Software Engineering

Masterarbeit

Frictions in software development: an interpretive phenomenological analysis

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Abstract

Background and objective: Enhancing productivity and efficiency at work is certainly one of the most important challenges when it comes to the improvement of processes in general.

In order to achieve progress, one has to find the origins of unproductiveness. These are called frictions. In this context, I formally establish and define the term friction, merging its usage within several articles to a common denominator. I investigate specific frictions in the software development sector within a team of data analysts in the consumer electronics sector. Moreover, I analyse the impact of frictions on the mindset of them.

Method: For the following analysis, I chose a qualitative approach, conducting an Interpretive Phenomenological Analysis (IPA), which is a methodology that has its origin in the health psychology sector. It enables to dig deeply into the feelings of participants and combines personal insights with interpretations of the author.

Result: Results of the study show a coherent pattern of frictions within the team under consideration. Interviewees name inefficient scheduling and conduction of meetings as well as inconsistency in tooling as the frictions with the greatest impact on their work. Frictions evoke annoyance and frustration on the one side, but, on the other side, also motivate the team members to put extra effort into the improvement of processes and reduction of frictions.

Discussion: The term friction helps to formalise problems and hindrances of productive work. Identification of friction is the first step for improvement and increased productivity. Frictions are similar, but the ways how people experience these are various and depend on the developer's mindset. Therefore, it is important for management to put a certain focus on the individual. In this context, IPA constitutes a good way to explore the feelings of developers.

Outlook: The IPA approach to analyse data is underestimated in the field of software development so far. It is especially suitable for larger research teams. The next step for future research is to use the gained insights and think about ways to reduce the frictions that are revealed in this study.

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1 Introduction

1.1 Motivation

Dissatisfaction among workers leads to a low level of productivity. Such a loss in productivity costs companies huge amounts of money due to wasted time that does not lead to commercial outcome [Del]. This context is nowadays more and more important in software engineering as well, and large software companies like Facebook or Google have realized this correlation so far. Therefore, these companies provide premium working conditions. For example, they make special areas available for their developers or provide schools for workers' kids in order to make the daily routine as comfortable as possible for their workers. As a consequence, they expect the developers to be able to concentrate on work to an applicable extent [Avg21]. In this context, it becomes interesting what factors in daily working routine distract developers from working efficiently, and, in turn how such distractions affect their feelings and the outcome of their work.

Recently, barriers, problems and challenges that keep workers from being productive are brought together in science as well as in media [BBA+10].

Increasing numbers of mentions of the term "friction", especially in grey literature and particularly in social media, can be spotted [Pol17] [HBMW18] [HB05]. The expression is mentioned in the context of issues that decelerate the progress of workers, but do not lead to complete stagnancy. Such issues are for example events, situations, relationships, steps or processes that prevent advancement in daily work. Consequently, frictions cause negative feelings such as dissatisfaction, annoyance or frustration for workers.

As a result, frictions hinder productivity. However, although friction as a term can be found in grey literature, one cannot find a universally valid definition of the term. Nevertheless, these mentions in literature obviously induce a commonly intelligible understanding of what frictions are and what they mean for software developers. Though, there seems to be a lack of understanding of the concept in scientific literature.

The present work aims to analyze friction in a software development team in the consumer electronics sector. The goal is to find out what kind of frictions the team has to deal with. I put an explicit focus on how developers in this team experience frictions as a phenomenon, and what feelings and moods the members of the team have to handle. Within the scope of the study at hand, I will conduct an IPA study, with software engineers as participants. The study aims to bring evidence of frictions and how they are experienced in the software engineering domain.

This work is of importance for science because behavioural software engineering is a growing research area in general [LFW15]. Since in the contemporary economic competition maximizing productivity becomes more and more meaningful, happy developers become increasingly important as well. As already mentioned, satisfaction at work leads to increased economic performance [GWA15] [KBH11]. In the past, feelings or a sense of well-being has not been a particularly relevant

topic. However, due to changes in the contemporary perception, workers and their human needs and desires are of vital importance. Thus, it is a consistent conclusion to also transfer research methods from psychological fields to behavioural software engineering [LFG+20].

1.2 Scope of this Work and Research Questions

The *objective* of this research is to analyse frictions, what they are, how they occur and how frictions influence the feelings and the productivity of software developers. The *purpose* is to find a suitable definition of the term "friction" and to apply and evaluate it with respect to appearance, origins and impacts on developers' daily work. This work is performed from the *point of view* and individual perspective of the researcher in the context of a team of data analysts in the consumer electronics sector. The following *research questions* aim to substantiate the goals of this study and have been derived from the research objective. They aim to bring structure to the wide field of goals stated above.

R1: In what form do frictions occur in the development team under consideration?

R2: How do software developers in the team under consideration experience friction in their daily work?

R3: How do frictions constrain the developers' impact on their tasks?

R4: How do frictions lead to frustration and influence productivity at work?

As research procedure and methodology I chose a qualitative approach to data collection and analysis (see Section 2.2). In particular, I apply a research method called IPA, which is commonly used in psychology, but not yet in the field of software engineering (see Section 2.2.2). For data collection, I performed personal interviews that are analysed afterwards.

The research method IPA suggests that the research questions may also be adapted throughout the study to fit new findings that arise from interviews [Wil08]. Anyway, the scope of the interview and the answers of the participants did fit well to the questions and there was no need for adaption throughout the study.

1.3 Structure of this Work

Chapter 2 of this study provides a substantial literature review, including fundamentals as well as definitions. In particular, the term friction is derived from various meanings it has been standing for so far and is set in the context of the study at hand. In Chapter 3 I describe the methodology of this study. This includes an explanation of the choice of the research method as well as data collection. I illustrate the way and structure of the interviews which constitute the basis of the analysis at hand. Furthermore, Chapter 3 deals with the ethical background. Moreover, it describes the interviewees and how data are collected and analysed. Next, Chapter 4 presents the results of the interviews and puts these in an analytic context. Following this, Chapter 5 includes the discussion of the results of the study and compares them to widely recognized research as well

as to my personal expectations. Also, the validity of the results is investigated. Finally, the study concludes by reviewing its outcomes and providing an outlook on further research in Chapter 6. Additional material can be found in Chapter 7.

2 Fundamentials and Literature Review

2.1 Friction

The term *friction* has its origin in the scientific field of physics as "the resistance to [...] motion" [NB08]. Physicians consider friction as the directed force pointing in the opposite direction of a movement, leading to the deceleration of a mass towards another mass. Formally, Nosonovsky and Bhushan [NB08] define friction in the physical context as the "mechanisms of energy dissipation resulting from the interplay of forces". Multiple authors, such as Saasen et al. [SEH+98], R. G. Allen [R G96] and R. D. [R D90] in experimental as well as applied physics mention friction as a "loss". Holmberg et al. [HAE12] calculate the global energy consumption due to friction losses in passenger cars, also mentioning the term in the context of inefficiency. Overall, it becomes obvious that in applied physics friction is considered a waste of energy that should be minimized.

Recently, the term friction frequently appears in grey literature describing a phenomenon in the business context. Especially in social media, bloggers such as Politis [Pol17] transfer the usage of the term from its original physical meaning to situations related to business, but also for describing a loss of energy in everyday life.

To my knowledge, there is no formal definition of the term friction available in the literature that describes its usage and meaning in an economic or business context. To establish a common understanding, I consult descriptions of bloggers who refer to friction as a current matter.

For example, [Pol17] states that "friction is the time spent not working but attempting to". This conforms to [You07] who refers to friction as "all the aspects of the environment that slow down your productivity". Therefore, friction commonly appears in terms of different processes or experiences within working groups or companies that slow down collaboration [HB05]. It produces a loss of productivity [Sta17].

Other authors use the term friction in a more neutral way. Hagel III and Brown [HB05] consider friction in working groups as the inevitable clash of different ideas that emerge from the process of finding the best solution. Also, they perceive friction as the emergence of new approaches. If a negotiation process has a productive outcome, the authors speak of "productive friction". In contrast, if the gap between opinions of group members is too large, and if the conversation does not approach an agreement, they speak of "unproductive friction". Nevertheless, in this work, I directly refer to friction to the negatively annotated meaning that slows down productivity.

Furthermore, Politis [Pol17] describes friction as a quantitative measure that is defined by the ratio between the time loss for friction and the time that is spent for actual work. In this connection, the goal is to minimize the time spent on friction. This so-called friction-to-work ratio is an objective measure to quantify productivity at work. Anyway, the impact of friction on productivity might be

greater than the time that is actually lost. Experiencing frictions, developers become frustrated and less motivated. Therefore, it is also important to explore the feelings of developers that arise from frictions at work in order to evaluate their work.

2.1.1 Examples for Friction

Politis [Pol17] names several typical examples of friction that occur at work, such as waiting time until a tool or browser is loaded or an email inbox whose storage capacity is full and therefore has to be cleaned manually until new emails can be received. He provides another example, namely the waiting time at the beginning of a conference call until all participants are successfully connected, and each participant is able to listen to the speaker.

2.1.2 How to reduce Friction

To reduce friction, it is necessary to go back to its origin. The root cause of frictions at work can be divided into two categories: frictions that arise from defective processes or planning and frictions that arise from insufficient tool support [Qui]. There are several measures that help to reduce process friction. On the one side, [Pol17] demands team leaders at work to drive their team to the usage of optimized processes or routines. On the other side, he requests that each employee states the occurring problems. It is very important to address frictions [Pol17]. Young [You07] highlights that routines at work are important, as it is easy to follow a habitat that saves energy for complex tasks. Often, one can improve these routines by eliminating steps that are unnecessary. In this context, setting up deadlines can lead to unnecessary pressure for workers and developers. [Qui] recommend to define prioritizations instead of a deadlines.

Also, each developer as an individual can reduce process friction. Young [You07] explains how balancing energy can reduce friction. The schedule of tasks over a day should be arranged in such a way that tasks with different focuses alternate. Tasks that are mentally challenging should be followed up by easy tasks that just have to be done, or tasks that are rather physically or socially challenging. This helps to prevent our brains from burning out. Otherwise, this could lead to friction. Even walking around might help to release the brain. The lack of personal motivation to fulfil a task may also be considered as a kind of friction as it definitely slows down productivity [You07]. To overcome the lack of desire to solve a task, the task has to be constructed as attractively as possible. For example, this can be done by focusing on the reason the task has to be fulfilled for, as well as on its result. In the case of boring tasks, it might also help to add an extra challenge that keeps workers motivated.

In order to reduce unsubstantial conversation calls, meetings should focus on single topics. Such, every participant knows about the background as well as the aim and can prepare and contribute only essential and constructive input.

For reducing friction that arises from bad tooling, leaders should invest in modern tools. For example, real-time document collaboration or version control are good instruments to reduce recurring frictions as described above [Pol17].
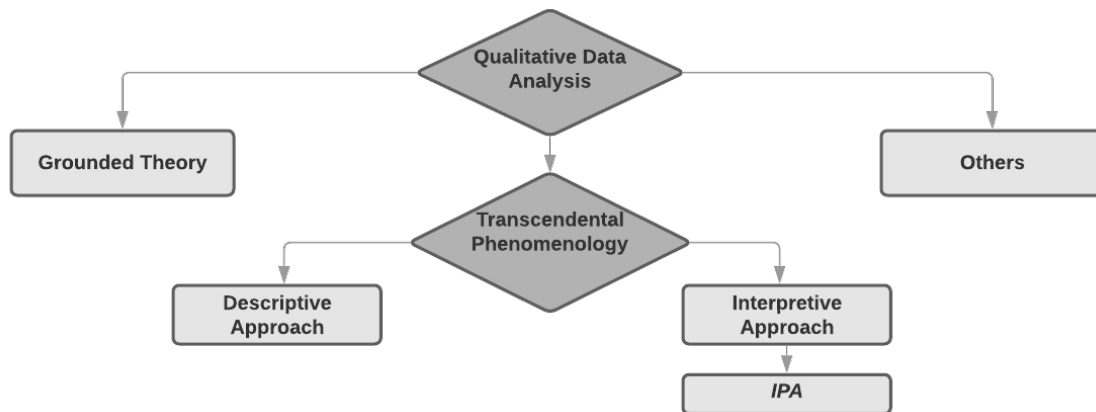
Figure 2.1: Classification of IPA within qualitative research methods

2.2 Qualitative Research Methods

Generally, research methods can be divided into two categories, namely quantitative and qualitative methods. While quantitative methods seek for statistical significance based on measured values and numbers, qualitative approaches explore new perspectives and elaborate experiences or background attitudes of participants [TSC07]. Even though a qualitative approach is not based on numbers its results "achieve a high level of quality and trustworthiness", assuming correct application [LM15]. In this study, I make use of a qualitative research method. I elaborate reasons why this is the best choice for the study at hand in Section 3.1.1.

Depending on the field of application, the research questions and the goals of research, there are several approaches to qualitative research methods. Among these, I selected IPA for this study. IPA is a research method that can be categorised into the field of *transcendental phenomenology*.

2.2.1 Transcendental Phenomenology

The philosophic field of transcendental phenomenology gets its name from the term "phenomenon". This term denotes anything that humans experience consciously [Gil14]. Willig [Wil08] describes phenomenology as the "world as it presents itself to us as humans". Depending on the situation, humans experience phenomena differently. "Context and location, [...] desires, wishes, judgements, emotions, aims and purposes" [Wil08] which humans feel or have strongly influenced the subjective meaning of a phenomenon. This dependence is called *intentionality*, as phenomena depend on the intentions of the respective perceiver. An example of this intentionality is a wedding ring: for the receiver and donor, the ring is an assertion of love, for the jeweller it simply is a business, whereas from the phenomenological point of view it is just a ring without a certain meaning.

Transcendental phenomenology is a philosophical theory. However, its basic ideas are of interest for qualitative research as well, where its methods are frequently applied [Wil08]. Researchers usually put their focus on the comparison of individuals. Searching for variances in individuals' perceptions of phenomena is an important goal of researchers in this field [Spi05].

Philosophers distinguish between two approaches towards phenomenology, which are *descriptive phenomenology* and *interpretative phenomenology* [Gil14] as depicted in Figure 2.1. Descriptive phenomenology is based on the work by Husserl [Hus12]. It aims to isolate the phenomena from subjective intentionality, which Gill [Gil14] calls *phenomenological reduction*. This approach towards phenomenology suggests that researchers "experience a state of pre-reflective consciousness" [Hus12]. Husserl's [Hus12] goal is to gain an outlook on "purified phenomena", bracketing assumptions that we have in everyday life.

In contrast, Heidegger [Hei96] as the putative founder of *interpretative phenomenology* explains that the "self and world belong together in a single entity", meaning that phenomenology can never be purely descriptive. According to that, individuals are always surrounded by a world that affects them. Alongside, it is also hardly possible to bracket all presuppositions as a researcher. Gill [Gil14] even names interpretation as an integral part of research that should never be dispensed.

However, it still is important to think about how presumptions influence the perception of a researcher. Dealing with reflexivity is an important aspect of qualitative research (see Section 3.7). The goal is to dive into the world of the participants by analysing what they describe, instead of building the situation based on the experience of the researcher.

2.2.2 Interpretive Phenomenological Analysis

Researchers in the philosophical field of phenomenology developed several research methodologies [Gil14] that differ both in the underlying philosophical concept and in the research process. A famous but rather young example of methodology supporting the interpretive concept is IPA, introduced by Smith [Smi96].

Transcendental phenomenology is interested in and deals with phenomena "as they present themselves" [Wil08]. Though, description and interpretation are not separated. The goal of the theory is to understand how people conduct social interaction, hence, how they react or feel about experiences [LFG+20]. It aims to interpret by exploring participants' experiences, understandings, perceptions and views [RFL05]. Following that, researchers try to explore from the viewpoint of the subject under analysis [PS14]. This is not possible without presumptions and background knowledge of the researcher [Sch98]. Researchers are not only "passive receivers of the reality" [BW06]. Therefore, they do not bracket presumptions, but consider them and let them emerge in presence of new findings. [Wil08].

Correspondingly, IPA accepts that it is not possible to understand phenomena experienced by participants without including their interpretation and own view of the world [Wil08].

Actually, IPA originates from the field of health psychology, applied to disclose reasons for mental illness [SFL09]. Assuming that irregular mental processes lead to illness, one can find parallels to suboptimal individual processes that lead to problems in software engineering. In this context, IPA is focused on perception of people [LFG+20].

IPA is composed of two steps [Gil14], phenomenology and hermeneutics. The concept of phenomenology means the gain of true understanding without including preconceptions and judgements. In contrast, hermeneutics refers to the interpretive perspective, which means interpretational

sense-making of a subject within the world of the researcher. In this context, IPA has its focus on single cases, analysing details, and does not aim to draw general conclusions. Therefore, it is suitable to deal with complex contexts and novel processes[BW06].

Additionally, due to the focus on detailing, the research method generally deals with rather small sample sizes which are chosen selectively. This allows to conduct such a detailed analysis [Gil14].

2.3 Related Work

2.3.1 Recurring Problems of Software Developers

With software development being an economic field that is extensively growing [MK11], the interest in efficiently building software is gaining more and more importance. In this context, up to now, literature rather aims for searching productivity drivers, i.e. finding out how productivity can be boosted. In general, factors that boost productivity can also hinder productivity if they are not present. Anyway, evaluating the lack of some productivity boosters may lead to different results than searching for frictions that explicitly obstruct productivity. In the following section, I summarise recent literature dealing with factors that influence productivity. Additionally, I discuss how these factors may appear as frictions.

By hypothesis testing of various influencing factors on the productivity in software development Mohapatra and Kumar Gupta [MK11] found that technology training leads to much higher productivity of developers. In other words, one can say, that the correct usage of modern and suitable tools leads to better performance. Turning this around leads to the statement that inconvenient tooling may occur as friction in software development. This coincides with the findings of Boehm et al. [BPS+84], also naming a suitable set of software tools as the factor with the highest payoff on productivity.

In addition, the capacity of computing resources has an impact on productivity [Sca95]. It is obvious that having a hardware system with low-bandwidth processing throughput limits the impact of the developer. The goal is to make the steps of software development more efficient [Boe87].

Concerning project team structure and team size, [Sca95] suggests small groups of experienced workers in a framework that facilitates collaboration. In larger software development teams it gets difficult to establish team spirit, share the tasks and work towards a common goal. This in contrast leads to low performance. Boehm [Boe87] names this to be an issue of management and staffing. In this context, inefficient communication and alignment of the large team may cause friction.

It is commonly mentioned in the literature that changes in requirements limit productivity and progress [Sca95] [MK11]. Work has to be redone and additional iterations are needed to achieve a software product that supports additional or even different functionality [Boe87].

More recently, the process of how to develop software efficiently and how to manage it is highlighted when it comes to improving productiveness [BBA+10]. Weak and static processes continuously get adapted to agile ones [FH01]. Still, agility is not implemented comprehensively in industry [BBA+10].

In the context of this literature review on influencing factors of productivity in software development, it becomes obvious, that most literature rather has a technical focus, missing social, emotional and human-related aspects. Behavioural software engineering is a growing research area with the goal to "move away from a mechanistic process" [SR96] and focus more on the individual and the real world. The individual personality and judgement play a vital role when analysing the work of software developers [FATS10].

Focusing on the individual software developer, Sommerville and Rodden [SR96] state that developers often have their view of a perfect process. Following this process that they have in mind often collides with the process foreseen by management. In this context, the author suggests leaving implementation details of the development process open to the research team. Theoretically perfect processes may lack practical realisation and need to be adapted to the specific circumstances [SR96].

2.3.2 How Feelings influence the way Software Developers work

A lot of work has been done on finding ways or methods to increase the productivity of developers. The majority of developers focus on single aspects like the software development process [DeM86] [FH01] [Pfa14].

In their study, de Barros Sampaio et al. [BBA+10] summarise research that has been done in the context of the productivity of software developers in recent years. They point out, that not only suited tools, processes and infrastructure drive productivity at work, but especially human aspects have to be considered when the performance of developers should be improved. These are for example the climate within the team, team motivation, mutual support etc. Hence, what the developer feels when working in the team plays an important role. From an empirical point of view, there is a positive correlation of happiness with the programming or developing task at hand and the self-assessed productivity of the developer [GWA15]. Provoking specific moods by physical activities or video clips, Khan et al. [KBH11] show that programmers' task performance is manipulated by these factors.

Keeping in mind that feelings and moods have an impact on productiveness, the next step is to analyse the driving factors of moods that supports productive programming. In this context, I investigate how frictions influence human aspects of software developers, such as feelings they have at work. It should be considered if they are happy about the tasks they have and about the environment they work in. If they are not and there are negative feelings correlated with their work in general, it is of major importance to seek their origins. Therefore this work aims to analyse if frictions possibly lead to negative feelings.

3 Methodology

In the following chapter, I provide a detailed description of the research methodology that I use to conduct this study. I elaborate reasons for the chosen methodology to be appropriate in the context of the research questions and goals of this work.

The first section (see Section 3.1) is concerned with the choice of the research method. In the following section, I deal with the conduction of the interviews (see 3.2). To ensure the ethical correctness of the study, I deal with correspondings topics in Section 3.3. I describe and provide reasons for the selection of participants of this study in Section 3.4. The following section 3.5 deals with the collection of data, which consists of the interviews that I conducted. An introduction into how the data has been analysed is presented in Section 3.6. As an integral part of qualitative research, I deal with reflexivity topics (see 3.7) in the closing section of Chapter 3.

3.1 Choice of Research Method

3.1.1 Qualitative Analysis

As stated in Section 2.2, qualitative research methods work with rich data, which are experiences, descriptions and stories of the study's participants. This kind of research can explore new visions and fields, where little is known yet. Its focus lies on the experiences and background attitudes of the participants. In contrast, quantitative methods work with numbers and degrees of significance.

According to that, the goal of this study is to explore individualities, leaving room for novel and unexpected findings. Therefore, a quantitative approach is not suitable. In this context, researchers, in general, apply qualitative approaches "to answer why and how research questions" [LM15]. This perfectly fits my purpose.

To define qualitative analysis more explicitly, one has to think of its quality standards in work [LMS99]. Qualitative analysis has proved its value and has sustained its position when it comes to complexity, process and novelty [BW06]. In this research project, it is without question that we have process and complexity. Hence, qualitative analysis is the appropriate instrument.

3.1.2 Phenomonlogy

Probably, the most common methodology to apply qualitative research is grounded theory [Wil08]. Nevertheless, I decided to use a phenomenological methodology for the study at hand. As both approaches are qualitative research methods, they share many similarities. Phenomenology and grounded theory work towards a similar goal: elaborating themes, categories etc. that emerge out of transcripts of interviews to extract their view of the world [Wil08]. Anyway, phenomenologists dig

deeper into personal, individual experiences [Wil08]. This ideally supports my research questions. On the one hand, compared to grounded theory, phenomenology is much more focused on single cases, their similarities and dissimilarities. On the other hand, grounded theory is more suitable for generalisations to the population [BW06].

Among several possibilities to implement a phenomenological research approach I chose IPA (see Section 2.2.2). Gill [Gil14] identifies that IPA is the best choice of phenomenological research methods if the research questions explicitly focus on individual experiences of the participants.

The interpretative part of IPA also improves the generalisability of the results. Therefore, it overcomes some shortcomings that phenomenology exhibits compared to grounded theory. Brocki and Wearden [BW06] state that the interpretative part of IPA allows the author to examine the findings concerning existing psychological theories and personal experiences. Like this, results are applicable on a larger scale as well. As it is a rather young research method [Wil08] and new in the context of software engineering [LFG+20], IPA may add new insights to the current state of knowledge in this field.

Additionally, since IPA is a comparatively young method of analysis, guidelines and processes that exist so far leave room for a personal exegesis of the methodology by the researcher [BW06]. The approach can therefore be adapted to the use case at hand. As the research community is discordant regarding the "best" procedure to conduct grounded theory analysis, this discussion can be avoided by using IPA [Wil08].

Nevertheless, Lenberg et al. [LFG+20] use other methods than grounded theory in the field of software engineering. According to this paper, phenomenology has never been used for qualitative studies in the behavioural software engineering domain so far.

Certainly, software engineering is an integral part of contemporary companies and therefore embedded in organisational environments as well. Gill [Gil14] claims that IPA is explicitly suitable to explore organisational identity. Albert and Whetten [AW85] define the organisational identity as the distinct and characterising properties of institutions or organisations that are experienced by their members. Therefore, IPA is highly applicable to explore individually perceived friction in the team under consideration. Following that, Lenberg et al. [LFG+20] calls phenomenology to be applicable "when interested in how software engineers make sense [experience] of a specific phenomenon in a given situation".

In this context, the big advantage of IPA is that it is a very flexible method that can both deal with areas with and without existing theoretical background [RFL05]. In the case of the study at hand, there effectively is both. That is, friction plays a role as a new topic, whereas research has already been done on the importance of feelings of developers in respect of productivity [GWA15].

3.2 Conduction of Interviews and Interview Agenda

For the conduction of interviews, I chose the method of semi-structured interviews. This is common in qualitative research. In this procedure, questions are used as a trigger for participants to talk [Wil08]. Since I want to explore and experience new fields I must subliminally encourage

and motivate people to talk about new and complex contexts. This is not possible with closed questions. In contrast, semi-structured interviews more easily allow discovering unknown topics and connections.

Conducting semi-structured interviews in IPA means having rather an interview agenda instead of a list of detailed, well-formulated questions. Key points or headwords on the agenda refer to topics of interest. Following this agenda ensures that the research questions will be answered during the interview [Wil08]. The agenda enables to lead the participant in the direction of interest. In addition, it encourages the participants to focus on phenomena of major individual importance, supporting the concept of IPA.

As a first step of the interview preparation, one has to find the topics of this agenda. For this, personal insight into the team under consideration was very helpful: As I have already been working in the relevant area, I have some impressions about occurring frictions in this field. According to this knowledge, I formulated open-ended questions or simply topic headings and asked for problems or hindrances in the specific context. Following the principle of Willig [Wil08], I started with questions about the team as well as about the personal or educational background. This kind of question is easy to answer and makes the participant feel comfortable and get into the topic. Subsequently, later in the interview, I asked personal questions that include emotions and feelings.

To get a good insight into the participant's world, I stated ignorance and also asked questions with obvious answers as suggested by Willig [Wil08]. By this, I obtain rich insights into the daily working routines of the participant that can be understood and interpreted without prior knowledge.

Generally, I did not adapt the agenda throughout the interviews. Within one interview, researchers might get to know new findings and fields. As a result, new topics arise that could be added to the agenda for the next participant. However, I did not do that, since I wanted to guarantee a uniform procedure. Anyway, the agenda has only been used as guidance. Also, I did not force the participant to follow the order of the questions during the interviews. In contrast, I gave the possibility for a free talk and meanwhile checked if questions are answered or topics are already dealt with. For many questions, no trigger was needed, and the participant got to the topic of the interview agenda himself. However, after finishing one topic and getting to the next one, the agenda helped to find the next thing to talk about.

A possible alternative for personal interviews is focus groups. A focus group is a conversation with multiple participants at the same time. However, this method is not suitable in my case. Interviews took place during the corona pandemic and therefore in an online setting. Online meetings with several participants are hard to follow; it is hard to acoustically understand each other. Each participant can hide behind the others or the less personal setting. By conducting personal interviews, I expect to establish a more familiar environment. This is important in my case since I'm interested in the participants' individual feelings. Therefore, participants have to feel comfortable overcoming a certain inhibition threshold. Also, I expect that participants express criticism to a larger extend in personal interviews since sometimes colleagues might be part of potential criticism as well.

3.3 Ethics

In order to ensure an ethically correct conduction of the study, I followed the basic considerations established by Elmes et al. [EKR12], which are the following.

First, I ensured that participants are fully informed about the research procedure *(informed consent)*. To assure that, as a very first step, I approached potential participants by writing an informal email, describing the general topic, time involvement and background of my study. I sent a consent form (see Appendix B) to those participants who were interested to participate in my study. Then I arranged a date to conduct the interview. I asked for a signature on the consent form of each participant before the actual interview took place. At the beginning of the scheduled time slot of the interview, I gave another detailed introduction to my topic, the way of analysis and the interview itself. The participants were given the opportunity to raise any questions that came to their minds. I also explained why I need to record the meeting; the reason for the record is that I need to create a verbatim transcript for data evaluation. In addition, afterwards, I handed out the transcript to the interviewee for comments. Parts of the interview that the participants did not want to be analysed were deleted.

Second, I guaranteed for *no deception*. The study design did not enforce any type of deception of the participants. The goals and content of the study were explained in detail to each participant as stated above. As all participants stated high interest in the outcomings of the study, both the benefit to research in general and to the participant is greater than the risk that is taken by the participants.

Third, I provided the *right to withdraw*. The consent form (see Appendix B) ensured the participant to withdraw the participation in the study at any time. Also, I mentioned this right at the beginning of each personal interview. I told the participants that there is no disadvantage for them when withdrawing from the study.

Fourth, I took care of *debriefing*, As I fully informed each participant about the aims of the study, no debriefing was necessary afterwards. All participants stated their interest in the outcomings of the study. I ensured to send a full copy of the study to them as soon as it is done.

Fifth, I ensured *confidentiality* by not mentioning the participants' names, nor the team, nor the company where the interviews took place by name in my study. Additionally, to maintain internal confidentiality in the team, I removed personal background information that is specific for each participant from the analysis and the results section. In addition, transcripts and recordings of the interviews are only stored locally on my own computer. I deleted the recordings after finishing the transcripts.

3.4 Sample Selection

I took a purposive sampling approach, considering my research questions for the selection of the participants, which is a common procedure for IPA research [Wil08]. For selecting a suitable sample, I consulted a full-time employee at the department under consideration, who forwarded my request to colleagues.

I only consulted potential participants that have insights into the field of interest of this study. All participants work in the same department and therefore share a common understanding and form a homogeneous group. This methodology follows the principles of IPA according to Smith and Osborn [SO03].

Anyway, the work of employees in this department is distributed over several projects with independent responsibilities, enabling also a certain variability of personal experiences for this research. I approached all potential participants for the interviews via their business email contact. All of them confirmed their participation in my study.

The IPA approach suggests that decisions on sample size should be done context-dependent, as there is no universally accepted sample size [SO03]. It is common to use a rather small sample size [RFL05], as the researcher deeply engages with every single participant; the focus is on the individual case. Larger sample sizes might lead to a loss of meaning of the individual case [BW06].

Qualitative researchers often use the concept of *data saturation*, meaning that they add new participants to the sample as long as new themes are emerging [BW06]. Data collection is stopped at the point when data seems to be saturated. Anyway, Smith and Osborn [SO03] states that this concept is inadequate for the IPA approach, as the next interview might always add something new to the findings and might also lead to different interpretations of the interviews that have already been conducted. Nevertheless, in summary, a sample size of five participants is conventional in IPA research [BW06].

3.5 Data Collection

Due to the ongoing Coronavirus SARS CoV-2 pandemic, the majority of employees in the department under consideration were working from home by the time the interviews took place. Therefore, I conducted the interviews in a virtual form via audio calls. I performed and recorded the calls by using the University of Stuttgart's conference call system Cisco [Cis21]. The participants were kindly asked to turn on their cameras during the interviews so that it is easier to explore emotions by gestures and facial expressions. Some of the participants decided to turn it on, others kept it turned off, partly because of the company's privacy settings not allowing an external tool ([Cis21]) to access the camera. I have not been present at the office of the department during the calls but conducted the interviews from my office at home. Connectivity issues did not disturb the interviews at all, so the potential loss of flow of information due to remote interview sessions could be kept small.

I interviewed all participants during the working time at their office to preserve the focus of this study on frictions *at work*. I arranged a two-hour time slot for each interview to make sure that no time pressure influences the outcome or the answers of the participants. At each call, only one participant was present and I did not arrange focus groups or similar data collection procedures. I also excluded non-participants from being present during the interview to avoid possible distractions. By organising the meetings during working hours, it was easier to convince the participants to take part in this study, as they do not have to spend their free time on it.

I conducted all interviews in a close sequence by the end of May 2021. Data analysis in IPA usually is built on annotated verbatim transcripts of the interviews [Wil08]. Therefore, I recorded the audio of the interviews. From time to time, I complemented the record with additional observations of non-linguistic features that I meanwhile collected on pen and paper *(field notes [BW06])*. From the records and field notes, I created an annotated verbatim transcript. To accelerate the transcription process I partly used the transcription software Amberscript [Amb21] which is subject to a fee. The software works on automatic speech recognition and entirely ensures privacy of the uploaded audio by their general terms and conditions that can be found on their webpage. I estimate the correctness of the automatically returned transcript to be about 70 %. I manually corrected words and sentences that have been misunderstood by the software. In addition, I added some non-linguistic features to the transcripts, such as laughter or hesitation during responding. As most of the participants didn't turn on their camera, gestures and facial expression could only be added to the transcript to a very small extent. I partly tidied up the transcript, removing filler words and extensive repetitions of words without any meaning to make the transcript more readable and easier to analyse.

Before starting with the analysis, I returned the transcripts to the participants. Participants could comment on their answers and were allowed to correct possible mistakes that arose from misunderstandings or during verbatim transcription. I provided the possibility to completely delete certain parts of the interview if these should not be analysed. Data analysis is based on the corrected and annotated version of the transcripts.

I conducted the interviews in the participant's preferred language. The participants mainly are German native speakers, so I conducted the interviews in German and also created a German transcript. For the interview that took place in the English language, I also created an English transcript accordingly.

3.6 Data Analysis

For data analysis I created an Excel [Mic18] tabular which is structured as follows. I separated each interview into single statements which I numbered starting from *one*. Each statement received a single line in the Excel file for analysis. There are four stages of analysis in IPA [Wil08] [Gil14]:

The first stage is reading, which means making unfocused notes, as well as first thoughts [Wil08]. These include topics, questions, and thoughts about what is in the content of the transcript. I collected these thoughts on the left side of the transcripts in a separate column of the excel file. Unlike in grounded theory, these notes also include my personal expectations and interpretations.

The second stage comprises the creation of labels and themes to the statements [Wil08], which are included on the right side of the transcripts in another column of the excel file. However, in my case, I recognised that sometimes one label is not enough. Statements might occur that fit into multiple different themes. Therefore, I added an option for a second label in an additional column of the Excel file. Annotations from the first stage helped to formulate labels. Sometimes, label names also include my own interpretation in a certain sense. For example, the statement "I would like to work on-site again" is put into the cluster *social aspects*, as I believe the participant misses his colleagues when working at home. Labels from the previous interviews were reused and supplemented by new ones in the following interview. Also, I sometimes took a step back to the previous interview, to change some label names under consideration of findings from the following interview.

As a third stage, I structured and ordered the findings from the previous stages. This stage includes clustering multiple themes from the second stage and giving meaningful names to clusters. To select the clusters, I put a special focus on frictions that might be described by participants. I assigned all corresponding statements to the cluster *frictions*, referring to the first research question of this work, exploring in what form frictions occur in the development team under consideration. I set another focus on the feelings of the developers that they express during the interview. Statements of the participants that are put into this cluster will serve as potential answers to the second and fourth research questions, as these questions concern how the participants feel when facing frictions. Partly, these feelings are directly described by the participants, but they also include personal interpretation. For example, the statement "sometimes that makes you..." is put into the theme *frustration*, considering the context of the interview and adding the personal interpretation of the analyst.

Lastly, the fourth stage is creating a summary table of structured themes (see Chapter 7 for the complete tables and Section 4.1 for a table with the most important aspects only). In the following summary, I exclude topics that are not concerned with the phenomenon under investigation and the research questions (see 4.2). The size of the themes I collected during analysis are not balanced and reflect the participants' point: If a participant mentions a certain theme several times or has a lot to say about it, more quotations are put into the table. The filter-functionality of the Excel-tabular [Mic18] helped to select and order the transcripts to create the table.

I followed these stages for each participant. Finally, I integrated the single cases into an overall picture. During the analysis process, I used the list of themes that I extracted from the analysis of the previous interviews to code the following interview. By this, new themes were added for each interview. Willig [Wil08] names this principle "integration of cases", as the clusters and themes of the first interview are reused in the second one, adding, changing and adapting them to new findings.

As described in Section 3.5, the language of the interviews was partly English, but mainly German. For uniformity, all analysis, starting from the creation of unfocus notes, is done in English. This includes the annotations and first thoughts, labels and themes as well as cluster names. The quotations that I put into the summary table are literal translations of the German statements in the interview.

3.7 Research Team and Reflexivity

To meet common quality standards of qualitative research design, I follow the criteria list collected by Tong et al. [TSC07] which consists of 32 items. An integral part of qualitative research is dealing with reflexivity and reporting background information of the research team. Close engagement of qualitative researchers with their participants inevitably leads to personal bias [TSC07]. This especially holds for an IPA research design, as this approach actively encourages and requests personal interpretations of the researchers. To enable external assessment of the results of my study, I provide background information of the research team, which consists of myself. In addition, I describe the relationship of the research team and the participants of this study following items 1-8 of Tong et al.'s [TSC07] list of criteria.

3.7.1 Personal Characteristics

All interviews were conducted by myself as part of my master thesis of software engineering at the University of Stuttgart. I am a male full-time student at the university, and up to now, I have completed a bachelor degree of science in mathematics as well as a bachelor degree of arts in the field of sports science. I already conducted another qualitative study at the University of Stuttgart dealing with the development process in the field of virtual reality applications [HKW20]. During my bachelor degree in sports science, I also engaged with social sciences and psychology in the respective field. In addition, this work is supervised by D. Graziotin [LFG+20] who published his PhD in the field of qualitative software engineering research.

3.7.2 Relationship with Participants

Since I've been a working student in the same department as the participants of this study, I partly know them quite well and have been collaborating with them on multiple projects. Anyway, as a working student, I am not entirely involved in processes, meetings and project teams. By this, I can maintain an external view on one side. However, on the other side, I have background knowledge about possible fields of interest for the interviews.

All participants received a consent form in advance of the interviews. Thus, they got informed that the interviews are part of my master thesis. The goal of the research and the research questions are also elucidated in this document (see Chapter 7 for the consent form and Section 3.3 for ethical considerations).

3.7.3 Personal Expectations of Researcher

In advance of the conduction of the study, prior to the master thesis, I was part of the team under consideration as a working student. Of course, as part of this work I was facing similar frictions, problems and challenges as permanent employees in this team do. Also, generating the interview agenda naturally is based on my personal expectations. Therefore, interviews also follow this pattern and answers will tend in a similar direction. As a result, topics that I expect to be relevant will be answered within the interviews in detail. Maybe others that I didn't think of are not mentioned at all.

In order to deal with reflexivity, I thought about all the aspects of the interview guide by myself before the interviews. Comparing the results of the participants in Chapter 4 it becomes obvious, that I in fact did face similar frictions and feelings as the majority of the participants did. On the one side, this is a confirmation of the results of the interviews. On the other side, it might be a threat to validity since I as a researcher might unintentionally lead the results into a direction that I expect the results to head for. This should be kept in mind when evaluating the results.

4 Results

4.1 Participants

For the interviews, I selected five participants with a purposive sampling approach as illustrated in Section 3.4. I purposively selected participants, aiming to get answers to the research questions [Wil08]. All participants work in the same department of a company in the consumer electronics industry. Their main task is the development of a generalised data evaluation pipeline for testing and quality assurance of the company's products in a laboratory environment. The position of the data evaluation team is the key link between data creation or measuring and customer communication. This central position within the structure of the company makes the analysis at hand of superior interest, as there are several interfaces where frictions might occur - not only within the team but also in the context of collaboration with other teams in the pipeline. Participants of the study form a homogeneous group and share similar experiences as they work in the same department. Therefore, the frictions they experience in everyday life are similar and comparable.

All of the respondents are male and have been working in the department for at least nine months. The most experienced team member has already been working in the department for 6 years. More experienced developers rather take organisational tasks within the company structure. The majority of the participants have a research background, and their PhD included coding or data analysis in a certain manner. In order to maintain the anonymity of the participants, I removed all personal information, research or study background from the summary tables.

4.2 Results of Interviews

This chapter summarises the findings of all the interviews. In the first step, results are described for each participant individually. All findings for each participant can be found in the corresponding summary tables as described in Section 3.6. Due to readability, I removed themes, clusters and statements from the summary tables that are less important. The level of importance is estimated by the subjective assessment of the researcher. According to this, themes that are mentioned multiple times during an interview are considered as important, corresponding to the number of statements to a certain theme of the summary table. Also, topics are considered to be more important if they are mentioned in different contexts throughout the interview. In this case, there are multiple statements in the summary table and the corresponding statement numbers have gaps in between, indicating that the statements are made in multiple, different contexts throughout the interview. This means that the particular participant refers to the respective topic multiple times, expressing the importance of this topic.

The complete tables including all themes, statements and clusters that I created during data analysis can be found in Appendix C.

Following the principle of [Wil08], results are presented as they fit the research questions (see Section 1.2). Clustering according to thematic fields that I created during data analysis brings structure to the great number of participants' statements and makes them comparable. As a first step, interview analysis of each participant focuses on stated frictions, referring to the first research question. As the second, third and fourth research questions all deal with the effects of frictions on work or on developers themselves, these are answered collectively.

In Section 4.2.1, I take a look into each individual interview as well as the participant's personal experiences in the context of the research questions. For an overall and more generalised picture, the findings from all participants are aggregated in Section 4.2.2.

In the following sections, direct citations from the interviews are used to attach value to the statements.

4.2.1 Single-Case Analysis

Participant 1

The analysis of the interview with the first participant refers to the data in Table 4.1.

The participant under consideration faces several kinds of friction during work. First, on the one hand missing access rights prevent him from being more productive, creating a "huge obstacle [P1 - 491]". These rights include access to file shares or documentation, but also permissions for the usage of certain software tools. Permissions are granted by management. The process of granting these rights often takes several days, causing unproductive work in the meantime.

Second, inconsistency at work leads to frictions in multiple ways; the execution of similar tasks in different teams of the company with the usage of varying tools makes work "chaotic [P1 - 515]". Changing interfaces in the data pipeline between data measuring and data evaluation demands manual adaptions in the code, leading to "unnecessary iterations" and again a loss of working time.

Third, another typical friction mentioned by participant 1 concerns meetings. The respondent states that the "meeting culture is lost [P1 - 339]" when colleagues simultaneously work on other tasks during a meeting. A meeting that is well structured with participants who are concentrated and that is also scheduled in a way that avoids interruption of coding tasks could lead to a significant reduction of frictions if conducted respectively.

Fourth, the participant regularly faces the friction of long waiting times for code reviews, which even leads to intensive, even negative emotions and makes him "angry [P1 - 499]".

In general, frictions seem to have two different kinds of impact on the interviewee. On the one hand, he shows a huge drive to improve and personal motivation. He "fights for being heard [P1 - 446]", for being able to "improve, what [he] has recognised [P1 - 463]". Hence, frictions also lead to motivation and activities that help to reduce frictions in the future. Moreover, this is reflected in the feelings that he experiences in this context, such as optimism and also happiness; he states that it's "a stroke of luck [P1 - 24]" that he is working in a good team with a great team spirit.

On the other hand, frictions definitely constrain his impact on work and also cause negative feelings as explained above. He feels a lot of time pressure, as "deadlines are close [P1 - 159]". In the context of frictions mentioned above, he is "stuck in daily work [P1 - 433]" and loses time that actually could be spent on improving processes or reducing frictions. Furthermore, even if there is time for the realisation of his ideas, he misses the support by higher management, which is a "big hurdle [P1 - 427]". This causes "a little frustration [P1 - 50]" for him and makes him "feel small [P1 - 431]".

Home-office is a coin with two sides for the first interviewee: At home, he can work very efficiently, but he misses his colleagues and wants "to work on-site again [P1 - 558]". The sense of belonging to the company gets lost to a certain extent, and home-office is "exhausting [P1 - 365]". This condition can also be considered as friction since mental exhaustion also leads to a reduction of productivity as stated by QuietSpacing [Qui].

Table 4.1: Participant 1: Summary table of data analysis, following the data analysis principle of [Wil08]

Theme labels	Quote or keyword	statement numbers
Frictions		
Inconsistant interfaces	"unnecessary iterations"	20
Inconsistant tooling	"no switch to MS teams yet, a little chaotic"	319, 515
Permission rights	"huge obstacle"	491
Scheduling of meetings	"only half an hour to next meeting"	172
Structuring of meetings	"should be better structured, meeting culture lost, doing something in parallel"	175, 339, 340
Waiting for review	"colleagues react delayed, waiting for response, angry"	464, 499
Company organisational structure		
Time management by team leader	"gets neglected, not thought carefully, plan ressources better"	55, 154, 250
Limited support by management	"project leader doesn't see as software development, project financial sources don't suffice, sensitize management"	57, 58, 106
Management missing	"need change management, I can't prioritize, a lot to criticise, does not know what I'm doing"	145, 162, 278, 280
Management slows down progress	"green light from above, not enough support, big hurdle, escalation"	305, 427, 438
Structural hierarchy	"hierarchies, could be different when working at site"	443
Feelings at work		
Frustration	"little frustration, managers don't know what software needs"	50
Exhaustion	"[home-office] negatively affects health"	361
Happiness	"stroke of luck [to work in this group]"	24

Hierarchy	"I feel small"	431
Time pressure	"deadlines are close; you have to deliver, you know, continously!"	159, 208
Missing confidence	"If they'd put more trust in me..."	215
Optimism	"it's getting professional, something good going on"	48, 299

Impedements at work		
Limited capacity for improvement	"too little time, stuck in daily work"	98, 433
Quality	"time pressure [...] decreases quality"	136

Personal motivation		
Drive to improve	"fight for being heard"	446
Fatigue and exhaustion	"working day on site is not that exhausting, only with hard disciplin, no more energy"	365, 368, 369
Innovative thinking	"great new thing, have fun learning"	97, 99
Need to structure	"we need a responsible, plan at least for one week, need two days for [only] programming, manifest workflows, again and again startup-mentality"	121, 144, 166, 180, 255, 314
Programming	"that is fun!, of course, programming!"	108, 119

Self confidence		
Leader	"took role of release manager, take over things, establish the workflow"	45, 103, 105
Qualifications	"I have this competence, what I know from before, using it for [...] 20 years, improve what I have recognised, experience"	9, 38, 72, 463, 519

Social aspects		
Anonymity in home-office	"See one's counterpart, see ourselves way too seldomly, [missing] sense of belonging"	332, 335, 400
Communication	"works really really well"	461
Missing colleagues	"like to work on site again"	558
Team spirit	"team [...] does the right thing, like how it works in team, always someone who listens"	283, 407, 419

Software quality topics		
Documentation	"Need more time, I'm excited how things are documented"	510, 514

Participant 2

The analysis of the interview with the second participant refers to the data in Table 4.2.

Participant 2 experiences frictions in his daily routine in a similar way compared to the first participant. For participant 2 inconsistency is a huge topic as well. He considers inconsistency in the usage of tools, especially variations in communication channels, as serious friction. The second participant criticises that in his working life he often does not know where to look for documentation, which tools to use and therefore many times cannot quickly find the thing he is looking for. In his view, especially the usage of emails as a tool for documentation leads to frictions and unproductiveness, as colleagues who are not "involved [P2 - 85]" will also not find the information in the mail.

Besides, the existing meeting culture in the company leads to frictions for him. He states that "other firms do this better [P2 - 309]". Especially, he regards the choice of invitations for meetings as bad and not target-oriented since meeting conductors tend to "simply invite everybody who could know something". For him as an expert in data evaluation being spontaneously invited to a meeting often implies interruption of work on short term notice. In turn, this also leads to mental exhaustion when such incidents rip him out of his coding tasks because then he instead has to "think deeply about the topic [P2 - 24]" of the meeting.

Furthermore, another kind of friction that the second participant explicitly mentions is dealing with the time that is lost when waiting for tools to load. This sometimes "takes forever [P2 - 565]". The time in between clicking on a tool and waiting until it is ready to use is unproductive because it is too short to start another task in between. Naturally, since this happens multiple times a day it must be considered as significant friction.

Especially inconsistency in the usage of tools, for example concerning communication channels, has a huge impact on the feelings of the second participant. He considers himself as a leader and organiser as he executes "more coordinative work [P2 - 130]". Therefore, he is even more annoyed if colleagues "don't stick to [processes], even if agreed upon [P2 - 187]". This causes strong negative emotions. He misses a clear statement from the management level, as they are the ones who should "define one standard [P2 - 531]" and also "demand for [P2 - 209]" it. Even though he has been fighting for more consistency for a long time he does "not feel the progress [P2 - 176]" and more and more gets "annoy[ed] [P2 - 176]" about that.

The participant shows strong feelings if hardware or software needs a long time to load. This definitely shrinks his impact on work and makes him angry. Throughout the interview, he uses strong metaphoric imagery like "dead times" to describe waiting time.

However, time pressure is not an issue for participant number 2. He "defintely feel[s] [P2 - 61]" it, but for him this is "no problem [P2 - 111]"; he can deal with it. Therefore, in this case, being pinched for time does not play a role in the context of frictions. Here it becomes obvious that participant 2 is an experienced employee with superior stress management.

In addition, for him, home-office also "works well [P2 - 335]". He still notices a good collaboration within the team. He states that the team is spread all over the world anyway, and therefore they had to meet online even prior to the pandemic situation. Nevertheless, home-office leads to frictions in the context of communication, as it takes much more time to clarify things via email. The interviewee admits that many "discussions wouldn't have happened if we had met in the office for five minutes [P2 - 340]". In his view, working from home sometimes makes discussions less efficient. Discussion and communication are integral parts of the daily tasks of participant number 2, and these are "very important [P2 - 47]" for him. Making these concepts much more efficient can therefore have a huge impact on overall productivity.

Table 4.2: Participant 2: Summary table of data analysis following the data analysis principle of [Wil08]

Theme labels	Quote or keyword	statement numbers
Frictions		
Email as documentation	"who's involved and who not?"	85
Inconsistant interfaces	"not stick to it, even if agreed upon, sometimes disenchanting seeing that, annoying"	187, 190, 202
Inconsistant tooling	"different communication channels used, tools not used, big problem, redundance in tooling"	80, 83, 86, 519
Loading time of tools	"takes forever"	565
Scheduling of meetings	"big problem, only half an hour to next meeting, unfavourable, scheduling on short-term notice, other firms do this better"	271, 280, 285, 308, 309
Structuring of meetings	"simply invite everybody who could know something"	303
Waiting for review	"for weeks, as we didn't find the time, does not always work out"	495, 503
Company organisational structure		
Mangement home-office	"I feel informed, don't know when I've seen group manager the last time"	380, 383
Management slows down progress	"fails because managers don't demand for..."	209
Management missing	"no real guideline, focus to define one standard"	524, 531
Feelings at work		
Annoying tasks	"thing that is annoying, because you don't feel the progress, only thing that helps: motivate them even stronger"	176, 178, 200
Dissapointment	"partly dissapointing for colleagues"	496
Happiness	"I have fun to ellaborate effects, I'm excited, I am lucky"	140, 146, 576
Exhaustion	"[Meetings], where you have to think deeply about the topic"	24
Impact of work	"we're the last ones who can squeeze out every last percent"	62
Time pressure	"have to give feedback very fast, relatively fast, you definitely feel this time pressure"	31, 36, 61
Optimism	"develop myself in the future, it's already planed, I see improvements, we got better"	131, 160, 233, 264, 500
Dislikes	"exactly, these dead times..."	560
Impediments at work		

| Communication | "discussion wouldn't have hapend if had met in office for 5 mins" | 340 |
| Getting interrupted | "even if you had something completely different in mind, you get called [...] and asked" | 306, 317, 418 |

Personal motivation		
Communication need	"very important and takes a lot of time"	47
Identification with company	"concerning work, it's there"	372
Need to structure	"[daily routines,] that's what you need"	359
Drive to improve	"challenging things [communication with] China"	442
Explorative work	"have fun to ellaborate effects, working creatively, I'm excited"	140, 143, 146
Programming	"of course, it's fun, programming has always been my favourite"	138, 139

Productivity drivers		
Stress management	"for me, it's [colliding interests] no problem, [I can deal with] time pressure"	111, 19
Productivity in home-office	"works well, for me, it's good, collaboration does not suffer"	335, 349, 377
Tooling	"well integrated"	478

Self confidence		
Leader	"more coordinative work, keep everyone up to date, we can retrace, who did what, [teach] and trace the reaction"	130, 258, 343, 415, 473
Qualifications	"coordinate less experiences colleagues, we're the ones who can analyse [...] fast, I had to manage a lot, long time experience"	30, 163, 527

Social aspects		
Team spirit	"[meeting] is very important, [I am proud as] they make great progress, within [my] team, works very well"	249, 408, 441, 444
Missing colleagues	"never met in person, what's missing is the personal exchange"	331, 339
Professional relation	"nobody ever felt offended [during code review]"	491

| **Software quality topics** | | |
| Documentation | "is no fun, but necessary, saves time at the end, helps a lot" | 398, 399, 416 |

Participant 3

The following analysis of the interview with participant number three refers to the data in Table 4.3.

Participant 3 appears to be a very positive and empathic guy. In total, he mentions fewer frictions compared to the other participants. He also comments on the team and its processes in a very positive way.

Nevertheless, for him, permission rights definitely appear to be huge friction as it "makes you slow [212]" not to have appropriate rights. He states that he cannot really work on his tasks as long as he does not have relevant permissions. Not having these permissions hinders progress in the team, especially when exploring new tools that might increase efficiency. Therefore, lack of permission is friction.

Similar to participant 2 he detects frictions in unnecessary meetings. It seems to be a waste of time if you are invited to a meeting without any visible reason, or if you cannot deliver any "content for a long time [P3 - 697]" within the meeting. In such a case, the interviewee loses time and gets more and more overwhelmed by time pressure concerning other tasks since "everything [should have been done] yesterday [P3 - 183]". Furthermore, he considers non-automation as a kind of friction. Several tasks in daily work that could be automated appear to be a kind of friction. When automated, the workload of simple, repetitive tasks is taken from developers. This saves time and gives the opportunity to work on other tasks. Non-automation "consumes resources of the company and [...] resources of your computer [P3 - 335]" and, as a result, reduces productivity.

Another thing that can also partly be seen as friction for participant 2 is that sometimes he cannot stick to his daily planned schedule and, additionally, that new tasks come in that have to be taken care of immediately. In addition to the interruption of the planned work, this is "a bit annoying [P3 - 479]" for him. Talking about these interruptions he states that these are "something which is... yeah... [P3 - 350]", indicating strong emotions, annoyance and dislike in his sensation.

However, he gets his motivation from his colleagues who "reward [him] for finishing [his] work [P3 - 49]". He really enjoys the recognition that he receives and he is proud of working for the company he works for, feeling himself "very much part of it [P3 - 660]". This evokes strong feelings as well as a desire to be productive.

Of course, frictions also obstruct him from being even more productive. Anyway, he also gets his motivation from exploring "new techniques [P3 - 282]" that might reduce friction in the future, for example, non-automation. Participant 2 is a guy with a strong drive to improve, "lov[ing] technical things [P3 - 98]" and loving to learn something new each day. Seeing the opportunity for improvement and an Optimistic future, he is very "happy [to be] part of the team [P3 - 262]" in which he feels support and good team spirit.

In total, he definitely experiences annoyance caused by frictions. However, he also feels motivation and happiness for being able to improve things in the future and be part of a change.

Social contacts are very important for this interviewee as he "work[s] with emotions [P3 - 599]". He needs recognition for his work from his colleagues as well as the team spirit, becoming a "part of the big picture [P3 - 80]". Therefore, he experiences home-office as a burden which is "not good for your mental health [P3 - 569]", although coding tasks can be solved "quiet effective[ly] [P3 - 636]" when working from home.

Table 4.3: Participant 3: Summary table of data analysis, following the data analysis principle of [Wil08]

Theme labels	Quote or keyword	statement numbers
Frictions		
Non-automation	"have to do multiple things, consumes [...] resources of company and [...] resources of your computer, time consuming"	335
Permission rights	"very tricky, permissions need to be taken care of, makes you slow, slowness in the system"	206, 210, 212
Structuring of meetings	"you are not a content for [long time], but your whole time is blocked"	697, 698
Company organisational structure		
Management slows down progress	"management [...] innovation [...] extra effort, once per week we should be allowed to work on innovative things, still need some convincing, things take time"	301, 312, 331, 376
Role in system	"[team external] didn't care about [...] code working or not, not aware of how our workflow is, very tricky, perspective of a data developer"	348, 531, 511
Feelings at work		
Annoyance	"a bit annoying [unplanned work comes in], becomes difficult, [external communication] one of the things which is annoying"	479, 491
Annoying tasks	"in the morning [before vacation] I get an email, it was [...] mixed-up"	465, 469
Burden	"[home-office] not good for your mental health"	569
Dislike	"communication issues"	453
Disappointment	"something which is... yeah"	350
Excitement	"you are excited [by progress], [progress] makes [...] my job very exciting"	149, 267
Fatigue and exhaustion	"don't even have time to have coffee or relax 5 minutes"	720
Frustration	"becomes a bit slow, sometimes that makes you..."	180, 192
Happiness	"very happy [...] part of this team, happy about it, everybody is happy, fruitful working together"	262, 363, 758, 66, 622
Optimistic future	"going towards that, hopefully it will be like [...] in the future"	386
Proudness	"I was the one, I was saying that [working for the company he works for]"	272, 664
Team spirit	"very, very supportive, happy [...] part of the team"	153, 262
Time pressure	"everything is yesterday, becomes very freaky, we need it tomorrow!"	183, 185, 458

Impedements at work

Communication	"[team external communication] problematic, I was not even aware of, "You know, guys, you need to be more efficient...!", communication gap, different kind of communication [when meeting in personal]"	472, 474, 476, 492, 674
Double work	"everybody's writing a new code, inefficient"	254, 257
Limited capacity for improvement	"a bit sluggish"	172

Personal motivation

Drive to improve	"learning the tools, exciting field, new techniques that I can explore, move a huge wheel [...] need[s] effort, need to do some trainings, excitement comes from these [innovative] tasks"	260, 264, 282, 351, 366, 396, 414
Identification with company	"very much part of it"	660
Innovative things	"I enjoyed learning, no choice of getting back"	99, 224
Need to structure	"organize my work"	459
Programming	"I love technical things"	98
Recognition and reward	"reward from finishing your work, [I] enjoy that"	49
Working for huge company	"motivation is always there"	672

Productivity drivers

Productivity in home-office	"quite effective"	636
Social contacts	"working together, work with emotions"	599

Self confidence

Self confidence	"[recognition by others] gives you confidence"	287

Social aspects

Compliments	"everybody says thank you to you, appreciation from the team, [extra work] will be appreciated"	239, 284, 367
Misses colleagues	"we'll go more often to office, rituals [...] fist bump, emotional bonding, we are humans"	593, 594, 602
Subordination	"I'm very new, new environment"	231, 246
Team spirit	"very systematic, part of the big picture, push it more together, [no] negative energy coming from the team, huge thing"	77, 80, 355, 748
Understanding and acceptance	"they have to keep in mind a lot of other things, management is under pressure, I can understand"	310, 317, 722

Software quality topics

Code quality	"minimum requirement that should be satisfied by each code"	429

Documentation	"not very fun"	129

Participant 4

The analysis of the interview with the fourth participant refers to the data in Table 4.4.

In general, the frictions mentioned by participant 4 are similar to the statements of the other participants. In the interviews before, a special focus on the problem of inconsistency has been described. Participant 4 puts much focus on this, as in the team he is responsible for solving this problem which causes a "very large overhead [P4 - 154]". If "pipelines break down [P4 - 118]" and the process that the team aims for "does not work for the umpteenth time [P4 - 112]", a lot of time is lost unproductively. Furthermore, the interviewee names the inconsistency of tooling, respectively documentation to be a huge "overhead [P4 - 719]", as "everybody does [it] differently [P4 - 723]". So searching for the tool or file system where the documentation is stored or the need for asking the specific documentation's responsible person wastes productivity.

Non-granting of permission rights for certain innovative tools sometimes grows from friction to a blocker. First, members of the development team face a long waiting time for the "permission [P4 - 420]" of a tool, recognising in the end that the tool is completely "blocked [P4 - 683]" by the IT department. Then, a lot of time is lost trying to solve the problem, having no practical result anyway. This of course results in annoyance for involved developers.

As the current participant takes many coordinative tasks, he has a lot of meetings. Due to that, frictions concerning meetings are a huge problem for him as well. He states that often colleagues schedule meetings "too tight [P4 - 257]" so that the scheduled duration of a meeting does not suffice to clarify a topic. Then, another time slot for a meeting has to be found. In the next meeting, discussions usually start again from almost zero, which is "not efficient [P4 - 261]".

What can also be seen as friction is the fact that in the daily rush, processes actually agreed upon and well established are lost, as "projects are hectic [P4 - 146]". This leads to additional work that would not have been necessary without the pressure of time.

All strong, negative feelings that occur for participant 2 are based on friction. Frictions not only waste time by themselves, but they also decrease the motivation, the state of mind and the way an employee feels at work. Therefore, it affects productivity when working on tasks that are not directly affected by friction as well. It is very important to take care of these tasks and try to reduce them.

Participant 4 gets frustrated if "things are out of hands [P4 - 113]" and if he cannot do anything about the friction that he is facing. An example of this case is when the IT blocks a tool that actually could ease up a process or reduce friction. A reason for the frustration might be his organisational role in the team and his responsibility.

Often meetings are scheduled in a way that he has few breaks and only short times in between, which exhaust him. He has to "mentally jump between the topics [P4 - 248]" in back-to-back meetings, which is very challenging.

In this context, he also misses working on-site. Also, the "small breaks you had in between [P4 - 327]" meetings when getting from one meeting room to the next one helped to get ready for the next task, to switch the topic or to help the mind to change the thematic field by also changing the

location. Working from home, he also misses "having a coffee together [P4 - 311]" with colleagues, which motivates and brings new energy. Anyway, for him working from home is "very efficient [P4 - 304]" as he faces much less "distraction [P4 - 307]".

In general, participant 4 enjoys that the company supports changes in processes, is "open-minded [P4 - 435]" concerning progress, new tools as well as possible reduction of frictions. He states that it is the "correct mindset [P4 - 445]" and he feels well in the team and about the support he gets. Frictions that occur also drive him to try new things, be creative and try to solve them. He likes to "take the coordinative part [P4 - 22]" and to find out if there are any "bottlenecks [P4 - 24]".

Table 4.4: Participant 4: Summary table of data analysis, following the data analysis principle of [Wil08]

Theme labels	Quote or keyword	statement numbers
Frictions		
Inconsistant interface	"does not work for the umpteenth time, pipelines brake down, again different name in different project, please use a consistant name, please!, very large overhead"	112, 118, 154
Inconsistant tooling	"two, three, four different versions, not consistant, leads to overhead, everybody does [documentation] differently"	414, 719, 723
Permission rights	"permission problems that occur, it gets difficult with permissions, blocked by CI, effort gets too large, happens often"	420, 651, 652, 683, 705
Scheduling of meetings	"multiple short meetings in a row, time pressure, because you don't manage to clarify in 30 minutes [too short meeting], get invited to tight, not efficient"	244, 245, 250, 253, 257, 261
Waiting for review	"reviewer has to seperate [the task] into multiple days"	613
Company organisational structure		
Management missing	"They give us too much freedom [concerning tooling], training issues: they should explain how to use the tool"	728, 732
Feelings at work		
Annoyance	"Annoying, annoying for us, of course annoying [inconsistant interface], meetings [concerning one topic] smeared over three weeks", extremly long time lost [by blocked tools]	120, 136, 187, 254, 659, 692
Disappointment	"you have to admit at the end: there is no solution, you have to live with it, wasted a lot of time [finding work-around for blocked tools]"	693, 696

Fatigue and exhaustion	"you have to mentally jump between topics [back-to-back meetings], no breaks in between, it's getting..., exhausting, these small breaks that you had in between [home-office]"	248, 316, 322, 323, 327
Frustration	"things that are out of hands, it's getting frustrating [long time for review]"	113, 575
Impact of work	"makes fun and brings benefit [interaction and organisation]"	91
Misses colleagues	"you just talk for a while, it's completely gone, it's missing, I've not been there for a long time"	328, 329, 376
Optimistic future	"go into the right direction, we'll get it done"	196, 303
Proudness	"it used to be ... smaller than it is today, we standardized [..] with all these tools that we have"	74, 721
Supportive atmosphere	"company is very open-minded, changed everything, the correct mindset"	435, 443, 445
Understanding and acceptance	"also for [them], it's very complex, nobody does it maliciously"	180, 294

Impediments at work

Large pull requests	"two problems that occur [in this case], reviewer is overwhelmed, get stuck for months, problem stays the same"	597, 603, 620
Process lost in daily rush	"projects are hectic, additional work"	146

Personal motivation

Communication need	"communicate accuratly"	98
Drive to improve	"[re-organisation] that's an interesting point!, it's a feat of strength, not a blocker [that] we always did it this way"	205, 447, 448
Identification with company	"[no] distance to company [by home-office], strong feel of belonging, because I interact with the people"	364, 365
Need to structure	"processes and planning, bring a structure to it, we have to clean up and maintain, we have to build up a team structure and define roles in the team"	7, 391, 393, 441
Spread knowledge	"explain it to the others and say "hey, you have to do it this way!""	93

Productivity drivers

Productivity in home-office	"no problem, [on site] you get disturbed frequently, better concentrated, very efficient, less distraction"	302, 304, 307

Tooling	"video function [of MS teams], tooling landscape well equiped"	348, 650
Self confidence		
Leader	"provide the infrastructure, my role [...] is the coordinative part, where are the bottlenecks?, look for another responsible, spread it to the people, define a format"	18, 22, 24, 38, 273, 394, 405
Qualifications	"Give feedback and make annotations"	54
Social aspects		
Feedback and criticism	"not offended, question of good character"	551, 561
Missing colleagues	"you don't meet each other, not possible to just have a coffee together"	310, 311
Social distance	"when I come [to office], [...] I don't know their name, and I never met them before, a little distance"	371, 372
Team spirit	"we got a seperate team, we actively work on it, as a team"	20, 412
Understanding and acceptance	"I can understand [the other teams]"	135
Software quality topics		
Documentation	"very important, not self-propelling"	386, 389
Technical debt	"not solved efficiently, [problems] just procrastinated"	121

Participant 5

The analysis of the interview with participant 5 refers to the data in Table 4.5.

Frictions that participant 5 is confronted with are comparable to the ones mentioned by other participants. Being a person who always tries to automate tasks, the participant refers to non-automation as severe friction. Still, he faces non-automation many times in his working life. If developers have to manually "click through things one after another [P5 - 175]", a lot of time is lost. In this context, there are large capabilities for improvement.

Furthermore, the problem of long waiting times until access rights are granted is a big problem for him as well. In the process of establishing new and innovative toolchains waiting for access rights hinders "working on a topic efficiently [P5 - 737]".

In accordance with other participants, meetings are an issue for participant 5. He states that he is "happy when there are no meetings [P5 - 111]". Therefore, meetings mostly seem to be an unwanted interruption of work. However, frictions occure within meetings, too. Often, within meetings of 90 minutes "only 5 minutes [...] are interesting [P5 - 235]". If meetings were structured in a better way and the meetings' participants knew when their feedback is needed, a lot of time could be saved and frictions reduced. Sometimes, he gets annoyed in this context; he states that colleagues should "discuss small things in extra meetings [P5 - 326]", where he is not part of it.

Participant 5 seems to be a very concentrated worker who deeply dives into the topic he is working on, being "free of distraction [P5 - 780]". Friction for him is that he frequently is disturbed by "questions after questions [P5 - 769]" from colleagues that come in spontaneously. In such a case he cannot concentrate well and becomes unsatisfied.

Additionally, participant 5 faces friction concerning inconsistency, especially in the context of documentation. The problem is that manuals or descriptions are "hard to find [P5 - 497]". This makes work "unnecessarily complicated [P5 - 540]". He wishes for decisions by the management level for more consistency in documentation. In general, the extent of documentation in the team is satisfactory since "a lot of documentation is lying around [P5 - 546]". However, consistency and the system within this documentation is missing.

From time to time, participant 5 gets a little disappointed as frictions keep him from doing what he really likes to do and what brings him the "most fun [P5 - 117]": programming complex tasks, on which he can "put [his] full focus on [P5 - 116]".

As a mather of facts, he is excited that the team is willing to improve things and that "a lot of things are happening [P5 - 335]" that aim to optimise processes, getting better and finally reduce frictions. In order to get to this goal faster, he would like to have more time and capacity to work for it, and he acknowledges that the team "could do so much [P5 - 332]".

Table 4.5: Participant 5: Summary table of data analysis, following the data analysis principle of [Wil08]

Theme labels	Quote or keyword	statement numbers
Frictions		
Access rights	"simply does not work, [hinder] working on a topic efficiently, get slowed down, took a while"	735, 737, 741, 750, 755
Inconsistant tooling	"the others won't know, hard to find, we should be consistant, unnecessary complicated"	487, 497, 535, 537, 540
Interruption of productive work	"questions after questions"	769
non-Automation of tasks	"click through things one after another, always the same, same step"	178, 185, 190
Scheduling of meetings	"happy when there are no meetings"	111
Structuring of meetings	"only 5 minutes of 90 are interesting, should have an agenda, topics have to be priorised"	235, 273, 307, 313
Waiting for review	"code reviews lie around for a long time"	709
Company organisational structure		
Limited support by management	"working hours specific for project, little temporal scope"	392, 393
Role in system	"find my role after a while and realise things"	366
Feelings at work		

Annoyance	"tasks, where you have to work moronically, put this topic to a seperate meeting, discuss small things in extra meeting, that's a topic [can't use tool that I want], why can't this go faster?, takes endless time [tasks with little outcome], not feeling good"	148, 322, 326, 490, 760, 152, 154
Curiousity	"I'm the one who learns"	365
Dislike	"do not enjoy to work into old code"	125
Disappointment	"far too little [time for programming], falling apart as we have no time, [review] and then, there is some critism anyway"	212, 337, 695, 696
Distraction	"really, you have to be free of distraction, when I find some peace"	780, 108, 114
Excitement	"what I think is exciting, most fun"	113, 117
Happiness	"I'm happy about it [to be able to learn]"	700
Misses colleagues	"this somehow is lost"	617
Optimistic future	"project that we started, a lot of things are happening, getting better and better"	162, 335, 506
Supportive atmosphere	"everybody helps, we find the time to meet"	426, 454
Time pressure	"unnecessary pressure, they put pressure"	472, 477

Impediments at work		
Communication	"they do not know the background, should present our whole process, [on site personal communication] is a whole different thing"	466, 468, 633
Large pull requests	"endless long, really needs time"	710, 711
Limited capacity for improvement	"we never finish, no capacity, we could do so much, same problem, [improvement] sets a new task that needs a lot of time"	295, 330, 332, 377, 378
Too long discussion	"meeting over before finished, you sometimes have to interrupt"	298, 310
Working in parallel	"not good at working in parallel [to meetings], not that productive, with one ear in meeting"	247, 249, 252, 791

Personal motivation		
Complex tasks	"put my full focus on, start from zero"	116, 123
Drive to improve	"I'm currently testing, I have to think about how to automate, lots of things to improve, many ideas, a lot to be done, look at it [feedback from others] and learn"	161, 164, 179, 329, 545, 699
Programming	"[have the time for] programming"	109

Productivity drivers		
Productivity in home-office	"works really well, nothing changed, no influence on productivity, [on site] there is noise, good step forward"	583, 610, 783, 784
Stress management	"Usually, it's okay to have it the next day"	458

Tooling	"Git is very important, can't imagine without [Git]"	656, 657, 658
Self confidence		
Leader	"tried to explain to colleagues"	677
Missing experience	"only know the theory, never applied"	351
Qualifications	"actually this is not the way..., there are better solutions"	667, 668
Social aspects		
Communication	"[daily stand up] each morning, very important, you can discuss, direct communication lost [in home-office]"	437, 439, 444, 632
Compliments	"I got feedback directly, they are really happy [with my work]"	199, 201
Missing colleagues	"there is no time"	593
Professional relation	"nobody feels offended, [reviews] are a good thing"	693, 697
Subordination	"I'm not in the position, I take what's there, the others are more experienced, I can't give so much feedback"	360, 363, 367, 370, 702
Team spirit	"there is always somebody who listens, they are supportive, always, get to solution together, everybody is into it"	376, 421, 423, 447, 451
Understanding and acceptance	"same from my side, everybody has his own process, there is feedback, it's not easy [to have a good meeting structure]"	137, 138, 203, 232
Software quality topics		
Code quality	"[higher code quality without pressure] I would say, less problems in the long term"	482, 722
Documentation	"extremly important, there is a documentation anywhere [for everything], a lot of documents lieing around"	518, 534, 546
Test-driven development	"takes a lot more time"	721

4.2.2 Integration of Cases

Summing up over the entity of all five conversations I conducted with the participants I now want to conclude by a summarising overview. Table 4.6 integrates the most frequently mentioned aspects found in the interviews from the previous section 4.2.1.

Several kinds of frictions occur remarkably often throughout the interviews (see Figure 4.1). First, there is inconsistency in the tooling landscape, especially in the context of documentation. Frequently, participants mention that there is documentation to a satisfying extent, but they have
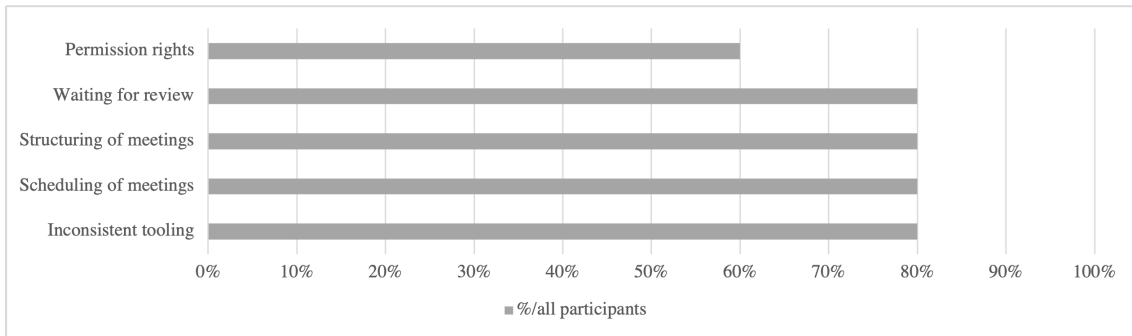
Figure 4.1: Frequently mentioned frictions among participants

difficulties finding the relevant documentation. They state that there should be one single tool that is consistently used throughout the company. Good documentation does not help if you cannot find it when you need it. Often, developers still have to ask the responsible person where the documentation can be found. Referring to them, especially emails should not be used as a tool for documentation as the content cannot be managed efficiently and information is hard to find. Additionally, the ones who are not involved in the email conversation do not have access to the information it contains. This is ineffective and must be considered as severe friction in developers daily routine.

Second, developers oftentimes face the issue of timing of meetings, more precisely how and when meetings take place. Overall, meetings take a large amount of time: "if I look into my schedule, it's actually only meetings [P4 - 46-47]". Concerning the number of meetings, there exists variance across participants. For some of them, all of the meetings are necessary. For others, the number could be reduced to gain working time. Participants (4 out of 5, see Figure 4.1) agree on the fact that scheduling of meetings could be improved; rather one longer meeting than several short ones would increase efficiency. In addition, if there are several meetings spread over the day, coding time and productive work get interrupted regularly. This should be avoided. Moreover, people should conscientiously select who is invited to a meeting and should only select colleagues who are relevant in the context of the selected topic. Also, the majority of participants (80 %, see Table 4.6 mention the structure of meetings as a friction. Participants suggest that it would be helpful to have an agenda for each meeting so that participants know if and when they are needed throughout the meeting. In that case, they could leave a meeting when they are not needed. Additionally, having a summary or minutes of the meeting for those who could not attend would be a source of value.

Third, 80 % mentioned a rather specific fact as friction in their working life. They have to spend a lot of time waiting until a code review is finished. Colleagues should conduct reviews with higher prioritisation. This would lead to less waiting time for the other developers. Also, after a long waiting time the respective code might not be needed anymore, as the developer might have found "another solution [P4 - 621]." In that case, the time needed for the development of the code is lost, code and review are obsolete. In the view of developers, this might cause frustration as well, since they put a lot of effort into the development of codes.

Fourth, the absence of permission rights or access rights for tools as well as for file shares is another friction that is mentioned frequently. Three out of five participants mention that this problem constrains their impact on their tasks at work. Especially when working on improvements of the
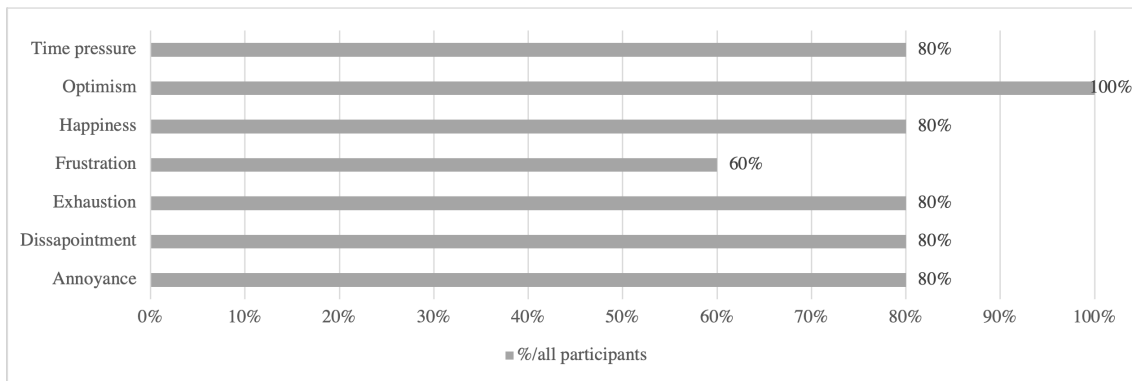
Figure 4.2: Frequently mentioned feelings among participants

data evaluation pipeline which is often related to testing new tools, permission rights for usage of these tools are needed. As there is little time for improvement in general, this makes it even harder to make progress and reduce frictions.

Concerning the way participants experience frictions, it is remarkable, that all participants look ahead optimistically. The team is aware of problems and frictions that definitely do occur in their daily work. This awareness becomes obvious when looking at frictions that are mentioned by almost each of the participants. The common comprehension results in a good team spirit on the one side. This team spirit is felt by each of the team members. The developers are happy to be part of the team; 4 of 5 participants explicitly mention this. Moreover, all of them show a personal drive to improve processes at the company. It is remarkable and a stroke of luck for the company management to have such highly motivated employees.

On the other side, participants also mention negative feelings at work. 80 % of them feel annoyed (see Figure 4.2). Reasons for this are various, but in all cases, annoyance is evoked by any kind of friction. The kind of friction that has the greatest influence on the person differs across participants. Hence, as a result of the fourth research question, in the team under consideration frictions rather lead to annoyance than to frustration.

Frustration especially arises when solving a problem or reducing friction is "out of hands" for participants. Then, they cannot do anything to reduce friction. For example, this occurs when access to a tool is not granted by the IT department or if colleagues do not stick to processes that are actually agreed upon.

As there is a lot of work to do in the department of the team and "deadlines are close [P1 - 159]", most of the participants are experiencing time pressure. As employees of a company in the consumer electronics industry, they have to work directly with customers. Due to that, they expect feedback relatively fast. This might be the reason that 4 out of 5 participants partly feel exhausted at work (see Figure 4.2). These feelings might build upon each other, as time pressure possibly leads to exhaustion.

The assessment of the home-office situation shows a completely uniform picture. All participants explicitly state that home-office increased their productiveness, as they can work more efficiently in the quiet of their desk at home, experiencing less disturbance. However, whilst working from home all of them miss social interaction and contact with their colleagues. Therefore, they want to return

unanimously to their workplace on-site at least partly, e.g. at 2 of 5 days per week. This social aspect which is missing in times of the pandemic situation can also cause friction, as it complicates quick and informal communication as well as an uncomplicated and casual exchange of information. In this context, working from home might also cause exhaustion and lack of motivation, also mentioned by the participants of this study.

Table 4.6: Summary table of data analysis following the data analysis principle of [Wil08], integrated across cases

Friction

	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5
Inconsistant tooling	319, 515	80, 519	—	414, 719	487, 535
Permission rights	491	—	206, 212	420, 651, 705	—
Scheduling of meetings	172	271, 309	—	244, 250, 261	111
Structuring of meetings	175, 339	303	697	—	235, 307
Waiting for review	464, 499	495	—	613	709

Company organisational structure

	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5
Management missing	145, 278	524	—	728	—
Management slows down progress	305, 427	209	301, 331, 376	—	—

Feelings at work

	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5
Annoyance	—	176	479	120, 187, 254, 659	148, 322, 490, 760
Disappointment	—	496	350	693	212, 337, 695
Exhaustion	361	24	720	248, 316	—
Frustration	50	—	180, 192	113, 575	—
Happiness	24	140, 576	262, 363, 622, 758	—	700
Optimism	48, 299	131, 233, 500	386	196, 303	162, 335
Time pressure	159, 208	31, 61	183, 458	—	472

Personal motivation

	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5
Drive to improve	446	442	260, 282, 351, 396	205, 447	161, 329, 545

Need to struc-ture	121, 166, 255	359	459	7, 391, 441	—
Programming	108, 115	138	98	—	109

Self confidence					
	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5
Role as leader	45, 103	130, 258, 343, 415	—	18, 38, 273, 394, 405	677
Qualification	9, 38, 73	11, 30, 163, 527	—	54	667

Productivity drivers					
	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5
Productivity in home-office	361	335, 377	636	302	583, 610, 783
Tooling	—	478	—	348, 650	656

Social aspects					
	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5
Missing colleagues	558	331, 339	593, 662	310	593
Team spirit	283, 407	249, 408	77, 355, 748	20, 412	376, 423
Understanding and acceptance	—	—	310, 722	135	137, 203, 232

Company organisational structure					
	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5
Documentation	510	398	129	386	518, 534

5 Discussion

In this chapter, I evaluate the results from the interviews in the context of literature (see Section 2.3) and my personal expectations (see Section 3.7). Also, I add my own thoughts and assessment to the results from the previous Chapter 4. In the second part of this chapter, I discuss potential threats to the validity of this study. I also take care of reflexivity issues and possible limitations.

5.1 Context Analysis and Interpretation of Results

In advance of close evaluation of the interviews, it is worthwhile to mention that the results rather disclose things that do not go very well within the team under consideration. This is due to the fact that exactly these things and conditions are the focus of the research question of the study at hand. However, this does not mean that software developers in the team are unproductive. In the centre of the study is disclosing frictions. As a result, of course, the majority of the findings are related to things that do not work perfectly in this team, since this is what the study aims for. For future research, it might also be of interest what works well in the working life of the developers.

The term friction is highly applicable to the team of software developers under consideration, and this can also be generalised. Probably, it is highly applicable to most teams of software developers because of its specific meaning. Participants well understood the term after I explained it to them in the introduction of the interview. They precisely thought about it and gave meaningful answers. Therefore, the term should be established in this context. Giving a name, categorising and explicitly mentioning things that cause unproductiveness is the first step to a more efficient future of daily routine. Having a generally accepted term eases to communicate problems to management in order to finally get capacities that allow reducing frictions.

There is a general understanding in the team about what kind of frictions they face in daily work. Furthermore, the team members highly agree with each other about which frictions have the greatest impact on their work. These are described in Section 4.2.2. Several frictions are repeated by almost each of the participants. Also, my personal expectations that I wrote down for reflexivity (see Section 3.7) highly coincide with things mentioned by participants. This suggests that members in the development team under consideration are quite aware of what kind of frictions they are facing. Furthermore, the review of literature in Section 2.3 names very similar factors to be pivotal for the productivity of software developers. Anyway, the workload and daily business prevent the developers in the team from solving frictions in an instant. Capacities must be explicitly assigned for improvements. This is exactly what many of the participants ask for: more support, budget and time to improve processes and in turn reduce frictions.

Examples for frictions that are presented in Section 2.1.1 are similar to the ones experienced by the participants of this study. Politis [Pol17] also describes that suitable tooling can help to reduce frictions. In his review on influencing factors on developers' productivity Boehm [Boe87] names a suitable tooling landscape as a great productivity driver. In accordance with that, inconsistent tooling is one of the major problems stated by the participants in this study.

Inconsistency not only appears as friction in the context of tooling but also in the data evaluation pipeline of the developers. Changing interfaces require manual adaptions, causing friction. This problem also is well documented in the literature, as inconsistency in requirements is a severe threat to productivity [MK11].

Additionally, the author [Pol17] suggests that meetings should be scheduled around one single topic so that each participant can specifically prepare themselves. This keeps a meeting short and efficient and therefore cares for the second major friction that occurs in the software development team under consideration, which is concerned with scheduling and conduction of meetings. Again, literature names communication as a major factor on productivity [Sca95].

It is remarkable that frictions described in the literature, frictions expected by me and also frictions experienced by the participants of this study coincide very well. Developers seem to have a common understanding of things that prevent them from working productively, independent of the product they work on, the company they work for or the place they work at. Therefore, there are reasonable factors to suspect that the findings of this study can be generalised largely, even if only observed at a small number of participants.

Chapter 4 shows that also long waiting time until a code review is done leads to severe frictions in the development team. In addition, they face problems concerning access rights and permissions. These frictions are very specific to the team under consideration. Therefore management or the team lead have to find specific solutions for them - existing, general guidelines probably are not suitable.

To summarise and list frictions that possibly occur in research teams around the world, the recurring ones stated in the previous paragraphs are a good start. Nevertheless, each development team possibly faces some frictions, that are caused by specific and individual internal problems and processes. For establishing a complete list, managers or team leaders need to analyse processes in detail.

As suggested by QuietSpacing [Qui], the main cause of frictions at work can be divided into two categories. The major frictions determined by this research can easily be assigned to these categories: The problem concerning scheduling and also structuring of meetings fit well into the category of frictions that arise due to *defective processes or planning*. Frictions concerning inconsistency in tooling fit into the category of frictions that arise from *insufficient tool support* [Qui].

The way how developers experience frictions is different between participants. For example, time pressure results from lost time due to friction. This makes some participants feel really pressured. They feel close deadlines which may lead to bad coding quality or even mental exhaustion. In turn, this leads to unproductiveness. Others (see Section 4.2.1) can deal well with this time pressure; these ones do not experience frictions in this context. Obviously, different people have different mentalities. For example, participant 3 is a very positive guy in general. He does experience frictions less severe. Therefore, he "can understand [P3 - 722]" his colleagues, even though they
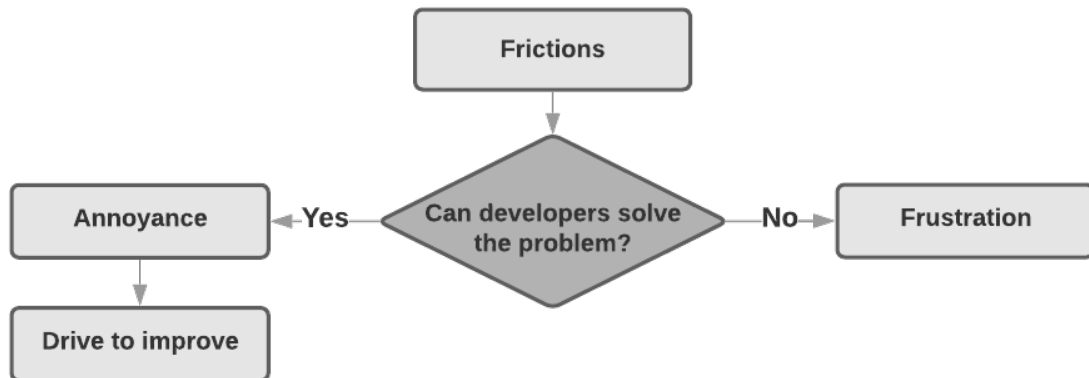
Figure 5.1: Effect of frictions on developers' feelings

might be responsible for certain friction as well. He empathises with them, keeping in mind that they feel time pressure similarly. Participant 1 rather misses the support by management that allows creating capacities for reduction of frictions. This desire leads to more severe feelings in the context of frictions. Authors of existing literature who also consider the emotions and feelings of developers when evaluating their productivity name the importance of regarding each developer individually [SR96]. Speaking in terms of transcendental phenomenology, the phenomenon of friction is a perfect example for *intentionality*, since it is experienced differently by the participants (see Section 2.2.1). The individual meaning of a phenomenon depends on the context, emotions, aims and purposes of each participant [Wil08]. Therefore, it is an important task of the management level to consider each developer individually. Only this way it is possible to increase productiveness, reduce frictions and prevent negative emotions of team members.

The analysis in Section 4.2.2 shows that frictions rather lead to annoyance than frustration. On the one side, annoyance should be avoided as it might shrink the motivation of developers. This leads to less productivity. On the other side, annoyance might drive the developers to measures that prevent them from getting annoyed. This, in turn, reduces friction (see Figure 5.1 for a visualisation). This effect can also be seen in Section 4.2.2: Participants look into the future optimistically, foreseeing the progress they will make. In this case, they are willing to put an extra effort into establishing more efficient processes. Frustration is a more severe feeling caused by frictions. Some of the participants also indicated to be frustrated by some frictions that occur during work. This especially happens when "things are out of hands [P4 - 113]" which is why the developers do not know how to solve the current problem.

Almost all participants, 80 %, mentioned that they feel time pressure and dread close deadlines (see Figure 4.2). This does definitely hinder productivity. It is important to have a clear prioritisation. If every task has the same level of importance, this creates unnecessary pressure [Qui]. In the end, it needs to be decided where to start. It turns out, that none of the tasks on the list is really important if prioritisation is not possible. Having a prioritisation list "facilitates getting more done with less friction" [Qui].

In summary, it becomes obvious that frictions not only have an impact on developers when they actually occur. Also, they have a strong influence on feelings and emotions. Participants get exhausted or frustrated (see Section 4.2) by frictions. This makes them less productive, even when no frictions occur at the same time. Therefore, it is extremely important to find, recognise and reduce frictions.

5.2 Validity of this Study

In the following, I will discuss objects that constitute threats to the study's validity based on [GW18].

Conclusion validity refers to the question if conclusions drawn within a study are correct, i.e. valid. This goes along with the correct understanding of subjects. Referring to this, I can say that the analysis of transcripts using qualitative research methods will always depend on the researcher [BW06]. This holds for IPA in particular, as IPA explicitly asks for the researcher's subjective, interpretative aspect. In this context, [Yar00] states that reliability may be the wrong criteria in order to evaluate qualitative research, as qualitative analysis always allows for many different interpretations.

Regarding *internal validity* one has to deal with methodological errors. However, I carefully selected the method of qualitative analysis (see Section 3.1.2). Furthermore, I checked the interview agenda with the reviewer of the study. Reliability is relevant to a lesser extent in the case of the study at hand; issues based on causal reasoning are only of small concern in qualitative research [Wil08]. In the case of a study, and especially within the scope of IPA, one has to ensure the right setting for data collection. I made sure that the subjects, i.e. participants felt comfortable during the interviews; it is common for them to have meetings at work. Also, I have met them in person before, during my employment in the team. Therefore, I could appear as a colleague in an unconstrained setting throughout the interviews. This simplifies interviews and interchange.

In order to check for the *construct validity*, I questioned if interviews did really answer the research questions or if they referred to something else with their answer [Wil08]. To ensure reference to the research questions I relied on the interview agenda for guidance during data collection. Semi-structured interviews boost securing the construct validity because they leave room for questions of the participants [LM15]. By this, I can ensure that the question and the concept are well understood by participants.

Next, I have to check for *external validity*. Issues with representativeness are typical obstacles for qualitative studies. Of course, on the one hand, I am not able to generalise all findings to software development in general, since it is hard to generalise when the number of participants is low, as it is the case in this study. However, at least it is possible to identify opinions that are repeated by almost every participant. Then, these are also subject of universalisation [Wil08]. On the other hand, I can rely on higher external validity since data is collected in the "real world", which would not be the case for a study conducted in a laboratory setting. This holds for qualitative research in general.

In order to overall ensure good validity, I followed each single item on the list of quality criteria in [TSC07] as recommended by Lenberg et al. [LFG+20]. Such checklists might reduce creativity. Nevertheless, advantages outweigh risks.

5.2.1 Reflexivity

Reflexivity describes the role of the researcher in qualitative studies [Wil08]. Personal reflexivity refers to how a researcher as a person shapes the process of the study. The study at hand in fact takes reflexivity into consideration (see Section 3.7) as it examines the expectations of the researcher *before* the conduction of the interviews. This way, it cares about the role of the researcher.

5.2.2 Limitations

The role of the text in the context of the interview transcripts clearly is an issue for studies that intend to go into feelings and perceptions of people. IPA works with texts, and in many cases, it might be difficult to express feelings in texts. The transfer of personal constructs and internal perceptions to words is limited. Furthermore, in connection to this, it is questionable if participants are able to describe emotions and experiences in a realistic manner in an, despite all, posed situation.

Interviews took place in an online setting. Due to that, I could only interpret gestures and facial expressions to a limited extent. Also, by all means, it is possible that I misunderstood some intentions or statements of participants which wouldn't have happened within personal meetings.

Four out of five interviews were conducted in German, whereas data analysis of this thesis is done in English. For interpretations and direct citations of the participants, I had to translate the original transcript into English. Some information might be lost during translating. Anyway, the alternative would have been to conduct English interviews, although the interviewer and interviewee are German native speakers, leading to a strange and even more posed situation. It's unquestionably easier for participants to express their feelings in their mother tongue. In addition, I tried to translate citations as literally as possible.

Regarding the relatively small number of participants, it is hard to draw generalised conclusions. Besides, results are also very specific to the team under consideration, as all participants are part of this specific team.

6 Conclusion and Outlook

This chapter summarises the findings of the study and provides an outlook on possible future work in a similar context.

6.1 Summary

The term friction has its origins in physics. I transfer its usage to my application and define the term to comprise situations, conditions or circumstances in the business context that decrease productivity, but do not completely block it. Hereby, I follow the term's usage and mentions in recent grey literature. In this study, I found the term to be very suitable to describe the phenomena under investigation. It was well understood by the participants of this study.

IPA is a qualitative research method that is more frequently applied in the field of psychology. It stands out by its ability to deeply explore the participants' thoughts and state of mind and strongly builds upon the interpretations of the researcher. Using IPA in the behavioural software engineering domain enriches the landscape of approaches to data collection and data analysis in the field. It posts an appropriate alternative to grounded theory research methodology.

Concerning the results of this study, it is remarkable that there is a common understanding of what kind of frictions occur within participants. The findings of this study coincide very well with the expectation of the researcher, with mentions of frictions in articles or blog posts, as well as with articles dealing with the productivity of software developers. Similar tasks may lead to similar problems.

Firstly, frictions that the participants of this study most frequently mentioned are concerned with meetings. The way meetings are scheduled, conducted and organised is often inefficient. Secondly, inconsistencies favour unproductiveness. In the team under consideration, inconsistencies occur at the interfaces of the data evaluation pipeline, leading to the necessity of manual adaptions in the code. They also occur in the context of documentation, which is not done uniformly. As already stated, this coincides well with statements in grey literature and research that has been done in this field.

Effects of frictions on the mindset of developers have not been investigated in literature yet. This study shows two different aspects of how developers experience frictions. Firstly, frictions lead to reduced productivity, which makes the developers annoyed about the problems they face. This, as a result, drives the participant under consideration to spend extra hours on improving processes and reducing frictions in the future. Secondly, the developers face frictions which are inevitable or situations where the solution to a problem is out of hands. This usually has a more severe effect on the emotions of the developer, causing frustration. In general, frictions definitely shrink the impact of the developers' work and reduce productivity.

6.2 Outlook

Within the scope of this work, I discovered frictions as problems and hindrances that occur in the software development team under consideration. These frictions reduce the productivity of the team. The discovery of deficiency, as known, is the first step for improvement. Naming and addressing frictions flags areas where progress is needed the most. As a logical next step for future research, measures to reduce frictions should be explored, discussed and finally realised. As the best solutions might be very specific to the setting and team under consideration, a similar research approach conducting an IPA study is suitable.

I leave it to future research to improve the implementation of methodology within a study based on IPA. First, meeting participant in person is an explicit advantage that the following studies should derive advantage from. Second, in future, analysis should happen in closer sequence to the interviews. It possibly leads to a better understanding of the transcripts, if the researcher still has the interview in his mind. For personal reasons, this was not possible in my case.

Additionally, it is reasonable for future research to combine focus groups as well as personal interviews. Application of focus groups could provide meaningful gains for a general understanding of concepts and deliver background information to build an even more interesting interview agenda. Subsequent meetings in person with single participants allow a more detailed interpretation of individual perceptions. Of course, this procedure constitutes a much higher temporal effort for participants as well as for the researcher.

Furthermore, future researchers in this field could meet with participants in an environment that is not related to work. Potentially, the participants can then talk about their work less biased, but freely and easily instead. However, in that case, it might be harder to gain enough participants for the study, as they would have to participate in their free time.

A larger research team would be of big advantage for future studies. A higher number of people and therefore aspects provide a larger variety of ideas for interpretation. This is an integral part of IPA. However, taking more people into account simply is not possible in the context of a master thesis. I leave it to future research to apply IPA in larger projects of the behavioural software engineering domain.

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All links were last followed on September 25, 2021.

A Appendix

A.1 Interview guide

The following interview guide has been used as a basis for the interviews.

A.1.1 What is this study about?

Inform the participant about this study!

- Explain what frictions are

    "Time spent not working, but attempting to"

    Name examples of frictions

- Explain goal of this study: Find out

    In what form do frictions occur?

    How are frictions experienced? Impact of frictions?

    Influence of frictions on productivity? Frictions lead to frustration?

- Explain methodology: Qualitative study

    IPA: Focus on each developer and his/her experience

A.1.2 Background information of participant

- Current field of work?
- General field of work?
- Task of department?
- When did you join this department?
- Background/university/studies

A.1.3 Moving towards personal topics

- Favorite task at work

- Task that participant doesn't like

    Why?

    Possible to make it more attractive?

- Of 8 hours/day: how long really programming?

    Remaining time?

    Like to program more? What has to happen that this is possible?

A.1.4 Exploring frictions by topics

I'll push the interview towards a certain topic to explore if there are frictions...

Share of tasks

- Back to your tasks at work: Are tasks shared well?

- Want to give some of your tasks to somebody?

- Want to take over someone else's tasks? *(effectiveness)*

Meetings

- Team meeting: what is it about? Useful?

    Does it help to work efficiently?

- Enough/too much meetings?

    Meeting = interruption of work?

home-office

- Working from home? How much?

- What did change in daily business?

- Still know what colleagues are doing?

- Still know whats going on?

- Do you miss social aspects?

Documentation

- How? Good solution?

- Do you like to create documentation?

Internal Communication

- Do you talk about problems/possible improvements? Example?

- Do you have a contact person for problems?

- How do you deal with lessons learnt?

    Are lessons learnt realised? Example?

External Communication

- Communication with measurement technique. Problems?

- Communication with project leader. Problems?

- Communication with technical experts. Problems?

Tools

- Version control: problems or improved efficiency?

    Repository structured well?

    How would you do it?

- Code reviews: constructive? Feel critized? Motivating?

- Writing generalised code: Worth the work?

- Any laws that hinder productivity?

    E.g. tools that are not allowed to use

Special examples of frictions

- Waiting time for IT service/approvals

- Waiting until calculation pipeline is done

- Waiting time in calls/meetings

Reducing frictions

- Do you sometimes think: is this step really necessary? Example?

- Sometimes tired of doing the same task for a long time?

- Can tasks be changed so that these are more attractive? How?

B Consent Form

The following consent form has been handed out to each of the participants. All participants commmplete read and understood this form and confirmed this by their signature.

B.1 Consent Form for the Master Thesis: "Frictions in software development: an interpretive phenomenological analysis"

B.1.1 DESCRIPTION:

You are invited to participate in my interview on frictions in your daily work, especially concerning your development process. The purpose of this interview is to extract things that slow down daily work, explore how these problems arise, how they influence work and analyse how the developer feels faced with frictions.

B.1.2 TIME INVOLVEMENT:

The duration of the interview may vary, but I limit the time to 2 hours per interview.

B.1.3 DATA COLLECTION:

During the interview I create an audio record which will be put into a verbatim written transcript afterwards. You'll receive the transcript of your answers afterwards. You can check the transcript for correctness and delete parts of it that shouldn't be analysed. After transcription, the audio record will be deleted completely from all file systems.

B.1.4 RISKS AND BENEFITS:

No risk is associated with this study. The collected data is securely stored. We do guarantee no data misuse and privacy is completely preserved. The identity of your company won't be mentioned in our study and remains completely anonymous. Your decision whether to participate or not in these interviews will not affect the way your company is mentioned in the study. The results of the study might be published in university context and might also help your company to improve the working conditions for developers.

B.1.5 PARTICIPANT'S RIGHTS:

If you have read this form and have decided to participate in this project, please understand your participation is voluntary and you have the right to withdraw your consent or discontinue participation at any time without penalty or loss of benefits to which you are otherwise entitled. The alternative is not to participate. You have the right to refuse to answer particular questions or topics. The results of this experiment will be analysed in my Master thesis, which is part of my Software Engineering Master at University of Stuttgart. Your identity is not disclosed unless I directly inform and ask for your permission.

B.1.6 CONTACT INFORMATION:

If you have any questions, concerns or complaints about this research, its procedures, risks and benefits, you may contact Paul Weise (st164790@stud.uni-stuttgart.de). By signing this document, I confirm that I agree to the terms and conditions.

Name of Participant
Signature of Participant

C Summary Tables of Data Analysis

The following tables include all themes, statements and clusters that I created during data analysis.

Table C.1: Summary table of data analysis, following the data analysis principle of [Wil08]

Theme labels	Quote or keyword	statement numbers
Frictions		
Access Rights	"huge obstacle"	491
Hardware support	"really need monitors, work at home efficiently, seperate areas for developers"	385, 393, 551
Inconsistant interfaces	"unnecessary iterations"	20
Inconsistant tooling	"no switch to MS teams yet, a little chaotic"	319, 515
Scheduling of meetings	"only half an hour to next meeting"	172
Structuring of meetings	"should be better structured, meeting culture lost, doing something in parallel"	175, 339, 340
Too many meetings	"too many, don't need me"	170, 177, 187, 242
Tool support	"skype simply does not work"	318
Waiting for review	"colleagues react delayed, waiting for response, angry"	464, 499
Inevitable frictions	"emails get deleted"	478
Company organisational structure		
Time management by team leader	"gets neglected, not thought carefully, plan ressources better"	55, 154, 250
Limited support by management	"project leader doesn't see as software devel(opement, project financal sources don't suffice, sensitise management"	57, 58, 106
Inefficient processes	"workflow not efficient, need to build structure"	126, 306
Missing management	"need change management, I can't prioritize, a lot to criticise, does not know what I'm doing"	145, 162, 278, 280
Organisational structure	"rather contact to other group, team should be a group, does not fit to what we do"	186, 285, 408
Ressources planning	"deadlines stay the same"	250
Management slows down progress	"green light from above, not enough support, big hurdle, escalation"	305, 427, 438
Structural hierarchy	"hierarchies, could be different when working at site"	443

Feelings at work

Frustration	"little frustration, managers don't know what software needs"	50
Exhaustion	"[home-office] negatively affects health"	361
happiness	"stroke of luck [to work in this group]"	24
Hierarchy	"I feel small"	431
Time pressure	"deadlines are close; you have to deliver, you know, continously!"	159, 208
Missing confidence	"If they'd put more trust in me..."	215
Optimism	"it's getting professional, something good going on"	48, 299

Impedements at work

Impact on work	"only reach managers over this [communication] chain"	444
IT support	"don't know if they have things under control"	322
Limited capacity for improvement	"too little time, stuck in daily work"	98, 433
Quality	"time pressure [...] decreases quality"	136

Personal background

Research background	"long time in research, I like to analyse, deeply [into a topic]"	67, 90, 91
Old job	"In old job, we were able to..."	133

Personal motivation

Drive to improve	"fight for being heard"	446
Fatigue and exhaustion	"working day on site is not that exhausting, only with hard disciplin, no more energy"	365, 368, 369
Ideas for improvement	"how to improve these things, lots of ideas"	22, 39
Impact on work	"I get myself involved into multiple topics"	49
Innovative thinking	"great new thing, have fun learning"	97, 99
Need to structure	"we need a responsible, plan at least for one week, need two days for [only] programming, manifest workflows, again and again startup-mentality"	121, 144, 166, 180, 255, 314
Identification with company	"[missing] sense of belonging"	400
Perfectionist	"take your time for making it nice"	531
Programming	"that is fun!, of course, programming!"	108, 119

Role within system

Autonomy and self-determination	"only reaction, not enough trust, autonomy is taken from us"	147, 201, 207
Impact on work	"ideas [...] lead to escalation"	451
Role of team	"need to define our scope, realise, what a [data analyist] does, not understood yet"	143, 265, 258

Self confidence

Achievements in life	"assistant software project lead"	11
Leader	"take over things, establish the workflow"	103, 105
No solution	"I'm not that clever"	241
Organisational talent	"That's release mangement!, I've been the methodologist"	44, 70
Qualifications	"I have this competence, what I know from before, using it for [...] 20 years, improve what I have recognised, experience"	9, 38, 72, 463, 519

Social aspects

Anonymity in home-office	"See one's counterpart, see ourselves way too seldomly, [missing] sense of belonging"	332, 335, 400
Communication	"works really really well"	461
Consensus	"Largely recognised [in team]"	30
Missing colleagues	"like to work on site again"	558
Social contacts	"really happy to meet..., highlight, I miss informal chat, absolutely, simply talk in another setting"	352, 353, 360, 395, 397
Team spirit	"team [...] does the right thing, like how it works in team, always someone who listens"	283, 407, 419

Software quality topics

Automation	"documentation generated over web interface"	524
Documentation	"Need more time, I'm excited how things are documented"	510, 514
Agile	"can't work agile here"	123
Object oriented programming	"it's a process, each functional unit, seperate file"	520, 521
Release management	"it's necessary, we want to ease up and define things"	43, 465
Software architecture	"I like architectural work, not enough time"	40, 95
Software Maintenance	"complexity creates need"	52
Technical debt	"and that is technical debt"	56

Table C.2: Summary table of data analysis following the data analysis principle of [Wil08]

Theme labels	Quote or keyword	statement numbers
Frictions		
Buggy self-made tools	"more slowly and more expensive, spend a lot of time on debugging"	553
Email as documentation	"who's involved and who not?"	85

Inconsistant interfaces	"not stick to it, even if agreed upon, sometimes sobering seeing that, annoying"	187, 190, 202
Inconsistant tooling	"different communication channels used, tools not used, big problem, redundance in tooling"	80, 83, 86, 519
Loading time of tools	"takes forever"	565
Scheduling of meetings	"big problem, only half an hour to next meeting, unfavourable, scheduling on short-term notice, other firms do this better"	271, 280, 285, 308, 309
Structuring of meetings	"simply invite everybody who could know something"	303
Waiting for review	"for weeks, as we didn't find the time, does not always work out"	495, 503
Waiting time	"just spend time waiting, huge problem"	572, 581
Inevitable frictions	"have to communicate a lot with asia, partly simply not feasible, but it has to be done"	284, 294, 172

Company organisational structure

Colliding interests	"different interests"	43
Team external collaboration	"should share code, develop code together, necessary condition, that colleagues there have know-how, sometimes problematic"	222, 239, 241
Mangement home-office	"I feel informed, don't know when I've seen group manager the last time"	380, 383
Management slows down progress	"fails because managers don't demand for..."	209
Missing management	"no real guideline, focus to define one standard"	524, 531

Feelings at work

Annoying tasks	"thing that is annoying, because you don't feel the progress, only thing that helps: motivate them even stronger"	176, 178, 200
Disappointment	"partly disappointing for colleagues"	496
happiness	"I have fun to ellaborate effects, I'm excited, I am lucky"	140, 146, 576
Exhaustion	"[Meetings], where you have to think deeply about the topic"	24
Impact of work	"we're the last ones who can squeeze out every last percent"	62
Time pressure	"have to give feedback very fast, relatively fast, you definitely feel this time pressure"	31, 36, 61
Optimism	"develop myself in the future, it's already planed, I see improvements, we got better"	131, 160, 233, 264, 500
Dislikes	"exactly, these dead times..."	560

Impedements at work

Communication	"discussion wouldn't have hapend if had met in office for 5 mins"	340
Getting interrupted	"even if you had something completely different in mind, you get called [...] and asked"	306, 317, 418
Realisation of processes	"that's what's missing"	231
Trust in tools	"bad performance, little trust"	546
Personal background		
Personal charateristics	"open, honest"	57
Tasks at work	"data analysis, laboratory environment, create standardised evaluations"	8, 9, 10
Personal motivation		
Communication need	"very important and takes a lot of time"	47
Identification with company	"concerning work, it's there"	372
Need to structure	"[daily routines,] that's what you need"	359
Drive to improve	"challenging things [communication with] China"	442
Personal energy	"daily routines very important, not everybody does it well"	352, 360
Explorative work	"have fun to ellaborate effects, working creatively, I'm excited"	140, 143, 146
Programming	"of course, it's fun, programming has always been my favourit"	138, 139
Productivity drivers		
Proud of his work	"we established..."	29
Stress management	"for me, it's [colliding interests] no problem, [I can deal with] time pressure"	111, 19
Working in parallel	"calender is blocked, can work in parallel, only short-time reaction necessary"	276, 278
Productivity in home-office	"works well, for me, it's good, collaboration does not suffer"	335, 349, 377
Tooling	"well integrated"	478
Self confidence		
Achievements in live	"put into practice, I've been improving continously"	27, 128
Leader	"more coordinative work, keep everyone up to date, we can retrace, who did what, [teach] and trace the reaction"	130, 258, 343, 415, 473
Qualifications	"coordinate less experiences colleagues, we're the ones who can analyse [...] fast, I had to manage a lot, long time experience"	30, 163, 527
Social aspects		

Sharing of tasks	"[I like] different roles in the project, [colleagues in other team] really should look into the data"	219, 232
Team spirit	"[meeting] is very important, [I am proud as] they make great progress, within [my] team, works very well"	249, 408, 441, 444
Missing colleagues	"never met in person, what's missing is the personal exchange"	331, 339
Social contacts	"it's strange [not knowing colleagues personally], less personal contact"	334, 373
Professional relation	"nobody ever felt offended [during code review]"	491
Software quality topics		
Documentation	"is no fun, but necessary, saves time at the end, helps a lot"	398, 399, 416
Tooling	"[change of proven tools] is an issue"	533

Table C.3: Summary table of data analysis, following the data analysis principle of [Wil08]

Theme labels	Quote or keyword	statement numbers
Frictions		
Implementation of ideas	"want something new, cannot really work"	151
Non-automation	"have to do multiple things, consumes [...] ressources of company and [...] ressources of your computer, time consuming"	335
Permission rights	"very tricky, permissions need to be taken care of, makes you slow, slowness in the system"	206, 210, 212
Structuring of meetings	"you are not a content for [long time], but your whole time is blocked"	697, 698
Company organisational structure		
Management drives team spirit	"I [...] congratulate the team management, did job very well"	759
Quality issues	"the pain [in the system]"	410
Role in system	"[team external] didn't care about [...] code working or not, not aware of how our workflow is, very tricky, perspective of a data developer"	348, 531, 511
Feelings at work		
Annoyance	"a bit annoying [unplaned work comes in], becomes difficult, [external communication] one of the things which is annoying"	479, 491
Annoying tasks	"in the morning [before vacation] I get an email, it was [...] mixed-up"	465, 469

Annonymity in home-office	"huge different in mindset, I like to meet people"	645
Burden	"[home-office] not good for your mental health"	569
Dislike	"communication issues"	453
Disappointment	"something which is... yeah"	350
Excitement	"you are exicited [by progress], [progress] makes [...] my job very exciting"	149, 267
Fascination	"[new things] are very fascinating"	424
Fatigue and exhaustion	"Don't even have time to have coffee or relax 5 minutes"	720
Frustration	"becomes a bit slow, sometimes that makes you..."	180, 192
Happiness	"very happy [...] part of this team, happy about it, everybody is happy, fruitful working together"	262, 363, 758, 66, 622
Optimistic future	"going towards that, hopefully it will be like in the future"	386
Proudness	"I was the one, I was saying that [working for the company he works for]"	272, 664
Team spirit	"very, very supportive, happy [...] part of the team"	153, 262
Time pressure	"everything is yesterday, becomes very freaky, we need it tomorrow!"	183, 185, 458
Impediments at work		
Communication	"[team external communication] problematic, I was not even aware of, "You know, guys, you need to be more efficient...!", communication gap, different kind of communication [when meeting in personal]"	472, 474, 476, 492, 674
Double work	"everybody's writing a new code, inefficient"	254, 257
Limited capacity for improvement	"a bit sluggish"	172
Management slows down progress	"management [...] innovation [...] extra effort, once per week we should be allowed to work on innovative things, still need some convincing, things take time"	301, 312, 331, 376
Number of meetings	"needs to be rearranged, too many meetings, inefficient"	694, 713, 726
Working in parallel	"not very efficient [to code during meetings]"	704
Personal background		
Research background	"enjoy designing new projects"	91
Personal motivation		
Career	"wants to raise up"	371
Complex tasks	"keep track of thousands of things that might go wrong"	542

Drive to improve	"learning the tools, exciting field, new techniques that I can explore, move a huge wheel [...] need[s] effort, need to do some trainings, excitement comes from these [innovative] tasks"	260, 264, 282, 351, 366, 396, 414
Excitement	"stimulus, work becomes interesting, I get up early"	277, 280
Excitement lost	"becomes routine, same thing, few things that excite you"	140, 146
Fascination	"fascinating [...] culture [working in industry]"	46
Identification with company	"very much part of it"	660
Innovative things	"I enjoyed learning, no choice of getting back"	99, 224
Need to structure	"organise my work"	459
Optimistic future	"[automation] will save our live"	546
Programming	"I love technical things"	98
Recognition and reward	"reward from finishing your work, [I] enjoy that"	49
Working for huge company	"motivation is always there"	672

Productivity drivers

Lessons learnt	"lessons learnt from every project"	484
Productivity in home-office	"quite effective"	636
Social contacts	"working together, work with emotions"	599

Self confidence

No solution	"out of hand, sometimes it happens"	188
Self confidence	"[recognition by others] gives you confidence"	287

Social aspects

Compliments	"everybody says thank you to you, appreciation from the team, [extra work] will be appreciated"	239, 284, 367
Misses colleagues	"we'll go more often to office, rituals [...] fist bump, emotional bonding, we are humans"	593, 594602
Private life	"[home-office] not good for the mind set of your family members, it's tricky"	676, 685
Social contacts	"managers [...] are very nice"	374
Subordination	"I'm very new, new environment"	231, 246
Team spirit	"very systematic, part of the big picture, push it more together, [no] negative energy coming from the team, huge thing"	77, 80, 355, 748
Understanding and acceptance	"they have to keep in mind a lot of other things, management is under pressure, I can understand"	310, 317, 722

Software quality topics

Automation	"doing right now, important"	148, 251

| Code quality | "minimum requirement that should be satisfied by each code" | 429 |
| Documentation | "not very fun" | 129 |

Table C.4: Summary table of data analysis, following the data analysis principle of [Wil08]

Theme labels	Quote or keyword	statement numbers
Frictions		
Inconsistant interface	"does not work for the umpteenth time, pipelines brake down, again different name in different project, please use a consistant name, please!, very large overhead"	112, 118, 154
Inconsistant tooling	"two, three, four different versions, not consistant, leads to overhead, everybody does [documentation] differently"	
Permission rights	"Permission problems that occur, it gets difficult with provisions, blocked by CI, effort gets too large, happens often"	420, 651, 652, 683, 705
Scheduling of meetings	"multiple short meetings in a row, time pressure, because you don't manage to clarify in 30 minutes [too short meeting], get invited to tight, not efficient"	244, 245, 250, 253, 257, 261
Waiting for review	"reviewer has to seperate [the task] into multiple days"	613
Company organisational structure		
Missing management	"They give us too much freedom [concerning tooling], training issues: they should explain how to use the tool"	728, 732
Organisational structure	"completely correct [to distribute tasks on different teams]"	206, 219
Team external communication	"would like to use your tools, but we don't know, what they do, to extern, [communication] is a different story"	401, 413
Feelings at work		
Annoyance	"Annoying, annoying for us, of course annoying [inconsistant interface], meetings [concerning one topic] smeared over three weeks", extremly long time lost [by blocked tools]	120, 136, 187, 254, 659, 692
Disappointment	"you have to admit at the end: there is no solution, you have to live with it, wasted a lot of time [finding work-around for blocked tools]"	693, 696
Dissatisfaction	"Nobody is happy [large branches to merge in version control]"	

Fatigue an exhaustion	"you have to mentally jump between topics [back-to-back meetings], no breaks in between, it's getting..., exhausting, these small breaks that you had in between [home-office]"	248, 316, 322, 323, 327
Frustration	"things that are out of hands, it's getting frustrating [long time for review]"	
Impact of work	"makes fun and brings benefit [interaction and organisation]"	91
Misses colleagues	"you just talk for a while, it's completely gone, it's missing, I've not been there for a long time"	328, 329, 376
Optimistic future	"go into the right direction, we'll get it done"	196, 303
Pleasant	"it's pleasant to have my peace"	303
Proudness	"it used to be... smaller than it is today, we standardized [..] witha ll these tools that we have"	74, 721
Supportive atmosphere	"company is very open-minded, changed everything, the correct mindset"	435, 443, 445
Understanding and acceptance	"also for [them], it's very complex, nobody does it maliciously"	180, 294

Impediments at work

Large pull requests	"two problems that occur [in this case], reviewer is overwhelmed, get stuck for months, problem stays the same"	597, 603, 620
Process lost in daily rush	"projects are hectic, additional work"	146
Realisation of processes	"you have to be after it"	114
Responsibilities	"It's not in our hands, they have their own process and don't want to get controlled, as we do"	131, 134
Structure of repository	"it's going to be two branches that are never merged"	483

Personal motivation

Communication need	"communicate accuratly"	98
Drive to improve	"[re-organisation] that's an interesting point!, it's a feat of strength, not a blocker []that] "we always did it this way""	205, 447, 448
Identification with company	"[no] distance to company [by home-office], strong feel of belonging, because I interact with the people"	364, 365
Need to structure	"processes and planing, bring a structure to it, we have to clean up and maintain, we have to build up a team structure and define roles in the team"	7, 391, 393, 441
Optimistic future	"we want to work on this [structured communication]"	395

Realisation of processes	"check, if the proess is realised and build upon it"	
Spread knowledge	"explain it to the others and say "hey, you have to do it this way!""	93
Productivity drivers		
Priorisation	"avoid going to [unnecessary] meetings, I have to priorise [in case of parallel meetings]"	271, 276
Productivity in home-office	"no problem, [on site] you get disturbed frequently, better concentrated, very efficient, less distraction"	302, 304, 307
Progress planing	"where do we want to go?, how will we change?"	26, 30
Tooling	"video function [of MS teams], tooling landscape well equiped"	348, 650
Self confidence		
Achievements in live	"progress step by step"	78
Leader	"provide the infrastructure, my role [...] is the coordinative part, where are the bottlenecks?, look for another responsible, spread it to the people, define a format"	18, 22, 24, 38, 273, 394, 405
Organisational talent	"I know that [I can delegate this task]"	278
Qualifications	"Give Feedback and make annotations"	54
Social aspects		
Body language	"need to [...] see the face and body language"	331
Feedback and criticism	"not offended, question of good character"	551, 561
Missing colleagues	"you don't meet each other, not possible to just have a coffee together"	310, 311
Social distance	"when I come [to office], [...] I don't know their name, and I never met them before, a little distance"	371, 372
Team spirit	"we got a seperate team, we actively work on it, as a team"	20, 412
Understanding and acceptance	"I can understand [the other teams]"	135
Software quality topics		
Automation	"automatic documentation gets created"	400
Code review	"not just pressing okay"	559
Documentation	"very important, not self-propelling"	386, 389
Technical debt	"not solved efficiently, [problems] just procrastinated"	121

Table C.5: Summary table of data analysis, following the data analysis principle of [Wil08]

Theme labels	Quote or keyword	statement numbers
Frictions		
Access rights	"simply does not work, [hinder] working on a topic efficiently, get slowed down, took a while"	735, 737, 741, 750, 755
Inconsistant tooling	"the others won't know, hard to find, why should be consistant, unnecessary complicated"	487, 497, 535, 537, 540
Interruption of productive work	"questions after questions"	769
non-automation of tasks	"click through things one after another, always the same, same step"	178, 185, 190
Scheduling of meetings	"happy when there are no meetings"	111
Structuring of meetings	"only 5 minutes of 90 are interesting, should have an agenda, topics have to be priorised"	235, 273, 307, 313
Waiting for review	"code reviews lie around for a long time"	709
Company organisational structure		
Limited support by management	"working hours specific for project, little temporal scope"	392, 393
Role in system	"find my role after a while and realise things"	366
Feelings at work		
Annoyance	"tasks, where you have to work moronically, put this topic to a seperate meeting, discuss small things in extra meeting, that's a topic [can't use tool that I want], why can't this go faster?, takes endless time [tasks with little outcome], not feeling good"	148, 322, 326, 490, 760, 152, 154
Curiousity	"I'm the one who learns"	365
Demotivation	"[documentation] annoying evil, has to be done, little joy"	519, 520
Dislike	"do not enjoy to work into old code"	125
Dissapointment	"far too little [time for programming], falling apart as we have no time, [review] and then, there is some critism anyway"	212, 337, 695, 696
Distraction	"really, you have to be free of distraction, when I find some peace"	780, 108, 114
Excitement	"what I think is exciting, most fun"	113, 117
Happiness	"I'm happy about it [to be able to learn]"	700
Misses colleagues	"this somehow is lost"	617
Optimistic future	"project that we started, a lot of things are happening, getting better and better"	162, 335, 506
Supportive atmosphere	"everybody helps, we find the time to meet"	426, 454

| Time pressure | "unnecessary pressure, they put pressure" | 472, 477 |
| Working atmosphere | "creates a better atmosphere [having coffee toogether, team spirit supports productivity, feel as a team with the colleagues]" | 598, 614, 616 |

Impediments at work

Annoying tasks	"the result is [not satisfying], takes endless time for small changes"	153, 155
Communication	"they do not know the background, should present our whole process, [on site personal communication] is a whole different thing"	466, 468, 633
Company goals: big picture	"completeley missing in home-office"	628
Different time zones	"communication restricted to the morning, almost a complete working day difference"	429, 431
Large pull requests	"endless long, really needs time"	710, 711
Limited capacity for improvement	"we never finish, no capacity, we could do so much, same problem, [improvement] sets a new task that needs a lot of time"	295, 330, 332, 377, 378
Number of meetings	"too much meetings, fills the schedule, actually have nothing to say"	219, 221, 234
Priorisation	"other things are more time critical"	387
Refactoring old code	"not that easy, partly takes a lot of time"	126, 127
Structure of repository	"repository grows big and slow"	663
Too long discussion	"meeting over before finished, you sometimes have to interrupt"	298, 310
Working in parallel	"not good at working in parallel [to meetings], not that productive, with one ear in meeting"	247, 249, 252, 791

Personal motivation

Code quality	"do your task faithfully"	478
Complex tasks	"put my full focus on, start from zero"	116, 123
Drive to improve	"I'm currently testing, I have to think about how to automise, lots of things to improve, many ideas, a lot to be done, look at it [feedback from others] and learn"	161, 164, 179, 329, 545, 699
Field of responsibility	"the others [...] didn't do any programming"	101
Programming	"[have the time for] programming"	109

Productivity drivers

Productivity in home-office	"works really well, nothing changed, no influence on productivity, [on-site] there is noise, good step forward"	583, 610, 783, 784
Stress management	"usually, it's okay to have it the next day"	458
Tooling	"Git is very important, can't imagine without [Git]"	656, 657, 658

Self confidence

Leader	"tried to explain to colleagues"	677
Missing experience	"only know the theory, never applied"	351
No solution	"I don't know..."	357
Qualifications	"actually this is not the way..., there are better solutions"	667, 668

Social aspects

Communication	"[daily stand-up] each morning, very important, you can discuss, direct communication lost [in home-office]"	437, 439, 444, 632
Compliments	"I got feedback directly, they are really happy [with my work]"	199, 201
Missing colleagues	"there is no time"	593
Professional relation	"nobody feels offended, [reviews] are a good thing"	693, 697
Social contacts	"social aspect missing [home-office], go for a coffee break"	590, 596
Subordination	"I'm not in the position, I take what's there, the others are more experienced, I can't give so much feedback"	360, 363, 367, 370, 702
Team spirit	"there is always somebody who listens, they are supportive, always, get to solution together, everybody is into it"	376, 421, 423, 447, 451
Understanding and acceptance	"same from my side, everybody has his own process, there is feedback, it's not easy [to have a good meeting structure]"	137, 138, 203, 232

Software quality topics

Code quality	"[higher code quality without pressure] I would say, less problems in the long term"	482, 722
Documentation	"extremly important, there is a documentation anywhere [for everything], a lot of documents lying around"	518, 534, 546
Test-driven development	"takes a lot more time"	721

Declaration

I hereby declare that the work presented in this thesis is entirely
my own and that I did not use any other sources and references
than the listed ones. I have marked all direct or indirect statements
from other sources contained therein as quotations. Neither this
work nor significant parts of it were part of another examination
procedure. I have not published this work in whole or in part
before. The electronic copy is consistent with all submitted copies.

Abstll, den 23.09.2021   Paul Weiz

place, date, signature