate knowledge theme 2: Team interaction tools

The second theme “Team interaction tools” covers the meeting landscape, but also includes practices to foster learning and the social interaction.

4.4.1.2.1 Practices, methods and tools to disseminate knowledge theme 2-1: Meetings

Meetings are an essential part, when it comes to team building and exchange. In general, a project starts with a kick-off meeting. It has the purpose to bring together all people involved in the project to foster team building and exchange. This should be maintained during the whole project phase. Hence, also ice-breakers were performed prior to starting a meeting.

These ice-breakers, as well as the kick-off meetings, in addition, helped to exchange some personal information, which can also be seen in the participants quotes:

> *"(…) I also found it quite nice that before we went to the technical topics, we were then asked about such personal sensitivities in the meeting. What you like to eat most, how often you would cook, whether you would have already ridden a bike today or what kind of car do you actually have? And everyone had to make a little bit of their contribution. This has also changed the mood immensely. It became more personal, more open and you had more fun at work." (Participant 523-SU)*

Interestingly, personal interaction had been mentioned as one important point to work together in a team. It is not only the professional exchange that increases a project's success. Therefore, also informal meetings came up as situations when knowledge could be exchanged. These informal meetings were also possible in remote settings:

> *"(…) Then I chatted on the phone for 1.5 hours in the evening with [a] German colleague who works in America, without us having now scheduled an official meeting with MSAT and all kinds of people. I just told her on the phone what we had learned and what she should pay attention to, and she then wrote some of the knowledge into the PSPD that was important to her." (Participant 730-SU)*

1:1 meetings can be used for a similar purpose. In addition, feedback can be provided in these meetings and professional subject matter expert-specific knowledge can be exchanged.

> *"(…) And, what I also used as a tool, I tried to give the groups such valuable feedback, not always in the big group, but that I had the opportunity for one-on-one conversations, which happened quite a few times or which you can also lead a bit, to the one-on-one conversation, that you really praise it again personally." (Participant 523-SU)*

Next to the personal contact of the team members having a defined structure for the meetings is crucial for the success of the project. Hence, standardized meetings and meetings to align on specific topics needed to be established. Alignment should also take part prior to the transfer to start with the same expectations. This had been stressed by the participants during the semi-structured interviews.

> *"(…) Alignment, I think would just be the most important things." (Participant 544-RU)*

> *"(…) There is a lot of prior knowledge and also separate technology projects which led to a harmonized platform within the receiving and sending unit, so that we could all assume the same starting conditions." (Participant 273-SU)*

As the transfer took part during the pandemic and across an ocean, nearly all of the meetings were conducted virtually. The transfer had been conducted according to the timelines and so there could be the assumption that no in-person contact is needed for a TT. Still, the participants of this study stressed the importance of face-to-face meetings as well as site visits and short-term assignments.

> *"(…) I was in Berkeley for a week and then I was also part of the Berkeley team, which was also very nice and there was also a lot of informal exchange. Also, with the colleagues from downstream: I then sat at my workplace and that was an open area and it really happened regularly that someone tapped me on the shoulder. "Can I ask you something?" People some of whom I didn't even know yet and then wanted to know things about the process, including downstream colleagues, who then wanted to know what about the titer etc impurities that we expect. And I think that was very, very helpful and of course that also creates trust…" (Participant 730-SU)*

During the interaction of the team members learnings were created during and after the meetings.

4.4.1.2.2 Practices, methods and tools to disseminate knowledge theme 2-2: Tools for learning

Therefore, the participants found it very important to share lessons learnt and feedback as also mentioned before. Also, when performing the hands-on work learnings were generated. During the semi-structured interviews, it was described in the following way:

> *"(…) So there was a lot of trial and error and a lot of things were decided that we would not repeat again. This was definitely the learning project for us. And so we definitely learned from it. I will say we're definitely doing lessons learned and we're applying those lessons to the next project." (Participant 330-RU)*

This practical knowledge had been of special importance for the participants. Hands-on practice hence, had been mentioned. Hands-on practice includes a practical component to gain experience of performing the required tasks and using the right equipment and devices.

Overall, it can be stated that a vital exchange and capturing of learnings helps a technology transfer to become successful. This can be done during formal meetings, but also during informal ones. Both forms of meetings are valued by the participants. Retaining the tacit

knowledge, however, is not an easy task. Hence, the next section discusses practices to capture the process knowledge.

4.4.1.3 Practices, methods and tools to disseminate knowledge theme 3: Tools to capture the process knowledge

The third theme mentioned during the interviews was capturing the process knowledge by visualisation and documentation.

4.4.1.3.1 Practices, methods and tools to disseminate knowledge theme 3-1: Visualization tools

One of the most often mentioned alternative method to show details was videos and photos. The technology transfer team members found it very helpful to provide them in addition to the normal process description in text format and during the execution of the process:

> *"(…) For example, we simply made videos of some steps so that the teams on site can easily imagine it, so that you can simply see it. A picture says more than 1000 words and a video even more." (Participant 273-SU)*

> *"(…) What did work a lot of the times was taking a lot of pictures, so when we ran our engineering run, we took a lot of pictures of our setup and tried to share them. When we're presenting the data. Just so that everybody could be on the same page." (Participant 579-RU)*

Another method for visual dissemination of knowledge that was mentioned are presentations. These presentations were given during the standardized meeting series and all team members were able to ask questions directly. Presentations via Microsoft PowerPoint for examples are standard procedures when presenting data.

> *"(…) With some have been in presentation, some have just simply been speaking in the meetings and giving detailed accounts of the process." (Participant 72-RU)*

As mentioned, presentations and videos plus photos were the used visual methods during this transfer. The participants, however, mentioned VR Headsets as an additional visual tool, that could be used during one of the next transfers. These tools, that are known well by the gaming and IT industry, could be used to live demonstrate a certain process step or an installation of an equipment.

> *"(…) If I could load up that model and put it into my headset and just look around, move around in a virtual space, see it at scale. You could get an idea of, especially during construction, where things are too far apart or*

> *maybe I need to move some stuff around, maybe a water drum needs to be in a different location because this doesn't make sense, but I think there are a lot of cool tools that we can or hopefully we start leveraging in the future to collaborate more." (Participant 297-RU)*

In addition to the visual presentation of the tacit knowledge, documents have to be prepared by the teams to provide the full insight of the process.

4.4.1.3.2 Practices, methods and tools to disseminate knowledge theme 3-2: Documentation practices

Best practices were used to complement the provided detailed process descriptions. They also set the basic knowledge to understand the presentations provided by the team. Hence, best practices are a valued tool.

> *"(…) in addition to the really evaluated risk assessment documents, which, for example, simply map certain process steps, i.e. what do you put in where and in what order, for example, a kind of best practice documents." (Participant 273-SU)*

Documents that were also used to provide more insight into the process were risk and gap assessments. These are standardized documents described in a standardized operating procedure (SOP) that are classically used during a TT to help to compare process steps and assess whether there are gaps between the process performed at the sending unit and the receiving unit.

> *"(…) Well, we simply did it in the classic way with Excel, with our gap analyses and our risk assessment templates as they are also provided for in our SOP." (Participant 273-SU)*

> *"(…) You've got also things like just lessons learned and dynamic risk assessments and these sorts of documents, which are probably the tool part in my opinion." (Participant 161-Ext)*

As sometimes the direct communication via phone or Microsoft Teams had not been possible due to the different time zones, the teams also used tools for the offline exchange.

> *"(…) Something we did more than we do in Germany during the transfer to Berkeley was working offline, i.e. that we edit documents simply because of the time differences, that we no longer sit down together and go over and discuss every single point of documents together, but I get mails in the morning with comments in the documents, where I was linked and then reply to these comments in the morning. And then, so to speak, we exchange knowledge offline - not (…) in meetings." (Participant 730-SU)*

One other thing that came up during the interviews was, that it is important to track actions of participants like e.g., tasks or documents that had to be provided. In addition, of course during meetings a lot of decisions had been taken that should also be available for team members that could not take part in the meetings. Hence, decision tracker documents as well as task tracking lists had been established.

> *"(…) So generally, first we build up a tracking list to track all these documents and we need the sending unit to provide and also we like to track like any change because sometimes they also revise the either the SOP and so that means like communication of change." (Participant 517-RU)*

In summary, it is very important to have visual and non-visual documentation tools in place to describe the process.

Overall, using technical tools, team interaction tools and methods to capture the process knowledge is essential to disseminate the knowledge needed to understand the process and its development. 25 practices and methods had been identified during the analysis of the semi-structured interviews that are compared to the findings from the focus groups in the subsequent section.

4.4.2 Findings of the focus groups for the practices, methods and tools used for knowledge dissemination

During the focus group discussions, a lot of practices, tools and techniques were mentioned. The discussion was focussed on the tacit knowledge dissemination and hence, methods, tools and practices for the sharing of tacit knowledge could be revealed. An overview of the results can be found in Table 16. This table, in addition, holds the results from the semi-structured interviews as well as the literature review. Practices marked in green have been found during both the focus group discussions and the semi-structured interviews. Practices indicated in yellow, have been discussed in more detail during the focus group discussions compared to the semi-structured interviews and practices coloured in blue have only been found during the focus group discussions. The comparison of the findings from this study to the literature review are discussed in the next section.

Table 16: Summary of the found knowledge transfer methods and practices derived from the focus group discussions.

Knowledge transfer mechanisms, techniques and practices	**Identified during the focus group discussions**	**Identified during the semi-structured interviews**	**Identified during the literature review**
Alignment on one technology platform	x	x	
Best practices	x	x	x
Celebrate milestones	x		
Collaboration and social networks	x		x
Collection of expectations	x		x
Communication channels	x	x	x
Communities of Practice (CoP) / Global project review meetings (communities of practice) with additional social event	x		x
Decision trackers	x	x	x
Digital tools • Screen sharing • Exchange platforms • Professional IT tools		x	
Face-to-face contact / joint workshops	x	x	
Feedback	x	x	
Follow-the-sun-approach / offline working		x	x
Goal setting	x		
Hands-on practice		x	x
Informal communication routes • Short messages via Teams • Coffee chats	x	x	
Ice breaker exercise		x	
Job Shadowing / Apprenticeships		x	x
Knowledge fairs			x
Lessons learnt and root cause analysis / after action review	x	x	x
Meetings • Structured (1:1 Meetings, Kick-off Meetings) • Informal and spontaneous • Steering committee	x	x	x
Mentoring / Coaching			x
Process visualization • Videos and photos • Presentations • VR headsets		x	
Retention of critical knowledge			x

Short-term assignments and visits / Long-term visits	x	x	x
Subject matter expert level exchange	x		
Social events / Pizza parties	x		
SOPs (standard operating procedures)	x	x	
Storytelling			x
Subject matter expert listings			x
Team charter	x		
Trial and error			x
Use of technology transfer tools	x	x	
Virtual exchange platforms	x	x	

In Table 16 it can be seen, that ten practices found during the focus group discussions are similar to the ones mentioned during the semi-structured interviews. These practices are marked in green. Some examples are the use of decision trackers, short term assignments, lessons learnt, feedback and the face-to-face contact. Having these practices stated in both data collection methods used in this study shows the relevance of these tools. Five practices have only been mentioned in the semi-structured interviews and not in the focus group discussions. Practices and tools that had been described in the previous section already, are not mentioned here again.

Some other practices like meetings, communication channels and standardized documentation had been discussed in more detail during the focus group discussions. These practices have been marked in yellow in the table above. Participants during the focus group discussions divided the meetings into structured, informal and formal meetings and whether these meetings take place face-to-face or in a remote setting. All these types of meetings are required for a full knowledge dissemination on different levels. Informal exchange most often happens on peer level, whereas management interaction most often takes place in scheduled meeting formats. Formal meetings are e.g. steering committee meetings with the higher management. The opposite is informal meetings that are unscheduled. One example for this type of meetings are coffee chats, which were also specifically mentioned during the focus group discussion as communication routes.

> *"(…) I mean these online meetings are great, but usually they are very focused and (…) you very almost always stick to your agenda, whereas if you have these face-to-face meetings, let's say you just go for coffee or so and you talk about something completely different. I mean sometimes that is the most important thing. You take back from that meeting, because maybe you come up with*

> *something that is not 100% related to the project, but it turns out: that is a great idea. And that is very difficult to capture in online meetings." (Participant 739-RUC)*

Another topic that had been discussed in more detail is documentation. Next to the already mentioned best practice documents also standard operating procedures had been mentioned as very important. These documents also offer the possibility to define the taxonomy used for the transfer. As mentioned before, it is crucial to speak the same language in a project also with regards to technical terms.

Practices and tools not mentioned in the semi-structured interviews that came up during the focus group discussions are marked in blue. The first two tools are related to the start-up phase of the project which are goal setting and team charter. These tools are important to define responsibilities and expectations. During the focus group discussions, the participants added that setting counterparts at both sites is also crucial for the team charter. All roles and responsibilities need to be staffed at the beginning of the TT, so that everybody knows who to talk to. The collection of expectations goes into the same direction, as the definition in the team charters. This collection should yet be done during each project stage. The project goals should be covered in the individual goal setting, but should be worded from the beginning on as a group effort to generate a joint ownership of the project. This can help to avoid conflicts and competition in the future. To enhance the team spirit and moral the celebration of milestones had been mentioned. In the fast-working environment it is sometimes hard to take a pause to reflect on milestones and celebrate the achievement. It is important though to do so as it increases moral and also fosters learning. To celebrate, social events and pizza parties can be used, but also smaller events like a meeting with cookies and a thank you from management are possible.

> *"(…) And so it became standard work that those responsible, (…), on the development side and on the MSAT side, and on the receiving site or the operations team if you will (…) we'd have a pizza party right at the start. It wasn't more complicated than that. It was get to know these people and it helped a ton." (Participant 362-RU)*

Getting in contact with people and collaborating is crucial within a project but also beyond. Hence, social networks should be established to foster exchange. This networking can be intra- or inter-company wide. The same goes for Communities of Practice (CoP) and global project review meetings. These meetings take place internally. Information is shared between

subject matter expert. It is important to know the right operators to exchange detailed information on the right level to generate a high-quality exchange. This exchange can be even more fostered by job shadowing of experts or apprenticeships in new areas to get an understanding of other functions needs. The more the team members interact and communicate, the better the learnings for the group are.

In summary, a variety of practices and methods have been identified that can support different purposes during a TT. This includes the start-up phase, but also learning, collaborating and networking. All of this is needed to achieve a successful transfer. As some additional mechanisms for the knowledge dissemination had been identified during a literature review, these practices are discussed in chapter 5.

Chapter 5 also holds the discussions for the findings in order to answer RQ1 and RQ2. These discussions can be found in the following sections.

5 DISCUSSION

5.1 DISCUSSION OF THE RESULTS FOR ANSWERING RQ1: WHICH TYPES OF TACIT KNOWLEDGE ARE USED DURING A TECHNOLOGY TRANSFER BETWEEN A GERMAN DEVELOPMENT DEPARTMENT AND AN US MANUFACTURING DEPARTMENT IN THE BI?

5.1.1 Discussion of the findings from the content and thematic analysis

In order to answer RQ1, 63 types of tacit knowledge could be identified as shown in section 4.2. These types of tacit knowledge were clustered into ETKs to support team building and ETKs to support effective project work. As in this research the definition for knowledge by Davenport and Prusak (1998), is used, the found types of knowledge are assessed whether they are in line with this definition. Davenport and Prusak (1998) state that knowledge is "a fluid mix of framed experience, values, contextual information, and expert insight that provide a framework for evaluating and incorporating new experiences and information. Knowledge originates and prospers in the minds of experts. In organisations, it often becomes embedded not only in documents of repositories but also in organisational routine, process, practices, and norms" (Davenport and Prusak, 1998; p.5).

Team building as mentioned is the first cluster of ETKs and is one of the most important aspects within a transfer, next to other aspects like the quality of the process itself, the chosen transfer mechanism, organisational structures and supporting and project management tools (Large, Belinko and Kalligatsi, 2000). This had also been reflected in the participants views during the semi-structured interviews. The following example had been mentioned in different facets by different participants and indicates the overall view of the participants with regards to teamwork:

> *"(…) I would say the biggest aspect of what has made us successful to date in getting the sending unit information properly to the right people within the receiving unit, has been definitely the working relationship between the two teams (…)" (Participant 343-RU)*

Team building considers the relationship between the sending unit and the receiving unit. This is crucial as it increases the chance of a successful transfer and a good flow of information (McBeath and Ball, 2012). This also includes open communication, that allows different views from all experts involved. ETKs mentioned with regard to communication and the team's relationship are "culture", "opinion", "attitude", "perspectives" and "communication skills".

When applying this open communication within the team, collaboration can take place. For a productive collaboration, a safe, supporting and engaging environment is crucial (Bstieler and Hemmert, 2010). Hence, all team members need to be included into the discussions and expertise has to be valued. When looking at the literature about important aspects of relationship building, emotional and social intelligence in combination with intellectual abilities are mentioned (Roffey, 2016). Types of tacit knowledge mentioned in this study are for example “empathy”, “people knowledge” as well as “emotional knowing”. “Shared history, norms and values” also help to create trust more easily during face-to-face interaction but also when communicating mainly virtually. Interestingly, some authors consider virtual teams as barriers for relationship building or at least to face more difficulty in building trust (Jawadi et al., 2013; Morrison-Smith and Ruiz, 2020). The barrier had not been confirmed during the semi-structured interviews. Participants agree that it is more challenging to work in such an environment, but also mentioned tools and mechanisms to overcome the issue of only meeting virtually. These tools and practices are summarized at the end of this chapter. Most of the mentioned types of tacit knowledge so far are embedded in the minds of the team members and connected to their values and culture. Hence, on a first glance it is hard to consider them as “real” knowledge. Still, when looking at the definition of knowledge provided by Davenport and Prusak (1998), they mention that knowledge is composed of values and contextual information amongst others. “Culture”, “people knowledge” and “shared history” etc. can assigned to these aspects of knowledge. Other mentioned types like “opinions”, “perspectives” and “attitudes” are derived from experience and experts’ insights and hence, can also be considered to be included in the definition of knowledge.

Next to team building, learning within the team is important to be effective. In general, lessons learnt, self-reflection and feedback are known characteristics to achieve exactly this effective team work (Mickan and Rodger, 2000; Tarricone and Luca, 2002; Ghazzawi and Bizri, 2014). These types of tacit knowledge have also been mentioned by the participants of this study. Team learning is involving processes like “problem posing, sharing knowledge and ideas, integrating new knowledge, gathering data and disseminating new information” (Lynn, Akgün and Keskin, 2003, p.202). Both learning and time efficiency is crucial to keep timelines and reduce the risk of changing market needs (Bstieler and Hemmert, 2010).

With regard to effective team work, the participants were mentioning “experience” in the context of hands-on knowledge, device and process experience. This is in line with the literature as also McBeath and Ball (2012) state, that the likelihood of a good tacit knowledge transfer is increased by experienced employees. Other authors also agree that the tacit knowledge use is experience related (Polanyi, 1966; Smith, 2001). Types of tacit knowledge found in the same direction are “thinking in practice”, “capability”, “skills” and “ability”. The literature agrees that the cluster, including especially the “skills”, is important to describe tacit knowledge in general (Polanyi, 1966; Ambrosini and Bowman, 2001). In the specific case of the technology transfer in the Biopharmaceutical Industry, these attributes are all needed to robustly manufacture an asset. Another important aspect for the participants is to understand the surrounding of the project related topics. Hence, types of tacit knowledge like “organizational mind”, “organizational knowledge and business practices”, “requirements” and “expectations” came up. When comparing these praxis related ETKs to the definition of knowledge by Davenport and Prusak (1998), all of these can be assigned to organisational routines, processes, practices, and norms as well as framed in experience and expert insight. This means they all also fall under this definition.

Overall, it can be stated, that only expected ETKs came up during the analysis that can be connected to the main challenges of the technology transfer, which includes the robust transfer of a scalable manufacturing process and the effective knowledge exchange (Ahamed, Ternbach and Ives, 2011). In the next section, the found ETKs during this study are compared to the existing framework of Haldin-Herrgard (2003).

5.1.2 Comparing the identified codes found during the thematic analysis to the Haldin-Herrgard (2003) framework

In addition to comparing the results from the content and thematic analysis, in this part of the discussion, the results from both, the content and thematic analysis, are compared to the already known ETKs identified by Haldin-Herrgard (2003). Conformity and differences to the types of tacit knowledge known from the literature are hence, shown in the data set. The comparision was also done to see if only synonyms used in the BI were identified during the study or if new and relevant ETKs can be added to the framework. Found ETKs during the analysis of the data set from this thesis had been marked in green and relevant synonyms for

the BI had been added to the ETKs in a separate column. In addition, new epitomes had been listed at the end of the table. The outcome of this process has been listed in Table 17.

Table 17: Comparison of the ETKs identified by Haldin-Herrgard (2003) (in alphabetical order) to relevant synonyms and new epitomes discovered during this study.

	ETK (Haldin-Herrgard (2003)	Relevant synonym for the BI	New epitome identified
1	Ability		
62	After-the-Fact Awareness	Lessons learnt	
63	Artistic vision		
47	Attitude		
27	Automatic Knowledge		
48	Beliefs		
59	Best Practice		
7	Bodily Skills		
5	Capability		
64	Care-Why	Global understanding (of processes)	
31	Cognitive Schemes		
8	Cognitive Skills		
4	Collective Ability		
36	Collective Know-How	Tribal knowledge	
49	Common Beliefs		
57	Common in Experience	Joint experience	
65	Common Sense		
9	Communication Skills		
10	Coordination Skills		
6	Crafts	Hands-on	
66	Creativity		
67	Culture		
68	Embedded Knowledge	Platform and process knowledge	
3	Embodied Knowledge		
70	Emotional Knowing	Empathy	
54	Estimation		
35	Expertise		
43	Feeling		
41	Feels as …		
21	Flashes of Insight		
23	Flashes of Inspiration		
71	Genres		
69	Get a Feeling for		
72	Group's Sense	Team spirit	
44	Gut-Feeling		
25	Hunch	(Advices)	
73	Improvisation	(Adaptation to change)	
11	Inductive Skills		
74	Inexpectable Mental Process		
75	Inner Competence		

20	Insight		
76	Instinctive Reactions		
18	Intuition		
19	Intuitive Knowledge		
53	Judgement	Assessment	
40	Know in Ones Body		
34	Know-How		
60	Knowledge Base		
38	Life Examples		
42	Looks as …		
12	Managerial Skills	Project management skills	
61	Master Sureness of Action		
28	Mental Models		
13	Negotiation Skills		
22	Non-Analytical Behaviour		
45	Norms		
39	Oneness of Body and Mind		
14	Operational Skills	Hands-on	
50	Opinion		
29	Organisational Memories	Shared History	
32	Organisational Mind	Organisational knowledge and business practices / Global understanding of processes	
58	Pattern of Experience	Process and platform knowledge	
91	People Knowledge		
15	People Skills	Empathy	
55	Perception		
77	Personal Competence		
56	Personal Experience		
51	Perspectives		
16	Physical Skills	Hands-on	
37	Practical Intelligence	Hands-on	
52	Predictions		
78	Routines		
79	Routinized Knowledge	Platform knowledge	
80	Rule-of-Thumb		
81	Sense Making		
26	Shared Believes		
92	Shared Code	Taxonomy	
30	Shared Meaning		
46	Shared Norms		
82	Shared Values		
2	Skills		
17	Social Skills	Empathy	
90	Sounds of…		
83	Talent		
84	Taste		

85	Techniques		
33	Thinking In Practice	Hands-on	
87	Thoughts		
86	Tricks	Advices	
24	Unconscious Norms		
88	Understanding		
89	Values	Mindset	
93			Assumption
94			Attention to detail
95			Expectations
96			Interpretation
97			Observation
98			Requirements
99			Self-reflection

Table 17 shows that the majority of the ETKs by Haldin-Herrgard (2003) were also covered by the participants of the interviews and were deemed relevant for the technology transfer. 63 of 92 matches could be found between the ETKs identified during this study and the ETKs by Haldin-Herrgard (2003). Some of the ETKs published by Haldin-Herrgard are not mentioned like “oneness of body and mind”, “genre”, “bodily skills” and “artistic vision”, which might be routed in the nomothetic background of all participants involved. During scientific driven TTs, these aspects are normally not relevant and hence, not needed like other types of knowledge. This might lead to the fact that they were not mentioned as important factors. Interestingly ETKs like “common sense”, “predictions”, “life examples” and “talent” did not come up during the analysis. Still, for the researcher, these are important factors for the BI. They have probably not been mentioned as they are not directly related to the TT in which knowledge for example is specific to the project and to processes used in the BI. Hence “common sense” is not the first association that comes up with this kind of knowledge. All the subject matter experts that were included in the study are talented people. “Talent” as a wording also appears in a lot of job descriptions. This leads to the hypothesis, that it is taken as a prerequisite and therefore, had not been mentioned in addition.

For some of the ETKs established by Haldin-Herrgard (2003) easier synonyms for the BI could be identified. One example is “after-the-fact awareness” which had been referred to as “lessons learnt” more often by the participants. Lessons learnt is a set vocabulary in the BI. A second prominent example is “taxonomy” that is more common in the BI compared to “shared

code". Adding the synonyms found to the existing framework helped to contextualize the ETKs even more.

When looking at the newly identified ETKs a lot of them go in a very intangible, subjective direction, e.g. "assumptions", "expectations" and "requirements". Still, these are important when thinking about social interaction within a team as well as stakeholder management in the context of the Biopharmaceutical Industry during an international transfer. These add up to 7 newly identified ETKs during the analysis. These ETKs can be used after verification in a potential follow up study in a general manner as they are assumed to possibly apply to other industries as well.

Overall, it can be seen, that there was a high coverage of the ETKs from the Haldin-Herrgard (2003) framework and the types of tacit knowledge mentioned by the participants. As expected, not all the ETKs are covered due to the nomothetic nature of the scientific transfer. Interestingly, the participants value tacit types of knowledge a lot when talking about their experience from the performed technology transfer. The next section summarizes the findings of the whole section.

5.1.3 Summary and Categorisation of the types of tacit knowledge used during a technology transfer in the BI

Answering RQ1 consisted of three steps as discussed in the previous sections. During the content analysis, which was based on the Haldin-Herrgard (2003) framework, 27 types of tacit knowledge mentioned in the semi-structured interviews could be identified. These 27 ETKs were also found during the thematic analysis of the same data set. As the goal of this analysis was also to identify specific ETKs, the in-depth analysis resulted in total in 63 ETKs found from the established framework and additional 7 types of tacit knowledge that can be used to supplement the list of ETKs for the future. This means a substantial conformity of the data could be shown in between the content and thematic analysis, but also when comparing the data to the Haldin-Herrgard (2003) framework.

In general, section 4.2 showed that there was a large amount of data generated with regard to answering RQ1 and therefore, to find out which types of tacit knowledge are used during a TT. This is interesting as a lot of scientists want to make tacit knowledge explicit for the

technology transfer. This might go together with the mantra from GMP again “if it isn’t written down, it didn’t happen” (Lipa, Kane and Greene, 2020, p.4).

> *When I first heard or saw the distinction between the explicit knowledge and the tacit knowledge, I recoiled. You know, when I saw tacit knowledge. (…), it's like a hidden gemstone that needs to be uncovered. I think in tech transfer the aspiration is that there should be no tacit knowledge. It should be a dirty word and we need to take all tacit knowledge and make it explicit. It's aspirational. We might never get there, but you need to have the goal of eradicating tacit knowledge so that it's all formalized and figure out how to get it into these source documents. (Participant 343-RU)*

Hence, getting more clarity and transparency about the types of tacit knowledge used during a TT might help to create more understanding about this type of knowledge and foster confidence to use it.

To summarize the findings, the different types of tacit knowledge had been categorized and listed in Table 18. To do so, the found types of tacit knowledge had been split up into mental, sensuous, social, practical and holistic ETKs. This exercise had also been done before by Haldin-Herrgard (2004). The idea behind this is to systemize the interaction between the researcher and the informant by creating a better understanding (Haldin-Herrgard, 2004). In addition to this, the ETKs had been further categorized into individual knowledge, team knowledge and job and company specific knowledge.

Table 18: Summary of the found types of tacit knowledge.

	Individual knowledge	**Team knowledge**	**Job and company specific knowledge**
Mental	Ability Attitude Perspective Rule-of-thumb Self-reflection Skills Prediction	Capabilities Opinions Knowledge base	Coordination skills Skills Estimations Organisational knowledge Global understanding of processes
Sensuous	Creativity Mindset Values Feelings Feels as Non-analytical behaviour Taste Emotional knowing incl. empathy	Mindset Values	Tips and tricks Expectations
Social	Communication skills People knowledge Social skills People skills	Common beliefs / Belief Culture Shared norms Shared values Tribal knowledge Joint history	People knowledge
Practical	Advices Assumptions Understanding Interpretation Negotiations Personal experience Personal competency	Common experience Lessons learnt and failure (After-the-fact awareness) Techniques Collective ability	Best practice Competence Expertise Life Examples / Stories Routine Taxonomy Thinking in practice / Hands-on Process and platform knowledge
Holistic	Attention to detail Embodied knowledge Know-how Sense making Observations Thoughts		Know-how Requirements

The shown distinction of the ETKs in into individual, team and job and company specific knowledge is important to the researcher, because when trying to broaden the understanding as well as the application of tacit knowledge in the working environment, people need to know

what kind of tacit knowledge they have to bring into the team by themselves. Examples for this are empathy, sense making, values and skills in general. These aspects are also often embedded in the company cultures. Again, this is especially important as TTs are often include remote and international elements, which makes it crucial to create a good and trustful team spirit. When the subject matter experts come together in their technology transfer teams, they have to provide their opinion but also strive for a common mindset and values with regard to executing the project. Their job specific knowledge like know-how and hands-on experience can help while executing the transfer. Knowing, in general, that there are these types of tacit knowledge available in a company for a TT helps to start the conversations about former technology transfers about in-depth process knowledge and might also trigger different thinking with regards to how valuable these types of knowledge are.

Hence, answering RQ1 helped to set a basis to create awareness of the types of tacit knowledge needed for a TT and to provide a comprehensive list of the respective types. In addition, it is also important to know how to influence the dissemination of these types of knowledge in a positive way. This is discussed in the next section.

5.2 Discussion of the Results for answering RQ2: What influences the knowledge transfer between the German development department and the US manufacturing department in the BI?

5.2.1 Discussion of the results from the semi-structured interviews and focus group discussions

Technology transfers are influenced by a variety of internal and external factors that foster the success or failure of the process. A lot of the literature focusses on the barriers and extrinsic factors like government, environment and finance when looking at influencing factors of the technology transfers (Kundu, Bhar and Pandurangan, 2015). Still, to be able to actively enable the technology transfer, it makes sense to look at the intrinsic enablers of knowledge dissemination, as these can be influenced by the team, the management or the company as assessed for by this study. Extrinsic enablers that can be controlled should be watched as well. Overall, 81 influences could be identified during this study. 71 influences were discovered during the focus groups discussions and 54 influences could be found during the semi-structured interviews. Only 9 influences did not come up during the focus group discussions that had been discovered during the semi-structured interviews. This means, most

influences from the semi-structured interviews could be confirmed during the focus group discussions even though the discussion was focussed on the tacit knowledge dissemination. Hence, the majority of the found influences during the semi-structured interviews are also valid for the tacit knowledge dissemination.

During this study, influencing factors in the areas of culture, team structure and characteristics, organization and motivation have been found. Culture covers a large variety of topics like how to communicate, how to decide about what is right or wrong, as well as having the knowledge and skills to know what is needed in certain situations (Miroshnik, 2002). Hence, it is a very general and diffuse topic, as it is a belief system embedded in a society (Chen, Sun and McQueen, 2010). For the researcher, it is one topic that directly comes into mind when thinking about disseminating tacit knowledge. But of course, the question is which facets of culture are of importance for the TT in the BI. Country specific culture plays a role in a lot of TTs as multinational teams are involved. Hence, the different cultures might need different project management skills and should be watched closely (Miroshnik, 2002). For the technology transfer especially, the culture embedded in the company and the team is of relevance. This is due to the fact that the company culture forms the basis of how people work together in teams. Knowledge should not be seen as something that should be kept, so that one person gains power through this knowledge, but it should rather be shared so that the whole team can grow. Already in the 16th century, Francis Bacon knew that “for knowledge itself is power”. In some people’s mind that could lead to the assumption to not sharing all their knowledge makes sense to stay irreplaceable. Therefore, it is necessary to generate an atmosphere of trust and unity within a team to enable the relevant knowledge transfer. Van Krogh, Ichijo and Nonaka explained that “knowledge enabling includes facilitating relationships and conversations as well as sharing local knowledge across and organisation or beyond geographic and cultural borders” (Von Krogh, Ichijo and Nonaka 2000, p.4). Therefore, trust in the team and the company needs to become a basic pillar in the team and company culture. In addition, it needs to be considered, that not everything is going to work at the first attempt and that not all the knowledge disseminated might be understood correctly. Hence, failure culture needs to be established in the teams and in the management. That means, even with time pressure, management should be tolerant of failure (Kundu, Bhar and Pandurangan, 2015). Management should be a role model in this case, so that also team members allow themselves to fail as mentioned by the interview’s participants. This also

creates learnings, which not only take place when failing, but also when getting feedback from others. Companies know that and a lot of them have implemented a feedback culture already. Feedback is defined as “a dynamic communication process occurring between two individuals that convey information regarding the receiver’s performance in the accomplishment of work-related tasks” (Baker et al., 2013, p.260). In general, culture plays a very crucial role when disseminating knowledge as it is people focussed. This is important as the people themselves foster the innovation and growth of an organisation (Baker et al., 2013). This also means the different facets of culture form the basis to enable the knowledge transfer.

Next to culture, effective team work is essential for a successful technology transfer. Already after the second world war, group derived value systems, the interpersonal behaviour, as well as the relationship of team members, which are two very important aspects of team work, were described as collectivism by the Japanese (Kundu, Bhar and Pandurangan, 2015). Japan still values collectivism and is very successful with regards to technology leadership (Kundu, Bhar and Pandurangan, 2015), which means the concept is also important for the technology transfer and hence, should be applied to enable effective team work. Collaboration and a good team spirit are important factors for effective team work and can only be established and maintained when having a trustful relationship between the team members. Trust again is vital for effective team work (Costa, Fulmer and Anderson, 2018). This goes into the same direction as the collectivism approach developed by the Japanese to look at interpersonal relationships and group-derived value systems. Trust can be differentiated into team trust and interpersonal trust (Costa, Fulmer and Anderson, 2018). Interpersonal trust has also been labelled as rapport and familiarity during the semi-structured interviews. These findings hence, could be confirmed by the literature. Costa, Fulmer and Anderson (2018) stated in addition, that the team level influences like composition, leadership and team spirit are important areas that should be watched when building trust within team. These aspects had also been mentioned during the semi-structured interviews as well. The same goes for individual level factors. Team interaction is crucial for building trust. In virtual environments it is, however, harder to achieve mutual trust as the exchange of social information is slower (Costa, Fulmer and Anderson, 2018). Over time, trust can also be built in a virtual team through “reliability, consistency, and responsiveness when dealing with teammates (… and by) taking initiative, expressing enthusiasm, responding in a timely and meaningful manner, increasing feedback, increasing perceptions of virtual copresence, providing transparent

information, focusing on tasks rather than on procedures, and exchanging information about team processes" (Costa, Fulmer and Anderson, 2018, p.176). A lot of these aspects were also regarded valuable by the participants of this study to create trust in the multinational, remote technology transfer team.

With regard to the team composition, experts from all involved areas need to be part of the team and counterparts at the SU and RU need to be available. All roles and responsibilities need to be transparent and clear to all members. This is in line with the ICH Q10 guideline for a TT in the pharmaceutical industry (European Medicines Agency (EMA), 2015). Labour issues are described as a barrier for an effective TT (Mohite and Sangle, 2017) and hence, have to be overcome by good planning. During the normal working routine, this can be difficult as team members are most often involved in more than one project and need to work on their daily tasks like documents and emails as well. Therefore, having a clear mandate to work on the TT and to prioritize these tasks is mandatory to be able to spend sufficient time on the transfer. It is important to keep possible changes in mind and to have a concept and hand-over protocol available. The retention of critical knowledge is important and should be discussed via risk assessment (Lipa, Kane and Greene, 2020). Team member change can be difficult for the whole team and especially for the counterparts as they have to adapt themselves to the new situation and to achieve a trustful relationship again. Therefore, being resilient to change is important. Even in stressful situations team members need to be patient and empathic to keep a good and productive atmosphere within the group. This can be related to psychologically safe work environments that become even more important when continuous improvement and learning is required in a process (Newman, Donohue and Eva, 2017). Psychological safety can be defined as "the extent to which individuals feel secure and confident in their ability to change" (Newman, Donohue and Eva, 2017, p.523). Remote teams face more difficulty in creating trust and hence, in creating safe environments, compared to co-located teams (Morrison-Smith and Ruiz, 2020). One reason for this is that body language and emotions are hard to capture in a virtual setting. Therefore again, empathy and already established relationships between the team members are crucial. Hence, benevolence and competence-based aspects enable the creation of a strong and trustful relationship, that helps to exchange knowledge and can even be reactivated after several years when team members had been working together on a project previously (Costa, Fulmer and Anderson, 2018). Additional topics that go together with trust are managing uncertainties and expectations.

Both are influences that can determine the success of a TT as they show if a proper philosophy and culture are established within the team to cope with these situations (Kundu, Bhar and Pandurangan, 2015). The management of expectation is, in addition, important as team members might be assigned to other projects and their time allocation for the TT can be different. This might cause challenges if one team member is more committed and invests more time compared to others (Dumitru, 2021). Hence, transparency and open communication about these topics are required. The team members want to have answers to their questions in a reasonable amount of time. Responsiveness and mutual understanding are two added influences in this regard from the focus group discussions. Both can help to create more trust within the group and enable a positive outcome for the project (Costa, Fulmer and Anderson, 2018).

The common goal of the TT team is to successfully transfer the process and all the knowledge required. The developed technology or process for a certain project is a valuable possession for a company as it may be patented. New and innovative technologies and processes ensure the competitiveness of a company (Kundu, Bhar and Pandurangan, 2015). New technologies and processes for monoclonal antibodies can be very complex and the team members need to understand the details to get comparable results at the RU compared to the SU. When this understanding is not established the team members can feel disconnected from the process. It is described in the literature, that a “not invented here” atmosphere can be a barrier of the technology transfer (Office of Technology Assement, 1993). This means, the pride of ownership usually occurs at the sending unit as they developed the process to be transferred. Hence, the transferred technology needs to be valued at the receiving unit. People at the RU need to be trained and need to stay in mutual exchange with the SU team (Kundu, Bhar and Pandurangan, 2015). In the end, both units need to have the feeling of ownership and to be willing to make the process successful. “In absence of a strong willingness, there will be no passion for learning and unlearning on both the sides. And without this passion, it is impossible to assimilate, adopt, adapt and generate new ideas and technology” (Kundu, Bhar and Pandurangan, 2015, p.83).

With regard to organizational influences, the location of the sites that are involved in the TT, is one very important influence. Their proximity determines how often the team members can meet face-to-face. The closer the sites are the easier the personal exchange to enable a

trustful relationship (Costa, Fulmer and Anderson, 2018). This was also stressed by the participants of this study. Distance is assumed to cause difficulties when sharing tacit knowledge (Mohajan, 2016). The same goes for language barriers as mentioned during the interviews. All of these organisational aspects are extrinsic factors that cannot be changed by the team members. Still, it is important to acknowledge them and to avoid developing issues connected to them. An organizational aspect that can however be influenced is the structure and hierarchy within a company. In general, it can be stated, the more formal the structures within a company are, the slower the decision-making process. This aspect can also influence the trust within a team as they might hinder the interaction potential (Costa, Fulmer and Anderson, 2018). Therefore, a flexible structure with regard to decision-making needs to be implemented in the government structures of technology transfer teams.

The last area of influences mentioned, were motivational factors. The factors in this area are clustered into intrinsic and extrinsic motivators. Intrinsic motivation is described as satisfaction and pleasure on the task of the activity itself (Olaya Escobar et al., 2017) and is particularly valuable when tacit knowledge is transferred (Dhawan, Roy and Kumar, 2002). Intrinsic motivation promotes a team spirit that involves all team members in the communication. Due to the intrinsic motivation, people feel more committed to the company, team and project. These influences enable the creation of trust that again helps to enhance the employee's commitment to the task. This commitment also increases the willingness to learn and self-develop (Cruz, Pérez and Cantero, 2009). Personal satisfaction and the learning and development of innovative technologies motivate team members to disseminate knowledge (Olaya Escobar et al., 2017). The SU focus group stressed the importance of backing and the support from management as it helped to feel safe and to be able to represent group decisions. As these aspects foster a safe environment, psychological safety of the employees is also supported. This is in line with the literature as the support from management can "affect employee commitment" (Abdelwhab Ali et al., 2019, p.1809). In addition, to being proud, the autonomy and empowerment to decide how to transfer knowledge and which knowledge to start with, as well as decision making had been mentioned in both the SU and RU focus group discussion. This is important to cultivate a feeling of competence within the group and for the individual team members to enhance the intrinsic motivation to share knowledge (Cruz, Pérez and Cantero, 2009). A shared and transparent goal in cross-functional teams is again related to better trust within the team

(Costa, Fulmer and Anderson, 2018). Next to these intrinsic motivators also external motivators can influence the knowledge dissemination during a technology transfer. In the literature extrinsic motivators, however, are not described as primary motivation for the teams to transfer knowledge (Cruz, Pérez and Cantero, 2009; Olaya Escobar et al., 2017). Extrinsic motivation is defined as personal incentives the employees receive for their work (Olaya Escobar et al., 2017). This includes their salary as well as trainings, promotions and recognitions. Team members that are focussed on their economic growth might find the aspects of promotions and recognitions crucial for their motivation. Reward and recognition hence, can also be used to value great achievements within the technology transfer. Especially in remote teams this is a watch-out as due to different reporting lines team members might have concerns how they are evaluated and whether they can receive project specific incentives (Dumitru, 2021). Training, if offered as extrinsic motivators, should be tailor-made to the needs of the project and the team and can be time-consuming like e.g. mentoring or coaching (Joia and Lemos, 2010). These training methods are discussed further in the practices part later in this thesis. It needs to be considered an investment in the future. More experienced employees transfer their knowledge in this on-the-job training to newer employees or employees from the RU who are not familiar with the process (Joia and Lemos, 2010). Interestingly, a lot more intrinsic motivational influences have been mentioned than extrinsic ones. This is in line with the literature. Cruz, Pérez and Cantero (2009) found out that intrinsic motivators for the knowledge dissemination in non-profit organisations are more significant compared to extrinsic motivators. This shows that keeping the intrinsic motivation high is an important tool to support the efficiency of the knowledge transfer during a technology transfer. These influences may increase the commitment to the transfer and the company and hence, foster the communication between team members, as employees want to achieve a joint goal. Extrinsic motivators, however, can help to enhance the success of a transfer, as well as they show appreciation for accomplished tasks. Hence, the visibility of certain team members is increased which builds a good reputation that can be important for future promotions and further expert exchange in the field. Overall, both intrinsic and extrinsic motivation needs to be watched to achieve a successful TT.

It can be seen, that a large variety of influences could be identified during this study. These influences are compared to the findings from the literature review in the next section.

5.2.2 Comparison of the practical findings for influences of the knowledge dissemination from this study to the findings from the literature

The identified influences from the semi-structured interviews and the focus group discussion are compared to the factors identified during the literature review. For this purpose, the results the literature review were added to Table 15. A large conformity between the three results is detected. Only four influences had not been identified during neither the semi-structured interviews nor the focus group discussions. These influences were knowledge storage, knowledge transference and passion, personal commitment / intention to share and the type of valued knowledge. Knowledge storage, however, goes into the same direction as data storage, defined procedures and SOPs, media or structure to share. Still, it is not entirely the same as it is broader than the influences mentioned during this study. Similar topics compared to knowledge transference did not come up. This is interesting as the team needs to think about whether all the knowledge required for the process can be transferred in the international setting. It requires technical support to store codified knowledge in databases, but also needs committed team members who communicate a lot and enable tacit knowledge sharing by building good relationships. The missing influence “passion and personal commitment / intention to share” is again reflected in other influences identified during this study. These include accessibility, commitment and availability, problem-solving mentality / pioneering character, motivation (intrinsic) and impact, seeing the bigger picture / understanding the rational and power and politics. Splitting the topic up in more sub-influences might have helped the team to sharpen the idea what is really influencing the knowledge transfer. The more general factor found during the literature review is still valid and includes more than the detailed influences identified during this study. The last non-identified influence was the type of knowledge valued. This is probably due to the nomothetic thinking in science. Hence, the difference between tacit and explicit knowledge is not known by everyone. Team members might value tacit knowledge but do not know that they do. Therefore, education in this regard is important to understand the difficulty of transferring tacit knowledge. Explicit knowledge, however, is managed well in most of the science driven companies.

Overall, 61 influences from this study could be added to the list compared to the pure literature review. Some of these influences can be clustered in a next step, but the researcher wanted to have them all listed for completeness, integrity and acknowledgement. When

searching in the literature for barriers of the transfer, which leads to a lot of publications, conformity for some influences can be found. Ownership is a good example in this regard. It did not come up during the initial literature review, but when looking at the barriers, not-invented-here can be found, which is the true opposite of this influence (Office of Technology Assement, 1993). Other factors like virtual culture, time zone and responsiveness were stressed due to the change to online tools and remote teams due to the pandemic as well as the far distance of the transfer. Hence, the time zone was of more importance than the proximity to the participants as they had to find time windows in the working hours of the SU and RU to communicate and to set up meetings. Another interesting category of influences that was identified are emotions and emotion related behaviour. This includes the celebration of success, body language and emotions, empathy, fun and joint will to succeed. Especially fun was mentioned often during the interviews. Hence, team spirit is very important to keep the team members satisfied with their work.

Overall, this study broadened and detailed the list of influences found during the literature review and to create an in-depth understanding about the participants perspectives of the influences of knowledge dissemination. It helps to understand the importance of organisational, motivational and team related influences. In addition, it also added different facets of culture that set the basis for the dissemination of knowledge.

5.2.3 Summary and visualization of the influences for the tacit knowledge dissemination identified during this study

During this study, 81 influences had been identified in total, that can support the technology transfer in the BI. These results were categorized into cultural, team, organisational and motivational influences. It is important to know positive influences for the involved teams as well as the individuals as a “technology transfer is a contact sport. People, not papers, transfer technology” (Foley, 1996, p.30). Hence, motivational aspects and team related influences should be managed well to get the best outcome out of a TT.

When conducting the literature review, the identified influences were illustrated in a model. Ipe (2003) highlighted that the nature of knowledge, opportunities and the motivation to disseminate are important influencing areas of the tacit knowledge dissemination. All of these areas are influenced by the underlaying company culture (Ipe, 2003). The interconnection of all these four areas lead to knowledge dissemination and is quite small as it is hard to achieve

a “perfect” dissemination atmosphere. 19 influences could be identified from the literature, that have been categorized into the influencing areas according to Ipe (2003). This assignment has been done by the researcher. The resulting influences from this study were added as well to this model to extend the results from the literature review in the context of the BI. These influences fitted well into the model framework. Some influences were clustered into one bullet point as they go into a similar direction. Added influences from this study or changes to the version from the original version are indicated in bold.

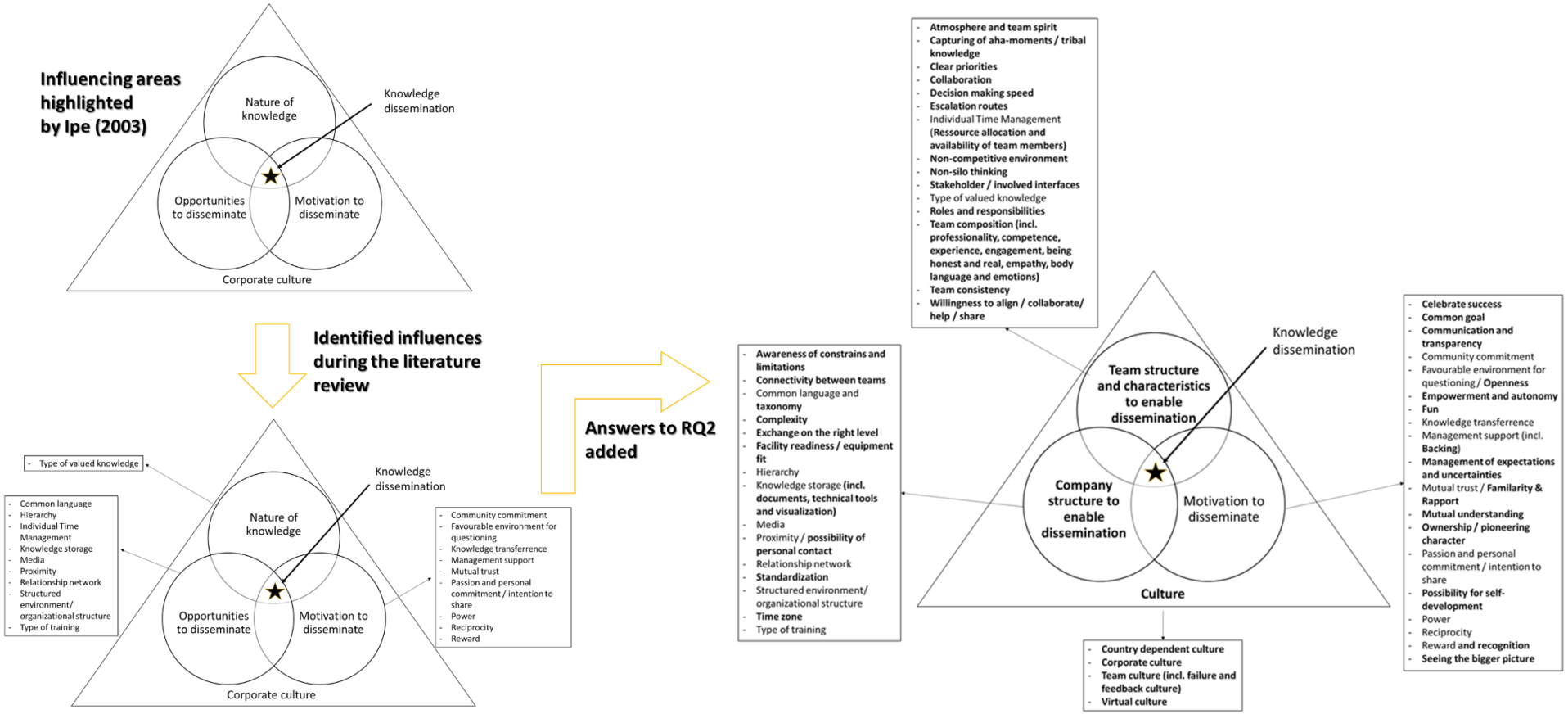

Figure 21: Assignment of the influences identified in this study to Ipe's (2003) influencing area model.

Figure 21 shows, that the model could be expanded by 32 entirely new bullet points of influences indicated in bold. Some influences found during this study were merged with already existing points shown as an extension in bold to an already existing bullet. When starting to look at the underlaying basis of knowledge dissemination by the outer layer, it can be seen, that corporate culture had been changed to solely culture. This is due to the fact that the results from this study show, that different facets of culture influence the technology transfer. Due to the multinationalism, this is county dependent culture and virtual culture. Virtual culture is crucial as the teams work mainly remote. Hence, codes of conduct for this type of collaboration have to be established. Corporate and team culture are also important as they set the basis for a defined language, symbols, rituals, and myths of a company or a team (Abdelwhab Ali *et al.*, 2019). Corporate, team and virtual culture can be adjusted by the management and the team members. It is crucial that the culture fosters the knowledge dissemination by enabling a good team and company structure for dissemination, as well as the motivation to disseminate.

The analysis of the data for this study showed that the team structure and characteristics next to the organisational structure and the motivation to disseminate is an important area of influences for the TT. The team also decides which type of knowledge they value. Hence, this category of influences replaces Ipe's (2003) category of the nature of knowledge. The team structure and characteristics category holds 15 influences of which 13 are new. Priorities, roles and responsibilities, team composition etc. are all factors that can be determined by the management. These aspects hence, should be transparent and clear from the beginning on. The decision-making speed, escalation routes and the non-competitive environment can be fostered by an empowered project management that develops clear project structures. Individual influences like the willingness to align and help or the engagement has to be maintained by the team members themselves. Hence, their motivation to achieve a successful TT plays a big role. The cluster of influences in the motivation to disseminate category comprises extrinsic and intrinsic motivators that influence the KT. It holds 20 influences in total, from which 10 have been added after the data analysis of this study. Extrinsic motivators like reward and recognition are the smaller bucket of motivators and their influence on the outcome of the TT is not deemed as significant as the one for the intrinsic motivators (Cruz, Pérez and Cantero, 2009). Intrinsic motivators like mutual trust, openness, common goals and empowerment and autonomy in the team should be assessed by the project management

from time to time to not miss any changes in the team dynamic. The management should be aware of the importance and also should implement the assessment of the existence of the intrinsic motivation in 1:1 meetings with their employees. The organisational structure should also foster these assessments. The organisational structure to disseminate knowledge in general consists of 15 influences of which 7 have been added new during this study. Some of these influences like the proximity, time zone or language are set and cannot be changed. These influences still should be considered and known when starting a TT. Other influences like the connectivity between teams, the data storage possibilities or the complexity of projects should always be improved and assessed on a regular basis.

In total, 32 entirely new influences or groups of influences could be added to the model after the analysis of the data from this study. The model should be used to create an awareness of the complexity of the influences of a TT. The 81 influences found during this study have been clustered or merged to get a model that is easy to use and fast to understand. The model should be used to identify influences that can be strengthened in a company. Not all of the influences might apply to every TT, but managers should be aware that they exist and that they can influence the outcome of the TT. These results also help to close the gap with regards to specific influences for the knowledge dissemination during a TT in the BI. Joia and Lemos (2010) who evaluated influencing factors of the knowledge dissemination for a major state-owned Brazilian oil company called for further research in this regard in other divisions, which has been done in this case for the Biopharmaceutical Industry. The relationship of single factors and their interdependency, however, needs to be explored further in additional studies.

As also practices and methods are important for the knowledge dissemination and hence, for a successful TT, the results for answering RQ3 are discussed in the next section.

5.3 Discussion of the Results for answering RQ3: Which practices can be applied during a technology transfer to support the dissemination of knowledge in the BI?

5.3.1 Discussion of the results from the semi-structured interviews and focus group discussions

During the semi-structured interviews and the focus group discussions, different practices to enable the knowledge dissemination have been found. These practices can be clustered into technical tools, team interaction tools and tools to capture the process knowledge.

Technical tools are important during a TT to be able to store data and communicate when geographically distributed. In this case the transfer took part from Germany to the US and hence, used a lot of technical and digital tools to connect the teams. In addition, the respective transfer looked at in this study took part during the pandemic, which made the tools even more valuable. The pandemic led to travel restrictions and less in person meetings as people needed to stay safe at home for a certain period of time. When communicating mostly through virtual tools, teams can be defined as “remote teams”. Challenges along remote teams like building trust easily as well as the communication due to the small meeting windows during the working hours of the respective teams were already mentioned before. But there are also positive aspects of working remotely, like the flexibility or that the best talents for the jobs are always available and that the need for travelling decreases (Morrison-Smith and Ruiz, 2020). Again, this had been of special importance due to the Covid-19 pandemic. For interacting in an effective way, it is important, that the team members have the technical competence required (Morrison-Smith and Ruiz, 2020). Technical capabilities of a unit depend on the learning culture and the learning process (Kundu, Bhar and Pandurangan, 2015).

When looking at team building and exchange and hence, team interaction, meetings are an essential part. They form the first subtheme of this cluster and can be either considered an organisational tool or a communication method (Allen et al., 2014). Meetings appear in different forms depending on their purpose, their formality and their participants. Participants during the focus group discussions divided the meetings into structured, informal and formal meetings and whether these meetings take place face-to-face or in a remote setting. This classification can also be found in the literature (Allen et al., 2014). Team building activities

normally go together with these different types of meetings. The first step to form a technology transfer team is a kick-of meeting. Pizza parties are also perfect to be performed after a kick-off meeting. They are a synonym for informal after-work exchange and help to decrease barriers between team members by exchanging personal information and gaining trust. Networking inputs help to develop foresight with regards to project specific needs but also with regard to competitive advantage (Kundu, Bhar and Pandurangan, 2015).

To avoid any confusion about tasks in the team, a team charter should be established at the beginning of the technology transfer. A team charter "specifies tasks and expectations, including information on team member availability, scheduling constraints, roles and responsibilities, deadlines, and other organisational structures agreed upon in an explicit written form created with the input of all project members" (Johnson et al., 2022, p.236). Team charters are especially important at the beginning of the transfer during team development (Johnson et al., 2022). However, they cannot be correlated to better outputs compared to teams with no charter (Johnson et al., 2022). But as they help the team forming, charters should be part of the set-up phase of the transfer. The same goes for goal setting. Another tool mentioned to increase the transparency in the team were decision trackers. Lipa, Kane and Greene (2020) argue in the same direction and say that decision trackers are important tools as they enable traceability and understanding for employees not involved in the decision-making process. This again helps to create transparency for all team members.

The last found cluster of practices were tools to capture the process knowledge. It is known that humans are visual creatures. Hence, capturing the knowledge in presentations, videos, photos and also by new technologies, help the team members to understand prior learnings. During the Covid-19 pandemic this has been of special importance, as team members were not able to travel as easily and shadow the experts when performing the process. As sometimes in addition to the face-to-face contact, the direct communication via phone or Microsoft Teams had not been possible due to the different time zones, the teams also used tools for the offline exchange. This offline exchange had mainly been performed by email or Microsoft SharePoint. This kind of working mode is known as Follow-the-sun approach (Morrison-Smith and Ruiz, 2020). Another offline tool that had been frequently used were documents. Known documentation practices mentioned already by e.g., Haldin-Herrgard (2003) are best practices. These were also mentioned by the participants. In addition,

standardized documents described in a standardized operating procedure (SOP) were established that are classically used during a TT to help to compare process steps and assess whether there are gaps between the process performed at the sending unit and the receiving unit. These documents are prepared to overcome barriers of the TT and make it a success (Kundu, Bhar and Pandurangan, 2015).

It can be seen, that a lot of helpful practices, tools and methods to disseminate knowledge during a TT could be identified in this study. The next section compares the findings of this study to the literature.

5.3.2 Comparison of the practical findings for practices and tools to disseminate knowledge from this study to the findings from the literature

In Table 16 it can be seen, that a lot of practices and methods to disseminate knowledge found during the literature review were also identified during this study. Still, seven additional practices came up in the literature that can be applied to the TTs. The first ones are mentoring and coaching, which are concepts focused on the professional development of employees (Hussey and Campbell-Meier, 2021). Both are practices that are known and applied in the BI as well, but had not specifically mentioned during this study. During a mentoring session a more experienced employees gives advices and provides feedback and support for his mentee (Hussey and Campbell-Meier, 2021). Coaching, on the other hand, works with “non-judgemental feedback on performance (…) and often involves senior professionals providing guidance for someone who needs to develop a specific skill or attribute” (Hussey and Campbell-Meier, 2021, p.510/511). The unguided version of learning is trial and error. In some cases, this might also be of relevance. For example, when new devices have to be used or certain consumables are not available anymore. It might also apply to new employees. When having specific questions, it makes sense to have all subject matter experts listed. This especially true for large companies with different sites. Knowledge can be distributed at the different sites and experts might not know that another expert is available to exchange with. The more the experts exchange, the more competitive knowledge can be generated. To not loose competitive knowledge in a company, employee turnover has to be managed. When experienced staff leaves the company or a team, it has to be guaranteed that the knowledge stays in the company. This can be done by the retention of critical knowledge process, which is a risk assessment and management to mitigate the loss of selected knowledge topics (Lipa,

Kane and Greene, 2020). The dissemination takes place through knowledge assets like white papers and through dialogue (Lipa, Kane and Greene, 2020). Another method to exchange knowledge and to get to know experts are knowledge fairs (Mohajan, 2016). Employees from the audience can ask specific questions during a conference setting. Participants during the focus group discussions mentioned project review meetings as a great tool for knowledge dissemination and networking. These review meetings can be conducted in a similar manner. The last method found during the literature review is storytelling. This approach covers the illustration of topics like norms, culture, and values by telling a personal story and adding meaning and context (Chennamaneni and Teng, 2011; Venkitachalam and Busch, 2012). Metaphors and body language can be used as well (Chennamaneni and Teng, 2011; Venkitachalam and Busch, 2012). Hence, with this approach tacit knowledge can be transferred as also used during this study in the semi-structured interviews.

All the additionally found practices and methods during the literature review are great to implement for a TT. Even though these practices had not been mentioned during the semi-structured interviews or focus group discussions, most of the approaches are commonly used. Still, it is valuable to have a comprehensive list to keep everything in mind that could be of relevance for a TT. To extract even more methods and practices for tacit knowledge dissemination an all-embracing literature review should be conducted in the future. Due to resource limitations, this had not been done during this study. Yet, the identified methods during the literature review, semi-structured interviews and focus group discussions form a great basis to choose from for TTs. The findings of this study are summarized in the next section.

5.3.3 Summary and categorization of the mechanisms, practices and tools supporting knowledge dissemination identified during this study

The results from the semi-structured interviews and the focus group discussions had been discussed in the previous sections. 30 practices and methods had been identified to support the knowledge dissemination during a TT. These practices can be categorized into practices used at the start-up phase of the TT, during the TT, at the end of the TT and project-stage independent practices. The categorization of the mechanisms and practices can be found in Figure 22.

Figure 22: Categorization of the mechanisms, practices and tools to disseminate knowledge found during this study.

In Figure 22 it can be seen, that the mechanisms of dissemination can be differentiated into eight categories. The classification has been done by the researcher according to the statements of the participants when the practices were used. Some practices have been assigned in more than one category as they serve different purposes. One example for this is “feedback”. Feedback can be used to learn, but is also important for team building as it fosters trust. In addition, it can be used after each milestone to reflect on the process. In general, the majority of the practices found can be applied during the transfer for different purposes like documentation, communication or team building. Tools like kick-off meetings and charters are applicable in the beginning of the TT, when the start-up of the team is required. Additional practices can be used at the end each milestone or the transfer. All methods should be chosen according to the project and team needs. This decision has to be jointly taken by the project management and the team members. Collateral project-independent knowledge dissemination practices should be applied to bring experts together and to share knowledge as much as possible within a company.

Together with the identified types of tacit knowledge used during a TT and the influences that can enable the knowledge transfer, this list of mechanism and practices to disseminate shown in Figure 22 can help managers, project managers and team members to gain better insight into their knowledge transfer. This study is especially intended to foster the understanding in this regard and hence, provided lists and diagrams to share with the employees in the BI. This shows the practical application of this study for the BI. The contribution on the theoretical and practical level is described in more detail in the following sections.

5.4 CONTRIBUTION

5.4.1 Theoretical contribution

The theoretical contribution of this research consists in answering different calls in the literature. The first contribution is related to the types of tacit knowledge used during a TT in the BI. According to Kane, Greene and Lipa (2019) only limited understanding for the tacit knowledge used during technology transfers in Biopharmaceutical Industry existed. This study helped to close this gap by identifing the types of tacit knowledge used during a specific TT and by enlarging the list of ETKs by Haldin-Herrgard (2003) when answering RQ1: Which types of tacit knowledge are used during a technology transfer between a German development department and the US manufacturing department in the BI?. As additional ETKs and

synonyms for the BI were found during this study, it helped to contextualize the list of ETKs by Haldin-Herrgard (2003) and the newly found ETKs more. This is in line with the call for contextualization of the tacit knowledge by Hadjimichael and Tsoukas (2019). In addition, as this study was conducted with subject matter experts from different functions who also perform hands-on activities for the processes, more insights into tacit knowledge associated with technology transfer for “shop floor” workers could be gained as requested by Nakano, Muniz and Batista (2013).

When providing answers to RQ2: What influences the knowledge transfer between the German development department and the US manufacturing department in the BI? influences in the areas of team structure and characteristic to enable knowledge dissemination, company structure to enable knowledge dissemination, motivation to disseminate and culture could be identified. During the focus group discussion especially influences for the tacit knowledge dissemination could be identified. As this study was conducted in a non-state-owned company, these results address the call from Joia and Lemos (2010) to perform research of influencing factors of the tacit knowledge transfer in non-state-owned companies. The specific influences for the BI had been the focus of this research, which means contextualization of the influences is provided as requested by Borges, Bernardi and Petrin (2019), Venkitachalam and Busch (2012) and Visvalingam and Manjit (2011). In addition, as this transfer was conducted mainly virtually, it evaluated additional, specific critical success factors during virtual technology transfers in the BI as requested by Lipa, (2021). These include e.g., the establishment of a virtual culture.

Answering RQ3: Which practices can be applied with a technology transfer in the BI to support the dissemination of knowledge? led to a list of methods, practices and tools. Hence, it provided insight into how tacit knowledge (and knowledge in general) can be transferred. Further research in this direction was asked for by Kane, Greene and Lipa (2019). The methods, mechanisms and practices found during this study also include tools for the dissemination of knowledge in the digital environment. This is also in parts adressing a call in the literature from Hadjimichael and Tsoukas (2019) who asked for additional studies for methods to transfer tacit knowledge in digital environment.

In summary, the results gained during this study contributed to closing a variety of gaps in the literature with regards to the tacit knowledge used during TTs, its influences and the methods

to disseminate this knowledge. Especially contextualized understanding of the aspects mentioned before had been highlighted. In addition, the learnings can be practically applied as shown in the next section.

5.4.2 Practical contribution

Next to the theoretical contribution, this study also wanted to contribute to practice. The lists for the types of tacit knowledge used and the influencing factors of the knowledge dissemination can be used to widen the awareness and understanding of tacit knowledge and knowledge transfer influences in the company. This is crucial as the "tacit knowledge transfer is frequently undervalued and underestimated by the technical teams managing the technology transfer project and (…) a frequent cause of failure and of on-going process-related problems post-transfer" (Kane and Lipa, 2020, p.25). This awareness is also important to understand whether all the required knowledge is transferred, because according to Shanley (2018) incomplete transfers, in which only parts of the required information is transferred, can cause delays in timelines. In addition, having worked out the supportive methods and practices for the knowledge dissemination, a flow diagram had been developed to simplify the choice of methods for managers and technology transfer team members. This diagram is intended to support the knowledge transfer during a TT and to make a TT more robust. Recent examples from the Covid-19 pandemic indicate the importance of effective knowledge transfers, as different fast drug development campaigns failed because of issues during the technology transfer (Thomas, 2021). The developed flow diagram is depicted in Figure 23. This flow diagram is based on the findings from answering RQ3, which are summarized in Figure 22. The findings were brought together with the experience from the researcher to establish the flow diagram. When establishing a new TT with a new team, start-up practices are required for the team to get to know each other and achieve clarity about roles and responsibilities. In addition, setting joint goals help to act in concert. After having set the basis structures for meetings and communication, documentation and learnings are needed. The corresponding practices and methods should be chosen according to the team and project needs. Incremental support for team building and clarity and transparency might be required during the project when team members change or if certain roles and responsibilities are added. After each milestone of the TT, the project manager should check whether additional facilitation of the different purposes is required. For each mentioned step or part of the TT the flow diagram holds different methods and practices, that can be chosen. A joint decision

on which practices and methods to use during the TT can help to enhance the team spirit and convey the feeling of empowerment.

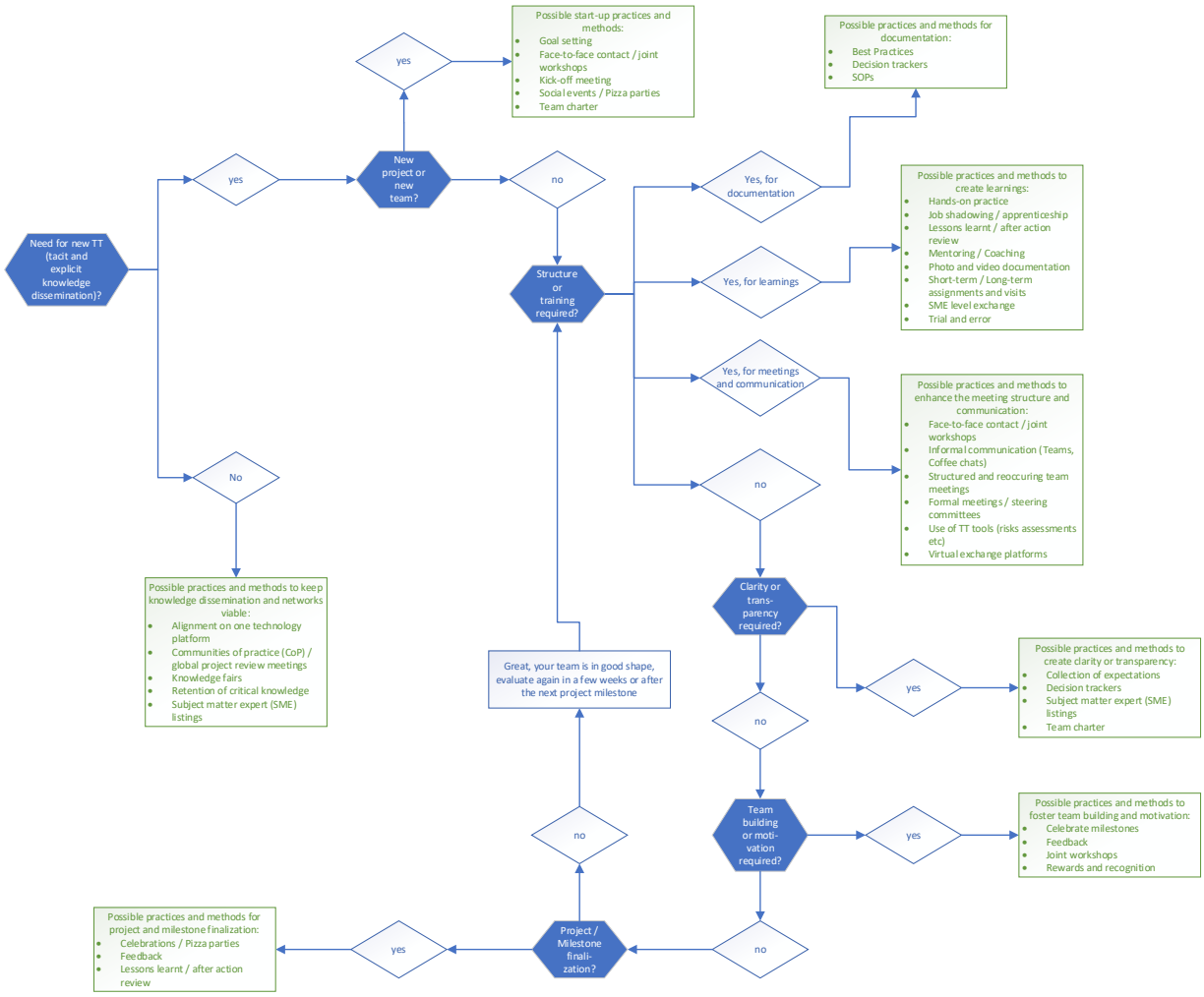

Figure 23: Flow diagram to identify feasible practices and methods for different purposes during a TT.

Overall, the developed flow diagram provides suggestions, which practices and methods to use for the different purposes during the TT. Not all of them have to be used and additional ones can be added according to the teams' needs. Together with the identified types of tacit knowledge used during a TT and the influences that can enable the knowledge transfer, this flow diagram can help managers, project managers and team members to gain better insight into their knowledge transfer and to make it more robust. Knowing more about the tacit knowledge transfer, has the potential to also simplify regulatory approval of drugs, as "regulatory approval typically requires the extensive codification of tacit manufacturing knowledge" (Nicholson Prince II, Rai and Minssen, 2020, p.913). Using context specific methods and measures to transfer the different types of knowledge during a TT is crucial (Hadjimichael and Tsoukas, 2019; Kane, Greene and Lipa, 2019). Hence, this study achieved

practical contribution by providing practical suggestions for future transfers. The next chapter concludes the achievements of this study and provides ideas for further research.

6 CONCLUSION

6.1 SUMMARY AND ACHIEVEMENTS

The research explored and identified the types of tacit knowledge used during a TT in the BI and the corresponding influences of the knowledge dissemination with a special focus on the influences of the tacit part to support the transfer in this regard. Along those lines, it also identified practices, mechanisms and tools useful for the knowledge dissemination. This addressed calls to contextualize tacit knowledge and its influencing factors (Visvalingam and Manjit, 2011; Venkitachalam and Busch, 2012; Borges, Bernardi and Petrin, 2019; Hadjimichael and Tsoukas, 2019) as well as to specifically broaden the understanding of tacit knowledge in the Biopharmaceutical Industry (Kane, Greene and Lipa, 2019). In addition, it also provided insight into how tacit knowledge is disseminated as requested by Kane, Greene and Lipa (2019). The detailed achievements of this study can be best summarized in more detail when looking again at the objectives that this research wanted to work on. In general, due to the identified gaps in the literature the objectives of this study were:

- To gain a better understanding of the types of tacit knowledge used during a biopharmaceutical technology transfer
- To identify the influencing factors for the knowledge dissemination for a specific transfer from a German development department to a US manufacturing department in the BI and compare them to the influences identified during the literature review
- To make recommendations on how to support the knowledge transfer for upcoming technology transfers in the BI by e.g., developing a roadmap or listing practices to use during a technology transfer

The following sections describe in detail which new insights could be generated per objective.

6.1.1 Objective 1: Gain a better understanding of the types of tacit knowledge used during a biopharmaceutical technology transfer

The primary goal for a TT is to repeatedly get same results with the transferred process at both sites. To achieve this goal, the process needs to be robust and scalable, which is a prerequisite of the transfer. For this effort both explicit and tacit knowledge regarding how the process was developed and how it is run is needed. In general, tacit knowledge

comprehends of technical and cognitive elements that are relevant to perform a TT. This includes for example know-how, expertise and skills but also beliefs, mental models and thinking patterns (Alavi and Leidner, 2001; Haldin-Herrgard, 2004; Liu and Cui, 2012). It is important to know that these types of knowledge exist to be able to transfer them, but also to stay innovative and develop also these elements further. During the analysis of the data derived from the semi-structured interviews as well as the focus group discussions, 63 types of tacit knowledge in line with the ETK list from Haldin-Herrgard (2003) could be identified for the TT in the BI. Among those especially experience, hands-on work, capability and skills were mentioned by the participants. This is not surprising as these ETKs are directly connected to the process execution. In addition, softer topics like emotional knowing, beliefs and culture came up. These are rather connected to the interpersonal component during the technology transfer in an international setting. Additional 7 types of tacit knowledge specific to the BI were found and used to enlarge to list provided by Haldin-Herrgard (2003). With the same data set also synonyms used in the BI for different ETKs were added to list. This helped to contextualize the ETKs for the BI even more. Language like “lesson learnt” or “taxonomy” is widely used in this industry and hence, easier to understand for the experts in this field compared to some expressions provided by Haldin-Herrgard (2003). Hence, an in-depth understanding could be generated about the types of tacit knowledge required during a TT in the BI. The findings were subsequently summarized in Table 18. This table is intended to systemize the findings and connect mental, sensuous, social, practical and holistic types of tacit knowledge to their informants (individuals, team or the organisation). It should help to get a better understanding of what tacit knowledge means in the BI and should provide a comprehensive list of types of tacit knowledge used during a TT. Overall, it can be stated that a great conformity with data from the literature could be found even though the transfer of a manufacturing process in the BI is a lot more complex compared to pure equipment transfers in other industries for example. This indicated that the translatability of the additionally found ETKs and synonyms during this study should also be tested for other transfers.

6.1.2 Objective 2: Identify the influencing factors for the knowledge dissemination for a specific transfer from a German development department to a US manufacturing department in the BI and compare them to the influences identified during the literature review

When answering RQ2 81 influences had been identified during the analysis of the semi-structured interviews, as well as the focus group discussions. In this case, internal factors were evaluated that are affected by the company and had a direct impact on the technology transfer for the manufacturing process of a biopharmaceutical asset. The influences were categorized into team structure and characteristic to enable knowledge dissemination, company structure to enable knowledge dissemination, motivation to disseminate and culture. As the influences were grouped and added to a model provide by Ipe (2003), 32 new bullet points of influences could be added. All of the found influences are specific to this special transfer and team. Still, they had been brought together in a model with the results from reviewing the literature to form a full picture. Interestingly, a lot of influences related to the TT team were mentioned by the participants that had not been identified in this degree of detail during the literature review. This study revealed that emotions like fun, the celebration of success and empathy are important for a good atmosphere in the team and hence, support the success of the project. In addition, clear roles and responsibilities and familiarity and rapport were stressed. Interestingly, these factors are directly affecting the SU and RU team members and hence, the way the work together as a team. The better they can communicate, the better the knowledge flow for the manufacturing process is. Another important finding had been the shift of importance to virtual culture and tools and the time zone as a lot of teams are working remote. During the Covid-19 pandemic these aspects became more and more important. Along those lines, also culture was mentioned. One concrete example that is very important for TTs in the BI is failure culture. This is due to the fact that not everything is going to work at the first attempt due to the complexity of a biologics process and that not all the knowledge disseminated might be understood correctly. Hence, failure culture needs to be established in the teams and in the management but also the company culture itself should enable good team work. In general, it can be stated that the study helped to create an in-depth understanding about what the participants regard as important factors to foster the knowledge dissemination during technology transfers in the

BI. This knowledge can be used to check whether similar transfers in the future can be supported by providing the required environment.

6.1.3 Objective 3: Make recommendations on how to support the knowledge transfer for upcoming technology transfers in the BI by e.g., developing a roadmap or listing practices to use during a technology transfer

Knowledge that is needed to be able to perform the manufacturing process needs to be assessed and transferred with different methods and practices. After having analysed the data from the semi-structured interviews, focus group discussions and the literature review, 30 practices and methods could be identified that can be used to support the knowledge transfer during a TT. This includes methods and practices to start a TT and to develop a team spirit and trust within the team as well as practices that can be used during the ongoing transfer and at the end of the transfer. Examples are kick-off meetings, in which the team members from the SU and RU can get to know each other. Other examples are site-visits and short-term assignments as well as job shadowing where the team members can perform the process together and learn from each other. Methods in the same direction are knowledge fairs and communities of practice where experts can share their lessons learnt and discuss specific topics. These methods and practices are tailor made for the specific transfer in the BI and provided additional in-depth understanding about what the participants are needing for a successful transfer. Overall, the identified mechanisms, practices and tools provide a good basis for TT teams to decide on which methods and practices to add to their normal procedure according to their needs. Still, data from other industries could be added and an all-embracing literature review should be performed, which might again lead to additional practices and methods that can be added to the list. Additional possibilities for future research and the limitations of this study are described in the next section.

6.2 Limitations and Future Research

This research study like others has limitations. In order to be transparent, this section lists the limitations the author recognized during this research. It should help the reader to interpret the results accordingly. In addition, it provides some ideas for future research.

This study was conducted with a team performing one specific transfer from a German development department to a manufacturing department in the US. This transfer had been

an intra-company transfer with a specific company culture. This company culture may have different focus topics compared to other companies. Transferring from a development department to a manufacturing department indicates that requirements between the two units are different due to their purposes. The manufacturing department has been entirely new established before the transfer and hence, the teams did not know each other. This causes a different team dynamic compared to teams that have a joint history. In addition, each project to be transferred has its own timeline and competes against other projects. The assessed project had been in late stage and hence, prior to launch. As for many biological assets, the state of the project had been insecure due to clinical results and competitors. This project had been special additionally, as it was conducted during the Covid-19 pandemic. The participants in this study had been experienced and hence, additional experience from other projects had been incorporated in some of their answers.

The achievements of the study have been listed in the previous section. As the whole research is very specific, the found types of tacit knowledge, influences and the practices and methods should be verified in the future in other studies. Future research should check, whether the identified additional ETKs can be applied to other industries than the BI. Additionally, the flow diagram for the practices and methods needs to be “live” tested in an upcoming transfer and should as well be tested in other industries. In addition, a comprehensive literature review on methods and practices also in other industries that conduct TTs could be performed to add more tools to the list. The identified methods and practices from this study and from the literature reviews should be assessed for their importance to establish a ranking in future studies. This may simplify the choice of methods for the practical application. Future research should also include measures about how successful the tacit knowledge transfer has been. With regards to the influencing factors, further studies with regards to emotions as fun and passion should be conducted which had been mentioned during this study. In addition, a comprehensive literature review for positive and negative influences should be performed. Along those lines, future research should also explore more about the influence of the Covid-19 pandemic to the tacit knowledge dissemination.

In addition to the theoretical and practical learnings derived from this study, the researcher personally learned a lot by conducting the research. These learnings are reflected in the next section.

6.3 Researcher's Reflection

The researcher had started this project as a scientist with interest in business and leadership topics and wanted to widen her understanding of tacit knowledge and different methods for data collection than quantitative ones. Due to her background in science, the researcher enjoys analysis of data by quantitative methods, but for leadership topics she values qualitative research. During the project she experienced how labour-intensive qualitative data collection can be. Still, it was fun to learn about the different perspectives of the participants and to increase her intra-company network. Even having done some technology transfers before, the researcher got to know more about interfacing functions and their needs. It was also great to see that the study was received well and that the participants liked to reflect on their experiences from the transfer and to interact in focus groups. Participants always did lessons learnt after their projects, but giving feedback about the whole process and having time to reflect was still different. In addition, having read so much about the different forms of knowledge and summarizing the finding of this study in this regard, increased the researchers understanding a lot about how valuable tacit and expert knowledge is supplementary to explicit knowledge. One of the researcher's favourite parts, was to learn about influences of the tacit knowledge dissemination. Aspects that can be controlled by the management are a great starting point for supporting the next transfer even better. Additionally, some influences can also be implemented in companies' culture initiatives as underlaying principles for team work. The last part of the thesis about practices and methods can be directly applied by the TT teams. Hence, the researcher is proud of having been able to develop the flow diagram to support decisions in this regard.

In addition, the methodological choice of this study let the researcher grow and helped to develop her skills in the qualitative area. She will implement more time for lessons learnt or even full focus group discussions after certain milestones in projects to reflect on the achievements and learnings. Knowing how powerful storytelling approaches can be, the researcher will apply these more often in one-on-one meetings. With regards to the achievements of this study, the researcher will try to focus even more on valuing the different types of tacit knowledge and to broaden the understanding of value of this type of knowledge in her teams. In addition, she will pay even more attention to the identified influencing factors

for the dissemination of knowledge in the areas of team structure and motivation. She will also use the developed flow diagram to decide on practices in her future TTs.

The researcher wants to end this thesis with discussing a great metaphor provided by one participant in the semi-structured interviews:

> *"(…) You know, it's likely cause we're so old fashioned but there's opportunities to take this tacit knowledge and make it explicit. And then hopefully we should aspire to the day to when there is no more tacit knowledge. You know, the gems are chipped away until there's nothing left but dirt in the mine." (Participant 343-RU-RU)*

This quote is interesting, as it shows that scientist like to make tacit knowledge as explicit as possible because this is their solid ground. The researcher agrees that some types of tacit knowledge identified during this study can be made explicit including but not limited to perspectives, opinions, values and techniques. Other types of knowledge, however, will stay tacit and need to be valued in this form. It is valuable in the end, to have both types of knowledge available during a TT. Different types of explicit and tacit knowledge will always be gems and the TT teams will need to retrieve them from the mine. If this is done effectively, the technology transfer is likely to be a success.

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8 APPENDICES

8.1 TRANSLATION OF THE EPITOMES OF TACIT KNOWLEDGE (ETKS)

	ETK	German translation according to Schmidt (2020)
1	Ability	Fähigkeit, Können, Eignung, Qualifikation, Geschick
2	Skills	Fertigkeiten, Fähigkeiten, Kompetenz, Geschick, Kenntnis
3	Embodied Knowledge	im Wissen verkörpert, Verkörperung des Wissensstands
4	Collective Ability	Kollektive Fähigkeit
5	Capability	Fähigkeit, Können, Befähigung, Tauglichkeit, Leistungsfähigkeit, Vermögen
6	Crafts	Handwerk, Fertigkeit
7	Bodily Skills	Körperkompetenzen
8	Cognitive Skills	Kognitive Fähigkeiten
9	Communication Skills	Kommunikationsfähigkeit
10	Coordination Skills	Koordinationsfähigkeit
11	Inductive Skills	Induktive Fähigkeit
12	Managerial Skills	Managementfähigkeit, Managementkompetenz
13	Negotiation Skills	Verhandlungsgeschick
14	Operational Skills	Operative Fähigkeit
15	People Skills	Soziale Fähigkeiten
16	Physical Skills	Körperliche Fähigkeiten
17	Social Skills	Soziale Fähigkeiten
18	Intuition	Intuition
19	Intuitive Knowledge	Intuitiv
20	Insight	Einblick
21	Flashes of Insight	Gedankenblitz
22	Non-Analytical Behaviour	Automatische Gedanken; Reflexive Reaktion, Reflexives Benehmen/Verhalten, Aktivitäten /Gedanken/Äußerungen, die nicht überlegt oder über logische Methoden erreicht sind
23	Flashes of Inspiration	Gedankenblitz
24	Unconscious Norms	Unbewusste Normen oder Glauben
25	Hunch	Ahnung
26	Shared Believes	Geteilte Überzeugung, Gemeinsamer Glaube
27	Automatic Knowledge	Latentes Wissen, Schlummerndes Wissen, Schlafendes Wissen, Verborgenes Wissen, Gebundenes Wissen
28	Mental Models	Mentale Modelle, Geistige Modelle
29	Organisational Memories	Gruppengedanke, Gruppenverstand
30	Shared Meaning	Gemeinsame Bedeutung
31	Cognitive Schemes	Verhaltensmuster
32	Organisational Mind	Gruppengedanken, Gruppenverstand
33	Thinking In Pratice	Praktisches Denken
34	Know-How	Fachwissen, Know-how
35	Expertise	Sachverstand, Expertise, Expertenwissen
36	Collective Know-How	kollektives Know-how, Schwarmintelligenz
37	Practical Intelligence	Praktisches Denken, Pragmatismus

38	Life Examples	Lebensbeispiele
39	Oneness of Body and Mind	Einheit von Körper und Geist, Ganzheitlichkeit des Menschen
40	Know in Ones Body	Körpergefühl ganzheitlich
41	Feels as …	Fühlt sich an als …
42	Looks as …	Sieht aus als …
43	Feeling	Gefühl
44	Gut-Feeling	Bauchgefühl
45	Norms	Normen
46	Shared Norms	Gemeinsame Normen
47	Attitude	Haltung
48	Beliefs	Überzeugung, Glaube(n), Normen, Grundkenntnisse
49	Common Beliefs	gemeinsame Überzeugung (religiös und säkular)
50	Opinion	Meinung
51	Perspectives	Perspektiven
52	Predictions	Vorhersagen
53	Judgement	Beurteilung
54	Estimation	Einschätzung
55	Perception	Wahrnehmung
56	Personal Experience	Persönliche Erfahrung
57	Common in Experience	Gemeinsame Erfahrung
58	Pattern of Experience	Muster der Erfahrung, Erfahrungsverhältnisse
59	Best Practice	Musterlösung, Best Practice, bestes Verfahren, bewährte Methode, Standardanweisung
60	Knowledge Base	Wissensbasis, Basiswissen, Grundlagenwissen, Wissensprofil
61	Master Sureness of Action	Handlungssicher
62	After-the-Fact Awareness	Nachträgliche Erkenntnis oder Bewusstsein
63	Artistic Vision	Kreativer Blick, künstlerische Vorstellung oder Darstellung
64	Care-Why	Mitfühlen, Zuneigung für etwas empfinden
65	Common Sense	Gesunder Menschenverstand
66	Creativity	Kreativität
67	Culture	Kultur
68	Embedded Knowledge	Eingebettetes Wissen
69	Get a Feeling for	Gefühl für etwas haben oder entwickeln oder kriegen
70	Emotional Knowing	Emotionale Intelligenz, emotionale Weisheit, emotionales Wissen
71	Genres	Genre
72	Group's Sense	Gruppenverstand/-weisheit, Gruppengedanken, Gruppensinn
73	Improvisation	Improvisation
74	Inexpectable Mental Process	Unerklärliche mentale Prozesse
75	Inner Competence	Innere Kompetenz
76	Instinctive Reactions	Instinktive Reaktion
77	Personal Competence	Persönliche Kompetenz
78	Routines	Routinen
79	Routinized Knowledge	Routiniertes Wissen

80	Rule-of-Thumb	Faustregel
81	Sense Making	Sinn machen
82	Shared Values	Gemeinsame Werte oder Prinzipien oder Standards oder Grundsätze oder Normen
83	Talent	Talent
84	Taste	Geschmack
85	Techniques	Techniken
86	Tricks	Tricks
87	Thoughts	Gedanken
88	Understanding	Verständnis, Verstehen
89	Values	Werte
90	Sounds of…	Töne von, klingt wie, Klang des/der
91	People Knowledge	Menschenkenntnis, Menschenwissen
92	Shared Code	Gemeinsame Vorschriften oder Normen, Kodifizierung/Kodifikation

8.2 KNOWLEDGE TRANSFER MECHANISMS AND PRACTICES (LISTED IN ALPHABETICAL ORDER).

Knowledge transfer mechanisms and practices	**Description**	**Source**
Best practices	Documentation of standardized methods or techniques to solve a problem.	(Harlow, 2008; Mohajan, 2016)
Collaboration and social networks	Creation of an environment of exchanging tacit knowledge for the employees, that goes beyond academic lectures and discussions. Informal conversations need to be fostered by networks.	(Liu and Cui, 2012; Nakano, Muniz and Batista, 2013)
Communities of Practice (CoP)	Connection of diverse people from a company with common interest in one topic to foster different views on one event. Personal tacit knowledge should be exchanged.	(Venkitachalam and Busch, 2012; Abdelwhab Ali *et al.*, 2019; Lipa, Kane and Greene, 2020)
Decision trackers	Listing of decisions taken during a project or process with the corresponding rationale to enable traceability and understanding for employees not involved in the decision-making process.	(Lipa, Kane and Greene, 2020)
Employee and management meetings	Discussion of current problems and ways to solve issues between members of different hierarchies.	(Mohajan, 2016)
Hands-on practice	Learning by doing rather than by just reading or seeing a specific task being done.	(Dinur, 2011)
Knowledge fairs	Experts talk about a certain topic and answer questions from the audience.	(Mohajan, 2016)
Lessons learnt / after action review	Focussing on extracting experiences and lessons from an event or project to enable better performance in the next project.	(McNichols, 2010; Lipa, Kane and Greene, 2020)
Mentoring / Coaching	Acquiring of tacit knowledge and know-how through guided experiences and exchanges.	(Joia and Lemos, 2010; McNichols, 2010; Mohajan, 2016)
Retention of critical knowledge	Risk assessment for individual knowledge that might get lost by employee turnover to define critical and unique knowledge. This knowledge has to be transferred during dialogues between expert and successor.	(Lipa, Kane and Greene, 2020)

Shadowing of experts / Apprenticeships	Observation of the experts work-process to benefit from shared experiences. Experts can share e.g. technical know-how, mental models and problem solving ideas. Experts can directly influence the process developing e.g. new mental models and have the opportunity to correct wrong behaviour.	(Chennamaneni and Teng, 2011; Dinur, 2011; Liu and Cui, 2012; Lipa, Kane and Greene, 2020)
Short-term and Long-term visits	Similar to shadowing of experts, but can also contain elements of hands-on-practices.	(Dinur, 2011; Mohajan, 2016)
Storytelling	Illustration of topics like norms, culture, and values by telling a personal story and adding meaning and context. Metaphors and body language can be used.	(Chennamaneni and Teng, 2011; Venkitachalam and Busch, 2012)
Subject matter expert listing	Listing of experts for certain area of knowledge (e.g. process steps and product knowledge in the Biopharmaceutical Industry) for future reference.	(Lipa, Kane and Greene, 2020)
Trial and error	As tacit knowledge is a very individual process, it follows a cycle of trying and self-correcting to be enriched and improved. Employees need to be involved in processes to be able to develop their tacit knowledge. Trial and error is comparable to hands-on practice.	(Liu and Cui, 2012)

8.3 INFLUENCING FACTORS OF THE TACIT KNOWLEDGE TRANSFER (LISTED IN ALPHABETICAL ORDER)

Factor	**Source**	**Explanation**	**Difficulty**	**Influencing area according to Ipe (2003)**
Common language	Haldin-Herrgard, 2000 Joia and Lemos, 2010	Terminology and jargon of knowledge needs to be the same for the sender and recipient to be able to understand each other	As a lot of tacit knowledge is stored in a non-verbal format, employees are not capable of expressing it	Opportunities to disseminate
Community commitment	Rese, Kopplin and Nielebock, 2020	A positive attitude towards the community fosters togetherness, attachment and belonging	Needs permanence in a group to be built up	Motivation to disseminate
Favourable environment for questioning / social climate	Joia and Lemos, 2010 Nakano, Muniz and Batista, 2013	The relationship between employees determines dealing with conflicts and divergent ideas → open and critical dialogue is needed to develop new ideas and visions	Absence of safe environment hinders different opinions and dissemination of tacit knowledge	Motivation to disseminate
Hierarchy	Joia and Lemos, 2010 Abdelwhab Ali *et al.*, 2019	People need to be accessible despite their hierarchical position in the company when their knowledge is needed	Limitation of tacit knowledge transfer by involving formal structures and control systems → hierarchical structures as well as politics hinder communication and transfer of information	Opportunities to disseminate
Individual Time Management	Haldin-Herrgard, 2000 Joia and Lemos, 2010 Nakano, Muniz and Batista, 2013	KT requires time to be experienced and reflected; Employees need a time contingent to disseminate knowledge	Business is evolving fast, but knowledge dissemination takes time → does not fit together well	Opportunities to disseminate

Knowledge storage	Hansen, Nohria and Tierney, 1999 Joia and Lemos, 2010	Tacit knowledge is accumulated experience of employees and related to employees who developed it	Tacit knowledge cannot be stored in databases and manuals like explicit knowledge	Opportunities to disseminate
Knowledge transference	Hansen, Nohria and Tierney, 1999 Joia and Lemos, 2010	Knowledge transference can be focused on the interaction of people (dialogue, relationship) or the reutilisation of codified knowledge (storage in databases)	Relies on technical support and involvement of people	Motivation to disseminate
Management support	Abdelwhab Ali et al., 2019	Knowledge dissemination needs to be supported by the top and middle management to inspire staff	Lack of support can affect the employee's commitment to disseminate knowledge	Opportunities to disseminate
Media	Joia and Lemos, 2010	Uncertainty and ambiguity during the transference of tacit knowledge has to be reduced by the choice of the right communication medium (personal communications, rules, reports etc.)	Culture needs to foster a rich communication that facilitates understanding	Opportunities to disseminate
Mutual trust	Nieminen, 2005 Foos, Schum and Rothenberg, 2006 Joia and Lemos, 2010 McNichols, 2010 Nakano, Muniz and Batista, 2013 Abdelwhab Ali *et al.*, 2019	Trust developed in a social and cultural context is essential to lower the risks and uncertainties for employees to transfer their tacit knowledge	Implementation depends on sharing of social and cultural values	Motivation to disseminate

	Rese, Kopplin and Nielebock, 2020			
Passion and personal commitment / intention to share	Nieminen, 2005 McNichols, 2010 Abdelwhab Ali *et al.*, 2019	Dissemination of knowledge is not only formally supported, but needs to be supported by the individual as well	Personal commitment needs to be internally present	Motivation to disseminate
Power	Haldin-Herrgard, 2000 Nieminen, 2005 Joia and Lemos, 2010	Knowledge can be used to empower employees in the company, it is associated with influence and professional respect and classified as an important asset in the workplace → the value of knowledge is in its accessibility and use	As "knowledge is power", the transfer of knowledge can mean loss of influence and job security to some individuals	Motivation to disseminate
Proximity	Mohajan, 2016	Proximity offers the opportunity for face-to-face meetings	Distance raises difficulties at workplaces	Opportunities to disseminate
Reciprocity	Ipe, 2003 Abdelwhab Ali *et al.*, 2019 Rese, Kopplin and Nielebock, 2020	Understanding that knowledge dissemination is a give and take process	Knowledge dissemination needs to be perceived as fair	Motivation to disseminate
Relationship network	Joia and Lemos, 2010 Nakano, Muniz and Batista, 2013	People who have the knowledge need to identify which colleagues need their knowledge and vice versa to effectively transfer tacit knowledge	Identification, where the knowledge is needed	Opportunities to disseminate
Reward	Haldin-Herrgard, 2000 Joia and Lemos, 2010 Rese, Kopplin and Nielebock, 2020	Encourage people to share their knowledge by rewarding favourable behaviour Rewards can be tangible (promotion, increase in salary etc.) or intangible (reputation)	Systems penalising those who make mistakes discourage innovation	Motivation to disseminate

Structured environment / organisational structure	Nakano, Muniz and Batista, 2013 Abdelwhab Ali *et al.*, 2019	Influences how knowledge gets disseminated trough the organisation; includes complexity, officialism and centralization	Formality, complexity and centralization in general decrease the amount of shared knowledge	Opportunities to disseminate
Type of training	Joia and Lemos, 2010	The type of training determines the prioritization in a company of disseminating tacit knowledge; tailored, time consuming strategies like mentoring and coaching are needed to transfer tacit knowledge	Formal trainings with presentations in class only facilitates explicit knowledge transfer	Opportunities to disseminate
Type of valued knowledge	Haldin-Herrgard, 2000 Joia and Lemos, 2010	Tacit knowledge appears in different forms like know-how, intuition, and personal skills among others → these forms of knowledge have to be valued in the same way as technical knowledge	In some companies' decision making by only logic and reason is preferred	Nature of knowledge

8.4 INFORMATION SHEET

University of Worcester

Version: 1.1

Date: 2022-04-07

PARTICIPANT INFORMATION SHEET AND PRIVACY NOTICE

TITLE OF PROJECT: Identifying the tacit knowledge gems during a technology transfer of a biotech product from Germany into a brand-new facility in the US

Invitation

The University of Worcester engages in a wide range of research which seeks to provide greater understanding of the world around us, to contribute to improved human health and well-being and to provide answers to social, economic and environmental problems.

We would like to invite you to take part in one of our research projects. Before you decide whether to take part, it is important that you understand why the research is being done, what it will involve for you, what information we will ask from you, and what we will do with that information.

We will in the course of this project be collecting personal information. The UK continues to be bound by the provisions of the General Data Protection Regulation which is now the "UK GDPR". Under UK GDPR we are required to provide a justification (what is called a "legal basis") in order to collect such information. The legal basis for this project is "**task carried out in the public interest**".

You can find out more about our approach to dealing with your personal information at https://www.worcester.ac.uk/informationassurance/visitor-privacy-notice.html.

Please take time to read this document carefully.

What is the purpose of the research?
This study aims to explore and identify types of tacit knowledge that are used during a technology transfer in the Biopharmaceutical Industry and to find influencing factors improving the success of the tacit knowledge transfer.

Who is undertaking the research?
Jennifer Dietrich
Doctor of Business Administration (DBA) student
Lab head in Cell line and Upstream Development, Bayer AG; not involved in the Technology Transfer Team
Director of Studies: Robin Bell; University of Worcester
Supervisor: Vessela Warren; University of Worcester

Who is funding the research?
The research is partly funded by Bayer AG.

Who has oversight of the research?
The research has been approved by the Research Ethics Panel for the College of Business, Psychology and Sport in line with the University's Research Ethics Policy. The University of Worcester acts as the "Data Controller" for personal data collected through its research projects and is subject to the UK GDPR and the Data Protection Act 2018. We are registered with the Information Commissioner's Office and our Data Protection Officer is Helen Johnstone (infoassurance@worc.ac.uk). For more on our approach to Information Assurance and Security visit: https://www.worcester.ac.uk/informationassurance/index.html.

Why have I been invited to take part?
You have received this invitation because you are part of the Technology Transfer Team and only individuals directly involved in the transfer can provide the needed information. We are hoping to recruit 28 participants for this study.

How do I take part?
It is up to you to decide whether or not you want to take part in this study. Please take your time to decide and talk to others about it if you wish. Deciding to take part or not will not impact on your work in the Technology Transfer Team.

The process by which you can agree to participate is to reply to this email 14 days after receiving this invitation.
If you do decide to take part, at the data collection stage, you will be asked to sign a consent form.

How can I withdraw from this study after agreeing to participate?
Once you have agreed to participate you can withdraw from the study anytime until 14 days following data collection. If you wish to have your data withdrawn, please fill the provided Forms document with your participant number and your data will then not be used. You will be given the Forms link as well as this number on the date of the interview. The number will be randomly assigned.

What will happen if I agree to take part?
If you agree to take part, you will get an invitation for an individual interview. Prior to starting the interview, you will be asked for your signed written consent form. The researcher will also ask for the permission to record the interview (audio and video).

The interviews are about to last approximately 30-45 minutes and will be conducted via Microsoft Teams video meetings. Interviews will be conducted in your language at work (GER: German; US: English). At the beginning of the interview, the researcher will collect a defined set of personal data that is listed in the following table:

Category	**Details**
Participant number:	
Membership of the SU or RU:	
Time in company:	
Time involved in the project:	
Involved in more than 2 TTs before:	

After the interviews the researcher will do a debriefing and address raised concerns and questions. You will be free to withdraw until 14 days after data collection. The transcript of the interview will be sent to you to check for accuracy.

After the initial interview you will be asked to join the focus group discussions as well. Before starting the focus group discussions, the researcher will do a short briefing to check whether there are questions or uncertainties, or additional information is required after the initial interviews. Like in the interviews, you will be free to withdraw until 14 days after data collection. Focus group discussions will last around 1,5 to 2 hours and will also be conducted via Microsoft Teams. Again, the researcher will also ask for the permission to record the interview (audio and video).
In the focus groups, you and the other participants will probably know each other as you are working together. Therefore, keeping the individuals anonymous is not possible during the focus group discussion. The ground rule for confidentiality (“No one will disclose confidential information shared with the group to people outside the group”) will therefore be strictly respected. The researcher will also do a debriefing at the end of the focus group discussion the reinforce previously agreed ground rules and to address raised concerns.

What are the benefits for me in taking part?

Your contribution in this study will help to add value on the theoretical and practical level. This study will contribute to theoretical work as it addresses gaps around tacit knowledge. It will add additional understanding regarding the tacit knowledge used during a technology transfer in the Biopharmaceutical Industry. It will also highlight influencing factors of the tacit knowledge transfer as well as the influence of tacit knowledge transfer on the whole transfer in a specific context which has not been explored yet. This will help to guide future theoretical work in this direction.
In terms of practical application, the study aims to widen the awareness for tacit knowledge in general in the company and clarify the value of it. This will help the employees to focus on tacit knowledge that contributes to a successful manufacturing transfer in the upcoming technology transfers. The study will also provide practical suggestions to enhance future transfers by taking the influencing factors into account. The combination of the awareness of tacit knowledge and the corresponding influencing factors can lead to the establishment of additional best practices in the company. It might also offer the opportunity for other companies to adjust the results for their needs.
Overall, the study will add new understanding and insight for the academic and practical application in terms of tacit knowledge.

Are there any risks for me if I take part?
The research will not cause any risk for you.

What will you do with my information?
Your personal data / information will be treated confidentially at all times; that is, it will not be shared with anyone other than the project supervisors. It will also not be shared with any third parties specified in the consent form unless it has been fully anonymised. The exception to this is where you tell us something that indicates that you or someone else is at risk of harm. In this instance, we may need to share this information with others; however, we would inform you of this and discuss this with you before doing so.

During the project, all data / information will be kept securely in line with the University's Policy for the Effective Management of Research Data and its Information Security Policy.

We will process your personal information for a range of purposes associated with the project primary of which are:

- To use your information along with information gathered from other participants in the research project to seek new knowledge and understanding that can be derived from the information we have gathered.
- To summarise this information in written form for the purposes of dissemination (through research reports, a thesis / dissertation, conference papers, journal articles or other publications). Any information disseminated / published will be at a summary level and will be fully anonymised and there will be no way of identifying your individual personal information within the published results.
- To use the summary and conclusions arising from the research project for teaching and further research purposes. Any information used in this way will be at a summary level and will be fully anonymised. There will be no way of identifying your individual personal information from the summary information used in this way.

If you wish to receive a summary of the research findings or to be given access to any of the publications arising from the research, please contact us.

How long will you keep my data for?
Your personal data will be retained until the project (*including the dissemination period*) has been completed.

At the completion of the project, we will destroy all data relating to the project.

How can I find out what information you hold about me?
You have certain rights in respect of the personal information the University holds about you. For more information about Individual Rights under GDPR and how you exercise them please visit: https://www.worcester.ac.uk/informationassurance/requests-for-personal-data.html.

What happens next?
Please keep this information sheet.

If you would be interested in taking part, please contact us using the details below and we will be delighted to answer any further questions you have about the research.

Our contact details are:
Jennifer Dietrich diej1_19@uni.worc.ac.uk

If you have any concerns about the project at this point or at any later date you may contact the researcher (contact as above) or you may contact the Supervisor / Principal Investigator / Project Lead:
Robin Bell r.bell@worc.ac.uk
or
Vessela Warren v.warren@worc.ac.uk

Thank you for taking the time to read this information.

If you would like to speak to an independent person who is not a member of the research team, please contact the University of Worcester, using the following details:

Secretary to Research Ethics Panel for College of Business, Psychology and Sport
University of Worcester
Henwick Grove
Worcester WR2 6AJ
ethics@worc.ac.uk

8.5 INFORMED CONSENT FORM

University of Worcester

INFORMED CONSENT FORM
Interviews

Title of Project: Identifying the tacit knowledge gems during a knowledge transfer of a biotech product from Germany into a brand-new facility in the US
Participant identification number for this study:
Name of Researcher: Jennifer Dietrich

I, the undersigned, confirm that:

1.	I have read and understood the information about the project, as provided in the Information Sheet dated 2022-04-07 or it has been read to me.	
2.	I have been able to ask questions about the project and my participation and my questions have been answered to my satisfaction.	
3.	I understand that taking part in this study involves an interview in a Teams based format that will be recorded via audio and video and will be transcribed afterwards. It has to be mutually agreed that the data can be sent back via their email address to me. The data will be stored at the researcher's University of Worcester OneDrive platform. After completion of the study all data will be destroyed according to the valid policies.	
4.	I understand I can withdraw until 14 day following data collection without giving reasons and that I will not be penalised for withdrawing nor will I be questioned on why I have withdrawn.	
5.	I understand that the information I provide will be used for: The researcher's thesis as well as potential presentations, reports or publications	
6.	I agree that my information can be quoted in research outputs	
7.	I understand that my real name will not be revealed, and pseudonyms will be used for quotes.	
8.	The procedures regarding confidentiality have been clearly explained (e.g. use of names, pseudonyms, anonymisation of data, etc.) to me.	
9.	I understand that personal information collected about me that can identify me, such as my name, or where I live, will not be shared beyond the study team.	
10.	I consent to the audio/video recording.	
11.	I understand that other researchers will have access to this data only if they agree to preserve the confidentiality of the data and if they agree to the terms I have specified in this form.	
12.	I voluntarily agree to participate in the project.	
13.	I know who to contact if I have any concerns about this research	

Name of Participant	Signature	Date
Name of Researcher	Signature	Date

8.6 TACIT KNOWLEDGE RESEARCH PUBLICATIONS WITH CORRESPONDING DATA COLLECTION METHODS (IN ALPHABETICAL ORDER BY AUTHOR)

Author	Paper	Study aim	Method	Design
Ambrosini and Bowman, 2001	Tacit knowledge: Some suggestions for operationalization	Definition of the term tacit knowledge and its re-definition, within the context of the resource-based view of the firm, as tacit skills	causal mapping, self-Q and storytelling	Empirical research
Borges, 2013	Tacit knowledge sharing between IT workers: The role of organisational culture, personality, and social environment	Identification of factors that influence tacit knowledge sharing	Questionnaire	Survey
Borges, Bernardi and Petrin, 2019	Cross-country findings on tacit knowledge sharing: evidence from the Brazilian and Indonesian IT workers	Comparison of the factors influencing the tacit knowledge sharing in two different cultures	Questionnaire	Survey
Chilton and Bloodgood, 2008	The Dimensions of Tacit & Explicit Knowledge: A Description and Measure	Assessment of the degree of tacitness of different dimensions of tacit and explicit knowledge	Questionnaire	Exploratory study
Dinur, 2011	Tacit Knowledge Taxonomy and Transfer: Case-Based Research	Examination of tacit knowledge and provision of insights into what makes it tacit	In-depth interviews	Case study
Foos, Schum and Rothenberg, 2006	Tacit knowledge transfer and the knowledge disconnect	Identification of key relationships that influence the transfer of tacit knowledge	In-depth interviews Survey	Case study
Haldin-Herrgard, 2003	Mapping Tacit Knowledge with "Epitomes"	Creation and testing of a method to map organisation-specific knowledge and systematic collection of Epitomes of Tacit Knowledge	Semi-structured interviews	Case study
Joia and Lemos, 2010	Relevant factors for tacit knowledge transfer within organisations	Identification of relevant factors for the tacit knowledge transfer	Bibliographical review and questionnaire	Single exploratory case study
Lipa, Kane and Greene, 2019	Effective Knowledge Transfer During Biopharmaceutical Technology Transfer - How Well Do We Do It?	Exploration of the current state of how KM enables technology transfer	Literature review Survey Expert interviews	Exploratory study
Nakano, Muniz and	Engaging environments: tacit knowledge sharing on the shop floor	Identification of factors that facilitate tacit knowledge sharing	Semi-structured interviews;	Case study

Batista, 2013			informal conversations and on-site observations	
Rese, Kopplin and Nielebock, 2020	Factors influencing members' knowledge sharing and creative performance in coworking spaces	Identification of factors that influence tacit knowledge sharing	Questionnaire	Structural equation modelling
Salleh *et al.*, 2013	The extent of influence of learning factors on tacit knowledge sharing among public sector accountants	Identification of the influence of learning factors for tacit knowledge sharing	Questionnaire	Survey

8.7 Full Adjusted List of the Semi-Structured Interview Questions

Research question	Question #	Initial interview question	Adjustment
Introducing questions	Q1	Can you tell me about your role in the project? What is your contribution to the TT?	No adjustment
RQ1 - Which types of tacit knowledge are used during a technology transfer between a German development department and an US manufacturing department in the BI?	Q2	In your view, what counts as knowledge?	**If you think about your daily work, what counts as knowledge for you?**
	Q3	What knowledge is needed in your view to robustly manufacture a biologics asset?	Position of question adjusted to enhance flow of interview **(position has been Q4; now Q3). Connection to the general knowledge question felt more natural during the interview.**
	Q4	What knowledge is most important to you and why?	No adjustment
	Q5	How important is knowledge during a technology transfer and why?	No adjustment
	Q6	How is the knowledge needed to for manufacturing in general transferred? Can you please provide examples on easy to transfer parts and hard to transfer parts?	No adjustment
	Q7	At which stages of the TT do you exchange knowledge? And how is it used? Can you please give an example?	No adjustment
	Q8	Are there different types of the knowledge used or needed by the sending and receiving unit? Can you give me one example each?	No adjustment
RQ2 - What influences the knowledge transfer between the German development department and the US manufacturing department in the BI?	**Q9**	Can you tell me an example of what has caused knowledge transfer failure during a technology transfer?	Position of question adjusted to enhance flow of interview **(position has been Q13; now Q9). As participants were already talking about the TT, it was easier to put this question into context.**
	Q10	Can you tell me an example of what has caused knowledge transfer success during a technology transfer?	Position of question adjusted to enhance flow of interview **(position has been Q14; now Q10). As participants were already talking about the TT, it was easier to put this question into context.**
RQ1 - Which types of tacit knowledge are used during a technology	**Q11**	What are the main challenges in a TT to transfer knowledge?	No adjustment

transfer between a German development department and an US manufacturing department in the BI?			
RQ3 - Which practices can be applied during a technology transfer in the BI to support the dissemination of knowledge?	**Q12**	Which practices sharing knowledge do you know and did you use during technology transfers? Can you please give some examples?	No adjustment
RQ1 - Which types of tacit knowledge are used during a technology transfer between a German development department and an US manufacturing department in the BI?	**Q13**	What is special in this knowledge transfer due to the current Covid-19 situation? How is it influencing the knowledge dissemination?	No adjustment
	Q14	How would you rate the current knowledge dissemination process during a TT and why?	As the wording "rate" indicated a more quantitative use of this question, it was changed to: **What is your overall summary of the transfer? Would you approach anything different for your next TT?** As this question was considered a good closing question it was moved to the end of the interview **(position has been Q10; now Q14).**

8.8 CONTENT ANALYSIS PILOT TESTING AND EXECUTION

8.8.1 Pilot testing of the epitomes - Preparation of the Content analysis in order to answer RQ1

With the first two pilot interviews a pilot testing for the coding units had been conducted. The goal of the pilot study was to identify the feasibility of using the ETKs by Haldin-Herrgard (2003) as the coding units for the content analysis. During the translation process of the ETKs, the researcher deemed the single epitomes as clear and easy to apply units. This has been proven right for epitomes that are not composed of two or more words or epitomes consisting of a noun and an adjective. These are often too specific to be found in a transcript. One example is “communication skills”: this is certainly an important point in the interviews, but participants did not necessarily call it “Kommunikationsfähigkeit” (the German translation of “communication skills”) but rather say “die kommuniziert sehr gut … (Participant 730-SU)” (“*she communicates very well…*”). In the other transcript used for the pilot study, an example in a similar direction can be found “… so this kind of communication is very bad (Participant 739-RUC)”. These examples show that the participants mentioned the skill in other words. Still, for the content analysis interpretation cannot be applied, which means this mentioning did not occur in the evaluation of the content analysis. However, this kind of analysis was done in the second step of the analysis (thematic analysis) and hence, was captured there. During the process of analysis, it was not easy for the researcher to ignore these findings. Therefore, they were marked in a different colour in the transcripts to not forget about them in second step of analysis. Another example that came up during the pilot testing was “experience”. In the ETKs experience can be found in the following forms: “Personal experience”, “Common in experience” and “Pattern of experience”. Again, meeting the exact wording is most often not the case. One example is “…, der Erfahrung des Einzelnen (Participant 730-SU)” (“*…, the individual experience*”), which would correspond to personal experience if interpretation would be allowed. As this was not the case, to capture these results anyways in the content analysis, the researcher decided to cluster the three different ETK into “experience”. The same clustering was applied to other epitomes which occur in the list of Haldin-Herrgard (2003) in different nuances. The chosen clusters are shown in Table 19.

Table 19: Clusters applied for ETKs after the pilot testing of the content analysis.

Cluster	**ETKs clustered**
Experience	Personal experience Common in experience Pattern of experience
Ability	Ability Collective ability
Intuition	Intuition Intuitive knowledge
Insight	Insight Flashes of insight
Norms	Unconscious norms Shared norms Norms
Belief	Belief Common belief Shared belief
Know-how	Know-how Collective know-how
Competence	Inner competence Personal competence
Values	Values Shared values
Routines	Routines Routinized knowledge

The application of clusters as shown in Table 19 led to a reduction of the ETKs from 92 to 79. The level of detail with regards to the types of tacit knowledge used during the technology transfer was increased during the second step of the analysis.

Another interesting finding from the pilot study had been, that for some ETKs the singular and plural are needed e.g., “perspective/perspectives” or “capability/capabilities”. Hence, the corresponding singular or plural form had been added to the search list.

8.8.2 Execution of the content analysis for all semi-structured interviews in order to answer RQ1

In summary, the whole transcripts were checked for the presence of these 79 codes. The found ETKs were recorded in a table and linked to the transcript. No distinct number of mentioning per transcript was needed for the analysis as only the types of tacit knowledge were of interest for this study. Hence, not the number of mentioning was recorded but the presence of the ETK in general in the transcript. The found epitomes and their occurrence in the data sets is shown in Table 20.

Table 20: Found ETKs during the content analysis.

Epitome of tacit knowledge (ETK)	**No. of participants mentioning the ETK**
Ability	5
Skills	5
Embodied Knowledge	1
Capability	5
Communication Skills	1
Insight	3
Know-How	3
Expertise	4
Feeling	3
Gut-Feeling	2
Attitude	2
Opinion	5
Perspectives	3
Predictions	1
Experience	18
Best Practice	3
Knowledge Base	2
Creativity	1
Culture	4
Get a Feeling for	1
Competence	1
Routines	2
Rule-of-Thumb	1
Taste	1
Techniques	1
Thoughts	3
Understanding	13

Table 20 shows how many participants mentioned the different ETKs during the semi-structured interviews. Overall, 27 ETKs could be identified.

8.9 EXECUTION OF THE THEMATIC ANALYSIS

8.9.1 Familiarization with the data set

This stage of the thematic analysis was intended to get familiar with the data. As mentioned before, the interviews were conducted in a Microsoft Teams based format by the researcher. By conducting the interviews herself, the researcher already captured the main messages and also nuances while talking to the participants. Thoughts, as well as detected patterns, were directly noted down in a Microsoft Excel log by the researcher to have them available for the next stages.

After conducting the interviews, they were transcribed into Microsoft Word format. During the process of transcribing the data, the researcher recapitulated the interviewing process again and added further notes to the Microsoft Excel log if required. The repeated listening to the interviews and capturing in a written format led to deeper familiarization with the data. The researcher used denaturalized transcription to clean up filling words and repetitions out of the transcripts, as they are not needed for either the content analysis nor the thematic analysis. The edited versions of the transcripts were easier to read and hence, easier to code. After transcribing the interviews, the transcripts were stored in the researcher's university Microsoft SharePoint in a structured way. These transcripts were then loaded into NVivo 12 for further data analysis.

Nevertheless, familiarization with the data set was not finalized by this stage of the thematic analysis approach. With each following step, the researcher got a deeper understanding of the data.

8.9.2 Coding and identifying / refining themes for the types of tacit knowledge used during technology transfers in order to answer RQ1

The coding phase is a reflective process in which the researcher needed to become even more familiar with the data and to revisit the complex data set multiple times (Nowell *et al.*, 2017). The coding itself was intended to simplify the data set. All 21 interviews were coded in NVivo12. After having coded close to half of the transcripts, the number of new codes found in the different transcripts decreased. Still, new codes were also found in the second half of the transcribed data. In addition, it made sense to confirm the findings of the first half of transcripts with the second half of the data to also show data saturation.

In the first phase of the coding, the researcher used known codes from the framework of the ETKs by Haldin-Hergard (2003). To do so, the different ETKs were read thoroughly and searched for in the data sets. Some of the ETKs had already been identified during the content analysis, therefore, the following table shows ETKs that have additionally been found during the coding process of the thematic analysis.

Table 21: Known ETKs from Haldin-Herrgard (2003) identified in addition to the content analysis by coding the interview data.

Automatic knowledge	Organisational mind
Beliefs	Prediction
Coordination skills	People knowledge
Emotional knowing	Sense making
Estimations	Shared norms
Feels as…	Shared values
Negotiation skills	Thinking in practice / hands-on
Non-analytical behaviour	Tricks

In Table 21, it can be seen, that 16 additional ETKs compared to the content analysis have been found. Some ETKs were easy to identify during the coding process as the participants only used a slightly different wording to describe the type of tacit knowledge they are using. One example for this is “sense making”. During the content analysis, this ETK has not been identified as no participant used the exact same wording. Instead, participants were saying “…makes sense (Participant 122-RU)”, which is more frequently used during direct speech. Another example in the same direction is “coordination skills”. In this case the participant was saying “… the facilitators were very good about coordinating if one group … (Participant 297-RU)” rather than using the term “coordination skills” directly. The two examples show the limitations of the content analysis, when only looking for specific wordings and also emphasize the importance of adding a deeper data analysis to identify all tacit knowledge used during the technology transfer. During this deeper analysis ETKs like “thinking in practice” and “emotional knowing” came up. These two ETKs are interesting, because synonyms were used by the participants to describe them. For “thinking in practice” the participants often used the term “hands-on” instead, whereas for “emotional knowing” some participants also referred to “empathy”. Others like “non-analytical behaviour” or “organisational mind” needed more interpretation of the data to be identified.

In addition to this, it was possible to split the cluster “experience” into more detail again. For the content analysis it made sense to look at experience in a broader context, but for the thematic analysis it helped to go into more detail again. The found subcategories of

"experience" were both ETKs "personal experience" as well as "common in experience". Participants were mentioning subject matter expert knowledge with regard to the personal experience, whereas "common in experience" covered technology transfer experience as well as knowledge derived from the platform processes. Subject matter expert knowledge covers the two points mentioned for "common in experience" as well. Still, it goes beyond as it also comprises of status of individual training and area of expertise. "Pattern of experience" could not be found directly. Still, the researcher found the new ETK "Platform and process knowledge", which in the researcher's mind is a synonym for "pattern of experience". It is still listed in Table 22 with the newly found ETKs as it is very specific to the Biopharmaceutical industry and does not cover general "patterns".

As the researcher assumed more than the ETKs mentioned by Haldin-Herrgard (2003) within the data, the researcher in-vivo coded these new types of tacit knowledge to have them available whenever found.

Table 22: New codes for the types of tacit knowledge used during a technology transfer identified through thematic analysis.

Adaptation to changes	Mindset
Advices	Observations
Assessments	Organisational knowledge and business practices
Assumptions	Process and platform knowledge
Attention to detail	Requirements
Expectations	Self-reflection
Global understanding of processes	Shared history
Interpretation	Tribal knowledge
Lessons learnt and failure	Visual learning (Videos and photo)

When looking at Table 22, it can be seen, that 18 new ETKs have been found during the analysis. In total, 63 relevant codes were identified during the thematic analysis. Three additional codes had been identified during the coding of the transcripts, which have been merged with other codes as they were describing the same phenomenon. "Joint history" had been merged with "shared history", "considerations" had been assigned to "thoughts" and "empathy" had been allocated to "emotional knowing". As for the author it seemed easier to describe them when grouped into categories, themes have been identified to cluster the new ETKs.

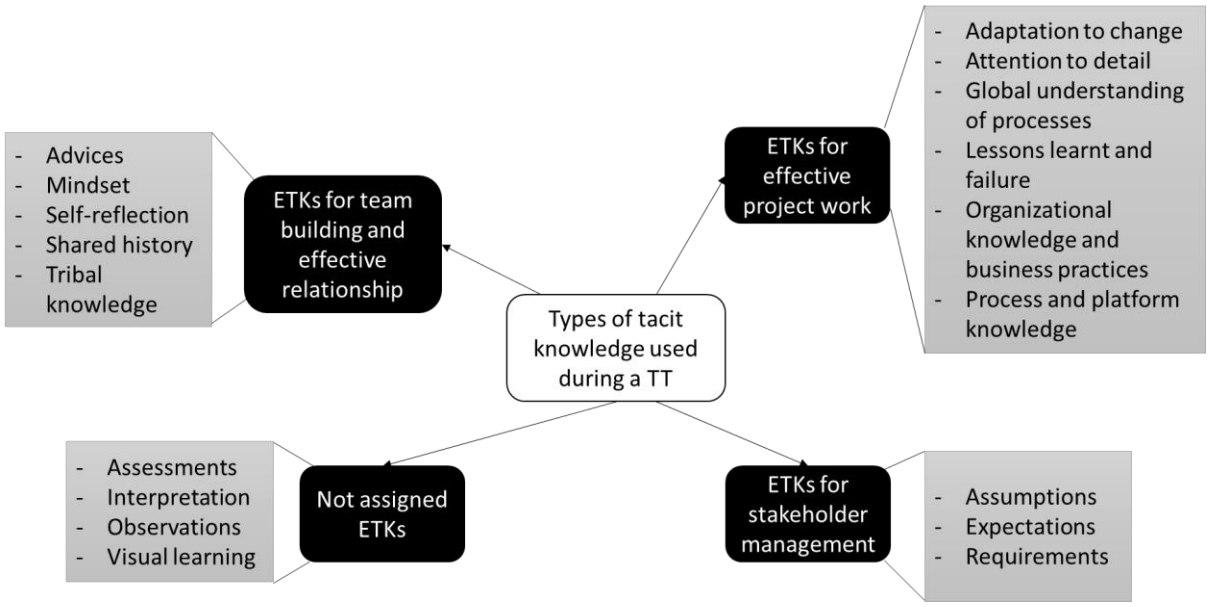

Figure 24: First themes for the new codes (ETKs) found during the thematic analysis in order to answer RQ1.

The mind map shows, that the new ETKs can be mainly categorized into “team building and effective relationships”, “effective project work” and “stakeholder management”. Examples for the first category “ETKs for team building and effective relationships” are “mindset”, “self-reflection”, “shared history” and “tribal knowledge”. All of these ETKs help to grow as a team and to get better while working together. The cluster of ETKs related to the “ETKs for effective project work” is even bigger. Here ETKs like “adaptation to change”, “attention to detail”, “global understanding of processes”, “lessons learnt and failure”, “organisational knowledge and business practices” and “process and platform knowledge” are examples. The next big cluster for a theme, that also influences the transfer is the “ETKs for stakeholder management”. Third parties are having a big impact on the effectiveness of the technology transfer. Hence, ETKs like “assumptions”, “expectations” and “requirements” are of importance. These attributes are important to know to fulfil all the needs from functions involved in a transfer. In general, most of the ETKs found are specific to the technology transfer in the Biopharmaceutical Industry. This was expected as the study was aiming to gain more insight into this field. Some new ETKs like “assessments”, “interpretations”, “observations” and “visual learning” fall into the category or theme of “not assigned ETKs”. For these codes, the themes had to be refined in the next step of the analysis. In addition, the codes identified matching the Haldin-Herrgard (2003) ETKs also needed to be included into the themes. All ETKs identified already during the content analysis were not added, as these are discussed in the content analysis results section.

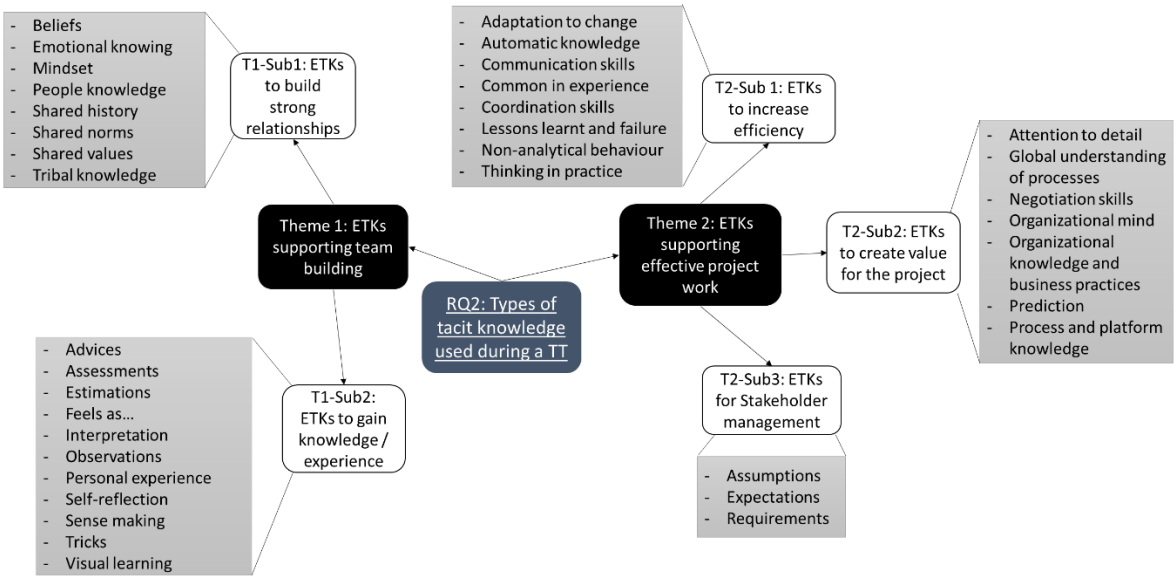

Figure 25: Revisited themes and subthemes allocated to the codes identified through the thematic analysis for the types of tacit knowledge used during a TT in order to answer RQ1.

In the mind map, it can be seen that two main themes evolved for the codes identified. The first theme is about the team needed for technology transfer and the second theme is about the effective project work in general.

Theme 1 “ETKs supporting team building”: This theme includes building of relationships by gaining trust through shared values, norms and history. In addition, these relationships are formed by getting people together who are willing to develop joint mindsets and beliefs. On the other hand, this theme also includes the development of individuals within the group by gaining knowledge and experience. This can go along with other members of the team offering advices and tricks or through self-development by observation or self-reflection. Hence, for this theme, the following subthemes have been identified:

- T1-Sub1: ETKs to build strong relationships
- T1-Sub2: ETKs to gain knowledge / experience

Theme 2 “ETKs supporting effective project work”: This theme is about increasing the efficiency of the project and the transfer by communicating and coordinating all the necessary tasks well. In addition, it is also about creating value by paying attention to detail and using the already existing process and platform knowledge that is available in the organisation. As different functions are involved in technology transfers, this theme is also about stakeholder

management. This leads to the following subthemes covered by the cluster “ETKs supporting effective project work”:

- T2-Sub1: ETKs to increase efficiency
- T2-Sub2: ETKs to create value for the project
- T2-Sub3: ETKs for Stakeholder management

A detailed discussion and depiction of the themes and subthemes is provided in the results and discussions chapter. A similar exercise as for the types of tacit knowledge used had been performed to find influences of the knowledge dissemination. The corresponding data analysis is shown in the next section.

8.9.3 Coding and identifying / refining themes for the influencing factors of the knowledge dissemination during technology transfers in order to answer RQ2

For the initial coding, the researcher identified the important elements from the semi-structured interviews by reading through the transcripts. No underlying framework had been used. The data was searched for influences of the knowledge sharing in general. All codes were generated from scratch out of the data sets. The codes found within the documents are shown in Table 23.

Table 23: Codes identified for the influences of the knowledge dissemination mentioned in the interviews (in alphabetical order).

atmosphere and team spirit	non-competitive environment
awareness of constrains and limitations	non-silo thinking
being honest and real	openness
body language and emotions	feedback culture
clear priorities	opportunity to share
collaboration	ownership
commitment and availability	personal contact
common goal	possibility for self-development
communication and transparency	power and politics
company and team culture	pragmatism
complexity	problem-solving mentality
creativity	professionality
culture	project management
data storage	proximity
decision making speed	relationship
defined procedures and SOPs	rewards and recognition
empathy	roles and responsibilities
engagement	seeing the bigger picture
environment to ask questions	stakeholder
equipment fit	standardisation

escalation routes	structure
failure culture	team composition
familiarity and rapport	team consistency
flexibility	technical tools and visualization
fun	time management and resource allocation
hierarchy	time zone
language	trust
management of expectation	willingness to align
management of uncertainty	willingness to help
media or structure to share	willingness to share
motivation and impact	

The table shows that, in total, 61 codes were identified during the initial step of analysis. During the coding two additional ones were identified, namely “prioritization”, which had been merged with “clear priorities” and “visual learning” and was deleted as it was not considered a real influencing factor anymore after having reviewed it. It can be seen that the codes are either related to individual skills of team members, the team itself or to the project itself and the corresponding project management. As the found codes depict the basic elements for further analysis of the data, they were grouped into initial themes to structure them. This grouping was done by interpretation of the data by the researcher.

Table 24: Initial identified themes for the influencing factors of the knowledge dissemination.

Individual influences	**Project management related influences**	**Team related influences**	**Influences not assigned yet / undefined**
awareness of constrains and limitations	clear priorities	atmosphere and team spirit	data storage
being honest and real	common goal	communication and transparency	defined procedures and SOPs
body language and emotions	complexity	company and team culture	equipment fit
collaboration	decision making speed	environment to ask questions	escalation routes
commitment and availability	management of expectation	failure culture	fun
creativity	management of uncertainty	familiarity and rapport	hierarchy
culture	project management	feedback culture	language
empathy	roles and responsibilities	relationship	media or structure to share
engagement	time management and resource allocation	team composition	proximity
flexibility		team consistency	non-competitive environment

motivation and impact		trust	non-silo thinking
openness			opportunity to share
willingness to align			ownership
willingness to help			personal contact
willingness to share			possibility for self-development
			power and politics
			problem-solving mentality
			rewards and recognition
			seeing the bigger picture
			stakeholder
			standardisation
			structure
			technical tools and visualization
			time zone

In Table 24 it can be seen, that a large number of codes were not easy to assign to the three themes “individual influences”, “project management related influences” or “team related influences”. It became clear, that it was hard to differentiate between “project management related influences” and “team related influences” as they have intersections. “Escalation routes”, “hierarchy” and “seeing the bigger picture” are some examples of codes that could not be assigned due to the fact that they would fit in both buckets. In addition, technical and environmental factors like “proximity”, “time zone”, “data storage”, “technical tools and visualization” etc. did not fit into the initial themes. The same goes for motivational aspects like fun and rewards and recognitions. These could also not be placed in any of the initial themes. Another topic that come up during the first mapping was, that there were different codes identified that were related to culture. Hence, having an own theme covering these cultural aspects is required when refining the themes. The first structure helped the researcher to detail out themes and sub-themes better.

To redefine the themes, a mind map was used to visualize the outcome. This mind map can be found in the following mind map.

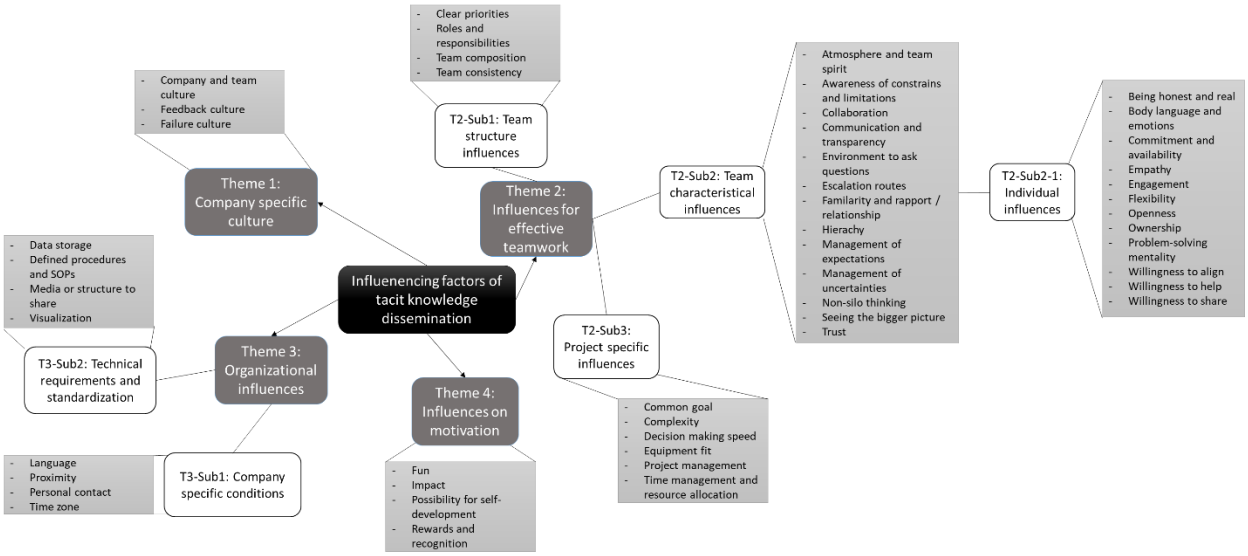

Figure 26: Redefined themes for the influences of knowledge dissemination in order to answer RQ2.

When rethinking the structure of the influences identified, the mind map presented came up. Four main themes were recognized, which include “company specific culture”, “influences for effective teamwork”, “organisational influences” and “influences on motivation”.

The cluster “company specific culture” includes different forms of culture like company, feedback and failure culture and hence, does not have any subtheme.

“Influences for effective teamwork” forms the biggest theme and includes individual factors like “flexibility”, “commitment” and “willingness to align/help/share”, but also structural and characteristically aspects related to the teams e.g. “roles and responsibilities”, “team consistency”, “collaboration” and “management of expectations and uncertainties”. The last facet covered in this cluster are the project specific factors. These include “common goals”, “project management” as well as “time management and resource allocation”. Hence, the following subtheme occur for the theme “influences for effective teamwork”:

- T2-Sub1: Team structure influences
- T2-Sub2: Team characteristical influences
    - T2-Sub2-1: Individual influences
- T2-Sub3: Project specific influences

The next theme identified was “organisational influences”. In this cluster technical requirements and standardized procedures like “data storage”, “equipment fit” and “defined procedures and SOPs” were mentioned. The theme also of course includes the company

specific conditions, which include the “language” spoken, but also the “proximity” of the teams as well as the “time zone” the teams are working in. In general, the following subthemes can be noted for the theme “organisational influences”:

- T3-Sub1: Company specific conditions
- T3-Sub2: Technical requirements and standardization

The last theme mentioned in the mind map are the “influences on motivation”. These include “fun”, but also “rewards and recognitions”. For this theme, no subthemes were identified.

A detailed description and discussions about the themes and subthemes found during the analysis is located in the results and discussion chapters of this thesis. Additionally, practices and methods for the knowledge dissemination had been identified with TA. This process is described in the next section.

8.9.4 Identification of practices, methods and techniques for the knowledge dissemination used during the technology transfer in order to answer RQ3

To search the data derived from the semi-structured interviews for the practices used during a technology transfer, the answers for Q12 from the interview guide: “Which practices sharing knowledge do you know and did you use during technology transfers? Can you please give some examples?”, as well as Q6: “How is the knowledge needed for manufacturing in general transferred?” were analysed in detail. The following practices could be identified from the semi-structured interviews via coding:

Table 25: Practices and methods used for knowledge dissemination mentioned in the semi-structured interviews (in alphabetical order).

Knowledge transfer practices	**Short explanation**
Alignment meetings prior to the transfer	Decide on used platforms prior to starting the transfer to have a common basis.
Best practices	Capture knowledge of process steps and interactions in documents to have guidelines in place for the transfer.
Communication channel	Use Microsoft Teams to exchange short messages and to do formal and informal video calls.
Decision tracker / Q&A tool	Capture decisions, as well as questions, in a document that is available for all team members so that they can access it to understand the rationale behind decisions and see if their question had already been asked before.

Detailed process descriptions	The sending unit should provide detailed process descriptions as a basis for the discussion of the process parameter to be transferred in the TT.
Detailed process presentations	Prior learnings and failures should be presented at the beginning of the transfer. That prevents the receiving unit from conducting the same mistakes again.
Exchange platforms	Use of Microsoft Teams and SharePoint to exchange documents. The tools have the advantage that more than one team member can access the document at once.
Face-to-face meetings / workshops	Dedicated meetings in the same time-zone force team members to spend the dedicated amount of time in a focussed way on the project. In addition, face-to-face meetings/workshops help to foster interactions between the team members
Feedback loops	Perform regular feedback loops to exchange learnings on both sites. New insights on the RU are also helpful for the SU and vice versa.
Hands-on trainings / Training on the job	Learn process steps from people who have already run the process and be able to gain your own practical experience.
Ice breaker prior to starting a meeting	Talk about small personal things in the beginning of a meeting to create a good atmosphere for professional discussions.
Informal parts within meetings	Coffee chats and breaks within meetings help to build trust.
Kick-off meetings	Build relationships via Pizza-Parties; establish meetings to get people informally into contact.
Lessons learnt	Discuss learnings from the current transfer to be able to apply them for the next transfer.
Offline exchange via documents / email	Use Microsoft SharePoint and Teams to answer questions during the working hours of the sending or receiving unit without a meeting. This helps to keep a better work-life balance for multinational teams.
One-on-one meetings	Use 1:1 meetings to provide feedback and allow team members to ask questions they are afraid to ask in bigger groups.
Onsite visits and short-term assignments	Transfer knowledge by visiting and watching the process to be performed at the other site.
Professional tools to track data and process parameter	Use modern data tracking tools to exchange and compare process parameters used with one klick.
Risk and gap assessments	Do a theoretical assessment of risks and gaps during the TT and use the standardized documents as a start for discussion.
Standardized documentation	Use standardized documents for transfer masterplans, risk assessments etc. so that all team members are used to the structure and synergies with other processes can be used.
Standardized meetings	Have a meeting series in place that is blocked in all team members calendars to have a routinized schedule for the TT.

Tracking lists	Track the status of documents that are needed for the transfer as well as changes that occur in these documents.
Use of digital tools	Digital sharing of screens / open up screen for remote access to be able to discuss data in depth and to also let another expert have a closer look.
Videos and photographs	Be able to present detailed photos and videos of certain devices or process steps rather than just writing or talking about them.
VR headsets	Use VR googles to do a live demonstration of the process for team members who cannot be onsite in the labs and show details if required.

Table 25 shows 25 practices that the participants mentioned during the semi-structured interviews. Most of these practices were used during the transfer, but in addition participants mentioned practices they knew from previous transfers e.g., "pizza parties as a kick-off" or practices they could imagine to use in the future like "VR headsets" to perform live demonstrations of process steps. Overall, the researcher viewed the following themes as relevant to the found practices: Technical tools, meetings, documents and visualization. With these themes, the following map was established:

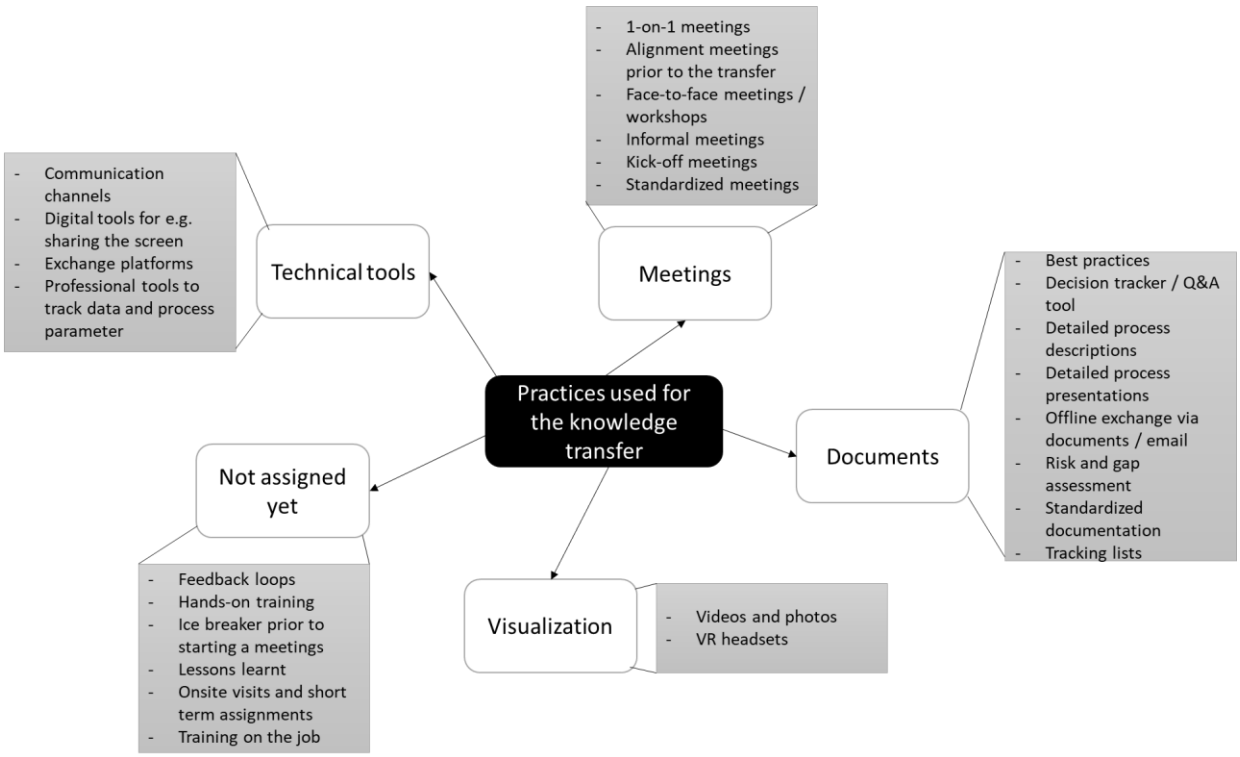

Figure 27: Initial themes to group the practices found during the semi-structured interviews in order to answer RQ3.

With regards to the assignments of the codes to the themes, it can be seen that most of the codes fitted well into the initial coding. However, the codes around social interaction like "ice

breaker" or "feedback loops" had not been covered yet. The same goes for practical work-related topics e.g., "training on the job" or "onsite visits". Hence, the initial themes had to be adjusted in this direction. The adjusted themes can be found in the following mind map.

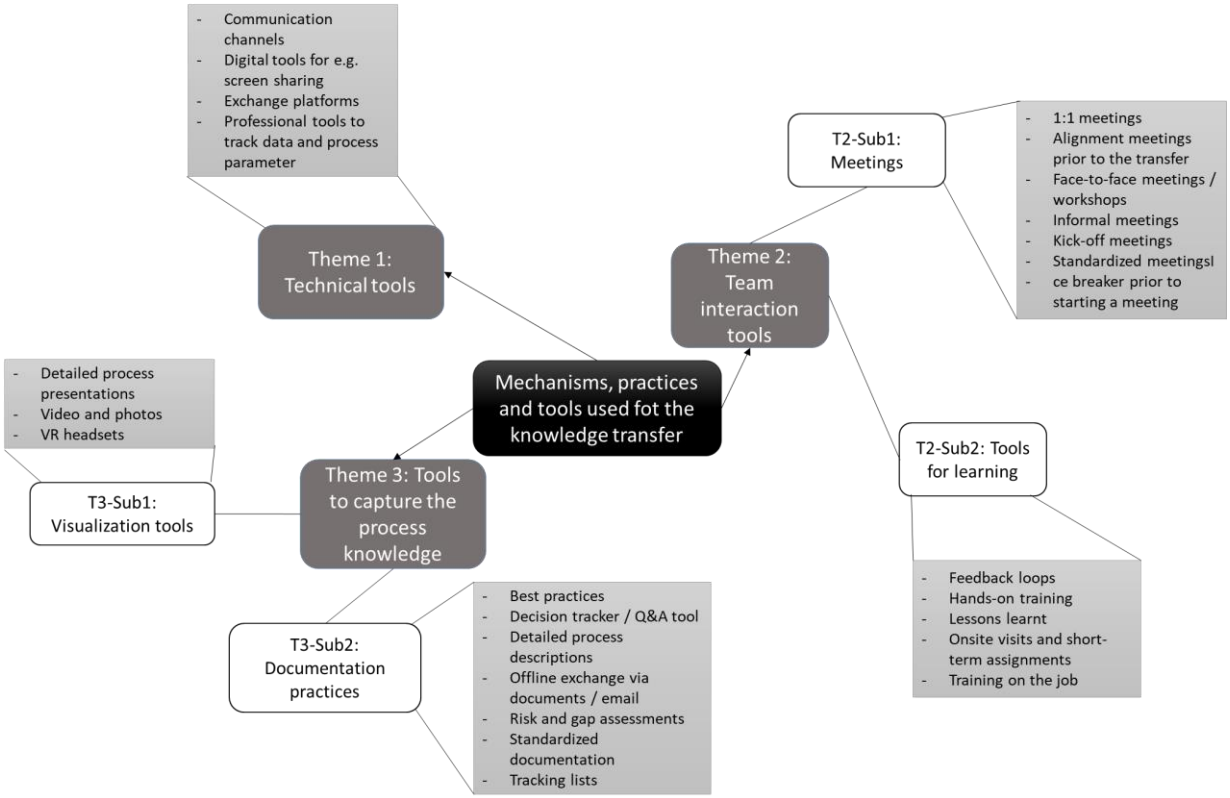

Figure 28: Adjusted themes to capture the practices mentioned during the semi-structured interviews in order to answer RQ3.

After restructuring the themes, it can be seen in Figure 28 that all codes could be assigned to a topic. The cluster for "technical tools" (Theme 1) remained the same and covers digital and professional tools to capture the knowledge.

The second theme "Team interaction tools" covers now the meeting landscape, but also includes practices to foster learning and the social interaction. Therefore, this theme involves two subthemes:

- T2-Sub1: Meetings
- T2-Sub2: Tools for learning

The practices for documentation and visualization of knowledge had been combined in theme 3 "Tools to capture the process knowledge". Hence, the two of them form the subthemes for T3:

- T3-Sub1: Visualization tools
- T3-Sub2: Documentation practices

In addition to analysing the semi-structured interviews, the focus group discussion data was used to confirm and complement the findings for RQ2 and RQ3. The process of analysis is described in the following section.

8.10 DATA ANALYSIS PROCESS FOR THE CAUSAL MAPPING

8.10.1 Data analysis of the focus group interviews in order to answer RQ2

After the transcription of the focus group discussions, the researcher used the questions from the onion model for the causal mapping as a tool to visualize the data. As depicting all influences and topics mentioned on circles was not well-arranged, the researcher decided on a table-based format to present the data.

The following tables show the data generated from the focus group interviews. A green colouring of certain wordings indicates influences that have been found during the discussions for the tacit knowledge dissemination. Blue colouring marks practices and techniques to disseminate knowledge.

Table 26: Data derived from the sending unit's focus group discussion analysed by causal mapping.

Which factor influences a good tacit knowledge transfer?	**Who's/What's influencing this factor?**	**Example**	**Story / more detailed insight / methods that correspond to the topic**
All relevant functions are represented within the team → input from all relevant functions given / counterparts on SU and RU available (resources)	TDT Lead or leadership of the functions → early discussion from higher management to identify Leaders and Team for the TT (support from management)	Not for all relevant functions a counterpart had been nominated from the SU and the RU at the kick-off due to the situation that a transfer from development to the new manufacturing unit had never been done before → no direct exchange possible; no clear contact person	Informal and spontaneous meetings discuss function specific topics with FTEs possible when counterparts given Some new teams were not sure about their responsibilities which made it hard to assess problems and to quickly go forward with the transfer
Catalysator / facilitator function in between SU and RU; clear project management	Involvement dependent on project stage (e.g. phase 1/2/3, commercial etc.); specified in SOP	Push from receiving unit to install the function to be able to reduce workload; Standardized meeting structure which made it easy to know which action items and tasks had to be delivered Coordination through structuring of meetings	Independent decision making and networking between functions given Collection of open action items and questions
Clear roles and responsibilities	Overarching steering meeting to check for capacities of functions as well	Clear definition of TDT lead, tech transfer lead and consulting functions from other departments that has been collaboratively aligned; involvement of different	No competition between team members in e.g. leadership functions as everybody was aware of his or her role

	as defining the roles and responsibilities	levels within discussion; worked well for the majority of the teams	For some roles however r&r were not clear as many functions were involved → nobody wanted to take responsibility for a certain topic and the atmosphere with the team became worse as everyone wanted to handover tasks
Team rapport	Scope of transfer / management	Involved colleagues from the development departments know each other, whereas the teams from the manufacturing unit had not been involved in a transfer with this group before → people had to get to know each other	Certain process steps needed to be discussed in detail and the taxonomy had to be clarified for the new team members; colleagues from the development departments know about the steps and taxonomy due to previous transfers No joint history; more explanation necessary; team kept up working to enable a successful transfer
Trust	Language and mutual understanding	Informal messages via Teams "can we quickly talk?"; trust helps to enable quicker exchange	Very detailed discussions about certain process steps cannot be discussed in whole team meeting → more effective in 1:1 that are more or less spontaneously triggered
Willingness to help / support within one unit & cooperative environment	Team members (intrinsic factor)	Everybody within the team was willing to help out during periods of vacation and illness Clear commitment of all team members seen during the transfer	Non-GMP colleagues stepped in for questions when GMP colleagues were out of office and vice versa
Willingness to help / support the other unit & cooperative environment	Openness to discuss critical aspects and willingness to receive help; personnel exchange needs to be beneficial and wanted from both sites' management	Transfer of consumables and material had been conducted successfully → necessary due to long lead-times due to Covid	Material transfer has been conducted successful; exchange of personnel could have been done more frequently/ with less discussions → difficult due to Covid-situation and build-up of facility
Commitment and possibility to exchange	Creation of exchange platforms like	Meeting created possibility to ask questions as well as exchange about important	Meeting helped to create more openness between SU and RU and led to a good

	e.g. regular meetings	topics → it showed that help was offered from the SU Clear route of how to get information (room to exchange)	atmosphere within the team → teams changed behaviour from separated groups prior to meeting establishment compared to afterwards Open atmosphere to enable critical discussions
Language & Taxonomy	Every team member has to fluently speak English	Samplings plans, process descriptions etc. available in English Exchange between team members possible → necessary to built trust and understanding	All documents have already been available in an English version before the transfer → no additional effort of translation needed → technicians in Germany see this as a chance to develop their skills to get more fluent in English (motivation) Previous efforts to align the taxonomy helped to create a better understanding
Experience	Open communication between SU and RU about status quo of knowledge and possible challenges	Teams with less experience on transfers try to mimic the process 1:1 which makes it easier for the transfer but issues just came up later after first trails, which then had to be solved by troubleshooting → prolonged the transfer process	New facility with new equipment led to new challenges within the transfer → no 1:1 transfer possible due to lack of facility fit When having teams with much experience the SU and RU are able to learn both from each other → open discussions whether other ways are more preferable
Clear structure / working in one unit	Functions need to know their responsibilities and need to have a common goal Hierarchy in company	Units usually have SOPs that describe the structuring of a team When working in one unit, the overarching goal for the transfer is the same	Freedom from higher management to trigger all the actions required to achieve the common goal → easier as only management of one organisation was involved → Empowerment
Team culture	Team members	Meetings with members from different sites to discuss projects and to meet informally afterwards helped to get to know each other and to build a joint culture	Dedicated exchange meeting created understanding for each other. E.g. what is different at the sites and how to handle this

Proximity	Company structure	Face-to-face contact fosters fast building of trust The closer the teams are the easier to meet and communicate directly	Transfers at one site are equipoised and follow a standard procedure that is accepted by all members; teams know each other well and trust each other Story from another transfer shared, which was conducted at one site: People who wanted to see a certain assay just went into the neighbour-building to see how things were done hands-on
Time slots in which can be communicated	Time zone and proximity	Meetings after 5pm/6pm/7pm are hard to combine with a good work-life balance	
Technical tools available & Data storage	Company & management	Availability of hardware and software incl. the required training for it Teams as a good platform to exchange via video	Documents could be signed via DocuSign; Review of documents via Teams etc worked well
Aligned procedures / standardization	SOPs and team members	The closer teams work in a GMP/QC environment the more procedures are standardized (reference standards)	Team needed to align on pragmatic solutions by trying to find the best way to bring the project forward
Common goal & defined milestones	Transparently communicated and shared goal in the team Joint will to succeed	Same understanding of timelines for the project, product quality Intrinsic motivation of team members to bring a project to launch Also celebrate milestones that have been achieved	Covering within individual goal setting with line manager can help to motivate → should be worded as group effort → can help to generate team spirit
Understanding the rationale behind the project	Communication within the team (TDT) Line Management	Know how the drug that is manufactured will benefit the patient	Line manager also needs to address how the project is helping the company, the unit and the patient (how does it fit into the big picture?)
Honouring achievements & celebrate success	Individual team members, management	Ownership and being proud on what had been achieved, like e.g. using new technologies	Pioneering character (creating something new as a scientist) → always strive to improve processes and products

		Reward & recognition can additionally be offered by the management to motivate the team	Knowing that knowledge is power, but sharing it to grow as one function
Failure culture / how to handle failure	All team members & company culture	Use failure to improve further No finger pointing	Conduct lessons learnt and use root cause evaluation to generate learnings Use feedback to get better
Virtual culture	Moderator or tech transfer lead should establish meeting rules / camera rules Everybody in the group should adapt the culture Management should be role model and generate guidelines	Some team members did not activate the camera → harder to communicate as body language is not visible	Due to the pandemic face-to-face visits were unlikely → Teams was used as an alternative, but the culture to use the video function had been handled differently at the different sites Feedback should be applied so that team members know that the others would like to see them
Country specific culture	Team member dependent and character dependent how distinct certain aspects of the country specific culture is used		What is regarded as polite etc.
Department culture	Management	Is only applied in parts of the organisation → would be easier to only have one overarching culture so that everybody is aligned	Single departments or teams can decide how to handle virtual culture → when working together beyond departments this leads to different handling
Onsite meetings		Personal contact as important tool to build trust	Talking also informally while having cookies or sweets → Icebreaker Use workshop settings as catalysator to generate effective teams (example: Joint project review meeting with different functions involved and social events to foster interactions of people

			that normally do not work together)
Prioritization and resource allocation	Management	Which tasks do the team members have and how are they prioritized Sufficient amount of time needed to conduct the transfer & to align	Resources with regards to time, personnel and consultancy need to be available
Backing	Higher management, line management and other team members	Line management needs to be aware of tasks within the transfer and needs to provide time to conduct the transfer, budget for travelling etc.	Decide on prioritization of tasks and agree to sending over one person to the RU to help out → free up time resources for the team member
Professionality	Team members & Management	All subject matter expert and technical knowledge available Good handover of tasks when subject matter experts leave or are on vacation	Same understanding with regards to biotech process at SU and RU available if experts are available
Facility fit		When having the same technology basis easier exchange; common understanding of devices available	Building and aligning on one technology platform throughout the last years helped If technology platform is different → high workload in Tech Transfer due to sourcing and URS establishment; new equipment also requires additional training
Stakeholder management	Project lead	Representation of team decisions to stakeholders	Collection of expectations

Table 27: Data derived from the receiving unit's focus group discussion analysed by causal mapping.

Which factor influences a good tacit knowledge transfer?	**Who's/What's influencing this factor?**	**Example**	**Story / more detailed insight / methods that correspond to the topic**
Connnection of teams involved in the transfer → communication		IT teams at the RU were not necessarily connected to the PD teams at the SU → process changes were communicated through RU PD team, which was complex	Communication was slow and broke down, so that it had to be repaired Not everybody was always informed about outcomes of the root cause analysis → communication strategies needed to be established (who

			to involve in meetings; how many people are needed)
Decicison making	Empowered team members in this case one dedicated member from the IT function and one dedicated member from the PD function	Process changes needed to be implemented into the receipes that were already established → time consuming → clear decision making needed when a change really is necessary	
Consistent platforms		Software used for the devices was different at the different sites → expertise from the SU could not be offered for the system used at the RU	Not all process parameters were easy to set at the RU → deep knowledge with reagards to how the control systems work required
Autonomy and empowerment	Management	Fostered ownership of the project by the staff	Was necessary due to the newness of the team and the facility Empowerment created more fun regarding the activities at work → people liked to do their tasks in a better way
Number of functions involved in the transfer / Closeness of business model (complexity)	Department structure at the SU and RU	SU had a different structure with regards to development and manfacturing compared to the RU → different routes of the transfer had to be taken then the teams were used to	Might have caused some double work at some interfaces → when only development colleagues from the SU were leading the transfer, details important for the manufacturing unit might not be transferred
Engagement (play-to-win / joint goal) and experience	Team	Good and knowledgeable set of subject matter experts Empowered people at both sites Everybody played to win and had a joint goal to work forward to	Good responsiveness to issues Having a high-quality group on each side might paper over deficiencies in the tech transfer where maybe tacit knowledge that may ideally formally documented was compensated by competency
Roles and responsibilities	Team and mangement	Clearly defined areas help to generate a good team structure	Workshops with face-to-face contact helped in other settings to be able to get alignment on areas of responsibility

Proximity and face-to-face contact		Covid made the personal contact hard to maintain, but the same goes for a tech transfer across an ocean Personal contact helps to get to know each other better and create understanding on the other unit	"Is tricky because, let's face it, when you throw a rock over a wall and you don't see who it hits, it's easier to throw that rock. (P362)" For former transfers it helped to establish pizza parties at the beginning of the transfers to get people informally into contact Visits of people can help to create relationships
Familiarity	Project management	Had been established trough regular meetings in which knowledge could be exchanged	Led to a cultivated atmosphere within the team At the beginning longer meetings were needed to establish relationships between the team members
Accessibility and availability		Meetings where the main way it was established, but then it set up a working relationship where people were more responsive and accessible to each other → team members get more familar	During these meetings for the gap assessments, these in-depth discussions or even in between meetings, team members were directly reaching out for clarifications or additional topics that came up
Interfaces between functions	Higher management	Due to the newness of the manufacturing unit supporting functions and communication channels had to be established	Some activities got deprioritized over others → needed to be clear from the beginning on e.g. if documents cannot be handeled in time due to a more important project that comes in Structures need to be more pragmatic and according to the functions needs
Visibility and transparency of the need to be successful		It is important that the team members understand the rational behind the efforts they are doing	For another project that had been unclear and there was this alternate narrative that sometimes came into play, that introduced unnecessary friction because people got unsure whether their efforts were good → erase insecurity by being more transparent
Explaining the big picture	Project management	Why is the tech transfer important? Why is this molecule important? Who is it	People get excited about being able to help patients

	and leadership team	important for? Why do patients need it? → explain the background to get people motivated	
Feedback and reward	Colleagues, line management, higher management	Capabilities of the team being recognized by team members visiting from the SU motiviated the team a lot	Especially after some drawbacks it was good to get the feedback that the collegues from the SU still trusted the RU colleagues → increased morale
Virtual culture		In a video setting it is easier to dismiss people compared to 1:1 Online meetings are often very structured and follow a strict agenda → no time for informal conversation (coffee chats)	Video is sometimes better than having a 1:1 meeting were masks have to be worn as at least facial expressions can be captured
Country specific culture		Specific attributes might influence the transfer	Prejudice like US people love to talk and Germans want to be always right might come up in some transfers
Company culture		Cultivate a culture of being helpful and being open minded and not being only committed to your perspective.	Sometimes company culture can override country specific culture so that it doesn't come into account so much anymore → Might also be combined with a team interal culture
Virtual environment		Shared documents and worksheets → sets focus for people Use Teams for meetings	Hybrid mode meetings might also involve people on the production floor as well as people working in the home office → problem encountered during a qualification activity → urgent topics were directly brought up and discussed → joint decision could be taken → this collaboration would have been impossible a few years ago
Facility readiness		Facility had not been fully qualified at the start of the transfer	
Facility fit		Differences came out in the gap analysis with regards to equipment Enter differences into tech transfer tools	Equipment used for the same purpose might still have differences with regards to handling → mixing tanks with similar volumes might have differences with regards to tubings etc.

Exchange on the right level		Subject matter expert level exchange is better and more direct than having only transfers on higher level management → higher quality exchange	Finding the right operators to do the job is cruicial
Capturing "aha-moments" / tribal knowledge		Can only be done by face to face visits → video is not enough	Onsite visits and job shadowing worked in former transfers to acquire tacit and tribal knowledge → people could gain hands-on experience → this cannot be achieved through videos

The first table shown, contains data derived from the sending unit's discussion whereas data from the receiving unit's discussion can be found in the second table. Whiteboard notes were compared to the list derived from the transcript to be able to see if some points were missing. A summary of the found influences for the tacit knowledge dissemination is depicted in Table 28.

Table 28: Identified influences of the tacit knowledge dissemination during the focus group discussions.

(country specific) Culture (SU/RU)	Language (SU)
Accessibility, commitment and availability (SU/RU)	Management of expectation (SU)
Atmosphere and team spirit (SU/RU)	Media or structure to share (SU)
Backing (SU)	Motivation (intrinsic) and impact (SU)
Body language and emotions (SU)	Mutual understanding (SU)
Capturing aha-moments / tribal knowledge (RU)	Non-competitive environment (SU)
Celebrate success (SU)	Openness (SU)
Clear priorities (SU)	opportunity to share (SU)
Common goal / defined milestones (SU / RU)	Ownership (SU/RU)
Communication and transparency (SU/RU)	Personal contact / face-to-face contact (SU/RU)
Company and team culture (SU/RU)	Possibility for self-development (SU)
Competency (RU)	Power and politics (SU)
Complexity (RU)	Pragmatism (RU)
Connectivity between teams (RU)	Problem-solving mentality / Pioneering character (SU)
Consistent platforms (RU)	Professionality (SU)
Data storage (SU)	Project management (SU)
Decision making speed (RU)	Proximity (SU/RU)
Defined procedures and SOPs (SU)	Relationship (RU)
Department culture (SU)	Required training available (SU)
Empowerment and autonomy (SU/RU)	Responsiveness (RU)

Engagement (RU)	Rewards and recognition (SU/RU)
Environment to ask questions (SU)	Roles and responsibilities (SU/RU)
Equipment fit / facility fit (SU/RU)	Seeing the bigger picture / understanding the rational (SU)
Escalation routes (SU)	Stakeholder (SU)
Exchange on the right level (RU)	Standardisation (SU)
Experience (SU/RU)	Structure (SU)
Facility readiness (RU)	Support from management (SU)
Failure culture (SU)	Taxonomy (SU)
Familiarity and rapport (SU/RU)	Team composition / sufficient resources (SU)
Feedback culture (SU)	Technical tools and visualization (SU)
Fun (RU)	Time management and resource allocation (SU)
Hierarchy (SU)	Time zone (SU)
Interfaces between functions (RU)	Trust (SU)
Joint culture (SU)	Virtual culture / environment (SU/RU)
Joint history (SU)	Willingness to help (SU)
Joint will to succeed (SU)	

In Table 28, the 71 influences are listed that had been discussed during the focus groups. These influences were derived from both, the sending unit's as well as the receiving unit's discussion. Influences marked with SU were derived from the sending unit's discussion, wheras influences marked with RU arised from the receiving unit's discussion. 16 of the influences had been mentioned by both the sending and the receiving units' team (marked with SU/RU). These were bigger topic like e.g. roles and responsibilities, culture in general, familarity and rapport as well as empowerment and autonomy. More detailed influences had been mentioned by either the sending or receiving units' focus group. This was mainly due to slightly different focus of the two discussion that was taken in the different groups. Some of the influences that were mentioned go also in the same direction like "competency (RU)" and "professionality (SU)". They are still listed sepately as they have a slightly different spin. There had not been a clear destinction with regards to what kind of influences were discussed in the RU and the SU group. Both groups discussed about softer topics, like rapport and team culture, but also about structures as well as environmental factors that were influencing the technology transfer. Hence, the mentioned aspects from both groups were used to complement each other and were discussed together in the discussion chapter.

8.10.2 Data analysis of the focus group interviews in order to answer RQ3

In addition to the influences practices, methods and tactics have been mentioned during the focus groups. These are listed in Table 27.

Table 29: Knowledge transfer mechanisms, techniques and practices mentioned during the focus group discussions (in alphabetical order).

Knowledge transfer mechanisms, techniques and practices	**Description**
Alignment on one technology platform	Exchange becomes easier when having one aligned platform and experts on the devices and process steps on both sites.
Celebrate milestones	Motivate team by also celebrating successes during the process of the technology transfer. Keep team on track with regard to timelines and create a joint will to succeed.
Collaboration and social networks	Creation of an environment of exchanging tacit knowledge for the employees between different functions.
Collection of expectations	Regular meetings with stakeholder and interfacing functions help to generate an understanding of the external expectations.
Decision trackers	Listing of decisions taken during a project and open action items, as well as questions.
Establishment of communication channels	Standardization of communication routes, both internal and external, with dedicated contact persons. Structures need to be pragmatic to serve all functions needs.
Face-to-face contact / joint workshops	Use kick-off meetings and joint workshops as catalysators to generate effective teams.
Feedback	Helps others to get better and to get to know the expectations of the other party.
Global project review meetings (communities of practice) with additional social event	Connection of diverse people from a division to foster different views on pipeline projects. Social events foster interaction and networking.
Goal setting	Add the success of the project as a group effort the individual goal setting to generate a joint ownership.
Informal communication routes a) Short messages via Teams b) Coffee chats	Short exchange helps to create trust and to exchange information that is not discussed during formal and structured meetings.
Job Shadowing	Capturing of hands-on experience and “aha-moments” by shadowing experts of the process.
Lessons learnt and root cause analysis	Focussing on extracting experiences, learnings and lessons from the project to get better for the next project.

Meetings a) Structured b) Informal and spontaneous c) Steering committee	a+b) Discussion of specific topics with FTE counterparts; create understanding for the different groups c) decisions on clear roles and responsibilities
Short-term assignments and visits	Experts can share e.g. technical know-how and hands-on-practices. Helps to get to know colleagues better and to create trust.
Subject matter expert level exchange	Finding the right operators to exchange detailed information on the right level to generate a high-quality exchange.
Social events / Pizza parties	Use social events and pizza parties as kick-off events to get people informally into contact and create a more personal atmosphere within the team.
SOPs (standard operating procedures)	Documentation of knowledge and team structure. Taxonomy can also be an important part to be standardized in documents during/prior to the transfer.
Team charter	Define roles and responsibilities and set counterparts at both sites.
Use of technology transfer tools	Create standardized tools for gap analysis, root cause analysis, shared documents and worksheets
Virtual exchange platforms	Create a possibility to exchange and to ask questions without constrains of time zones.

In total, 21 methods, techniques and practices were mentioned during the focus group discussions. Like in the semi-structured interviews, the practices can be categorized into technical tools, team interaction tools, as well as tools to capture the process knowledge. Most of the practices mentioned were also found during the analysis of the semi-structured interviews. Still, also some new aspects arose from the groups discsussions like e.g. the subject matter expert level exchange, the celebration of milestones and the establishment of team charters. These practices can be useful standard tools for each transfer to enhance the exchange even more.

8.11 SUMMARY OF THE MENTIONED ETKS FOUND DURING THE CONTENT ANALYSIS.

Mentioned (content analysis)	**Type of tacit knowledge identified**
x	ability
x	attitude
x	best practice
x	capability
x	communication skills
x	creativity
x	culture
x	embodied knowledge
x	expertise
x	feeling
x	get a feeling for
x	gut-feeling
x	insight
x	know-how
x	knowledge base
x	opinion
x	personal competence
x	personal experience
x	perspectives
x	predictions
x	routines
x	rule-of-thumb
x	skills
x	taste
x	techniques
x	thoughts
x	understanding

8.12 QUOTATIONS FOR NEW ETKS IDENTIFIED DURING THE THEMATIC ANALYSIS

Known ETK from Haldin-Herrgard (2003)	**Coded example from the interviews**
Automatic knowledge	"…Right now, in the industry, whether you are in an antibody or you are in cell therapy or gene therapy (…) I think that everybody has a good idea what a platform looks like, what a unit operation…, what needs to be there. Nobody needs to reinvent it, right…" (participant 500-RU)
Beliefs	"…instead it's this belief system…" (participant 362-RU)
Communication skills	"she communicates very well… (participant 730-SU)" "…on the tech transfer team, we want to make sure that those sides are in communication, that we have meetings set-up." (participant 343-RU)
Coordination skills	"… the facilitators were very good about coordinating. If one group had an issue or questions about stuff that came up, they were very prompt about creating action items and going over these things…" (participant 297-RU)
Emotional knowing	"… empathy is another topic, asking the right questions without looking annoyed…" (participant 730-SU) „…Same thing (…) tone is a huge part of communication, (…) like, what's the verbal versus body language versus the actual syntax of speech?" (participant 297-RU)
Estimations	"… when doing an initial estimation/assessment…" (participant 846-SU)
Feels as…	"… Do you feel like the receiving unit is getting their questions answered (…)" (participant 343-RU)
Negotiation skills	"…the person for any of the raw materials that will then cover raw material sourcing, supply selection, negotiation as well as some of the technical part like for example we are getting certification, (…) to make sure that the raw materials will be available for tech transfer and GMP runs…" (participant 537-RU)
Non-analytical behaviour	"... sometimes you have to admit to yourself that you haven't thought much about it yourself and that it might even have an influence if you don't set boundaries. This also means that we have actually learned something about our process in retrospect,..." (participant 730-SU)
Organisational mind	"... and this information was of course very, very important for us and we had to get to know each specific player on the other side and the information, what role does everyone have in the team on the other side?" (participant 523-SU)
Prediction	„…some of the data may give us a prediction" (participant 517-RU)
People knowledge	"... If you have 2 experts, (...) and also the corresponding feeling to access the employees directly. We have also agreed very clearly from the

	beginning, which accelerates the transfer of knowledge ...” (participant 149-SU)
Sense making	“…determination of what makes sense for the process” (participant 122-RU) “… don't look detailed enough or don't make sense…” (participant 161-RU)
Shared norms	“…let's say a general kind of rules are if it is a product contact right, it's critical…” (participant 537-RU)
Shared values	“… in general to follow the same principles…” (participant 846)
Thinking in practice / hands-on	“… people who really know the details of their process, they’ve done hands on” (participant 343-RU) “… general experience of being on the production floor is helpful…” (participant 579-RU) “…exchange knowledge practically” (participant 149-SU)
Tricks	„... that one site is offering tips to the other site and vice versa…” (participant 273-SU)

Cluster	**ETKs clustered**	
Experience	Personal experience	“... and we have the knowledge, the experience of the individual. And the (experience) differs from person to person and also the extent and some of that is not written down.” (participant 730-SU) “…It's where the experience of the person who do the tech transfer is also coming through.” (participant 161-RU) “… I think that's overall is the experience of the sending unit, especially like the subject matter experts, the lead of the sending unit that really define the most of the success of the transfer.” (participant 517-RU)
	Common in experience	“… site had a technology transfer experience” (participant 72-RU) "... due to the availability of a lot of experience with this platform process” (participant 730-SU)
	Pattern of experience	n/a