In-App Reflection Guidance at Work

by

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Abstract

Reflective learning can be seen as the conscious re-evaluation of past situations or experiences with the goal to learn from them and to use the gained insights to guide future behaviour. Reflective learning in the context of workplace learning has been identified as a core process which aims at getting new insights, deriving better practices and finally improving own work. Reflective learning, which is a cognitive process based on the individual's intrinsic motivation, cannot be directly enforced, but guidance techniques like prompts, journals or diary writing, and visuals can foster reflection while using tools or software applications during work.

The goal of this thesis is to conceptualise reflection guidance as adaptive software components that provide technologically supported guidance independent of the application and the working environment. In order to achieve this, a literature review was conducted to identify key challenges necessary to provide meaningful technological support for guiding reflective learning at work. Based on those challenges, technologies were investigated and analysed to extract those technologies that are the most suitable ones for providing reflection guidance and are able to trigger reflective learning. Finally, core components and architecture were derived to present a general applicable reflection guidance framework. The theoretical underpinning is grounded in existing reflective learning theory and theoretical models and processes supporting reflective learning.

The design science research methodology is used as underlying research method to thoroughly present the conducted research. Altogether fifteen field studies consisting of one focus group, two design studies, six formative field studies and six summative field studies were conducted in different work-related settings. The field studies together with an extensive literature research led to the development of five iteration cycles of two different reflective learning applications to trigger reflective learning. Finally the thesis resulted in 9 publications (7 accepted and 2 under major revision).

The research conducted was divided into three different phases.
First, form the extensive literature the following key challenges emerged: (i) the timing of reflection (when to motivate to reflect: during an activity or after an activity), (ii) the appropriate tool used to motivate for reflection (prompts vs. diaries vs. visuals vs. contextualisation) and (iii) the work-related context of reflection (to not disrupt the work-flow).
Second, an in-app reflection guidance concept was developed, which provides reflection guidance in form of adaptive components. To illustrate how the concept can be instantiated in work-related settings, different components of the concept were implemented in three applications adopting various approaches to support reflective learning. The results showed that (i) prompts, diaries, and contextualisation are effective tools for initiating reflection when presented at the right time and an in the right place and (ii) their integration in the work processes needs to be carefully considered in order to not interrupt or annoy the user during work.
Third, a general applicable conceptual reflection guidance framework called "Reflector" has been elaborated including requirements, lessons learned and necessary features for providing meaningful technologically supported reflection guidance. This framework can be seen as a kind of a technical summary of the insights gained from the literature review and the implemented and evaluated reflection guidance concept.

This thesis contributes scientifically to the area of technology-enhanced learning and provides a novel approach on how to provide meaningful technologically supported individual reflection guidance at work.

Kurzfassung

Als reflektives Lernen bezeichnet man das bewusste Neubewerten von abgeschlossenen Situationen oder Erfahrungen mit dem Ziel daraus zu lernen und die gewonnenen Erkenntnisse dazu zu nutzen das zukünftige Verhalten zu steuern. Reflektives Lernen wurde auch im Arbeitskontext als Kernprozess identifiziert um neue Erkenntnisse zu gewinnen, um bessere Prozesse abzuleiten und um letztendlich die Arbeit zu verbessern. Bei reflektivem Lernen handelt es sich um einen kognitiven Prozess, der von der intrinsischen Motivation des Einzelnen abhängt und daher nicht erzwungen werden kann. Allerdings kann dieser Prozess durch Techniken während der Benutzung von Software Applikationen während der Arbeit unterstützt werden, z.B. mit Eingabeaufforderungen, das Schreiben von Journalen oder Tagebüchern oder Visualisierungen.

Das Ziel dieser Dissertation ist die Reflektionsunterstützung als adaptive Software-Komponenten zu konzeptualisieren, um technologisch unterstützte Anleitung für das Reflektieren zur Verfügung zu stellen, unabhängig von der verwendeten Software und dem Arbeitsumfeld. Es wurde zuerst eine Literatur-Recherche durchgeführt um die zentralen Herausforderungen zu identifizieren die notwendig sind um nützliche technologische Unterstützung für das reflektive Lernen zur Verfügung stellen zu können. Basierend auf diesen Herausforderungen wurden Technologien untersucht und analysiert und daraus die Technologien extrahiert, die am besten für das Initiieren von reflektivem Lernen verwendet werden können. Schlussendlich wurden die Schlüsselelemente und eine Architektur abgeleitet um ein generell anwendbares Framwork zur Reflektionsunterstützungs zu präsentieren. Die zugrundeliegende Theorie basiert auf existierenden reflektiven Lerntheorien, Modellen und Prozessen.

Die "Design Science Research"-Methode wurde verwendet um die durchgeführte Forschungsarbeit zu präsentieren. Insgesamt wurden fünfzehn Feldstudien

bestehend aus einer Fokusgruppe, zwei Designstudien, sechs formativen Feldstudien und sechs summativen Feldstudien in unterschiedlichen Arbeitsumgebungen durchgeführt. Die Feldstudien haben zusammen mit dem Literatur Review zur Entwicklung von zwei unterschiedlichen, reflektiven Lernapplikationen in fünf Iterationszyklen geführt. Schlussendlich sind im Rahmen dieser Arbeit 9 Publikationen entstanden (7 veröffentlicht und 2 in umfassender Revision).

Die Forschung ist in drei Phasen erfolgt. In der ersten Phase wurden durch eine Literatur-Recherche die folgenden Herausforderungen abgeleitet: (i) das Timing der Reflektion (wann soll zur Reflektion aufgefordert werden: während einer Aktivität oder nach einer Aktivität), (ii) die Verwendung des geeigneten Tools für die Reflektion (Eingabeaufforderungen vs. Tagebücher vs. Visualisierungen vs. Kontextualisierung) und (iii) der arbeitsbezogene Kontext der Reflektion (um den Benutzer während der Arbeit nicht zu unterbrechen). In der zweiten Phase wurde ein "In-app Reflection Guidance Konzept" entwickelt, das Reflektionsunterstützung als adaptive Komponenten zur Verfügung stellt. Um zu zeigen wie das Konzept im arbeitsbezogenen Umfeld instanziiert werden kann, wurden die Komponenten des Konzepts in drei Applikationen implementiert. Die Ergebnisse zeigten, (i) dass Eingabeaufforderungen, Tagebücher und Kontextualisierung effektive Tools sind um Reflektion zu initiieren und unterstützen wenn sie zum richtigen Zeitpunkt eingesetzt werden, und (ii) dass ihre Integration in Arbeitsprozesse sorgfältig überlegt werden muss um Benutzer während der Arbeit nicht zu unterbrechen. In der dritten Phase wurde ein allgemein anwendbares, konzeptionelles Reflections Guidance Framework namens "Reflektor" ausgearbeitet, das die Anforderungen, Lessons Learned und notwendige Funktionalitäten beinhaltet um technologische Reflektionsunterstützung zur Verfügung zu stellen. Dieses Framework kann als eine Art technische Zusammenfassung von den zuvor gewonnenen Erkenntnissen aus der Literatur-Recherche und dem Reflection Guidance Konzept gesehen werden.

Diese Dissertation trägt wissenschaftlich zum Bereich von Technology Enhanced Learning bei und stellt einen neuen Ansatz für die technologische Unterstützung von Reflektion am Arbeitsplatz zur Verfügung.

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1 Introduction

In the area of workplace learning, reflection has been identified as a crucial method for informal learning, as it does not rely on explicitly available learning material, curricula, or teachers. Instead, Lindstaedt et al. [100] define the term work-integrated learning emphasizing *"that learning at the workplace needs to be truly integrated in current work processes and practices and makes use of existing resources within an organization"*, which holds also true for reflective learning.

Reflective learning has been a research topic at least since Dewey [29] started the discussion about "How we think?" in 1933. Reflective learning is the conscious re-evaluation of past experiences with the goal to learn from them for the future, which is in-line with the definitions of Dewey [29] and Boud et al. [11]. Schön [142] differentiates between "reflection-in-action" and "reflection-on-action"; the first describing reflection during an action, the second focusing on reflection on past, finished actions. In addition to available definitions of reflective learning, there also exists models or processes describing mandatory steps in order to achieve reflective learning. The computer supported reflective learning model (CSRL model) [89] consists of four steps namely "Plan and do work", "Initiate reflection", "Conduct reflection session" and "Apply outcomes" to trigger reflective learning. This model can serve as underlying model for the development of technologies supporting reflective learning.

Until today, reflective learning is seen as an important learning strategy in educational as well as work-place learning. At the same time, recent advances in computer-mediated learning offer a plethora of possibilities on how to technologically support reflective learning. Currently, such technologies or tools for supporting reflective learning are mostly investigated in formal learning environments using conventional learning management systems. These tools consist for example of prompts, journals, ePortfolios, diaries, as well as visuals or other uncategorizeable tools (see Chapter 3). Some of these

tools already provide additional guidance for reflection in form of reflective questions, which aim at organising, retrieving, monitoring or evaluating knowledge and as a consequence motivating students to reflect about their learning, as described for example in [28, 27, 6, 82, 164].

In contrast, in work-related settings, there is only little research on providing reflection guidance to trigger reflective learning [37, 42, 43, 136, 115]. The reasons are many and varied: First, working tasks are not always known beforehand or are only vaguely known, thus it is very challenging to provide meaningful fitting reflection guidance e.g. in form of prompts. Second, the time of when to present reflection guidance needs to be well considered in order to not disrupt the ongoing work. Third, most workplaces are very stressful and work-intensive. Therefore, it has to be very well considered, if and how time consuming approaches like diaries can be applied in work-related settings.

This thesis was motivated by the question on how to provide meaningful and sophisticated technologically supported reflection guidance in order to trigger reflective learning at the workplace. Meaningful in this sense means effective, efficient and productive with regard to reflective learning. Guidance within this respect means to provide technological help or advice to trigger reflective learning.

The main contribution of this thesis is the development of an "in-app reflection guidance concept", its implementation in three different applications and its evaluation in four different work-related setting. This "in-app reflection guidance concept" conceptualises reflection guidance as adaptive components. For the development of this concept, I followed the design science research approach of Hevner et al. [69, 67, 68]. At the beginning, an extensive literature research was conducted to base the conducted work upon the current state-of-the-art. Subsequent, the concept was developed in parallel to three different applications coping with three different strategies to initiate reflective learning on an individual level: (i) the MoodMap App, an application for capturing and tracking individual mood to show how mood influences the individual work-life, (ii) Medical Quiz, a quiz enriched with reflective questions to connect theory with practice and (iii) KnowSelf, an application to support individual reflective learning regarding time management and self-organisation of knowledge workers. In mutual interplay, I refined and implemented this concept in these different applications and finally evaluated this concept in four summative field studies in different working environments. As a result of

these empirical investigations, I was able to develop a theoretical framework called "Reflector", which can be seen as kind of a technical summary of the insights gained from the implemented and evaluated reflection guidance concept.

1.1 Research Context

The research presented in this thesis was conducted within the EU Project "MIRROR - Reflective Learning at Work"[1] in close collaboration with Marina Bratic, Sandra Feyertag, Granit Luhznica, Viktoria Pammer-Schindler, Alfred Wertner and Gudrun Wesiak from the Know-Center and Verónica Rivera-Pelayo from FZI (Forschungszentrum Informatik, Germany). With Marina, Sandra, Granit and Alfred I worked closely together on the Medical Quiz, KnowSelf and the MIRROR User Profile App. The MoodMap App was developed in close cooperation with Verónica. Gudrun provided psychological expertise for the evaluations and the corresponding results. Viktoria acted as supervisor for all mentioned activities. My focus with regard to this thesis was set, beside the development and evaluation of different applications, especially on the research, development and implementation of the reflection guidance concept and subsequently on the general applicable reflection guidance framework, called "Reflector".

I performed my thesis as part of my work for the Know-Center GmbH Research Center for Data-Driven Business & Big Data Analytic.

1.2 Research Questions

This thesis is motivated by the question on how to provide meaningful technological support in order to provide guidance for reflective learning. To answer this main research question, the work has been split into three sub-questions:

[1] MIRROR - Reflective Learning at Work: www.mirror-project.eu

RQ1: What are the key challenges in order to provide meaningful technological support for guiding reflective learning at work?

This research question aims at investigating which technologies and tools already exist and are able to effectively, efficiently and productively trigger reflective learning. To answer this research question, a literature review was conducted in Chapter 3 which analysis and discusses tools and technologies with regard to (i) the timing of reflection, (ii) the participants of reflection (iii) the implemented guidance for reflection and (iv) gained insights and lessons learned for successfully stimulating reflective learning.

RQ2: Which technologies are most suitable for providing reflection guidance in order to trigger reflective learning?

In order to answer this research question, the first developed "in-app reflection guidance concept" was implemented in three different applications and evaluated in four different working environments. The results of the conducted field studies were analysed in detail to investigate the usefulness of the implemented reflection guidance components and to which depth reflective learning did occur.

RQ3: What are the core components and architecture for a general applicable reflection guidance framework?

Based on the insights gained from RQ1 and RQ2, a general applicable reflection guidance framework was developed. This framework focus on the one hand on data analysis in order to detect significant triggers worth being reflected on. On the other hand the focus was put on how to present the detected trigger in a sophisticated and unobtrusive way to the user.

The first and the second question investigate the general approach on a socio-technical as well as technological level in order to provide technologically supported reflection guidance. The third research question strives to present a general applicable reflection guidance framework.

1.3 Structure of this thesis

Chapter 2 provides the theoretical underpinning for this thesis. It outlines the definition and understanding of reflective learning with regard to this work. Furthermore, it shortly summarizes models for reflective learning processes as underlying theory for the different applications developed and evaluated within the scope of this work. Chapter 3 presents a literature review on technologies and tools using various techniques like prompts, journal writing or visuals for guiding reflective learning. Chapter 4 describes the research methodology of these thesis based on the design science research model of Hevner et al. [69, 67, 68]. Thus it illustrates vividly the interplay between the conducted field studies, the cyclic application development and the scientific contribution. Chapter 5 presents the developed in-app reflection guidance concept and its implementation in three different applications. Chapter 6 is the core of this thesis and accounts the results of the conducted summative field studies of the applications with regard to the implemented reflection guidance concept in various working environments. In Chapter 7, the conceptual reflection guidance framework called "Reflector" is introduced. Finally, Chapter 8 concludes this thesis with answering the research questions.

1.4 Scientific Contributions

In this section, the scientific contributions of this thesis are outlined. Overall, the scientific contributions can be summarized as follows:

- *Literature Review*: An extensive literature review on reflection guidance technologies was conducted to shed light on the current state of the art of tools supporting reflective learning. Research papers from educational as well as work-related settings were divided into reflective learning tools (e.g. prompts, reflective journals/ePortfolios/Diaries, visuals and miscellaneous) and were analysed according four dimensions. The following key challenges for guiding reflective learning were derived: First, the timing, when to ask users to reflect during work, needs to be carefully considered. Second, in learning environments it is well investigated to present prompts tailored to the learner's learning activities and tasks. In work-related settings, it is a key challenge to provide prompts related

to the workers' current working activity. Third, it needs to be carefully considered if and how time-consuming approaches like reflective diaries or journals can be smartly be integrated in fast-paced and work-intensive working environments. Fourth, in order to provide sophisticated visuals for initiating reflective learning work, it is a key challenge to decide which data to track and to present worth being reflected on.

- *In-app reflection guidance concept*: This concept was developed as core of this thesis and conceptualises reflection guidance as adaptive software components. This reflection guidance concept was implemented in three different applications and evaluated in four work-related settings in order to show up its value for triggering reflective learning at work. The results and insights can be summarized as follows: Reflection-in-action and reflection-on-action components in form of prompts work well for initiating reflective learning, when being presented at the right time and without interrupting ongoing working processes. Mandatory contextualisation in form of predefined context possibilities of reoccurring working tasks together with free adaptable context in form of self-defined keywords both in combination with reflective questions can make contextualisation a powerful reflective learning tool. Reflective diaries are successful technologies to guide reflective learning; however, it is very difficult to motivate users to really use a diary during work. What is missing is a quick apparent and obvious benefit for the user that immediately convince a user to keep a reflective diary as it can improve own work over longer period of time.
- *"Reflector"*: The developed reflection guidance framework called "Reflector" can be seen as kind of a technical summary of the insights gained from the literature review and the results of the implemented and evaluated reflection guidance concept. It consists of two main components: the "Reflection Engine" responsible for data analysis and trigger creation and the "Reflection Guidance" presenting the detected triggers at the right time, in a sophisticated way and at the corresponding device. These two components can be seen as the core components for developing a general applicable reflection guidance framework as their mutual interplay of detecting and presenting triggers form a powerful framework to stimulate individual reflective learning. And although the "Reflector" has not been implemented yet, it promises to be a very well considered concept and serves as base for the generalisation of providing meaningful technologically supported reflection guidance.

1.4.1 Research Papers

I contributed to altogether nine scientific research papers. They consist of two journal papers, two conference papers and two workshop papers, one poster while two papers are still under major review.

P1: Motivation and User acceptance of using physiological data to support individual reflection.

Authors: **Fessl, A.**, Rivera-Pelayo, V., Müller, L., Pammer, V., and Lindstaedt, S.
Contribution: This paper sheds light on the motivation to use physiological sensors in the workplace. Three user studies have been conducted in five companies to assess the motivation to wear sensors and reflect on the captured physiological data during work. The focus group conducted at a stroke unit in a German hospital (Chapter 4), was one of the conducted studies of this thesis. With regard to the goal of this thesis, this research and the corresponding results showed first evidence that users need more support in order to learn from their own captured data and that there is a need to guide users through the reflection process.
Published in: 2nd MATEL Workshop at European Conference for Technology Enhanced Learning.
Year: 2011

P2: Mood Tracking In Virtual Meetings.

Authors: **Fessl, A.**, Rivera-Pelayo, V., Pammer, V., and Braun, S.
Contribution: Within this paper, the results of the first MoodMap App evaluation in a small department of a big telecommunication company were presented (Chapter 4). The usage and usefulness of tracking own mood and creating awareness about the mood of team members in virtual meetings was investigated with regard to reflective learning. The insights gained for this thesis encompass that users are interested in tracking own mood, that they need to relate their mood to the current working context, and that they wish to receive feedback or other helpful input from the app in order to achieve reflective learning. Thus, this also confirmed the need for guidance.

Published in: Proceedings of the 7th European conference on Technology Enhanced Learning, EC-TEL'12, Springer-Verlag (Berlin, Heidelberg), 377–382.
Year: 2012

P3: Continuous learning with a quiz for stroke nurses.

Authors: **Fessl, A.**, Bratic, M., and Pammer, V.
Contribution: This paper presents the Medical Quiz as continuous learning solution, which allows stroke nurses to keep the vast body of theoretical knowledge fresh, stay up-to-date with new knowledge, and relate theoretical knowledge to practical experience (Chapter 4). In this paper, the first promising results with regard to the implemented reflective questions (prompts) within the quiz were presented and upcoming barriers to integrate a quiz into work processes within an emergency ward such as a stroke unit were discussed. Both gained insights contributed mainly to the development of this thesis.
Published in: International Journal of Technology Enhanced Learning, 6(3), 265 - 275.
Year: 2014

P4: Application Overlapping User Profiles to Foster Reflective Learning at Work.

Authors: **Fessl, A.**, Luzhnica, G., and Wesiak, G.
Contribution: This publication presents a combined visualisation of data captured by different applications to enhance the support for reflection about the working behaviour and experiences (Chapter 4). This work was conceptualized as a first proof-of-concept. Its goal was to investigate if such an approach indicates that a combined user profile application and especially it's visualisations can be beneficial with regard to reflective learning and can enhance the awareness about multiple aspects of a user's work life. The contribution for this thesis were rather less, however further insights on individual reflective learning and the perceived benefits contributed to the development of the reflection guidance concept.

Published in: Proceedings of the 4th Workshop on Awareness and Reflection in Technology Enhanced Learning (ARTEL) at the 9th European conference on technology enhanced learning (EC-TEL'14), 51–64.
Year: 2014

P5: Introducing Mood Self-tracking at Work: Empirical Insights from Call Centers.

Authors: Rivera-Pelayo, V., **Fessl, A.**, Müller, L., and Pammer, V.
Contribution: This paper presents two field studies with a mood self-tracking application within a total of four teams of employees in two call centers (Chapter 4). The challenges of the introduction and the role of mood self-tracking at work were investigated as well as its impact on individuals and teams. The analysis of the results shows that (i) capturing moods and explicitly relating them to work tasks facilitated reflection in-action, (ii) mood self-tracking increased emotional awareness and this improved cohesion within teams, and (iii) managers pro-actively reacted to trends and changes in team members' mood. The results of these paper directly influenced the work of this thesis, because a first version of the reflection guidance concept was implemented and evaluated.
Under major revision at: International Journal of Human-Computer Studies

P6: In-app Reflection Guidance for Workplace Learning.

Authors: **Fessl, A.**, Wesiak, G., Rivera-Pelayo, V., Feyertag, S., and Pammer, V.
Contribution: In this paper, a generic concept for in-app reflection guidance for workplace learning was presented, including its implementation in three different applications, and its evaluation in three different settings (one setting per app), (Chapter 4). From this experience, the following lessons learned were drawn: First, the implemented in-app reflection guidance components are perceived as useful tools for reflective learning and their usefulness increases with higher usage rates. Second, smart technological support is sufficient to trigger reflection, however with different implemented components also reflective learning takes place on different stages. A sophisticated, unobtrusive

integration in the working environment is not trivial at all. Automatically created prompts need a sensible timing in order to be perceived as useful and must not disrupt the current working processes.
Published in: Design for Teaching and Learning in a Networked World, G. Conole, T. Klobucar, C. Rensing, J. Konert, and E. Lavouee, Eds., vol. 9307 of Lecture Notes in Computer Science. Springer International Publishing, 85–99.
Year: 2015

P7: Fostering Reflective Learning at Work: Implementation and Evaluation of In-app Reflection Guidance.

Authors: **Fessl, A.**, Wesiak, G., Rivera-Pelayo, V., Feyertag, S., and Pammer, V.
Contribution: This work is an extended version based on P6, and was enriched with another field study (Chapter 4), further analysis and additional results especially with regard to insights on reflective learning.
Under major revision at: Journal of IEEE Transactions on Learning Technologies.

P8: The Known Universe of Reflection Guidance: a Literature Review.

Authors: **Fessl, A.**, Blunk, O., Prilla, M., and Pammer, V.
Contribution: In this work, a literature review was conducted on various approaches and tools (e.g. prompts, journals, visuals) providing guidance for facilitating reflective learning. From this analysis, the following insights, guidelines and recommendations for the design of reflection guidance functionality in computing systems were derived: (i) ensure that learners understand the purpose of reflective learning, (ii) combine reflective learning tools with reflective questions either in form of prompts or with peer-to-peer or group discussions, (iii) for work-related settings consider the time with regard to when and how to motivate to reflect. This paper serves as base for the literature review conducted for this thesis.
Published in: Int. J. of Technology Enhanced Learning. (in press)
Year: 2016

P9: A Reflective Quiz in a Professional Qualification Program for Stroke Nurses: A Field Trial

Authors: **Fessl, A.**, Wesiak, G. and Pammer, V.
Contribution: This poster is the follow-up paper of P3 (see Chapter 4). For health care professionals like nurses, reflective learning is an important strategy to keep the vast body of theoretical knowledge fresh, stay up-to-date with new knowledge, and to relate theoretical knowledge to practical experience. We developed and evaluated a quiz for stroke nurses that can stimulate reflective learning by presenting reflective questions at different points in time. The results show that by playful learning and presenting reflective questions at the right time, participants were motivated to reflect, deepened their knowledge and related theoretical knowledge to practical experience.
Accepted as poster: European Conference on Technology Enhanced Learning (EC-TEL'16).

P1, P2, P3, P4, P5, and P9 present the results of one or two field studies conducted within this thesis. Their results and contributions provide significantly the path for the development of the reflection guidance concept. In P6 and P7 the developed reflection guidance concept was presented. P6 was published on a conference and the enhanced version P7 is currently under major revision as a journal paper. Both research papers built the core of this thesis and serve as basis for Chapter 5 and Chapter 6. P8 complements this work with a literature review on reflection guidance technologies and serves as base for Chapter 3.

2 Background: Reflective Learning at the Workplace

Reflective learning has been a research topic at least since Dewey [29] started the discussion about "How we think?" in 1933. Until today there exists several definitions about reflective learning as well as different types of theoretical models and processes on how reflective learning can be stimulated. The following two sections will present the theoretical underpinning on reflective learning and existing models in order to set the theoretical background of this thesis.

2.1 Reflective learning: Understanding and Definition

One of the first definitions with regard to reflective learning was given by Dewey [29], who specifies reflection as an *"active, persistent and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusions to which it tends"*.

Starting in 1990's, several researchers worked on reflective learning and how to learn from experience. Boyd and Fales [12] define reflective learning as *"... the process of internally examining and exploring an issue of concern, triggered by an experience, which creates and clarifies meaning in terms of self and which results in a changed conceptual perspective"*. Boud et al. [11] define reflective learning as *"those intellectual and affective activities in which individuals engage to explore their experiences in order to lead to new understandings and appreciations"*. Daudelin [26] investigated reflective learning of managers in rapid changing working environments in order to be prepared and successful in their business environments. She defines reflection and learning as follows: *"Reflection is the*

process of stepping back from an experience to ponder, carefully and persistently, its meaning to the self through the development of inferences; learning is the creation of meaning from past or current events that serves as a guide for future behaviour". Another definition was given by Moon [114], who explored the relation between reflective learning and experiental learning in higher education. She defined that reflection *"... is part of learning and thinking. We reflect in order to learn something, or we learn as a result of reflecting, and the term 'reflective learning' emphasises the intention to learn from current or prior experience."*

With regard to professionals, Schön [142] brings in the "timing" dimension for reflection. He differentiates between "reflection-in-action" and "reflection-on-action". Reflection-in-action, describes reflection during an action at work in which a change can still be applied to the action itself. Reflection-on-action focuses on past, finished actions where the outcome of the detached reflection cannot influence the action anymore, but reflection outcome might influence actions or experiences taking place in future. Eraut [34] states that the existing definition of Schön is impractical for categorizing reflection support since it neglects time pressure. Time is a major factor for how much focus and deliberation one can spend on reflection and thus affects the kind of reflection support tools have to offer. He differentiates between "deliberate reflection-in-action" and "rapid reflection-in-action". The former describing reflection-in-action in situations in which a decision has to be taken quickly and the latter describing situations in which one can take a break from the action for reflection.

Taking into account the definitions above with regard to this thesis, I see **reflective learning as the conscious re-evaluation of past situations or experiences with the goal to learn from them and to use the gained outcomes to guide future behaviour**. In order to be successful in triggering reflective learning, the timing - when to reflect - needs to be taken into consideration.

2.2 Theoretical Models for Reflective Learning

In literature, there exist several important approaches on how to model reflective learning processes.

Kolb's experiental learning cycle [83] consists of four stages: Concrete Experience, Reflective Observation, Abstract Conceptualisation and Active Experimentation. He states that learning only occurs if a person runs through all for stages: having an experience, reflecting and observing this experience, develop some abstract concepts and derive some conclusions from the experience, and testing the insights gained.

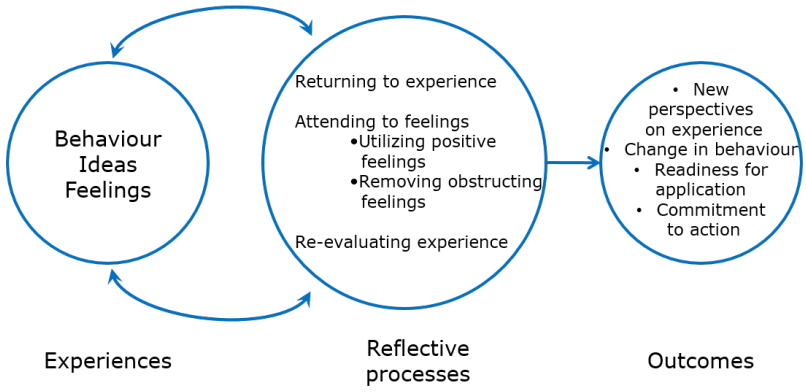


Figure 2.1: Model of Boud et al. [11]

Also the model of Boud et al. [11] is based on experiences as depicted in Figure 2.1. These experiences consist of behaviours learners have engaged with, ideas learners are aware of and feelings learners have experienced. To make reflection a successful process three major steps have to be taken into consideration when returning to the experiences: First, return to the experience as it has happened, replay the initial experience and recount corresponding features. Second, attend to feelings, use positive feelings to recollect good experiences and to put attention to pleasant aspects of the intimidate environments. Remove obstructive feelings to precursor a rational consideration of events. Third, re-evaluate the experience by re-examining the experience in the light of the learner, associate new knowledge which is already possessed and add this new knowledge to the learners conceptual framework. The outcome of reflection can encompass a new cognitive map, the identification of a new set of ideas, the development of new perspectives or changes in behaviour, changes in the emotional state, individual attitudes

or sets of values. Action can occur at any step in the reflection process and can be again a starting point for a new reflective process.

The reflection process by Daudelin [26] consists of the following four stages: (1) articulation of a problem, (2) analysis of that problem, (3) formulation and testing of a tentative theory to explain that problem and (4) action (or deciding whether to act). In the first stage, the issue is defined which is the topic of reflection. Being able to articulate this issue is a first step to an insight in itself. The second stage led to the search of different possibilities on how to deal with the issue and might lead to the posing of different questions in order analyse the issue form different perspectives. In the third stage, a hypothesis is generated and tested to solve the detected problem. The fourth stage, closes the reflection process as it is the final test of the created hypothesis and consists of an articulation of a new way on how to act in future when being faced with a similar issue.

The Computer Supported Reflective Learning Model (CSRL Model) by Krogstie et al. [89] (see Figure 2.2) is mainly based on Boud et al. [11]. If focusses on supporting reflective learning at work and sees the reflective learning process as a number of multiple, interconnected cycles on an individual and collaborative level. The model consists of the following four stages: (1) Plan and do work, (2) Initiate reflection, (3) Conduct reflection session and (4) Apply outcome. In the "Plan and do work" phase, individuals or groups perform work-related tasks in their working environment. These tasks set the frame for reflection and therefore "Initiate reflection". Within the subsequent "Conduct reflection session", the objective and the reflection topic given by the frame are addressed individually or in groups and result in an outcome. In the "Apply Outcome" stage, this outcome can be a change of work or serve as input for another reflection cycle. Triggers, external (someone or something reminds or motivates to reflect) or internal triggers (an inner voice nagging us that something does not quite fit and thus making us reflect), starts the reflection and can occur in all phases of the model.
It is noticeable that especially this model can be used to inform the design and implementation of tools and technologies supporting reflective learning. A designer or software developer can use the model to analyse and describe cases for reflection with regard to the planned tool or technology. Then, she can choose proper technologies in order to support activities important for initiating a reflection process following the four stages of the model.

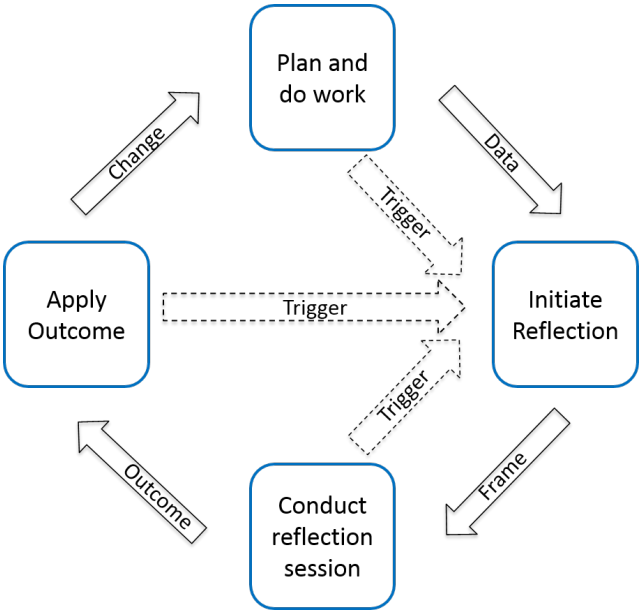


Figure 2.2: Computer Supported Reflective Learning Model of Krogstie et al. [89]

Another model for reflection has emerged in the Quantified Self community. This community is interested in self tracking tools to collect data about oneself and to reflect on this data with the goal to gain new insights on own behaviour and habits. Such tools or systems that help people to collect personal information and to reflect about this data is called in science "Personal Informatics". Li et al. [96] investigated problems and challenges within personal informatics and derived a model composed of five stages: (i) preparation, (ii) collection, (iii) integration, (iv) reflection and (v) action. In the preparation stage, users start with personal self-tracking and decide on the data they want to capture and reflect on. In the collection stage, users collect data about themselves and observe their behaviour, habits and inner thoughts. Afterwards, in the integration stage, the collected data is prepared, combined and transformed for the reflection stage. In the reflection stage, users reflect on their personal information either immediately during the

collection ("short-term" or reflection-in-action) or days or weeks afterwards ("long-term" or reflection-on-action). After reflection, users take action with regard to the insights gained.

All presented models have in common that they refer to an experience or a problem, analyse and/or reflect the experience in order to derive some outcomes or action worth to be tested in the future. Only the CSRL model by Krogistie et al. [89] provides a kind of step-by-step instruction on how to develop tools or technologies supporting reflective learning - this model will be used as reference model for the applications used and developed within this thesis.

2.3 Conclusion

This thesis is based on the definition of reflection by Boud et al. [11] and the developed applications of this thesis are based on the CSRL Model described in Krogstie et al. [89]. Reflective learning is seen as the conscious re-evaluation of past situations or experiences with the goal to learn from them and to use the gained outcomes to guide future behaviour. Reflection is both a crucial part of learning - in formal as well as work-place learning - and a response to past experiences - in learning as well as working environments. These experiences the individual was engaged in serve as starting point for the reflective process, while triggers for reflection, external as well as internal triggers, play a crucial role to stimulate reflective learning. The CSRL Model was used as underlying model for all developed applications mentioned in this thesis. The model was used in order to ensure that each application is able to fulfil the particular characteristics of supporting reflective learning processes at work, by addressing all four stages of the model.

3 Literature Review on Reflection Guidance Technology

3.1 Introduction

Reflective learning is a cognitive process based on intrinsic and extrinsic motivation of the individual [26], thus it cannot be directly enforced. Reflection techniques like prompting approaches, diaries as well as video recording or meaningful visuals etc. can spark respectively foster reflection while using tools or applications in educational as well as work-related settings. These techniques will be considered not only if they are able to stimulate reflective learning but also if meaningful guidance for reflection was provided and in what way.

This chapter presents a literature review on technologies, tools and applications using various techniques like prompts, journal writing, visuals for guiding reflective learning. Then, the investigated literature will be analysed and categorized according four different dimensions relevant for reflective purposes:

- *Dimension I: reflection-in-action and reflection-on-action*: this dimension focus on the proximity between reflection and action meaning whether the corresponding reflection tool is more useful in reflection-in-action or reflection-on-action [142].
- *Dimension II: reflection participants: individual vs. collaborative*: this dimension allows a closer look at which level reflection is supported.
- *Dimension III: reflection guidance*: this dimension provides insights on if and how reflection guidance approaches were applied within which different setting [42]
- *Dimension IV: success and results of reflection*: this dimension highlights the success and the achieved depth of reflection with the used tools.

These dimensions emerged while doing the literature research. Dimension I is strongly related to the work on Schön [142] who brings in the timing of when to reflect. The second dimension takes into account the individual as well as the collaborative perspective on reflective learning. And although this work focusses on the guidance of individual reflective learning, collaborative reflection needs to be taken into consideration in order to not miss relevant insights, approaches or methods, which might be also applicable for individual reflective learning. The third dimension focus on existing and successful approaches for guiding reflective learning which need to be taken into consideration as underlying concepts right from the beginning of this thesis. And the last dimension encompasses insights on what already worked well in literature in order to integrate these approaches into the upcoming concept.

The analysis according these four dimensions will lead to deeper insights with regard to reflective learning in general and reflection guidance in particular.

Thus the contribution of this chapter lies in answering the first research question of this thesis: *RQ1: What are the key challenges in order to provide meaningful technological support for guiding reflective learning?*

Answering the following four sub-questions contributes to answer the first research question of this thesis.

- Which tool or technology supports which timing of reflection?
- Which tool or technology supports which participants of reflection?
- Which reflection guidance approaches exists and work in relation with which tool?
- Which insights or lessons learned can be derived for successfully stimulating reflective learning?

This literature review is published in Fessl et al. [36]. The published paper contains not only the literature serving as state-of-the-art for this thesis but also the research papers published with regard to this thesis. In contrast, the literature research presented in this chapter contains only the literature this thesis is based on. In the discussion section, I will shortly self-reflect on my own contributions with regard to this literature review and shortly discuss the corresponding dimensions.

3.2 Related Work: Existing Literature Reviews

In literature, there exists a handful of research papers presenting different approaches of literature reviews dealing with reflective learning.

Kottkamp [85] conducted one of the first literature reviews with regard to tools (e.g. writing, journals, case records) supporting reflective learning. Lin et al. [99] focus in their work on how to design and use technologies to realize reflective learning environments using three main implications from social constructivity theory regarding reflective thinking, (i) the involvement of social interaction, (ii) the active, intentional, and purposeful process of exploration, discovery, and learning, and (iii) the understanding one's own learning processes. From their literature review, they derived four design features relevant for scaffolding reflective thinking in form of effective instructional strategies: (i) process display, which shows students their steps to solve a task or problem, (ii) process prompts, which are used to motivate students to explain and evaluate what they do at the beginning, during and in the end of an problem-solving act, (iii) process models, representing the steps of an expert to solve a problem and (iv) reflective social discourse, which adds the social component to the reflective thinking processes. Verpoorten et al. [159] focused their work on reflection amplifiers, special prompts motivating to reflect in learning environments. They developed a framework for identifying relevant attributes necessary for reflection amplifiers split into input and output attributes of reflection processes. Baumer et al. [9] did a literature review on how to design for reflection. In their analysis, they come up with patterns, trends and themes followed by an interpretation and suggested directions of future work on designing for reflection. They suggest, *"that engaging with the conceptual and theoretical literature may provide valuable grounding and inspiration for more sophisticated, subtle, or nuanced designs for reflection"*. Subsequent, Baumer [8] comes up with the term of "reflective informatics", which is a *"conceptual approach that helps bring clarity and guidance to the discussion of designing for reflection"* based on three dimension of reflection, namely breakdown, inquiry, and transformation. Kori et al. [84] made a literature review of reflection technologies with regard to reflection support in technology-enhanced learning. They divide the tools found into technical tools, technical tools with predefined guidance and technical tools with human interaction guidance. Li et al. [97] did not perform a literature research, but an interview-based study on "personal informatics" in the area of ubiquitous computing in order to

investigate the self-reflection needs of users. Their goal was to find out, which kind of questions users ask about their collected data (questions about status, history, goals, discrepancies, context, and factors) and how to present this data to answer these questions. On the other hand they set the users' information needs in relation to the two extracted phases of reflection, "discovery" and "Maintenance", in order to raise self-awareness and subsequent lead to good decision making and changing behaviour.

Until now, literature reviews focus either on pure technologies with or without guidance for reflection [85, 84], on one specific technology like prompts [159] or on the design for reflection tools [9, 8]. What is missing is a review on tools in combination with existing reflection guidance approaches. In this work the focus is put on the following three aspects: (i) tools with regard to their usefulness in educational and work-related settings in combination with the timing component [142, 34]; (ii) the implemented and applied reflection guidance approaches and (iii) the achieved results with regard to reflective learning.

3.3 Literature Review: Paper Selection Process

At the beginning, three major prerequisites for papers in order to be considered for this review were defined. First, the definition of reflective learning has to correspond with the understanding of reflection with the author, being the conscious re-evaluation of past experiences with the goal to learn from them to guide future behaviour. Second, a technology, a tool or an application has to be presented (stand-alone or integrated in for example a learning environment) which aims at motivating, guiding or triggering users to reflect. Third, this tool ("tool" is now taken as synonym for technology or application) has to be evaluated with regard to reflective learning and present corresponding results (e.g. Did reflective learning take place?)

After having defined these prerequisites, it became clear, that a conventional keyword search in ACM, Springer or Google Scholar would not fit to find relevant papers. The author of this thesis and the co-authors of the corresponding publication P8 [36] are dealing with reflective learning for more than five years

within the projects "MIRROR - Reflective learning at work"(http://mirror-project.eu) and "EmployID" (http://employid.eu). We took all papers collected for these projects as starting point, used their references and skimmed conferences dealing with TEL in general and reflective learning in particular. Furthermore, we restricted the literature found to the years between 2000 - 2015. We do not claim completeness for all papers available in this area. Finally, 53 papers were analysed fulfilling our prerequisites mentioned above.

3.4 Literature Overview

During the literature review, the following technological approaches and tools emerged and are used to categorize the reviewed literature accordingly:

- *Prompts:* a prompt is a message that appears on a computer screen asking the user for action or to provide information. With regard to reflective learning such prompts try to motivate people to reflect. For example, asking thinking ahead questions or checking understanding questions as well as making aware of past situations might be the content of a prompt.
- *Journals, ePortfolios and diaries:* they represent a space where users can record and reflect upon their learning experience in order to explore and analyse their ways of learning and thinking. The differentiation of the three tools depends on the collected data (e.g. a diary contains only individual thoughts, while an ePortfolio consists of different types of artefacts) and on the intention of being shared and with whom (e.g. while a diary is kept private, a journal is intended to be shared with a supervisor or teacher).
- *Visuals:* Visuals consist of sophisticated visualisations in IT-based tools and encompass images or videos or other relevant information and representations worth being reflected on. Examples for such visuals are timelines, heatmaps, tag clouds etc.
- *Miscellaneous:* this category was added for tools and technological approaches which are used for reflective learning but did not fit to one of the three previous categories.

Each of the reviewed papers will be assigned to one of these categories. The presented papers will consist of a short description about the use case, the

reflective learning approach followed by the results of reflection. Where possible, educational and workplace learning [42] will be distinguished, because these settings have different demands with regard to reflection guidance (e.g. known activities vs. unknown activities, time pressure during work).

3.4.1 Prompts

Prompts are not a tool per se, but can be seen as kind of an intervention combined with or without a specific IT based tool (e.g. a prompt implemented in a learning environment). They are often used in the form of questions or instructions [6] in order to facilitate recall strategies. The term "reflection prompt" by Chen et al. [20] defines prompts as a strategy to engage learners in reflective practice in online learning environments. Another approach of prompts are so-called "reflection amplifiers" defined by Verpoorten et al. [159] as a *"[...] deliberate and well-considered prompting approach, which offers learners a structured opportunity to examine and evaluate their own learning"*. Additionally, a prompt should be context-specific regarding the context a user is currently in as suggested by Davis [28].

Prompts in Educational Settings

Manifold approaches of implemented prompts and reflection amplifiers can be found in literature (chronologically ordered): Davis [28] distinguishes between self-monitoring prompts and activity prompts. While self-monitoring prompts use "Thinking ahead" or "Checking our understanding" questions to motivate students to reflect on their own learning and understanding, activity prompts focus reflection on the student's progress in their activity and create awareness to pay attention to each aspect of their project. Later on, Davis [27] focusses her studies on generic and directed prompts presented before and after a learning activity. Directed prompts contain specific instructions on how to approach a certain task, while generic prompts ask students to "stop and think" about the learning activity. The goal of the study was to compare these two types of prompts with regard to reflective learning. Irrespective of presenting generic or direct prompts, overall there was no significant difference in the project scores. However, students receiving generic prompts did better work, conducted more useful activities and engaged more in reflective

learning than students receiving directed prompts. Ifenthaler et al. [73] follow Davis' [27] categorisation to support self-regulated learning within problem solving processes. They found that generic prompts give learners more guidance to use different problem solving strategies but at the same time retain their autonomy to a certain extend. In contrast, directed prompts give more step-by-step instructions and restrict autonomous work. Van der Boom et al. [154] investigated if reflection prompts are successful to increase the student's self-regulated learning competences. Three types of reflection prompts, "forethought" (reflection-before-action), "intermediate thought" (reflection-in-action) and "afterthought" (reflection-on-action), were implemented and enhanced with individual feedback from tutors. The results showed that only reflection prompts in combination with tutor feedback significantly increased the development of self-regulated learning competences. Interesting is also that those groups with tutor feedback but independent of the presented prompt, received higher scores for self-regulation, external regulation and lack of regulation than the those without direct feedback. Furberg [49] investigated content-oriented reflection prompts in order to motivate students to reflect about the currently learned topics. The answers to the prompts could be summarized as follows: *"they were short, non-argumentative, declarative formulations with a strong resemblance to formulations and text passages in the system"*. Thus, the students answered the questions only because they were graded by teachers and did not try to reflect. Chen et al. [20] use high-level prompts in form of comprehension questions or integration questions in combination with high-level peer observation, a special form of guidance for learning, to enhance the learner's reflection level. Their results showed that providing high-level prompts and high-level peer observation for learning has significant influence on the reflection level achieved. O'Hanlon and Diaz [120] evaluated process modelling supported by videos and self-monitoring prompts in an online course assignment in two courses. In the first course, they used open-ended reflection questions, while in the second course these questions were converted into multiple-choice reflection questions, which lead students to answer more precisely. Overall results regarding the answers were similar, thus multiple-choice reflection questions are a viable option for large online courses Tabuenca et al. [149] investigated the learning affordances of students throughout a day by sending them reflection amplifiers via SMS. The students reflected directly when receiving the SMS. The insights gained could be summarized into four categories: gains in meaning, gains in self-assessment and gains in consciousness. Bannert et al. [7] investigate the role of self-regulated

learning prompts with and without training. The goal of the prompts was to motivate the learners to carry out specific self-regulated activities, and at the same time to make them think about these activities and tasks in order to better understand their learning. The results of the study showed that the students with training performed better, but not in a convincing way and that further research is necessary in this area. Kori et al. [84] investigated if reflective prompts could enhance the reflection quality and transformative inquiry skills based on the given tasks on research projects. The design and phrasing of the reflective prompts was aligned with the four reflection levels of Leijen et al. [94], namely description (lowest reflection level), justification, critique and discussion (highest level). In a pre- and post-test comparison of their reflection worksheet (with reflection prompts) they showed that the number of answers on the critique level increased while the number of the justification level decreased. McNicol et al. [108] developed two tools for collaborative reflection on student's project work. With the first tool, students can record audio newsflashes guided with prompts asking what they have done, what they will do next and any problems encountered. The second tool was a kind of diary for the recordings. The results showed that reflection took place if students have understood the value of reflection with regard to their learning and thus gained rich insights on their individual learning progress and the collaborative project development over time. However, student's who did not see the value of reflection also did not really reflect. Verpoorten et al. [160] follow the approach of reflection amplifiers as defined in their previous work [159]. They investigated an annotation tool in an online course with regard to reflection under three conditions - without the annotation tool, with the annotation tool and free-style notes, and with the annotation tool and question-based notes. They found out that neither the availability of an annotation tool alone nor the question-based annotation tool induce higher marks at the final exam. On the other hand, they showed that students with more individual annotations in combination with other reflective enactments (page views, dashboard views of annotations) brought extra benefits for the learning performance and showed significant positive impact on the final mark.

Prompts in Work-related Settings

In work-related settings, there exists little research on the usage of prompts and their implementation in tools or applications. Although the following two papers did not evaluate a tool and present research results, they lay out a concept on how prompts might by valuable for reflective learning at work. Prilla [129] discusses the usage of prompts with regard to collaborative reflective learning at work and developed a concept of prompts addressing different levels of reflection. First level prompts ask users to use the tool. Second level prompts motivate for the use of features within the reflection tool and third level prompts ask for leaving traces of face-to-face meetings. Blunk and Prilla [10] enhanced this approach and developed a concept for goal-driven tool-supported collaborative reflection in which different types of prompts address well-defined goals related to the "Computer Supported Reflective Learning" model by Krogstie et al. [89].

3.4.2 Journals/ePortfolios/Diaries

Reflective journals, ePortfolios and diaries are predominantly used in formal educational settings. Diaries are personal notes not meant to be shared; hence most studies focus on the effect diary writing has on learning e.g. [150]. In contrast, journals are intended to be shared e.g. with supervisors or teachers; they are used in different training settings (e.g. athletes) [161] and in work-related settings, especially in medical education of nurses [153, 21, 61]. EPortfolios are mostly defined as a collection of information and (physical) artefacts, gathered for specific purposes by a user over time [2], both in educational [33] and work-related settings [58]. All these tools and techniques have in common that they are very time-consuming in being kept and maintained.

Journals/ePortfolios/Diaries in Educational Settings

Tang [150] described the usage of a reflection diary to draw conclusions for practice in a higher education course for teaching, its facilitation and assessment of reflective learning. Before each lecture the participants noted down their goals for the upcoming session and afterwards they listed the most important point they have learned and the main unanswered question. The

evaluation showed that reflective learning has taken place and that users got insights on their individual current teaching and assessment practice. George [50] investigated the use of a (paper-based) reflection journal for a data structure and algorithm course. The students' task was to reason their working steps, evaluate the subjective knowledge and consider the benefit of the journal for themselves. Although the reflective journal *"was not universally accepted by all students, it was recognised as a valid teaching and learning activity by some"*. Loo and Thorpe [102] introduced a reflective learning journal to improve both individual and team performance during project work in an undergraduate course for management majors. They were able to show that a reflective journal is an effective tool to initiate reflective learning on both levels. Furthermore, they proved that motivating students to take actions lead to own learning improvement and a higher team effectiveness. Land and Zembal-Saul [91] defined three primary scaffolding strategies for keeping an web-based ePortfolio in a project based experience: (a) facilitate ongoing articulation, (b) support explanation building and generating of working hypothesis and (c) structure opportunities to organize, reflect upon and revise. These strategies were implemented with computer-based prompts. The findings showed that the provided scaffolds were useful for articulation, reflection and revision of explanations, if the participants had enough background knowledge for understanding and using the provided scaffolds. Alexiou et al. [2] wanted to highlight the support of ePortfolios with regard to self-regulated learning including self-reflection on one's academic and learning career. Clarke [23] did a study in teacher education with journals. Teachers were writing journal entries about internships they did using guided questions for the journal entries. Additionally they used shared group discussions amongst the associate teachers to test whether this helps to engage in reflection. Clarke found that both conditions helped teachers starting to reflect and improved professional learning.

Journal/ePortfolios/Diaries in Medical Education

Many reflective journal-writing approaches can be found in medical education; especially in this area reflective practice is seen as a very important strategy [66, 105] for learning. Elango et al. [33] investigated the perspective of medical students on ePortfolios as learning tool. The students were asked to keep an ePortfolio for four semesters and to report on complete cases, evidence-based reports, individual reflections on softer issues (e.g. moral,

social and ethical issues) and on patient management. Their results show that ePortfolios helped the students to improve their communication skills and their work, to support self-directed learning, to reflect on cases and problems and encouraged self-reflection. And although they confirmed that the ePortfolio is a useful learning tool, they also felt that portfolio writing was very stressful and that guidance for portfolio writing was missing. Chirema [21] examined levels of reflection in a case study on the usefulness of paper-based journal writing in further education settings of nurses. In a first round, the journal content was searched for elements of reflection following Boud et al. [11] e.g. attending to feelings, association, integration, validation, appropriation, outcome of reflection. Afterwards the students were divided in "non-reflectors", "reflectors" and "critical reflectors" based on the theories of Mezirow [110, 111]. Interviews point out that identifying textual elements according the levels of Boud et al. (ibid) was more difficult and less reliable than assigning the students to one of the three categories of Mezirow (ibid). Their findings reveal that reflective journal writing has the potential to support reflection and mainly positive views were expressed regarding the value of journal writing. Negative feedback mentioned the difficulty of writing and time constraints. Harris [61] used reflective journal writing also for nurses in further education. They investigated, if and how it is possible to guide reflective writing with given educational structures and methods e.g. critique, scaffolding and socratic questioning. They did not analyse the content of the reflective journals but investigated how the support with writer-responders was perceived. The results confirmed that for good reflective writing, students need *"regular, specific and sensitive critical response from their writer-responder and follow-up supportive contact"*. Van Horn and Freed [155] did a study about journaling for nursing students and they compared individual journal writing to pairs working on one journal together. While creating the pairs they matched students with high critical thinking scores with those who have lower scores to increase benefits for the pairs. To facilitate the weekly journal entries (and discussions for the pairs) they used guided questions. After a content analysis evaluating the presence of problem explanations, thoughts, plans to improve on weaknesses etc., they found that while the reflective skills of individuals remained unchanged, there was a significant increase of reflectivity in the journal entries of paired students. This emphasizes the value of collaborative reflection also in journal writing. Hashemi and Mirzaei [62] conducted a qualitative study on journal writing in a medical school with first year students. Twice a week they met in a course and were asked to reflect on a topic of their

choice and write down their thoughts. The journal entries were analysed with regard to reflection, change of attitude about writing sense of self. The results showed that reflection took place, including looking back to past experiences, suggesting new ways to handle situations including feelings. They also found out that the writing process expanded the sense of self and a confidence in their capacity to become successful journal writers.

Journal/ePortfolios/Diaries for Affective States

Lindstrom et al. [101] started with the development of the Affective Diary. This kind of diary uses data captured by a user during a day via a mobile phone to create an *"ambiguous, abstract colourful body shape"* representing body postures and arousal on a timeline. This body shape represents seven characters with different body postures representing movement and arousal during the day. Colour is used to convey emotions (red = most energy, blue = least amount on energy). Activities captured with the mobile phone e.g. like text messages, are added in order to summarize the whole activities of a day (including movement, emotions, and mobile activities). The goal of the Affective Diary was to motivate people to reflect on their whole day, but first results demand for further improvement. In Stahl et al. [146], the Affective Diary was enhanced and a study with 4 persons within 2-4 week was conducted. Their study aimed at whether the affective diary representation has the potential to trigger reflection about the own embodied experiences. During their reflection, the four participants used SMS and photos taken with their phones and put them in relation to the diary figures representing movement and arousal on a timeline. Analysis revealed different forms of reflection and some emotion based patterns. Two participants really identified themselves with the representations and used it for reflective purposes; one changed her behaviour on the gained insights, the other made sense out of the data for herself. The other two participants were struggling to use this type of diary, because they could not do anything with it for themselves.

3.4.3 Visuals for Reflection

Visuals do not only include typical sophisticated visualisations in IT-based tools, but also encompass images or videos worth being reflected on.

Tag Clouds and Smart Indicators

Glahn et al. [51, 54, 55] did a series of studies regarding tag clouds. Early trials with one person indicated that tag clouds might stimulate reflection [51]. Subsequent, they did a study to analyse different approaches on how to design tag clouds in order to better facilitate reflection [54]. They used user-based tag clouds with regard to the user's tag changes, tag development in the user's personal network and tag trends of the whole network as basis for reflection. In Glahn et al. [55] they conducted a qualitative study as follow up of [51, 54] with the goal to (a) investigate if tag-clouds can stimulate meta-cognition of learners and (b) identify design factors for reflection support. The results showed that personal tag clouds can trigger reflection on the user's tag activities and the concept of situated learning can be applied for developing tools for self-regulated learning.

Another type of scaffolds is implemented in form of smart indicators as described in [52, 53], which have also the potential to stimulate reflection. They tried to enrich learning experiences in informal and non-formal learning environments by showing effects and progress of own ongoing learning processes. After an intensive literature research, they distinguished between four groups of visual indicators: (i) embedded content indicators, including modified backgrounds, highlighting content and coloured links, (ii) 1D-graphical indicators, consisting mainly of colours encoding indicators like progress bars or counters, (iii) 2D-graphical indicators presenting relations between information like in hierarchical structures and (iv) 3D graphical indicators showing complex structures or different dimensions of information in 3D. As follow-up, Glahn et al. [56] used graphical indicators of user interaction data to engage and motivate learners to participate and contribute in an open community platform. Two different types of indicators - one for representing user's activity and the other for user's performance in relation to the average user performance - were implemented. It was shown that the participants seeing the activity indicator focussed after an initial phase more on the general functions and the usability than on the indicator. Participants seeing the performance indicator performed relatively more than the participants seeing the activity counter. Although the potential of the indicators with regard to reflective learning was not directly addressed by the investigation, participants confirmed that "playing the system" had a positive effect on reflecting about their social context and contextualised their activities to the community.

Video and Images

Leijen et al. [93] used ICT facilitation in form of video streaming to guide dance students of two classes (choreography and ballet class) through the reflection process. During their courses, students were asked to take videos, select video fragments to conduct reflection assignments together with the teacher and the researcher. The reflection assignments were motivated by some questions addressing the analysis of authentic situations, the reflection on these situations and the demonstration of acquired competences. For students in the choreographic class the video facilitation supported their thinking process, while for the ballet class the facilitation resulted in detailed and elaborated self-evaluations. Leijen et al. [92] introduced a guided reflection procedure to support experienced and inexperienced student teachers. Supporting the oral reflection resulted in more benefits for the student teachers than doing the reflection alone.

Harper et al. [60] did a study with the Microsoft SenseCam, an action cam hanging from one's neck which is periodically creating pictures throughout the day providing a record of experiences. Participants reported that the images (i) helped to discover unknown own behaviour, (ii) served as a source of creativity, and (iii) also inspired reflection about their behaviour and their daily lives. Fleck & Fitzpatrick [44] did a follow up study on SenseCam with teachers, tutors and their mentors during teaching a lecture in a classroom setting. The discussions about the screenshots were transcribed and coded according their reflection level system [45]. Having recorded images of the experiences allows users to return to the experiences more easily and reflect upon them.

Timelines

Krogstie and Divitini [88] investigated post-mortems workshops using individual and shared timelines to motivate students to reflect on their project work in a software engineering course. Each team member created first an individual timeline, and afterwards the team members created a shared timeline of their project. This timeline creation allowed all team members to return to project experiences and to reflect on them first alone and then together, which lead to new perspectives and insights. Kristiansen et al. [86] developed

a TimeLine for mobile devices with the goal reflect on capture learning and working environments presented on a timeline. The tool was evaluated in a big meeting setting where people were asked to add images, notes, as well as their mood. The results showed, that the tool itself was easy to use and that the participants like it. However scaffolding mechanisms, which motivate to use the applications were missing as well as that navigating through the timeline initiates a reflection session leading to learning.

3.4.4 Miscellaneous

Freed [47] investigated forum entries, referred to as "reflective dialogues", with regard to reflection. The students were enrolled in a leadership graduate program, had to read six predefined articles and discuss them in the forum. Although most posts written in the study remained on a descriptive level the authors noted various posts which lead to increased activity. Those posts contained questions and metaphors, which are strongly related to the concept of reflective dialogues. The study emphasizes that metaphors are a "tool" to spark reflection when used during online discussions. Prilla et al. [131] analysed a self-developed tool, called "TalkReflect", supporting peer exchange amongst nurses and caretakers in care homes to facilitate reflection. The system offered sharing of reflection content as well as specifying outcomes of collaborative reflection. Findings showed that users linked own experiences to collaborative reflection and increased chances to reach a reflective outcome in an online discussion. Sanches et al. [140] developed a tool called "Affective Health". It aims at stress detection by stimulating reflection providing two different sophisticated visualisations. The system provides a biofeedback loop providing bodily reactions in real-time and supports users to detect positive as well as negative stress patterns. In a small study, they found out that both visualisations increased bodily awareness and detected stress and stress patterns worth being reflected on. Isaacs et al. [75] developed a technology-mediated reflection tool, which was used for recording everyday activities. It presented prompts to motivate users to explicitly reflect on the recorded events and to repeatedly revisit those reflections in order to improve their individual well-being. Users who reflected benefited by *"generalizing from positive experiences and by drawing positive lessons from negative events"*. Xiao and Carrol [163] did a study with a self-developed tool, which allows students of a project management course to share and work collaboratively on

"rationales". These rationales were assigned to challenges assessment activities during project work in a virtual working space. The rationales were used for externalizing reflective thinking processes during the development of these challenges. Results included that the length of the rationale was strongly connected to the achieved depth of the reflective thinking process.

Mentis et al. [109] developed a tool for sharing experiences through bodily interaction with friends. The tool stored traces of the user experienced in an art exhibition while it played traces left of friends at the same time. The visitors perceived the tool as kind of additional "friend" accompanying them through the exhibition. The relationship experienced was more between the visitors and the tool itself than between the visitors and their friends. Reflection took place on an individual level. Allan et al. [3] developed an assessment process, for reflective essays of students enrolled to a first year writing course. For developing the assessment process, they first created a common reflective writing environment by using reflection prompts in form of reflective questions about writing and research processes. The analysis showed that during the research and writing process strong reflection statements were used to reflect on the own students research and writing process. *"Students were able to identify places of difficulty and evaluate their success by discussing their choices, strategies, or limitations."* In contrast, the analysis of the students reflection about their own learning, showed less reflection - it seemed that they did not really know how to cope with reflection about their learning.

Miscellaneous in Dementia Care and Emergency Management

Mora et al. [115] presented a mobile augmented reality tool to support reflection on crowd management. The tool consists of an augmented reality viewer, enriched with tools for synchronous and asynchronous communication, keyword and timeline based navigation, and a connection to Twitter and Pachube. Two experts evaluated the tool and confirmed its usefulness for triggering reflective learning. As challenge was mentioned that there needs to be scaffolding mechanisms that makes sure that all information relevant for the reflection session is explored. Maiden et al. [103] developed and evaluated the MIRROR Dementia App Sphere, consisting of different tools supporting reflection and creativity of carers, in several care homes in the UK. The results showed that reflective learning and creativity has high potential to improve

the work of carers for their residents, however to successfully introduce and apply such tools, the tools need to be carefully adapted and aligned to the care strategies of each individual care home. Müller et al. [119] investigated two tools, CaReflect in dementia care and WaTCHiT for preparedness for crisis management, which aimed at supporting reflective learning by using context information gathered with sensors as learning content. The results of both settings confirmed that that reflective learning took place. While carers in dementia care got deeper insights on their working patterns and on general organisational issues, rescuers in their emergency training setting got new insights on their behaviour during performing their task.

3.5 Categorization and Analysis of the Reflective Learning Tools

The given body of literature was analysed according to four different analytical dimensions to assess the value of each tool for reflection.

3.5.1 Analytical Dimension I: Reflection-in-action and Reflection-on-action

This dimension focuses on the proximity between reflection and action, meaning whether the tool is more useful in reflection-in-action and reflection-on-action. Reflection-in-action is split into "rapid reflection-in-action" and "deliberate reflection-in-action". The first describes situations in which a decision has to be taken quickly while the second describes situations in which one can take a break from the action for reflection [34]. Combining one of these two types with reflection-on-action is labelled "intertwined reflection".

Prompts

Table 3.1 presents the literature about prompts assigned to three out of four analysed dimensions, the timing of reflection, individual vs. collaborative reflection and reflection guidance. In educational settings, prompts are often

Table 3.1: Prompts and their assignment to the dimensions.
"r-i-a": reflection-in-action;
"r-o-a": reflection-on-action

Literature	**Reflection Type**				**Reflection Participants**	**Reflection Guidance**
	rapid r-i-a	deliberate r-i-a	r-o-a	inter-twined	indi.(I)/ collab. (C)	
Prompts in formal learning settings						
Davis [28]		x			I	
Davis [27]		x			I	
Van der Boom et al. [154]		x			I	x
Chen et al. [20]		x			I	x
Furberg [49]		x			I	
Hanlon and Diaz [120]		x			I	
Bannert et al. [7]				x	I	
Ifenthaler [73]		x			I	
Tabuenca et al. [149]			x		I	
Kori et al. [84]		x			I	
McNicol et al. [108]	x				I	
Verpoorten et al. [160]		x			I	
Prompts in work-related settings						
Prilla [129]			x		I / C	

used in exercises or projects, which are performed by students alone or in groups. Prompts often play the role of guiding the user through an activity (activity prompts) or to facilitate reflection ((self-) reflection prompts). In the analysed literature, most prompting approaches can be assigned to deliberate reflection-in-action, because they are shown while doing an activity mostly without time pressure. Only McNicol et al. [108] described a system in which students should record so called news flashes within 60 seconds enriched with prompts to highlight certain activity relevant aspects. These prompts support rapid reflection-in-action and act as a scaffold to structure their contributions. The approach of Tabuenca et al. [149] can be assigned to reflection-on-action as

they focussed on what students learned during one given day, whose learning phase is finished in the evening. Bannert et al. [7] used an intertwined approach; they presented several prompts directly during the learning phase and asked after the learning phase to evaluate the student's learning progress.

In workplace settings, prompts are mostly used to reflect on working situations, either directly during the work or afterwards. Prilla's approach [129] can be classified as deliberate reflection-in-action for current patients or reflection-on-action for patients who will not be taken care of by the reflecting nurse anymore.

Journals/ePortfolios/Diaries

The term "journal" will be used as synonym for ePortfolio, diary and affective diary. The terms will only be distinguish where it is of crucial relevance. Table 3.2 presents the corresponding literature about journals and their assignment to the three dimensions, the timing of reflection, individual vs. collaborative reflection and reflection guidance.

Research for reflective journal writing is mostly conducted in nursing or teacher education contexts and journal entries often focus on exercises or content taught in class. Writing a journal entry about exercises in class can be reflection-on-action since the exercise was already done. On the other hand, it can be also deliberate reflection-in-action where the action consists of a series of similar exercises throughout a semester.

From the journals used in educational settings Tang [150], and Loo and Thorpe [102] can be clearly labelled as reflection-on-action: Tang [150] used a reflection diary to facilitate and assess reflective learning for teaching purposes and to draw conclusions for practice. Loo and Thorpe [102] used journal writing to reflect on collaborative project work in a management course with the goal to improve individual and team performance. Approaches in George et al. [50], Land and Zembal-Saul [91] and Alexiou and Paraskeva [2] are assigned to intertwined reflection. In George et al. [50] students had to submit a reflection journal entry per week about exercises as well as their solution approach within that exercise. Thus the timing depends on when the journal entry was written either during conducting the exercise or afterwards. In Land and Zembal-Saul [91], deliberate reflection-in-action took

Table 3.2: Journals/ePortfolios/diaries and their assignment to the dimensions.
"d r-i-a": deliberate reflection-in-action
"r-o-a": reflection-on-action

Literature	**Reflection Type**			**Tool**	**Reflection Participants**	**Reflection Guidance**
	d r-i-a	r-o-a	inter-twined	Journal (J) / ePortfolio (eP)/ Diary (D) / Affective Diary (AD) Affective Tool (AT)	individ.(I)/ collab. (C)	
Journals/ePortfolios/Diaries in Educational Settings						
Tang [150]		x		D	I	
George [50]			x	J	I	
Loo and Thorpe [102]		x		J	C	x
Land and Zembal-Saul [91]			x	eP	I / C	x
Clarke et al. [23]	x			J	I	
Alexiou et al. [2]			x	eP	I	x
Journals/ePortfolios/Diaries in Medical Education						
Elango et al. [33]		x		eP	I	
Chirema [21]		x		J	I	
Harris [61]			x	J	I	x
Van Horn and Freed [155]			x	J	I / C	x
Hashemi and Mirzaei [62]		x		J	I	
Journals/ePortfolios/Diaries for Bodily Expressiveness						
Lindstrom et al. [101]		x		AD	I	
Stahl et al. [146]		x		AD	I	

place during the project work alone or in the project team (two students), while reflection-on-action took place after the project work in a large group

discussion. Alexiou and Paraskeva's [2] approach followed the model of Zimmerman [166]. In the forethought phase, the students had to use their ePortfolios to set a goal and to plan their work (deliberate reflection-in-action). During the performance phase, they worked on given exercises enriched with self-control and self-observation techniques (deliberate reflection-in-action). In the self-reflection phase, they reflect on the collected information and evaluated their performance (reflection-on-action). Only Clarke [23] can be categorized as deliberate reflection-in-action since the associate teachers wrote their journal during their intern-ship. The provided questions to guide reflection targeted points like what do you want to learn, indicating that teacher could still influence the action.

In medical education, Elango [33], Chirema [21], and Hashemi and Mirzaei [62] can be assigned to reflection-on-action. In all three studies, students had to report via a journal or ePortfolio on interesting cases or critical incidents they dealt with during work or nursing education and to individually reflect about their taken notes. Van Horn and Freed [155] and Harris [61] can be seen as intertwined reflection. Students had to keep a diary, which is clearly assigned to reflection-on-action, but additionally they were guided by reflective questions. These reflective questions cannot influence past actions, but might have influence on future actions.

The affective diary by Lindstrom et al. [101] and Stahl et al. [146] can be assigned to reflection-on-action. In both studies, the bodily experiences captured during a day was the purpose to reflect on and to draw conclusions out of it, afterwards.

Visuals for Reflection

Visuals, consisting of visualisations, can be implemented in learning environments showing or summarizing actions taken in the past, worth being reflected on to influence actions in the future. Recordings in form of videos or images capture past activities to better re-evaluate past situations or experiences. Table 3.3 presents the overview of research on visuals for reflection.

Both, the different types of tag clouds in Glahn et al. [51, 54, 55] as well as smart indicators described in Glahn et al. [52, 53, 56] are assigned to deliberate reflection-in-action. The tag clouds try to motivate users to reflect on personal

Table 3.3: Visuals and their assignment to the dimensions
"d r-i-a": deliberate reflection-in-action
"r-o-a": reflection-on-action

Literature	Reflection Type		Tool	Reflection Participants	Reflection Guidance
	d r-i-a	r-o-a	Tag Clouds (TC) / Smart Indicators (SI)/ Video (V) / Image (I)/ Timeline (T)	indi.(I)/ collab. (C)	
Tag Clouds and Smart Indicators					
Glahn et al. [51, 54, 55]	x		TC	I	
Glahn et al. [52, 53, 56]	x		SI	I	
Video and Audio					
Leijen et al. [93]		x	V	I/C	x
Leijen et al. [92]		x	V	I/C	x
Harper et al. [60]		x	I	I	
Fleck & Fitzpatrick [44]		x	I	C	
Timelines					
Krogstie and Divitini [88]		x	T	I/C	x
Kristiansen et al. [86]		x	T	I/C	

focus, shared interests and network trends while using the application. The smart indicators motivate to reflect on past activities and user performance. In both approaches, reflection takes place during the usage of the application in a deliberate way and can influence the current or future actions. The work of Leijen et al. [93, 92] use video recording as basis for reflection, one conducted with dance students, the other with students teachers. Harper et al. [60] and Fleck & Fitzpatrick [44] used screenshots as basis for reflection. All four approaches can be referred to as reflection-on-action because reflection

took place after the action. Krogstie and Divitini [88] and Kristiansen et al. [86] supported reflection-on-action, too. The first by reflecting on past project experiences and drawing individual and shared timelines, the second by collecting artefacts during a meeting and presenting them on a timeline afterwards.

Miscellaneous

Table 3.4 summarises the very diverse tools and approaches according three out of the four dimensions. Mentis et al. [109] developed a tool for sharing experiences and directly reflect about them, thus it is assigned to the category of rapid reflection-in-action. In this use case reflection took directly place when starting to feel the experience captured with the tool. Deliberate reflection-in-action is the approach of Freed [47], who investigates "reflective dialogues" in an online course discussion forum. The assessment process of Allan et al. [3] is assigned to deliberate reflection-in-action as well. Students have to write reflective essays on their research, writing process and learning process guided by reflective questions during writing. The approaches in Sanches et al. [140], Isaacs et al. [75], Xiao and Carol [163], and Prilla et al. [131] can be assigned to intertwined reflection. In the Affective Health tool of Sanches et al. [140] deliberate reflection-in-action takes place when reflecting on the current own stress level, and reflection-on-action when passing the stress level in review over a longer period of time. In Isaacs et al. [75] reflection took place while consciously capturing an activity, and reflection-on-action took place when reflecting on the activities afterwards. The same categorisation is given to the approach of Xiao and Carol [163], whose students had to write a rationale for each activity and a summarizing report in the end of all activities done. The notes created by nurses and caretakers in Prilla et al. [131] can alos be labelled as intertwined reflection in dependence on the time the notes were created.

The mobile augmented reality tool of Mora et al. [115] support deliberate reflection-in-action during an event e.g. concert and reflection-on-action after such an event for improving crowd management. In Maiden et al. [103] and Müller et al. [119] also both types of reflection took place, however due to the stressful job of carers, reflection-on-action took place more often than deliberate reflection-in-action.

Table 3.4: Miscellaneous tools and their assignment to the dimensions.
"r r-i-a": rapid reflection-in-action
"d r-i-a": deliberate reflection-in-action

Literature	**Reflection Type**			**Tools**	**Reflection Participants**	**Reflection Guidance**
	r r-i-a	d r-i-a	inter-twined	Affective Tool (AT)/ Well-being App (WA)/ Assessment Process (AP)/ Forum (F) / Mobile Augmented Reality (MAR)/ new-line Mirror dementia App Sphere (MDAS)/ Sensor Data (S)	indi.(I)/ collab. (C)	
Miscellaneous						
Freed [47]		x		F	I	
Sanches et al. [140]			x	AT	I	
Isaacs et al. [75]			x	WA	I	x
Xiao and Carrol [163]			x	R	C	
Mentis et al. [109]	x			AT	I	
Allan et al. [3]		x		AP	I	x
Prilla et al. [131]			x	F	I/C	
Miscellaneous in Dementia Care and Emergency Management						
Mora et al. [115]			x	MAR	I/C	
Maiden et al. [103]			x	MDAS	I/C	
Müller et al. [119]			x	S	I/C	x

3.5.2 Analytical Dimension II: Reflection Participants: Individual vs. Collaborative

In the second dimension the analysis focus on whether reflective learning took place individually or collaboratively. Most approaches and definitions e.g. [142, 11] focus on individual reflective learning. Collaborative reflective is based on individual reflection and enhances it by *"sharing individual understandings, establishing a shared understanding and construction of knowledge."* as stated by Prilla et al. [130].

Prompts

Out of 13 use cases dealing with prompting approaches for reflection, only Prilla [129] supports collaborative reflection. The remaining 12 papers support individual reflective learning.

Journals/ePortfolios/Diaries

Similar to prompts, journals mostly support individual reflection. There exist three approaches dealing with collaborative reflection [102, 91, 155] in journals: In Loo and Thorpe [102] the focus was to reflect on team performance and team work in a management course. In Land and Zembal-Saul [91] students enrolled in a university course for project management worked in pairs, thus reflected together on re-evaluating and improving their project work. Van Horn and Freed [155] directly compared individual journal writing with pairs working on one journal together.

Visuals for Reflection

The literature by Glahn on tag clouds [51, 54, 55] and smart indicators [52, 53, 56] focus on individual reflection, and the same applies to one of the two SenseCam studies done by Harper [60]. In the second SenseCam study by Fleck and Fitzpatrick [44] as well as in both approaches of Leijen et al. [93, 92] individual as well as collaborative reflection was investigated. Krogstie and Divitini [88] asked for individual as wells as collaborative reflection during

the timeline creation and also the timeline approach by Kristiansen et al. [86] supported both types of reflection depending on whether the timeline was kept private or shared with others.

Miscellaneous

All but three of the approaches have in common that they focus on individual reflective learning. Xiao and Carrol [163] work on collaborative reflection while students share and work collaboratively on "rationales". In Maiden et al. [103] individual reflection of carers took place at home, while collaborative reflection took place in team meetings at the care homes. In Prilla et al. [131] nurses and caretakers could choose between keeping entries private or sharing them with their colleagues allowing for collaborative reflection. All tools in the dementia care or emergency management sector [115, 103, 119] support individual as well as collaborative reflection.

3.5.3 Analytical Dimension III: Reflection Guidance

Prompts

Because prompts themselves should guide and facilitate reflective learning, only few approaches were enhanced with other types of guidance. In educational settings, Chen et al. [20] and van der Boom et al. [154] inform about peer support or feedback by tutors with regard to the given answers to the prompts. For all other approaches, independent of educational or workplace setting, no further guidance for reflection was reported.

Journals/ePortfolios/Diaries

Two different types to guide reflection during journal writing were detected: guidance with reflective questions and guidance by peer or writer responders. Loo and Thorpe [102], Land and Zembal-Saul [91], and Van Horn and Freed [155] used various reflective questions to guide journal writing. Harris [61] used guidance by critique, scaffolding and socratic questioning by writer responders directly responding to the journal entries, while in Alexiou

and Paraskeva [2] peers guide the reflective writing process. No others have applied additional guidance.

Visuals for Reflection

In Leijen et al. [93] the collaborative reflection session was guided by questions while in Leijen et al. [92] the three reflection sessions afterwards were planned in more detail. First selecting a relevant positive and negative incident, second reflecting on the incidents alone or with a teacher or peer guided by questions and third doing a written reflection on the incidents afterwards. Krogstie and Divitini [88] also provided guidance in form of questions to get deeper insights on the project work. For all other approaches, no explicit guidance was available.

Miscellaneous

Isaacs et al. [75] and Allan et al. [3] use guidance in form of prompts: In Isaacs et al., the prompts motivate to reflect on past activities and reflections conducted [75]. In Allan et al. [3] the prompts were tailored to reflective essay writing and ask about the writing process, research process and self-evaluation. Müller et al. [119] a kind of guidance is given in the WATCHiT application, by providing predefined steps for the reflection process. The remaining approaches did not provide any further guidance to facilitate reflection.

3.5.4 Analytical Dimension IV: Success and Results of Reflection

The fourth analytical dimension focus on the success, achieved results and gained insights with regard to reflective learning.

Prompts

The insights and results gained with prompts in educational settings were very different. Davis [28] and Ifenthaler [73] showed that the success of reflection strongly depends on the type of prompts. Activity prompts or directed prompts give more step-by-step instructions than motivate to reflect, while self-monitoring or generic prompts encourage students to reflect. Davis [27] found that generic prompts help students to produce more coherent ideas than directed prompts although overall there was no significant difference in students' performance. Chen et al. [20] and Van der Boom et al. [154] confirmed both that the guidance provided by peers and teachers significantly influenced reflection in a positive way. Kori et al. [84] stated that prompts can enhance the level of reflection and sending prompts to students via SMS as reported in Tabuenca et al. [149] lead to the gain of insights on different levels. Verpoorten et al. [160] relates a success of reflection amplifiers only as combination of the number of inserted annotations with other reflective enactments, but not on reflection amplifiers alone. Furberg [49] and McNicol et al. [108] found out that without seeing the value of reflection, students only answer prompts in order to receive a positive grade.

Journal/ePortfolio/Diaries

All case studies used in educational settings like [150, 50, 102, 2] showed evidence that reflective learning could be triggered. The topics of reflection encompass current teaching and assessment practice, better understanding of concepts, awareness of the attitude towards learning and team performance. In medical education [33, 21, 62], improvement could be achieved in communication skills, self-directed learning as well as expanding the sense of self and a confidence in their capacity. The reflection achieved with the affective diary on bodily expressiveness [101, 146] strongly depends on how appealing the bodily representation for self-identification was for the individual. From those studies with reflective questions as guidance [102, 91, 155], only Land and Zembal-Saul [91] investigated the usefulness of the provided scaffolds and showed that they were useful for articulation, reflection and revision of explanations. Loo and Thorpe [102] saw improvements with regard to team performance and team management (because this was the purpose of the

study) and Van Horn and Freed [155] saw improvements only in paired journal writing instead of individual journal writing. The results of both studies with peer support showed that reflective learning took place; in Alexiou and Paraskeva [2] with regard to enhancing self-regulated learning skills. Harris [61] clearly stated that for good reflective writing, students need *"regular, specific and sensitive critical response from their writer-responder and follow-up supportive contact"*.

Additional drawbacks for journal writing are time constraints and stressfulness of keeping it [50, 33, 21] as well as the difficulty of writing it [21]. Additionally some approaches only work, if the participants were experienced enough and understood the potential value reflective learning might have for the individual [91].

Visuals for Reflection

Glahn et al. [51, 54, 55] showed during their development of the tag clouds that they can trigger reflective learning on tag activities with regard to self-regulated learning. The smart indicators of Glahn et al. [52, 53, 56] were not directly used for reflective learning, but trying to influence the indicators lead to reflection about the users' social context and activities. The results of Leijen et al. [93] showed that reflecting on videos taken during dancing classes depend on the study of the participants. Leijen et al. [92] showed that only experienced student teachers gained valuable insights for teaching when reflecting on videos on their teaching. Furthermore, they stated that reflecting together with peers resulted in more benefits for the individual than reflecting alone. Both SenseCam studies [60, 44] confirmed, that reflecting on pictures taken during the day help to re-evaluate past experiences and inspire reflection on own behaviours. By asking students first to create individual and afterwards to create a shared timeline of a team project work, Krogstie and Divitini [88] motivated their students to return to past experiences, including the attending to feelings and to reflect on them. For the timeline in Kristiansen et al. [86] it is not clear if reflective learning really took place.

Miscellaneous

The results of Freed [47] showed that reflection took place in so-called "hot spots", posts with high activities. These posts contained questions and metaphors strongly related to reflective dialogues. Sanches et al. [140] derived three design features necessary for initiating interpretation and reflection with visualisations to for stress detection: (i) available history of prior bodily states, (ii) aliveness in the interface and (iii) fluent visual transitions between states for all variables. Isaacs et al. [75] showed that "Reflecters" on activities perceive benefits of positive experiences and draw positive lessons out of negative events. Xiao and Carrol [163] associate the length of a rational with the depth of reflective thinking. Mentis et al. [109] achieved individual reflective learning on the experience. Allan et al. [3] found out that the reflective essays contained strong reflection statements with regard to their research and writing process. However, it seemed that students did not really know how to cope with reflection about their learning. Prilla et al. [131] showed that it helps increasing chances to reach a reflective outcome in an online discussion when users add their own experiences to collaborative reflection. The augmented reality tool by Mora et al. [115] was not evaluated in a real setting yet. Maiden et al. [103] and Müller et al. [119] proved that reflective learning took place, however to be more successful, the caring strategies of care homes need to be taken into consideration in order to give carers more opportunities and time to reflect during work. Additionally both approaches confirmed [103, 119], that more experienced carers and rescuers benefited more from reflective learning than less experienced persons.

3.6 Discussion

Which tool or technology supports which timing of reflection? The literature review showed evidence, that papers using prompting often support deliberate reflection-in-action. Users are still being somehow in the action thus influencing their actions is still possible. At a first glance, it seems that all journals belong to reflection-on-action; but having a closer look at the action and their duration as well as if journal entries are guided by reflective questions led us to the conclusion that some of them can also be aligned to deliberate reflection-in-action. Videos and images are focused on reflection-on-action,

while the assignment of work in miscellaneous depends on the investigated tool. Altogether only two papers are dealing with rapid reflection-in-action, which points out a research gap which might worth being explored further. When creating a new tool for reflection, designers have to analyse the nature of the action users should reflect on. For rapid reflection-in-action prompts might help facilitating reflection, though the literature basis on this is very thin with only two studies explicitly stating time pressure. Deliberate reflection-in-action as well as reflection-on-action can be supported by prompts, journals, ePortfolios, or diaries, however the user's context, e.g. carers in care homes for dementia, needs to be carefully considered.

Which tool or technology supports which participants of reflection? Designers need to know whether individual or collaborative reflection is desired. All analysed papers show their applicability for individual reflection. There are only few papers supporting collaborative reflection, which indicates that this research area is currently under-represented in literature. This can be explained with the fact that reflective learning most often begins on an individual level, supported by the fact that reflective learning is an individual cognitive process. Only when sharing insights or thoughts in face-to-face discussions or with technological support or when doing project work in groups, collaborative reflection can be stimulated.

Which reflection guidance approaches exists and work in relation with which tool? Providing meaningful guidance during the reflection process seems to be a challenge worth paying attention to. Participants of [33, 61] explicitly mentioned that guidance for reflection was missing. Prompting approaches reported in [154, 20, 160] were very successful in combination with peer, tutor or teacher support and also [92] confirmed more benefits for guided reflection with teachers. Also journal writing guided with reflective question like in [102, 91, 155] confirmed the usefulness for reflection. The described guidance techniques often use reflective questions (or question prompts), like self-monitoring prompts vs. activity prompts or directed vs. generic prompts. These questions might be shown during the usage of a tool (e.g. in form of pop-ups) or are used during peer-to-peer meetings or group discussions. No other type of guidance could be found in literature. Although only few studies provide reflection guidance, it seems that guidance is one of the most important success criteria for reflective learning. Moreover, a combination of reflective learning tools with peer-to-peer or group discussions seem to be the most promising way for facilitating reflective learning.

Which insights or lessons learned can be derived for successfully stimulating reflective learning? All of the literature reviewed report about their successfulness with regard to reflective learning. However, some crucial challenges emerged, which need to be taken into consideration when stimulating reflective learning.

Independent of the setting, introducing reflective learning is a challenge on its own. First, there needs to be a clear benefit for participants answering the questions "What is in for me?" to make a reflective learning tool successful and beneficial for each individual [50, 149]. Second, participants need to understand the purpose of reflective learning. Otherwise, like reported in [49, 50] students would fill in prompts or journals only for getting a positive grade and prompting approaches like described in [108] will not work. Third, depending on the goal of reflection, participants need to have enough background knowledge about the topic they should reflect upon right from the beginning in order to understand and utilize the provided scaffolds [91, 103, 119].

The timing of automatically presented prompts need to be thoroughly planned to optimize learning in formal education [152] and at the workplace to not disrupt the current workflow For journal writing, which is very time consuming and stressful [50, 33, 21], it needs to be carefully considered if such an approach makes sense in fast-paced and time pressured working environments.

3.7 My Work in Relation to the Analysed Dimensions

So far, this chapter describes the current state-of-the-art with regard to reflection guidance and therefore provides the theoretical basis for this thesis. However it is worth reflecting about the own published literature and literature closely related to the defined dimensions and corresponding insights according all four dimensions.

The approaches presented in my work within this thesis are all conducted in work-related setting using different prompting approaches initiate reflective learning. Fessl et al. [42, 43] (P6, P7 (under major revision)) describe three applications evaluated in three different work-related settings on how reflection amplifiers can support reflective learning at work. While [42, 43] focus on the

used prompts, the subsequent literature reports on the associated applications. The MoodMap App [40, 136], a mood tracking application, uses reflection amplifiers to motivate call takers in a call centre to reflect on their manually stated mood points during work. The results show that reflective learning could be triggered, proven by the analysis of the inserted notes. The Medical Quiz [37, 41] (P3, P9) used an integrated form of reflection amplifiers during the quiz play to motivate nurses to reflect about work-related knowledge and to draw connections between their theoretical knowledge and practical work experience. While the reflection amplifiers presented during the quiz play were perceived more as disruptive, the willingness to reflect on the reflection questions was given more with the questions presented at the beginning and at the end of the quiz. KnowSelf [121, 122] is an application designed to support individual reflective learning on time management and self-organization of knowledge workers during work. The tool showed time-triggered reflection interventions (prompts to motivate the application usage) and event-triggered prompts to make aware of unusual user behaviour. The participants perceived the notifications sometimes as disruptive when they were working intensively on a task. On the other hand, the general reminder to reflect about the data in the application and the notification about the most used resources were positively evaluated.

Analytical Dimension I: Reflection-in-action and Reflection-on-action: The approach of Fessl et al. [37] can be classified as intertwined reflection. Depending on the quiz type prompts can be rapid reflection-in-action (answer of a prompt in the quiz-against-time), deliberate reflection-in-action (deliberate answer of a prompt in the other quiz types) and reflection-on-action (relate prompt to work situation). Prompts used in Fessl et al. [42] and Rivera [136] with regard to the mood capturing tool are added to the category deliberate reflection-in-action. These prompts occur during the action with the tool, but users have enough time to reflect and mention why they selected which mood status. The prompts used in Fessl et al. [42], Pammer [121], and Pammer et al. [122] are categorized as intertwined reflection. Prompts occurring during the application usage based directly on the actions of the user are categorized as deliberate reflection-in-action. Prompts showing up at a fixed time asking to reflect on past situations during work are referred to as reflection-on-action prompts.

Analytical Dimension II: Reflection Participants: Individual vs. Collaborative: All presented prompting approaches in this work focus on individual reflective

learning, as this is the focus of this thesis.

Analytical Dimension III: Reflection Guidance: Because prompts themselves should guide and facilitate reflective learning, none of these approaches were enhanced with other types of guidance.

Analytical Dimension IV: Success and Results of Reflection: Fessl et al. [40, 37, 42], Rivera-Pelayo [136, 137] and Pammer [121, 122] showed that prompts are able to induce reflective learning on own and other's mood, new gained knowledge in relation to practical experiences and with regard to time management. What emerges in all work-related settings is that especially the timing, when to present the prompts, need to be carefully considered in order to not disturb the user's current work-flow.

3.8 Conclusion

The conducted literature review focussed on tools supporting and guiding reflective learning. Altogether 48 research papers from educational as well as work-related settings were divided into reflective learning approaches and tools including prompts, reflective journals/ePortfolios/Diaries, visuals and miscellaneous and analysed according four dimensions. The analysis was used to derive new insight, guidelines and recommendations for guiding reflective learning. It emerged that reflective learning tools enriched with guidance by reflective questions in form of prompts and additionally in relation with peer-to-peer or group discussions seem to be the most promising way to achieve reflective learning. While in educational settings, guidance in form of prompts is well investigated; in work-related settings the correct timing is still an open issue in order to avoid disruptions in ongoing work processes. Furthermore, two areas were identified which are currently under-represented in literature and still needs further investigation: support for rapid reflection-in-action as well as tools supporting collaborative reflection, both independent of the setting.

With regard to this thesis and especially RQ1, the following key challenges for providing meaningful technological support for guiding reflective learning during work can be derived out of this literature review:

Following Schön [142], it has to be very well considered which tool to use for which type of reflection. "Reflection-in-action" support can be provided by tools, which ask during an activity or task for reflection, while "reflection-on-action" tools ask for input after the action is over. As there exists a number of different tools supporting both types of reflection, it strongly depends on the working environment and activity, which tool to choose.

Prompts or reflection amplifiers are powerful tools to guide reflective learning and are well investigated in learning environments. The success of prompts in learning environments benefit from the fact that activities and tasks of the learners are known beforehand and that the prompts can easily be adapted according to these activities. In contrast, in work-related settings the tasks are not always known beforehand or only vaguely known. Therefore, it is rather difficult to present a prompt supporting the worker's working task.

Diaries, journals and ePortfolios have in common that they are very time-consuming in being kept and maintained, but especially for educational settings, they serve as powerful learning tools. In contrast, most workplaces are very stressful and work-intensive, thus the introduction of an additional tool like a journal or diary can increase the already existing workload of the individual knowledge worker. Therefore, it has to be very well considered, if and how time consuming approaches like diaries or journals can be applied in work-related settings.

Visuals are very well investigated in learning environments with regard to the individual learning progress or learning activities in learning environments. In contrast, in work-related settings, visuals a rarely used to motivate knowledge workers to reflect on working tasks. This can be explained with the fact that knowledge workers are afraid of being monitored how they perform their work. Thus it is a challenge to track working activities (e.g. application and resources usage during work), other work related data (e.g. who talks with whom) or personal data (e.g. health data like pulse or heart rate), which might be worth being reflected on.

4 Research Methodology

This chapter will present the underlying research methodology, including the research procedure, the conducted field studies, the developed applications and the scientific contributions of this thesis.

4.1 Introducing the Design Science Research Cycle

The design science research cycle (depicted in Figure 4.1), based on Hevner et al. [69, 67, 68], is used as underlying model for presenting the research methods and tools used for this thesis. This cycle splits the design science in information systems into three closely connected cycles relevant for information system research projects in general. This design science research cycle presents the close connection of three individual activity cycles combining the requirements of future application environments (Relevance Cycle) with the knowledge base of scientific foundations (Rigor Cycle) and the iterative design and evaluation of design artefacts or tools (Design Cycle).

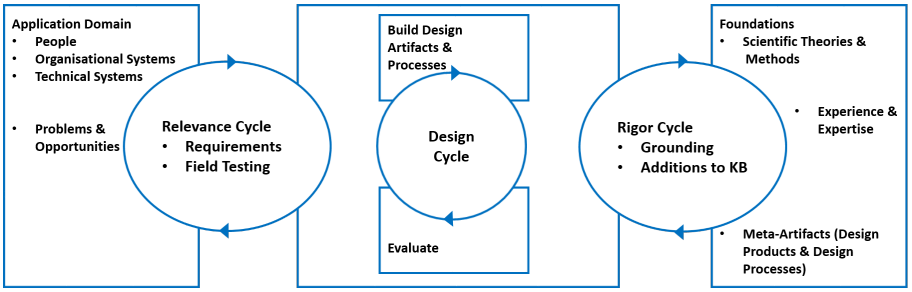


Figure 4.1: Design science research cycle by Hevner and Chatterjee [68]

The *Relevance Cycle* introduces the application environment including a specific goal to improve the environment with new and innovative artefacts and corresponding processes. This environment encompasses not only people, organisational and technical systems, but also problems and opportunities for improvement. The artefacts will be tested within the environment and the results will be fed back to determine if an iteration of the relevance cycle is needed e.g. change the requirements, improvement of the functionalities of the artefacts.

The *Rigor Cycle* associates the vast knowledge base of research to ensure the planned innovation. This knowledge base consists of the current state-of-the-art research (including experiences and expertise) as well as existing artefacts and processes both available for the application domain. The task of the researcher is twofold: on the one hand she has to select appropriate theories and methods for constructing and evaluating innovative artefacts. On the other hand she has to contribute to the research knowledge base in order to sell the research to an academic audience as well as to attract other practitioner audiences, and not only the original application environment.

The *Design Cycle* is the core of any design science research project. It cycles between the artefact development, its evaluation, followed by refinements based on received feedback. At all times, the input from both other cycles needs to be considered and the balance between development and evaluation maintained. The artefact needs to be thoroughly tested in laboratory or experimental settings before the field test takes place. This scientific evaluation is the most essential part, because these gained results and insights contribute significant to the relevance and the rigor cycle.

By presenting the conducted research along the design science research cycle, this method will show how the in-app reflection guidance was developed over time. This method is used to present the iterative development process of the individual reflective learning tools and when and how the in-app reflection guidance was applied. Furthermore, it will reveal the relevance of the in-app reflection guidance for workplace learning and its relevance with regard to reflective learning.

4.1.1 Research Methods and Tools

For the research conducted within this thesis, a set of different strategies, methods and tools was used. Qualitative research methods, like focus groups, design workshops (or studies), group discussions, interviews, participation and observation were used, to get an understanding of underlying work processes, opportunities for improvement, opinions and motivations. The tools used for this thesis are described in more detail in Knipfer et al. [82].

The following qualitative research methods were used in this thesis:

- *Focus Group*: Focus groups [117] are moderated group discussions, in which researchers bring a focus via different impulses into a group. The goal of a focus group is to narrow down existing ideas and to concentrate on one possible solution applicable for the corresponding work-related setting.
- *Design Workshops*: Design workshops based on participatory design approaches [79] are used to discuss with end-users the design and features of a tool or application, after an initial trial has taken place. The goal of a design study is the improvement of the discussed application with regard to the user interface and features.
- *Workshops*: Depending on the setting, workshops were conducted after some evaluations in order to discuss in small participant groups the perceived insights, experiences, or possible improvements as well as upcoming barriers and shortcomings.
- *Interviews*: Interviews [82], face-to-face and telephone interviews, were conducted after some evaluations to get further and deeper individual insights regarding the user's experiences with an application.
- *Formative Field Study*: The main goal of formative field studies [35] is to improve an application. An application is tested by a small number of users and their feedback is used to drive the next software development iteration. The focus of the improvements is put on the user interface and the functionality.
- *Summative Field Study*: Summative field studies [82, 35] are used when the application and the usage method have reached a good maturity. The summative field studies allow to assess relevant indicators for reflective learning and their impact for individuals and teams, as well as the organisation as a whole. In order to achieve this, the conducted

evaluations need to have a continuous app-support for several weeks. Furthermore, these field studies try to achieve reflective learning on all four levels of the model of Kirkpatrick [81]. The levels consist of: level 1: Reaction, level 2: Learning, level 3: Behaviour and level 4: Results (more details see Section 6.2)

Quantitative research methods like questionnaires or the analysis of log data were used to quantify usage, opinions, attitudes, user behaviour. Classical statistics were used to present the corresponding results. For the questionnaires a set of core questions were used, which are applicable to all conducted evaluations and therefore allow comparisons across different applications and/or work-related settings. These questionnaires cover general topics like IT-attitudes, barriers for application usage, general application effects, behavioural intentions as well as questions on reflective learning encompassing application specific reflection questions or a short-reflection scale. These core questions can be found in Knipfer et al. [82].

4.2 Three Individual Reflective Learning Applications

Before describing the research procedure and the corresponding research activities, it is of crucial relevance to present the three corresponding applications, which were relevant for the development and application of the reflection guidance concept and its evaluation. All of these applications are based on the Computer Supported Reflective Learning Model (CSRL Model) by Krogstie et al. [89] to support the process of work-related reflective learning (see Section 2.2).

4.2.1 MoodMap App

The **MoodMap App** (V3.0) [40, 136] is a web application that maps mood on a coloured map along the two dimensions of Russell's Circumplex Model of Affect [139]: valence (feeling good - feeling bad) and arousal (high energy - low energy). Thus, the mood is captured by clicking on a bi-dimensional mood map coloured according to Itten's system [76] (see Figure 4.2). Mood

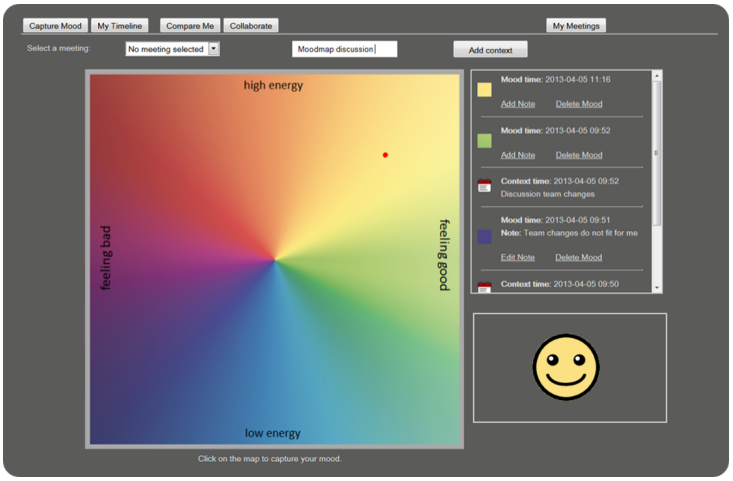


Figure 4.2: The MoodMap App

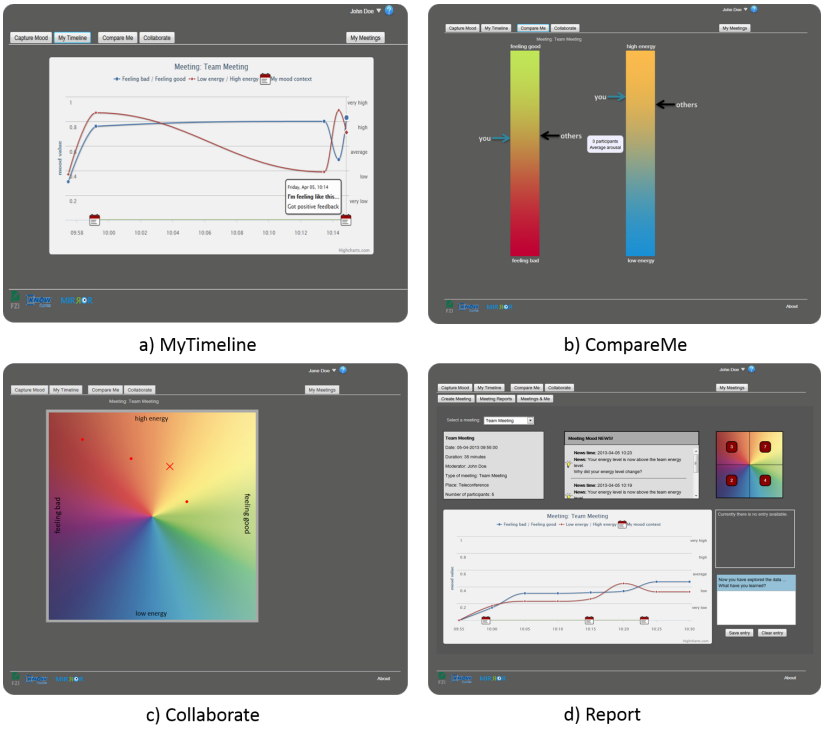
- positive as well as negative as mentioned by Boud et al. [11] - can serve as starting point for reflection focussing on work-related issues, which have impacted on individual's mood and daily work.

Various implemented visualisations like the own mood development over time (see Figure 4.3, a), own mood in comparison to average team mood (see Figure 4.3, b), or average team mood (see Figure 4.3, c) present the captured moods on an individual as well as collaborative level to provide different perspectives about the data and to trigger reflective learning about the mood development.

Furthermore, two reports are implemented, which summarize the mood development during a day or meeting from different perspectives (see Figure 4.3, d). Additionally, for superiors a TeamView is implemented, which gives more detailed information about the mood development of each team member.

A detailed description of all visualisations and features implemented within the MoodMap App can be found in Appendix 9.1).

Learning Goal: Mood self-tracking and reflection on own as well as the team's mood can lead to insights of how mood influences the work with regard to



a) MyTimeline b) CompareMe

c) Collaborate d) Report

Figure 4.3: The visualisations and report of the MoodMap App

work performance and collaboration within a team.

Relation to CSRL Model: Considering the single phases of the Computer Supported Reflective Learning model, the MoodMap App supports the following reflection cycle: Capturing one's own mood, positive as well as negative ones, during work ("Plan and do work") can be used for reconstructing and reflecting on experiences from work. Reflection can be either initiated by asking users to add a compulsory context and note to each inserted mood point or by exploring and analysing the different visualisations and data reports ("Initiate reflection"). The application supports the re-evaluation passively, relying on a data-explorative approach by the user, by providing different

visualisations and a reflection journal to keep track of the users insights and reflection outcomes ("Conduct a reflection session"). When reflecting again on the individual mood, the mood development over time or the journal entries, users can check whether they were able to improve their work and emotional state ("Apply reflection outcome").

4.2.2 Medical Quiz

The **Medical Quiz** (V2.0) is a web-based quiz especially developed for nurses working at a Stroke Unit in German hospitals (see Figure 4.4).

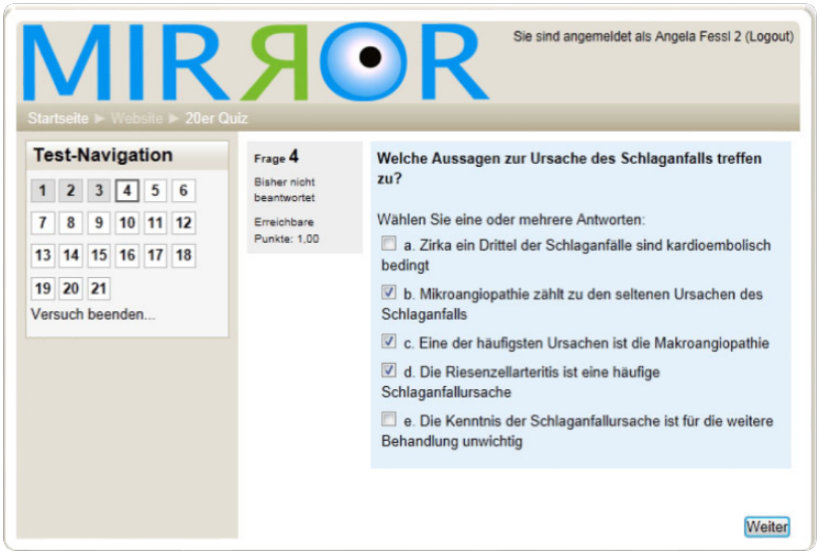


Figure 4.4: The Medical Quiz

Four different quiz types were implemented: A Quiz-against-time (answer as many questions as possible in 5 minutes), the Quiz-of-20 (answer twenty questions), the Quiz-of-10 (answer 10 questions) and the Quiz-of-5 (answer 5 questions). The content-based questions, randomly chosen out of a database, are multiple-choice or single-choice questions, which provide users the possibility to check out their current knowledge status. All content-based questions

were developed by nurses and physicians working at the German Stroke Unit.

A detailed description of the quiz can be found in Appendix 9.2.

Learning Goal: The quiz helps users to refresh existing or acquire new knowledge. Reflection components should motivate users to connect theory with practice.

Relation to MIRROR CSRL Model: Considering the single phases of the CSRL model, the quiz supports the following two types of reflection cycles:

Cycle triggered by content-based questions: While playing the quiz ("Plan and do work"), the nurse can become aware of individual knowledge gaps or needs ("Initiate reflection"). After playing the quiz, she might find out in more detail, by having a look at the quiz results, which knowledge is missing and where she has to deepen her knowledge ("Conduct reflection session"). After having deepened the missing knowledge, she might play the quiz again and reflect about here learning progress. This can be directly checked within the quiz results. Whether the new insights or knowledge gained by playing the quizzes were applied during work, cannot be supported or checked by the application itself. (Missing: "Apply outcomes").

Cycle triggered by reflection questions: While playing the quiz ("Plan and do work") reflection questions are presented, with the goal to directly trigger reflection ("Initiate reflection"). Depending on the type of the reflection question (at the beginning, during or at the end of a quiz play), a reflection session might be conducted to, for example, reflect about individual learning progress or relate working experiences to the content of the quiz ("Conduct a reflection session"). Insights and outcomes can be directly inserted into the quiz by answering these questions during the quiz play. Whether the users actually apply their gained insights or outcomes during work cannot be checked by the quiz itself. (Missing: "Apply outcomes").

4.2.3 KnowSelf

The author of this thesis was not involved in the development of the KnowSelf application itself but involved in the implementation of the reflection guidance concept and its corresponding evaluations.

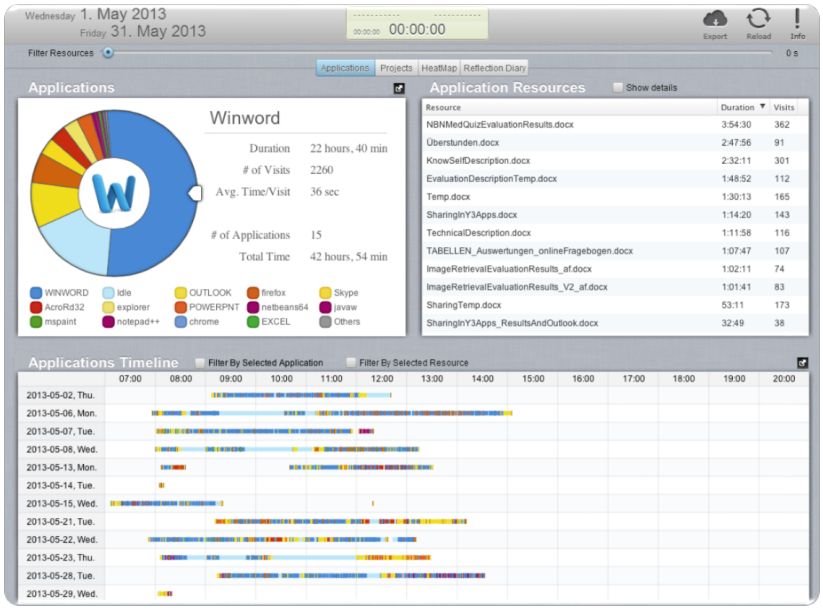


Figure 4.5: KnowSelf

KnowSelf (V1.2) is designed to support individual reflective learning regarding time management and self-organisation of knowledge workers during work (see Figure 5.4). The application automatically records working activities on a personal computer by capturing resources and applications used during work. Manual project and task recording, as well as manually inserted notes and comments complete the data captured by KnowSelf. The application visualizations expose, in particular, the frequency of application and resource switching, the time spent in numerous applications and the time spent on different activities.

A detailed description of all KnowSelf including its visualisations and features can be found in Appendix 9.3.

Learning Goal: KnowSelf is designed to support individual reflective learning regarding time management and self-organisation of knowledge workers.

Relation to MIRROR CSRL Model: The KnowSelf App can be related to

all four phases of the CSRL Model. The app records all working activities a user is doing during work. This captured data enable users to consequently reconstruct the user's individual work time and review of her work and learning history ("Plan and do work"). The user can set herself objectives or goals with regard to her time management or self-organisation. The app helps to track this objectives in that it enables gaining insights regarding personal time management and actual recorded activities ("Initiate reflection"). Subsequently, the user uses the data captured with KnowSelf and reflects on the data having in mind the goals she set herself. By selecting different working days and comparing them with each other, it is possible to compare similar work experiences and situations ("Conduct reflection session"). All insights gained can be inserted into the Reflection Diary and serve as a basis for planning the future changes. Based on the reflection outcomes from the previous phase the user decides, whether some changes in the work life should be implemented and in what way. Again, Reflection Diary can be used to set goals for behavioural changes which can be reviewed at a later point and all goals checked as soon as they have been accomplished ("Apply outcome").

4.3 Research Procedure

Figure 4.6 depicts an overview of the conducted research procedure.

The research procedure started with the development of the MoodMap App, which provides the possibility to easily state ones own mood. After the iterative development of the application and after the second out of six field studies of the MoodMap App, the first reflection guidance concept emerged. This concept was generalized and subsequently applied in the MoodMap App as well as in the Medical Quiz and the KnowSelf Application.

Furthermore the MIRROR User Profile App (MUP) was developed in order to find out if a combination of mood data with activity data can have additional value for initiating reflective learning. This approach was not further pursuit as the focus was put mainly on the reflection guidance concept.

After the successful implementation, application and evaluation of the reflection guidance concept in three different applications and corresponding work-related settings, it was possible to abstract this concept and to develop

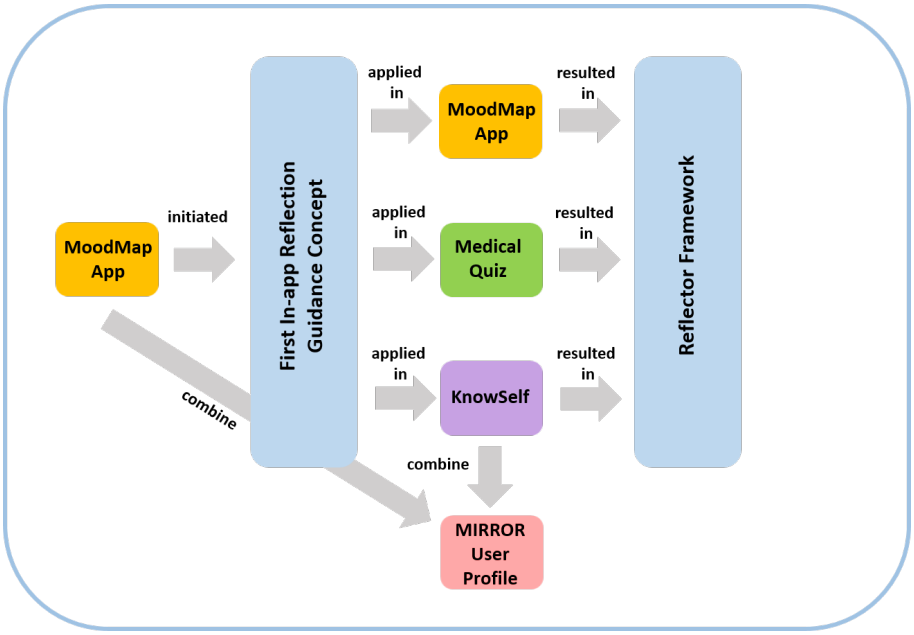


Figure 4.6: The Research Procedure

the 'Reflector' framework, a general applicable reflection guidance framework. This framework can be seen as a kind of technical summary of the insights gained from the implemented and evaluated reflection guidance concept.

4.4 Research Activities Overview

This section will give an overview of all research activities conducted for writing this thesis. All activities presented contribute more or less to the development and evaluation of the in-app reflection guidance concept.

Altogether one design study, one focus group, five formative and six summative studies have been conducted. These studies can be divided into three strands, two major strands and a minor strand:

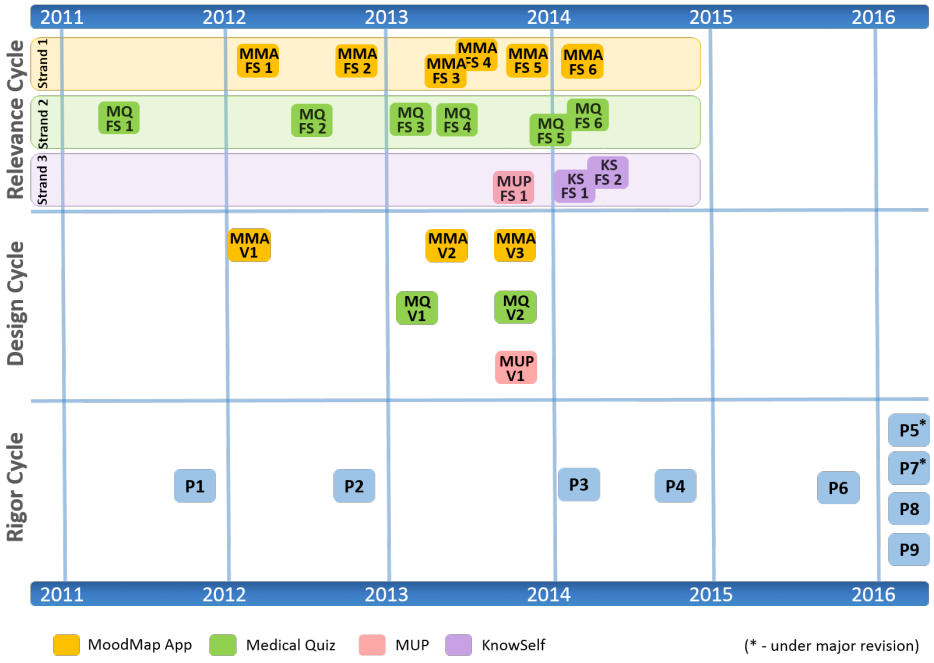


Figure 4.7: Overview of all research activities of this thesis

- Strand 1: this strand (encompassing six field studies) focus on mood and how individual reflection on own mood can influence work performance and collaboration within a team in different settings.
- Strand 2: this strand (encompassing also six field studies) points at playful learning, on the one hand to refresh existing knowledge and gain new knowledge, on the other hand to connect this theoretical knowledge with working practices and to reflect about it.
- Strand 3: it consists of two parts: The first part (2 field studies - not conducted by the author) focus on individual reflective learning regarding time management and self-organisation of knowledge workers. The second part (1 field study) combines mood tracking with time management and self-organisation.

All conducted studies per application are built up on each other. All of them contributed step-by-step to the development and evaluation of the reflection guidance concept by taking into account the insights gained. Specifically the last 4 summative field studies and the corresponding three publications (P6, P7 (under major revision), P8) have led to the most relevant contribution with regard to this thesis.

The next sections will give more detailed information about the three strands including the conducted studies, the cyclic prototype development and how they contribute to the development of reflection guidance concept.

4.4.1 Relevance Cycle: Field Studies

Strand 1: MoodMap App Field Studies

All MoodMap App field studies were conducted in close cooperation with Forschungszentrum Informatik (FZI). Five field studies out of six, were conducted at British Telecom (BT), a large telecommunications company in Great Britain (see Appendix B 10.2.1). The sixth field study was conducted at an Italian IT Company (see Appendix B 10.3.1).

For the MoodMap App one design study, three formative field studies and two summative evaluations were conducted as presented in Table 4.1. The goal was to explore how mood self-tracking and reflection on own as well as the team's mood can lead to insights on how mood influences the work with regard to work performance and collaboration within a team in different settings.

The initial field study in form of a formative evaluation (MMA FS1, see Table 4.1) took place at BT Flexible Working Services (FWS) department. The MoodMap App was evaluated within virtual weekly team meetings with regard to the user's interest in mood capturing, the usability and features of the application and the perceived benefits. The first gained insights showed that people's interest in mood tracking and sharing range from very interested to not being able to deal with such an application, furthermore, no clear benefit was directly perceived. However the app's potential for reflective learning was confirmed especially with regard to the two implemented collaborative views. The conducted study and results were reported in P2 [40].

Table 4.1: Field studies conducted for the MoodMap App

ID	Type	Setting	Version	Participants	Date/ Duration
MMA FS1	Formative	BT - FWS*	1.0	12 product manager and consultants	13 Feb. 2012 - 12 March 2012
MMA FS2	Design	BT - FWS*	1.0	two researchers, two project members, the quality manager, and six end users	15 Oct 2012
MMA FS3	Formative	BT - FWS*	2.0	13 product managers and consultants	24 Mai 2013 - 24 Aug. 2013
MMA FS4	Formative	Call Centre: BT Dundee	2.0	2 managers, 10 coaches, 10 call-takers	13 June 2013 - 16 Aug. 2013
MMA FS5	Summative	Call Centre: BT Dundee, BT Alness	3.0	4 managers, 2 coaches, 65 call takers	20 Nov. 2013 - 20 Dec. 2013
MMA FS6	Summative	Regola	3.0	35 employees from 5 departments	12 Feb. 2014 - 31 March 2014

* FWS - Flexible Working Group Services

Subsequent, a design workshop (MMA FS2, see Table 4.1) was conducted within the same setting and the same participants of the first field study. The results of this design study contributed significantly to the development of the reflection guidance concept. For the first time of the relevance cycle, major design components were named - reflection interventions, reflection amplifiers as well as contextualisation, reports and journals - and divided into "reflection-in-action" and "reflection-on-action" design components.

The next two formative field studies (MMA FS3, MMA FS4, see Table 4.1) were conducted in BT FWS again and in a call centre of BT. In the BT FWS setting, the results were rather disappointing, because the participants were not motivated to use the application. As reasons were named no perceived benefit and distraction from the meeting as well as difficulties in the department as a whole. In contrast, the formative evaluation at two call center teams in one call center led to further improvements on the application itself as well as for the reflection guidance concept. These results included the integration of the application in the call center's internal system (which was planned but could not be realized), close relation between mood data and working processes

referring to the guidance concept (contextualisation) as well as further team visualisations.

The two summative field studies (MMA FS5, MMA FS6, see Table 4.1), the first conducted at two BT call centers, the second conducted in a whole Italian IT company, led to deeper insights on individual reflective learning on mood with regard to work performance and collaboration within teams. Furthermore, deeper insights were gained with regard to the implemented reflection guidance concept, its usefulness and it application. These field studies contributed to the publications P6 [42] and P7 [43] (under major revision).

Strand 2: Medical Quiz Field Studies

All field studies were conducted at the Neurologische Klinic Bad Neustadt (NBN), Germany. A description about the clinic can be found in Appendix B 10.4.1.

The development of the Medical Quiz started with a focus group, followed by a design study, before two formative and two summative field studies were conducted as presented in Table 4.2. The goal of the quiz is not only to provide an easy to use possibility to refresh existing knowledge or to gain new knowledge, but also to connect theoretical knowledge with working practices and to reflect about it.

The focus group (MQ FS1, see Table 4.2) was conducted to get a first impression of which technology might potentially fit at a Stroke Unit to support reflective learning at work. Four different triggers (photos or videos, physiological data, mood and games) were provided and discussed together with nurses, before a medical quiz emerged as most promising approach.

Based on the results of the focus group, it was decided to further develop the idea of a quiz within a design workshop (QF2, see Table 4.2). From an organisational point of view, the objective of the design workshop was to investigate, how such a quiz could be embedded in working or learning routines within the stroke unit. From a technical point of view, the objective of the design workshop was to derive the functionality and design of a graphical user interface for the quiz application.

Table 4.2: Field studies conducted for the Medical Quiz

ID	Type	Setting	Version	Participants	Date/ Duration
MQ FS1	Focus Group	NBN	-	4 stroke nurses	13 April 2011
MQ FS2	Design Study	NBN	-	the NBN project leader, the qualification programm leader, a project coordinator of a telemedicine project, 2 researchers	2 Aug. 2012
MQ FS3	Formative	NBN: Qualification Program	1.0	19 nurses	31 March 2013
MQ FS4	Formative	NBN: Stroke Unit	1.0	8 nurses	May - June 2013
MQ FS5	Summative	NBN: Qualification Program	2.0	21 nurses	October 2013 - January 2014
MQ FS6	Summative	NBN: Stroke Unit	2.0	3 nurses	February - March 2014

Two formative field studies (MQ FS3, MQ FS4, see Table 4.2) of the quiz were conducted in two settings: in the context of the qualification programme called "Special Care at Stroke Units" and at the Stroke Unit itself. In both settings reflective questions were integrated into the quiz during the quiz play, and the positive results confirmed their usefulness for relating the content of the quiz questions with practical work experiences as reported in P3 [37].

One year later, two summative field studies (MQ FS5, MQ FS6, see Table 4.2) were conducted, again in the context of the qualification programme called "Special Care at Stroke Units" and at the Stroke Unit. The results gave evidence that asking reflective questions at the right time can trigger reflective learning and thus contributed crucial to the developed reflection guidance concept. P9 reports on detailed insights on presenting reflective questions at different points in time([41] accepted as poster at the EC-TEL).

Strand 3: Mixed Field Studies

Table 4.3 presents three further field studies conducted.

Table 4.3: Mixed Field Studies: 2 KnowSelf studies, 1 Combined Study

ID	Type	Setting	Version	Participants	Date/ Duration
KS FS1	Summative	Infoman	KS 1.2	12 consultants	16 Jan. 2014 - beginning of March 2014
KS FS2	Summative	IMC	KS 1.2	10 participants	January 2014 - March 2014
MUP FS1	Formative	KC	MUP 1.0	6 participants	2 Oct. 2013 - 15 Oct. 2013

KnowSelf is designed to support individual reflective learning regarding time management and self-organisation of knowledge workers. The KnowSelf application was not developed within the scope of this theses, however, in two summative field studies (KS FS1, KS FS2, see Table 4.3) parts of the developed reflection guidance concept were implemented within the app and evaluated. These studies let to insights with regard to event-triggered and time-triggered prompts as well as the usage of the reflection diary within two different IT company domains.

Another field trial (MUP FS1, see Table 4.3) in form of a technical feasibility study was conducted on the MIRROR User Profile App, presenting combined data, in our case mood data (captured with the MoodMap App) together with work activity data (captured with KnowSelf). The goal was to find out if combined data has further potential to trigger reflective learning and might be a valuable research strand to follow for reflection (P4, [38]). However, this study and its results did not explicitly contribute to the developed reflection guidance concept.

Contributions of the Three Strands

All three strands together provided deep insights with regard to individual reflective learning. Investigating especially the results of all summative evaluations with regard to technological guidance for promoting reflective learning contributed mainly to the success of the developed reflection guidance concept. These conducted field studies and the gained insights led to two relevant

publications, P6 [42] and P7 [43] (under major revision), and the scientific contribution will be presented in the next chapter 5 as core of this thesis.

A detailed description of the four relevant summative field studies can be found in Appendix B 10.

4.4.2 Design Cycle

Table 4.4 presents an overview of the five conducted design cycles, three for the MoodMap App, two for the Medical Quiz and one for the MIRROR User Profile App (MUP). After each prototype release (MMA V1, MMA V2, MQ V1, MUP V1) formative field studies followed, while for the final prototypes (MMA V3, MQ V2) summative field studies were conducted.

MoodMap App

After the first formative evaluation (MMA FS1) of the MoodMap App (MMA V1), a design workshop (MMA FS2) was conducted in the same setting, through which major improvements for the application emerged. These improvements included beside feature requests also deeper insights with regard to reflection guidance and how these guidance can be technologically provided. The upcoming ideas included prompts, contextualisation as well as diaries and were implemented in the second Moodmap App prototype (MMA V2). Two formative evaluations (MMA FS3, MMA FS4) followed, one in the BT FWS and one at the BT Call Center in Dundee. The evaluation at BT FWS brought no further insights or requirements for improving the MoodMap App. In contrast, the results of the call center setting unfold further features necessery to be implemented as prerequisites for the summative evaluation in two call-centers (MMA FS5). These features encompassed mandatory context options tailored to the call centers' working processes, three team views especially designed for superiors and a user administration. All requirements were implemented in the last prototype of the MoodMap App (MMA V3). This prototype was also used for the summative fiels at the IT Company Regola (MMA FS6), but instead of the mandatory contextualisation general prompts were used. A detailed description of the MoodMap App V3.0 can be found in Appendix A 9.1.

Table 4.4: Prototypes of MoodMap App, Medical Quiz and MUP

Tool	ID	Version	Release Date	Functionality
MoodMap App	MMA V1	1.0	January 2012	Mood capturing, Moodlist, Timeline View (Individ.), CompareMe View (Collab.), Collaborate View (Collab.), Simple MoodMap Meetings
	MMA V2	2.0	June 2013	Reflection Interventions and Reflection Amplifiers (Prompts), Mood Contextualisation, Improved Timeline View (Individ.), Meeting Creation, 2 Meeting Reports with Diary, Email Notification
	MMA V3	3.0	November 2013	Mandatory Contextualisation, User Administration, Three Team Views
Medical Quiz	MQ V1	1.0	31 Jan. 2013	Quiz-of-20, Quiz against time, In-between Reflective Questions (Prompts)
	MQ V2	2.0	October 2013	Quiz-of-10, Quiz-of-5, Reflective Questions at the beginning, Reflective Questions at the end
MUP	MUP V1	1.0	October 2013	Visualizing data from different apps, Different chart types (e.g. line chart, timeline chart), Filtering, Grouping and Mapping of Data

Medical Quiz

For the quiz, the development started with a focus group followed by a design workshop, before a first version of the quiz (MQ V1) was released. The results of the two formative field studies within a qualification programme called "Special Care at Stroke Units" (MQ FS3) and at the Stroke Unit (MQ FS4) both at the Neurologische Clinic Bad Neustadt (NBN), gave further insights on how to improve the application with regard to reflective learning. Two further quiz types were implemented, more questions were developed and

most important for the reflection guidance concept, reflective questions were not only presented during the quiz play but also at the beginning and at the end of the quiz. The second protoype (MQ V2) was again evaluated within the qualification program (MQ FS5) and at the Stroke Unit(MQ FS6). A detailed description of the Medical Quiz V2.0 can be found in Appendix A 9.2.

MIRROR User Profile App

For the MIRROR User Profile App one prototype was developed and a technical feasibility study was conducted. This application uses data captured by other applications and present this data in an overlapping view using different types of visualisations. A second prototype was subsequently developed, but the results did not contribute to this thesis, thus it will not be mentioned here.

4.4.3 Rigor Cycle

The following research papers comprise the scientific contribution of this thesis in relation to the corresponding research questions:

- RQ1: What are the key challenges in order to provide meaningful technological support for guiding reflective learning at work?
- RQ2: Which technologies are most suitable for providing reflection guidance in order to trigger reflective learning?
- RQ3: What are the core components and architecture for a general applicable reflection guidance framework?

Table 4.5[1] gives an overview of them in relation to the conducted field studies and their contribution to the research questions.

[1] Abbreviations: MQ FS: Medical Quiz field study; MMA FS: MoodMap App field study; KS FS: KnowSelf field study; MUP FS: User profile field study

Table 4.5: Scientific Contributions

ID	Ref.	Year	Field Study	Contribution to Research Questions
P1	Fessl et al. [39]	2011	MQ FS1	RQ1, RQ2
P2	Fessl et al. [40]	2012	MMA FS1	RQ2, RQ3
P3	Fessl et al. [37]	2014	MQ FS3, MQ FS4	RQ2, RQ3
P4	Fessl et al. [38]	2014	MUP FS1	RQ2
P5	Rivera et al. [137]	(maj. revision)	MMA FS4, MMA FS5	RQ2, RQ3
P6	Fessl et al. [42]	2015	MMA FS5, MQ FS5, KS FS1	RQ2, RQ3
P7	Fessl et al. [43]	(maj. revision)	MMA FS5, MMA FS6, MQ FS5, KS FS1	RQ2, RQ3
P8	Fessl et al. [36]	2016	Lit. Review	RQ1
P9	Fessl et al. [41]	2016	MQ FS5	RQ2, RQ3

5 The In-App Reflection Guidance Concept

5.1 Introduction

This chapter presents the in-app reflection guidance concept that conceptualises reflection guidance as adaptive software components [42]. I see this concept as a promising instructional strategy, as these components aim at triggering reflective learning. At the workplace, such components should draw the workers' attention to their own thoughts and experiences, and motivate them to understand and reflect on their daily working tasks. I instantiated the components of the concept in three different applications: 1) MoodMap App, an application for capturing and tracking individual mood to show how mood influences the individual work-life or teams at work, 2) Medical Quiz, a quiz enriched with reflective questions to support learning in an educational work-related setting, and 3) and KnowSelf, an application to support individual reflective learning regarding time management and self-organisation of knowledge workers.

5.2 Synthesis from the Literature Review

A detailed literature review on tools and technologies supporting reflective learning was already presented in Chapter 3. For presenting the developed reflection guidance concept, I will recapitalize and synthesize shortly the tools and techniques relevant for the concept.

Technologically supported scaffolding types to trigger reflective learning in form of prompts or reflection amplifiers are of major interest in the area of self-regulated learning and extensively investigated within learning management systems (see Section 3.4.1). In such settings, prompts are used very often to organise, retrieve, monitor or evaluate knowledge as well as to reflect on students' learning [7, 74, 80, 164]. In work-related settings, there is only little research on the usage of prompts [129, 10, 10, 90].

Other tools and techniques to trigger reflective learning are diaries, reflective journals and ePortfolios [26, 58, 33, 125] (see Section 3.4.2). Diaries are personal notes not meant to be shared, journals are mostly used to describe diaries that are intended for sharing and ePortfolios are mostly defined as a collection of information and (physical) artefacts, gathered for specific purposes by a user over time [2] especially in educational [33] and only rarely in work-related settings [58].

Visuals, including sophisticated data visualisations in applications as well as images or videos, are seen as good approach to trigger reflective learning (see Section 3.4.3). These visuals are not restricted to a different type of topic or content, in contrast there exists manifold visualisations differing in form, topic, presentation used to trigger reflective learning. For example smart indicators [52, 53, 56], tag clouds [51, 54, 55], timelines [88, 86] were used just like videos and images [92, 60, 44].

Summarizing the investigated tools with regard to reflection guidance, the following important aspects need to be taken into account for the developed reflection guidance concept:

1. Investigating and evaluating prompts in learning environments benefit from the fact that the learning activities and tasks of the learners are known beforehand and the prompts can easily be adapted according to these activities. In contrast, in work-related settings the tasks are not always known beforehand or only vaguely known. Therefore it is rather difficult to present a prompt supporting the worker's working task.
2. The perfect timing of prompts can be directly adapted to the learning progress of each student. This advantage helps students to reflect on the current topic at the right time and does support the learning progress instead of distracting it. In work-related settings, it has to be carefully

considered when to present which type of prompt, in order to not interrupt the workflow of the worker and to be not perceived as annoying. Thus, it is very challenging to provide meaningful prompts in a working environment.

3. Diaries, journals and ePortfolios have in common that they are very time-consuming in being kept and maintained, but especially for educational settings they serve as powerful learning tools. In contrast, most workplaces are very stressful and work-intensive, thus the introduction of an additional tool like a journal or diary can increase the already existing workload of the individual knowledge worker. Therefore, it has to be very well considered, if and how time consuming approaches like diaries or journals can be applied in work-related settings.
4. Reflective learning refers to past experiences with the goal to learn from them. Thus, including the user's learning or working context information can very powerful to support reflective learning. On the one hand, the content of the created prompts can be perfectly adapted to the current user context and on the other hand, showing context information (e.g. if collected over time) when writing a journal or diary entry can help to better re-evaluate past experiences. Therefore, including context information to provide reflection guidance is a important aspect to initiate reflective learning independent of the setting.
5. Visuals are very well investigated in learning environments with regard to the individual learning progress or learning activities. In contrast, in work-related settings, visuals a rarely used to motivate knowledge workers to reflect on working tasks. This can be explained with the fact that knowledge workers are afraid of being monitored how they perform their work. Thus it is a challenge to track working activities (e.g. application and resources usage during work), other work related data (e.g. who talks with whom) or personal data (e.g. health data like pulse or heart rate), which might be worth being reflected on.

5.3 Components of the Reflection Guidance Concept

The first reflection guidance concept emerged after several field studies of the MoodMap App and was improved over time by integrating also the results of subsequent field studies conducted in this work. The developed guidance concept conceptualises reflection guidance as adaptive components. I see this concept as a promising instructional strategy, as it provides various components in order to trigger reflective learning. At the workplace, such components should draw the workers' attention to their own thoughts and experiences, and motivate them to understand and reflect on their daily working tasks.

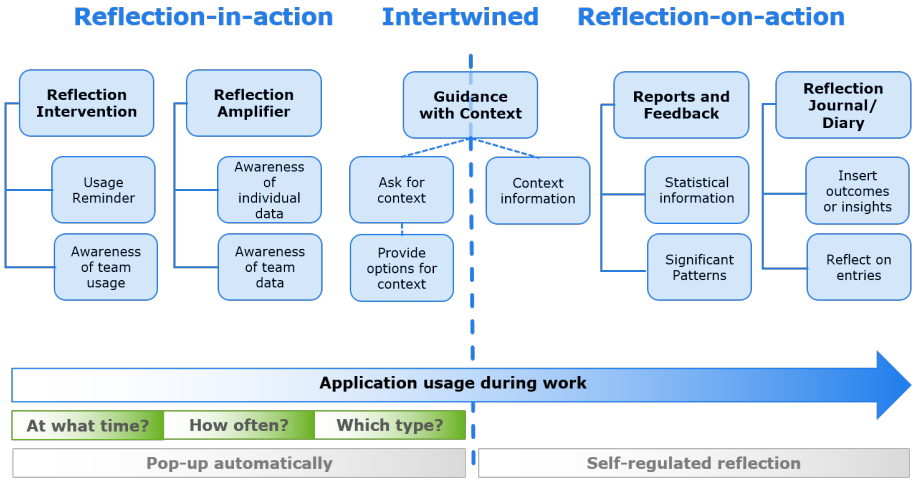


Figure 5.1: 1st Reflection Guidance Concept

Figure 5.1 shows a schematic representation of the concept taking into account the timing of reflection with regard to Schön [142]. He defines *reflection-in-action* as reflection which takes place while doing own work, whereas *reflection-on-action* refers to analysing reactions to any situation and exploring the reasons and consequences afterwards. Consequently, the design components

are divided in these two main categories, complemented by a third category combining both types of timing:

5.3.1 Reflection-in-Action Components

"Reflection-in-action" components present motivational triggers to provide a more accurate guidance of the reflective process and should make people aware of any significant changes or unusual behaviour. These components are automatically presented to the user when starting to use an application or during the usage of an application. I define two types of reflection-in-action components:

Reflection interventions: Reflection interventions are prompts that aim at motivating users to utilise an application in general. This type of prompts are similar to the *activity prompts* by Davis [28], which have the goal to facilitate the completion of specific aspects of given activities. Reflection interventions pop up when opening the application for the first time of the day or at the end of a day. They occur during a working day, if the application was not used for a longer time or if a new event (e.g. beginning of a meeting) is starting. All these prompts ask for input regarding the user's activities.

Reflection amplifiers: Regarding the *reflection amplifiers*, I follow Verpoorten et al. [159] seeing them as deliberate and well-considered prompting approach for initiating reflection. This is also in line with Davis [28], whose so-called *self-monitoring prompts* provide questions to foster planning and reflection. At work, reflection amplifiers support planning and reflection by making users aware of deviations from standard behaviour, unusual working patterns or other significant situations on an individual or collaborative level. Furthermore, they motivate users to reflect about such situations and to insert their thoughts directly into a corresponding application.

5.3.2 Reflection-on-Action Components

"Reflection-on-action" components are features that can motivate users to reflect about the gathered data after having used the application, e.g. at the end of a working day. These components consist of reports as well as reflection diaries or reflection journals. "Reflection-on-action" components encompass:

Reports: Reports provide an automatically created summary of past experiences or events captured during work. Depending on the purpose of the application, such reports present working tasks or activities including unusual situations worth being reflected on. The aim is to provide guidance for reflection based on the available data and in relation to different time periods (e.g. hourly, daily, weekly reports). Re-evaluating or comparing them with own or others' working behaviours can lead to the detection of behavioural patterns, insights about one's own working behaviour and finally result in learning outcomes.

Reflection Diary: The reflection diary is used to store insights, thoughts, artefacts, or learning outcomes in a structured way. Using this diary consequently (e.g. at the end of a day) in a reflective learning application can result in an important collection of learning outcomes. Re-evaluating these entries again can trigger reflective learning and in the end lead to the detection of significant working patterns or meaningful insights to guide future behaviour at work.

5.3.3 Intertwined Component

Contextualisation: In order to be able to return to experiences, which is a relevant step for reflection as suggested by Boud et al. [11], it is important to track the context either automatically or manually during the application usage. Automatically tracked context can gather all interactions with an application and consists therefore of vast amounts of data. In contrast, manually inserted context can be a self-defined word, a short phrase or the selection of pre-defined context types adapted to the current working environment; it is just a hint, which represents what is currently going on during work. This contextualisation can support reflective learning twofold. First, directly when entering context information the user has to think about it. Second, displaying the available context information when revisiting the captured data later on (e.g. at the end of a day) supports the user to better remember the respective working situation.

5.4 Applications and their Implemented Reflection Guidance Components

In this section, I describe how different reflection guidance components were implemented in the three different applications.

5.4.1 Reflection Guidance Components in the MoodMap App

In the MoodMap App, two different versions of the reflection guidance components were implemented:

a) MoodMap App with mandatory contextualisation

b) MoodMap App report with diary

Figure 5.2: The MoodMap App

Compulsory contextualisation: The contextualisation component is implemented in a mandatory way. For each inserted mood, a pre-defined context has to be chosen out of the following four options especially tailored to a call centre setting: "after a call", "after a coaching session", "after a break" or "other" (shown in Figure 5.2.a). Afterwards, a note has to be added, which is motivated by a reflection amplifier question like *"What are you currently thinking?"* or *"What influences your current mood?"*. The purpose of this mandatory contextualisation is to 'force' the user to think about the current inserted mood and add the user's thoughts into the application.

Table 5.1: Reflection Interventions on an individual (I) and team (T) level

Type	Level	Prompt text
RI 1	I	Welcome to the MoodMap App. Express yourself for the first time today.
RI 2	I	Welcome to the meeting: "nameOfTheMeeting". Express yourself for the first time of the meeting.
RI 4	I	Add your thoughts to your last inserted mood.
RI 3	I	The meeting is over now. I want to have an email notification with the most relevant meeting information. I want to see the meeting report now.

Reflection interventions and amplifiers: The reflection interventions occur automatically when a user enters the MoodMap App for the first time of a day or when the user enters a meeting for the first time (see Table 5.1). Their goal is to motivate users to use the application and to state the user's current mood. Furthermore reflection amplifiers automatically pop up during the application usage to motivate users to reflect about the current mood. This is done by making the user aware of a significant mood change of the own individual mood but also in relation to the collaborative mood and by directly asking for input (see Table 5.2).

Additionally, two types of reports are implemented in the MoodMap App. One report summarizes the individual mood development of a day (see Figure 5.2.b) and the other presents the individual mood development with regard to the team mood development in order to stimulate reflection. In both reports a reflection diary is available to store insights gained.

5.4.2 Reflection Guidance Components in the Medical Quiz

The quiz is enriched with three different types of reflective questions - an integrated form of reflection amplifiers: *"learning progress reflective questions"* at the beginning of all quizzes, *"work-related reflective questions"* during the Quiz-of-20 and *"general reflective questions"* at the end of the quizzes, except the Quiz-against-Time. Their goal is to stimulate reflective learning on different topics and at different points of time during the quiz play.

Table 5.2: Reflection Amplifiers on an individual (I) and team (T) level

Type	Level	Prompt text
RA 1	I	You are more energized now, but you are not feeling very good. What happened?
RA 2	I	Your energy level decreases, but your feeling is quite good. Why did it change?
RA 3	I	Your mood is decreasing. What is the reason for this change?
RA 4	T	Your feeling is more positive than the average team mood. What is the reason for this?
RA 5	T	Your feeling is more negative than the average team mood. Why do you feel so bad?
RA 6	T	Your energy level is now above the team energy level. Why did your energy level change?
RA 7	T	Your energy level is now below the team energy level. What happened?
RA 8	T	Your mood changed to a more positive mood than the team mood. What was the reason for this change?
RA 9	T	Your mood is much more energized than the team mood. What is the reason for this?
RA 10	T	Your mood is much more positive than the team mood. What happened?
RA 11	T	Your mood is significantly below the average team mood. What is the reason for such a bad mood?

Table 5.3: Examples of reflective questions at the beginning of the quiz

Reflective at the beginning of the quiz
You are very motivated and you play the quiz at least once per week - you results are really very good. How could the quiz help you to learn?
You are very motivated and you play the quiz at least once per week - you results are really very good. What is your success recipie?
Your knowledge is very constant. How could the quiz help you to learn?
Your knowledge is very constant. Think about and describe shortly, how you could further improve your knowledge?
Unfortunately your state of knowledge is very low. How could the quiz help you to learn?

The reflective question at the beginning (see Table 5.3) motivates users to reflect about their knowledge status (based on previously quiz results) and their play frequency (how often the user played the quiz). The question is composed of an introduction statement followed by a reflective question. The

Figure 5.3: The Medical Quiz and an in-between reflection amplifier

goal of the reflective question is to make the player aware of the individual current knowledge status and play frequency and to reflect about it.

The in-between reflective questions, only implemented in the Quiz-of-29, are presented together with a content question (see Figure 5.3). They aim at focussing on the content-based question and how this content question refers to the users past working experiences and working practices (see Table 5.4).

The question posed at the end of the quiz asks explicitly for gained insights or new knowledge with regard to the currently played quiz. This type of questions is used in all quiz types but the Quiz-against-time (see Table 5.5).

Table 5.4: Examples of reflective questions during the quiz

Reflective questions during the quiz
Does the question posed above remind you on an interesting situation or discussion during work (during the qualification programme) and if yes, on which one?
If you have a look at the question stated above, would it help you to have more information about the related topic e.g. direct access to a medical book or to an internet page? If yes, which information would you like to have? If no, why don't you need any further information?
How important is the question above for your work?
Have you already needed this information in practice and if yes, how? If no, do you think you could use this knowledge in future for your work?
To what extent is the question stated above relevant to your work?

Table 5.5: Reflective questions at the end of the quiz

Reflective questions at the end of the quiz
Reflect on the currently played quiz. Have you perceived any special insights for yourself?
Reflect on the currently played quiz. In what regards are the quiz questions related to your work?
Reflect on the currently played quiz. Do you take something with you for the future with regard to the currently answered questions?
Reflect on the currently played quiz. What did you particularly like with regard to the quiz?
Reflect on the currently played quiz. How satisfied are you with your quiz result and do you want to change something?

5.4.3 Reflection Guidance Components in KnowSelf

In KnowSelf, time-triggered reflection interventions and event-triggered reflection amplifiers are implemented.

The time-triggered reflection interventions (see in Figure 5.4) are shown on a specific day at a specific time which can be adjusted by the user and remind the user to reflect by offering feedback on various topics regarding the user's behaviour. These prompts appear regularly and ask for example to reflect on an unusual work behaviour, to visit a visualisation like the Heatmap or serve as remember to write a diary entry.

The event-triggered reflection amplifiers are generated when a significant change has been detected, e.g. when the number of switches is higher than

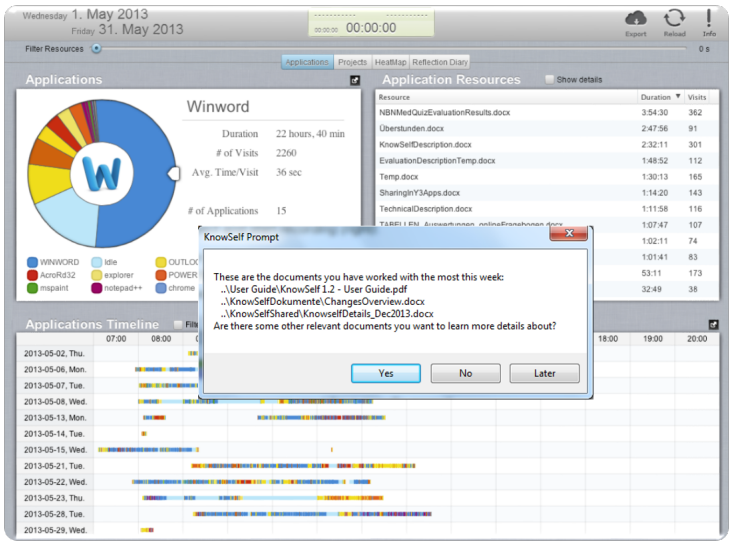


Figure 5.4: KnowSelf and a reflection amplifier

usual or after long periods of idle time. Table 5.6 summarizes all time-triggered and event triggered prompts. Additionally, a reflection diary is implemented, where all notes, thoughts or reflection insights can be stored.

5.5 Conclusion

In this chapter, I introduced the in-app reflection guidance concept to facilitate technology-supported reflective learning at work. The concept consists of reflection-in-action, reflection-on-action and intertwined reflection components, supporting reflective learning during different points in time [142]. Different parts of the concept were implemented in various ways into the three applications, the MoodMap App, the Medical Quiz and KnowSelf. Due to the fact that these apps were very heterogeneous, chances are high that reflection guidance can be successfully added to any app designed to support reflective learning.

Table 5.6: KnowSelf prompts

Topic		**Timing**
Numbers of switches	On _DATE_ you reached the highest level of switches between _FROMTIME_ and _TOTIME_. Do you have an idea what is the reason for it? Would you like to see your recordings in the App which could help you to reflect on it?	On Wednesdays
	In the heatmap you can see the number of switches per hour and per day. Do you want to learn new valuable information about your time use with help of the KnowSelf app?	On Tuesdays
	On _DATE_ between _FROMTIME_ and _TOTIME_ you had higher switches than you usually have in that time. Do you have any idea why? Would you like to take a look at your captured activities in the App and reflect on it?	When number of switches during a 15 min interval gets unusually higher comparing to his/her usual switches.
Idle time	On _DATE_ you had more idle time than you have on average. Do you have any idea why? Take a look at your idle times in the App and reflect on it.	When the daily idle time (whole idle time of the day) is unusually higher than usual
Projects recorded	You have recorded these projects so far: _____ (list up to 3 project names) Are there any additional projects or activities you would like to record to keep track of your work?	On Fridays
	You haven't recorded any project so far. Are there any projects or activities you would like to record to keep track of your work?	In case a person haven't record any projects so far.
Top 3 most used documents	These are the documents you have worked with the most from _FROMTIME_ to _TOTIME_: ___, ___ and ___. Are there some other relevant documents you want to learn more details about?	On Thursdays
Reflection diary	Do you have any goals regarding your time management you would like to accomplish? Would you like to write them down in your reflection diary and mark them as goals? This could help you to follow up on them!	On Fridays

6 In-App Reflection Guidance in the Wild

This chapter is the core of this thesis and will present the results of the summative field studies of the evaluated reflection guidance concept. This chapter is mainly based on the two publications P6 [42] and P7 [43] (under major revision).

6.1 Introduction

Chapter 5 presented the first reflection guidance concept and its implementation in three different applications. This chapter reports on four summative field studies (see Section 4.4.1, MoodMap App field study 5, MoodMap App field study 6, Medical Quiz field study 5 and KnowSelf field study 1) in which the three applications were used and evaluated in the wild.

By analysing the results of all field studies, the following two research questions will be answered, mainly contributing to RQ2 and partly to RQ3 of this thesis.

- How were the implemented reflection guidance components perceived with regard to their usefulness at work?
- To which depth [132] does reflective learning occur (lowest level: descriptions of experiences and emotions; medium level: interpretation and justification of actions; highest level: insights, learning and conclusions)?

6.2 Summative Field Studies: Assessing Reflective Learning

Summative field studies are used when the application and the usage method have reached a good maturity. The summative field studies conducted allow to assess relevant indicators for reflective learning and their impact for individuals and teams, as well as the organisation as a whole. In order to achieve this, the conducted field studies need to have a continuous application-usage for several weeks.

The conducted field studies try to achieve reflective learning on all four levels of the model proposed by Kirkpatrick [81]. Therefore, the set-up of the field studies are designed to address these four levels with the help of questionnaires and tools tailored to the four levels. Also the results of the field studies are structured according these four levels to show the achieved results on reflective learning.

The four levels can be summarized as follows:

- *Level 1: Reaction*: This level tries do find out to what degree participants react favourably to the application. This can be measured by the usage of the application (objective usage). In addition the user experience can be evaluated through subjective evaluations.
- *Level 2: Learning*: This level investigates to what degree participants acquire knowledge, skills, attitudes, confidence, and commitment. Therefore, this level addresses the actual support of reflection that the applications provide. Furthermore, it assesses the participants' general tendency to reflect and the importance they place on reflection.
- *Level 3: Behaviour*: This level focus on to what degree participants apply what they learned. Therefore the conversion rate of behavioural intentions into actions was measured. In addition, the impact on the specific actions on the respective reflective learning processes by monitoring the related KPI's of the process were measured. More intangible outcomes can be measured with "before" and "after" evaluations.
- *Level 4: Results*: This level evaluated to what degree targeted outcomes occur as result. Therefore the organisational KPIs were measured starting at or before the evaluation until the end of it. Care has been taken that only the relevant unit(s)/personnel who used the applications were

assessed. As KPIs were to be defined according to the specific field study and application.

A detailed description of the conducted summative evaluations can be found in Appendix 10. The corresponding evaluation framework based on Kirckpatrick [81] can be found in Knipfer et al. [82].

With regard to thesis, the presented results focus only on the implemented components of the reflection guidance concept and if, how and to which depth reflective learning can be triggered on an individual level.

6.3 Methodology

The applications and the implemented reflection guidance components were evaluated with field studies conducted in four different work settings. All evaluations followed a similar approach using the tools listed in Table 6.1. Objective usage rates were captured via users' log-data and written text entries were collected within the apps. Demographic data was gathered in the pre-questionnaire, whereas the post-questionnaires contained questions on how supportive the apps were with respect to reflective learning (app-specific reflection questions) and how useful participants perceived the reflection guidance components. In the post-questionnaire, the items were presented as 5 pt. rating scales ranging from 1 - "I strongly disagree" to 5 - "I strongly agree". For the app-specific reflection questions an existing item pool of 43 questions was used (see [82], p. 38), which cover a wide variety of features reflection apps may provide. Out of this, an adequate subset of items was selected for each evaluation (see Table 6.3).

The conducted interviews and the workshop provided deeper information about the applications and the implemented reflection guidance components. For the analysis of the written content with regard to the achieved stages of reflection (low, medium and high), a qualitative analysis schema [132] was used. The coding schema consists of three main stages subdivided into 9 categories. Stage one, the lowest level of reflection, consists of categories 1 and 2 encompassing descriptions of experiences and emotions. The second stage, categories 3 - 7 referring to the medium level of reflection, includes the interpretation and justification of actions and working on solutions. The

Table 6.1: Used Evaluation Tools

Tool	App	Stage	Content
log data	all	during usage	interactions with the application, quiz results
pre-questionnaire	all	at the beginning	consent form, demographic data
post-questionnaire	all	at the end	feedback about the applications and the guidance components, questions about reflective learning
interviews	all	at the end	additional feedback about the applications and the guidance components
workshop	Quiz	at the end	group discussion about the evaluation and the quiz

third stage consists of categories 8 and 9 which belong to the highest level of reflection and comprise insights, learning and conclusions from reflection. All notes stored within the apps were independently analysed and categorised by two to three researchers (see Table 6.5).

6.4 Applications and their Evaluations

Table 6.2 gives an overview of the four conducted summative field studies, the corresponding work-settings, the implemented reflection guidance components and their duration. All field studies are shortly described in the following sections. An extended description can be found in Appendix B 10.

Table 6.2: Evaluation Overview

ID	Application	Reflection Guidance	Setting	Duration
MMA FS5	MoodMap App	Compulsory Contextualisation	Call Centre (GB)	4 weeks
MMA FS6	MoodMap App	Reflection interventions and amplifiers	IT Company (IT)	6 weeks
MQ FS5	Medical Quiz	Reflection amplifiers	Stroke Unit (GE)	4 months
KS FS1	KnowSelf	Reflection interventions and amplifiers, reflection diary	IT Company (GE)	6 weeks

6.4.1 The MoodMap App Evaluation in a Call Centre

Setting: Four teams out of two call centres of a large telecommunications company in Great Britain participated in this evaluation (see appendix B 10.2.1).The two call centres are situated in Scotland and together they have about 450 employees. They are part of a large telecommunications company, serving customers in more than 170 countries. The first call centre employs more than 300 people (divided in 19 teams) and 157 people (divided in 7 teams) work in the second centre. Such call centres can handle an average of 27.000 calls every day, working in a range of functions from directory enquiries to residential and business broadband. Each team consists of call takers, coaches and managers. The call takers are responsible for taking the calls and solving any issues directly with the customers. The coaches support and coach the call takers for their work, while the managers ensure that the call takers are performing against their targets, review their performance and supervise the training sessions. In this field study, the MoodMap App with the compulsory contextualisation component was evaluated.

Procedure: The evaluation of the MoodMap App started on the 20th of November and lasted until the 20th of December 2013. The MoodMap App was introduced by the responsible project manager of the telecommunications company. During this introduction phase the team members were asked to fill in the questionnaires. All participants (call takers, coaches and managers) were asked to integrate the MoodMap App in their daily working routines. Their task was to state their moods, choose a mandatory context and add a note during all days of the evaluation period. They were also asked to reflect about their inserted moods and notes individually.

Participants: From the 33 participants who used the application and filled out the post-questionnaire, 2 gave interviews and 24 shared their demographics. Of these, 14 are male, 10 female, 67% were aged between 20 and 29, 26% between 30 and 39, 8% between 40 and 49. On average they were 3 years in their current position.

6.4.2 The MoodMap App Evaluation in an IT Company

Setting: The Italian company (see Appendix B 10.3.1) is leading in the development of software-technology and cloud services in the emergency domain. This encompasses the development of information and communication technology systems for emergency centres and volunteering associations. The company consists of altogether 38 employees distributed over 5 departments. In this study, the MoodMap App with the implemented reflection interventions and reflection amplifiers was evaluated.

Procedure: The evaluation of the MoodMap App started on the 12th of February and lasted until the 31st of March 2014. The MoodMap App was introduced by a responsible project manager of the company to all five departments and their employees. During this introduction the project manager described on the one hand the MoodMap App itself and how it should be integrated into their working routine. On the other hand, he presented a success story which emerged during an other evaluation in order to show them a meaningful insight and a clear benefit. During the application usage period, all participants of the study were asked to insert their moods during their working shifts and to reflect about their inserted moods and notes individually. The managers were additionally instructed to use the team visualisations in order to reflect about the mood development of their departments and take actions if necessary with regard to each team member.

Participants: 32 employees, 24 male and 8 female, have participated in the MoodMap App evaluation. They were aged between 20 and 59, with 9% of them aged between 20 and 29, 75% between 30 and 39, 13% between 40 and 49 and 3% between 50 and 59. They had worked on average about 7 years in their current position.

6.4.3 The Medical Quiz Evaluation at a Stroke Unit

Setting: The Medical Quiz was introduced to the nurses participating in a qualification program for stroke nurses, which takes place once a year in a German hospital. (see Appendix B 10.4.1). All participants were nurses working in different German hospitals and were in education to become a nurse for a Stroke Unit. The qualification program lasted for 4 months, starting

in October 2013 lasting until January 2014. In one week of each month the participants came together for the training at the organising hospital.

Procedure: In the first week of the qualification program, the Medical Quiz was introduced to the participants by the evaluation responsible of the organising clinic. All participants received a neutral account for the quiz to ensure their anonymity and avoid the feeling of being observed. Then, they were asked to fill in the questionnaires and to play the quizzes consistently. On the one hand, they should use the content questions for memorising and strengthening their newly gained knowledge. On the other hand, they should use the integrated reflective questions for reflecting about the quiz content connecting the new knowledge with their daily work practices. In week two and week three of the course, the participants got feedback regarding their quiz play. In the fourth week of the program, the post-questionnaire was handed out. In addition, a half-day workshop and interviews were conducted to collect deeper insights from the participants with regard to the quiz and its reflection support.

Participants: 18 nurses (16 female, 2 male) participated in this evaluation and 3 gave interviews; 66% were aged from 20-29 and 33% between 30 and 59. 95% were nurses and 5% were head nurses. The average time in their current position was 4 years.

6.4.4 KnowSelf Evaluation in an IT Company

Setting: The evaluation took place in a German consulting company (see Appendix B 10.5.1) that consults, sells, and personalises customer relationship management software to help analyse and optimise the marketing, sales and service processes of their customer companies (small and medium enterprises). Employees mainly work in small teams of two to three people. Altogether, the company has about 60 employees, most of them based in the headquarters. The employees have many meetings with customers at the customers' site and their daily work is heavily focused on customers' needs. This requires a high level of flexibility and the development of individual best practices. Consulting and sales involve a high degree of reflection regarding interactions with customers.

Procedure: The KnowSelf evaluation started on January 16th and lasted until the beginning of March 2014. In a kick-off meeting at the company, the

application was presented and explained to the participants by the evaluation responsible of the company (see [135], p. 25). They were asked to install KnowSelf on their business PCs and to use the application over a period of six weeks as well as to reflect on the collected data on a daily basis. During the six weeks, they received a weekly email including a reminder to reflect on the captured data, enter observations and to fill in a short online questionnaire to provide feedback.

Participants: 10 employees (3 females, 7 males) participated in the evaluation and 7 gave interviews; 10% were younger than 19 years, 40% each were aged from 20-29 and from 30-39 and 10% were aged from 40-49. All of them were employed full-time with three-quarter of them on the management level. On average, the participants have been working in their current positions for more than one year with total work experience of about 4 years.

6.5 Results

6.5.1 Usage Data

The MoodMap study at the call centre had 33 participants; the MoodMap study at the IT company had 32 participants; the Medical Quiz study 18 and the KnowSelf study 10 participants. During the evaluation period, the average number of interactions (e.g. visiting different visualisations) of the participants with the MoodMap study at the call centre was M = 42.67 (SD = 72.7), ranging from 1 to 338 interactions. The MoodMap study at the IT company showed on average 49.78 interactions with the application (SD = 82.75), ranging from 1 to 391 interactions. KnowSelf was used on average for M = 38.5 minutes (SD = 23.8) by each participant, with a maximum of 53.72 and a minimum of 7.76 minutes. The participants of the Medical Quiz answered on average M = 461.9 (SD = 341.0) questions, with a maximum of 1358 and a minimum of 25 questions. Thus, participants used the applications frequently enough in order to test and evaluate the implemented reflection guidance components.

6.5.2 Reflective Learning

The post-questionnaires of the four studies contained seven app-specific reflection questions (see Table 6.3) for both MoodMap and the Medical Quiz studies and five questions for the KnowSelf study. Mean ratings range from M = 2.91 (SD = .75) for the MoodMap at the IT company over 3.25 (SD = .92) for the MoodMap at the call centre and 3.28 (SD = .66) for the KnowSelf to 3.51 (SD = .42) for the Medical Quiz. The ratings indicate that three out of four apps can slightly support reflective learning. Relating the objective usage data to these ratings reveals positive correlations for two apps. More exactly, correlating the extent of app usage and how users perceive the apps' support for reflective learning reveals significant Pearson coefficients for the Medical Quiz (r = .612, p = .015) and the KnowSelf (r = .850 , p = .015), whereas the correlations for both MoodMap studies are not significant (call centre study: r = .226, p = .247; IT company study: r = .24, p = .177).

Table 6.3: Application Specific Reflection Questions

Questions	**Apps**
[The app] helped me to collect information relevant to reconstructing experiences from work.	MoodMap, KnowSelf
[The app] helped me to reflect on experiences from work.	MoodMap
[The app] helped me to collect information that could help me decide when to reflect	MoodMap
[The app] helped me to reconstruct a work experience.	MoodMap, Quiz
[The app] helped me by capturing my reflection outcomes.	MoodMap, KnowSelf
[The app] helped me by making reflection outcomes available for later use.	MoodMap, Quiz
[The app] helped me by capturing information for evaluation of learning/reflection.	Quiz
[The app] helped me by reminding me to reflect.	Quiz, KnowSelf
[The app] helped me by providing information relevant for the decision to reflect.	Quiz
[The app] helped me by providing accurate information about my work.	Quiz, KnowSelf
[The app] guided me in capturing information about my work experiences.	MoodMap
[The app] guided me in deciding whether/when to reflect.	Quiz
[The app] provided relevant content for reflection.	KnowSelf

6.5.3 Usage and Usefulness of Reflection Guidance Components

The implemented reflection guidance components were adopted as follows:

Contextualisation in the MoodMap study at the call centre was evaluated by means of three questions asking how helpful the contextualisation of mood points was for associating the inserted mood to certain situations (Q1), for recalling past experiences (Q2) and if the chosen activities (e.g. a call) helped to better reflect about a past situation (Q3). With mean ratings of Q1: M = 3.39 (SD=0.86), Q2: M = 3.21 (SD = 0.74) and Q3: M = 3.24 (SD = 0.94) the participants perceived the contextualisation as slightly positive. The analysis of the context information shows that 31% of the moods were inserted "after a call", 6% "after a break", 2% after "a coaching session" and 61% in "other", not pre-defined contexts. The more detailed analysis of the "other" context revealed the following situations as the most common ones: start or end of shift, before break or lunch, back from lunch or a certain event, problem or issue (e.g. crash, waiting for other departments), feeling better after dealing with a problem, successful events, feeling tired or having finished a certain task.

Reflection interventions in form of time-triggered prompts were implemented in KnowSelf and evaluated with two explicit questions in the post-questionnaire. Users rated the reflection intervention reminding them to use KnowSelf in general slightly positive with M = 3.22 (SD = 1.09) whereas the reminder of project recording was perceived slightly negative with M=2.75 (SD=1.28) as shown in Table 6.4. Reflection interventions in the MoodMap study at the IT company were not explicitly evaluated.

Reflection amplifiers were implemented in all four apps. For the MoodMap study at the call centre, the amplifier in form of a prompt to add a note to the mood-context resulted in 475 notes inserted by the participants. In this field study, the perceived usefulness of the prompts was not explicitly evaluated.

In the MoodMap study at the IT company two questions about the reflection amplifiers were inserted in the questionnaire. On average participants slightly disagreed that the questions about their own mood changes (M = 2.84, SD = 1.05) and their mood changes with regard to the team's mood (M = 2.54, SD = 1.36) motivated them to reflect. Altogether 2067 moods and 203 notes were

inserted. Furthermore 1106 prompts (reflection interventions and reflection amplifiers) were automatically presented and 136 of them were answered. To get more detailed information about how the reflection amplifiers were perceived, seven participants, including two managers, four staff members and one evaluation responsible took part in an interview. All of the participants mentioned that the evaluation was conducted in a very stressful and work-intensive time, where they nearly had no time to use the MoodMap App properly. The managers mentioned that they have seen the reflective prompts, but used them very rarely: *"I often write a motivation reason, the reason why I changed it [my mood]."* or *"Because I was really stressed for a particular reason, in this case I wrote a comment on the mood."*. Also the coordinator admitted that he had never used the reflection amplifiers, nevertheless he stated that *"I think that it was a pity, because maybe it should be a good thing to do that, to focus on why I was feeling happier or worse, or compared to the others or compared to myself five minutes before"*. The staff members - except one - did use the amplifiers. However one of them commented that *"Sometimes I feel the pop-up was very useful to remember me to write something about my mood. In other case I felt it was very annoying"* and another mentioned that *"I used the pop-ups to annotate and give context, because my natural is to reflect about my work. I used this tool and I found it useful but just to formalize a way to work, in my usual way of working."*

In the Medical Quiz, we integrated reflection amplifiers by presenting reflective questions at the beginning, during and after a quiz play. Figure 6.1 shows the results of the answered (bottom bars) and not answered (top bars) reflection amplifiers per quiz type.

Reflective questions at the beginning: For the Quiz-of-20, altogether 205 reflection questions at the beginning were shown and more than 50% were answered by the players (Figure 6.1, bar "Q20 B"). For the Quiz-of-10 only 18% of the 53 posed reflective questions were answered (Figure 6.1, "Q10 B"), for the Quiz-of-5 38% out of 47 questions (Figure 6.1, "Q5 B") and for the Quiz-against-time 13% were answered out of 51 questions (Figure 6.1, "QaT B").

Reflective questions in-between the Quiz-of-20: The two in-between reflective questions were only added to the Quiz-of-20, which all had the task to motivate the player to relate the presented content-based question to possible situations during work. For both in-between questions, the participants had also answered more than 50% of the presented questions (Figure 6.1, "Q20 I1" and "Q20 I2").

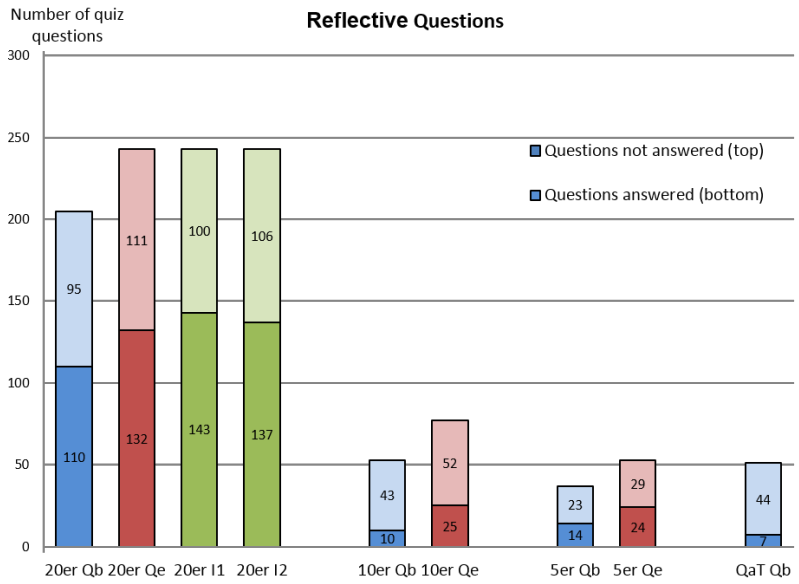


Figure 6.1: Reflective questions in the medical quiz

Reflective questions at the end: At the end of each quiz, except the Quiz-against-time, a reflection question was presented with the goal to motivate the users to reflect about the currently completed quiz and to evaluate whether they could gain any benefits or insights out of the currently played quiz. These reflective questions were chosen randomly out of altogether 8 questions. At the Quiz-of-20 243 of these reflective questions were presented to the players and 54% of them were answered (Figure 6.1, "Q20 E"). For the Quiz-of-10 77 questions were presented and 32% were answered (Figure 6.1, "Q10 E"), and for the Quiz-of-5 the users answered 45% of the 53 posed questions (Figure 6.1, "Q5 E"). In the Quiz-against-time no reflective question was presented at the end.

Altogether out of 1205 reflective questions, 603 (52%) were answered in a meaningful way, which indicates that the quiz players have thought about the posed questions and that reflective learning could be triggered. Looking at the time the questions were posed, results indicate that users preferred questions

at the beginning of the quiz (59.3% responses) over those at the end (51.5%) and were most reluctant to deal with questions while playing the quiz (42.4% answered).

In KnowSelf, the usefulness of the event-triggered reflection amplifiers was explicitly investigated (see Table 6.4). Participants rated the notifications about most used resources as rather helpful (M = 3.30, SD = 1.25), whereas the notifications about unusual amounts of idle time and notifications about specific amounts of switches were not perceived as very helpful. The general rating regarding KnowSelf prompts and their potential to motivate participants to reflect was rated rather low M = 2.00 (SD = 1.06).

In KnowSelf, the participants documented their experiences, insights and comments regarding the application in the **Reflection Diary**. Six participants were willing to share their explicit data and altogether 103 statements were inserted in the diary (the content is discussed in the next section). In contrast, the MoodMap App provided **reports** including a **reflection diary** but these were not used by the participants in any study. In the quiz, there was no diary implemented.

Table 6.4: Assessment of KnowSelf Prompts

Questions	**KnowSelf**	
	Mean	**SD**
Please indicate your agreement with the following statement (scale: 1 - strongly disagree, 5 - strongly agree):		
The KnowSelf Prompts motivated me to reflect.	2.00	1.06
To what extent were the following categories of KnowSelf Prompts helpful to you? (scale: 1: not helpful at all to 5: very helpful):		
Reflection Intervention: Reminder for using KnowSelf generally (e.g. look at heatmap, write diary entries)	3.22	1.09
Reflection Intervention: Reminder of project recording	2.75	1.28
Reflection Amplifier: Notification about specific amount of switches	2.30	1.34
Reflection Amplifier: Notification about unusual amount of idle time	2.57	0.79
Reflection Amplifier: Notification about most used resources	3.30	1.25

Table 6.5: Analysis schema: number of notes per category and evaluation

Categories of reflection elements	MoodMap call centre	MoodMap IT company	KnowSelf
Stage 1			
1. Description of an experience	141	150	54
2a. Own emotions	185	48	0
2ap. Emotions with physical conditions (e.g. pain, illness)	0	18	0
2b. Other emotions	50	0	0
Stage 2			
3. Interpretation or justification of actions	17	14	33
4. Linking an experience explicitly to other experiences	3	0	1
5. Linking an experience to different pieces of knowledge, rules, values, organisational documents	0	0	0
6a. Responding to interpretation of the action (inquiry/different/alternate perspectives)	0	0	1
6b. Responding to interpretation of the action (challenging or supporting assumptions / opinions / attributions)	0	0	0
7a. Working on a solution based on assumptions, insights (explanation of reasons)	0	0	7
7b. Working on a solution (giving suggestions without proposing to set them in practice/referring to an experience)	1	0	4
Stage 3			
8a. Insights / learning from reflection (different / better understanding of experience)	0	0	5
8b. Insights/learning from reflection (generalising from experiences, finding patterns across experiences)	0	0	6
9. Drawing conclusions and implications from reflection	0	0	8

6.5.4 Content Analysis of the Inserted Notes

For the final coding of the notes collected in both MoodMap and the KnowSelf studies, we used only those notes which were assigned in agreement of all raters. Agreement was achieved either in the first step of analysing and categorising notes independently or in a second step after discussing deviating assignments. Some of the notes belong to more than one category, however in

those cases all raters agreed on all categories. Table 6.5 presents the number of notes per category and field study, distributed according the three stages of reflection.

In the MoodMap study at the call centre, participants attached 475 non empty notes to 548 inserted moods. Out of these, 283 could be identified as individual reflective items. 95% of the reflective notes were assigned to the first stage, which includes descriptions of experiences or emotions. The remaining 5% belong to the second stage which refers to interpretations and justifications of actions and working on solutions. Examples of notes for each category are presented in Table 6.6.

In the MoodMap study at the IT company 203 non empty notes were captured. 188 notes could be identified as reflective items. Beside the categories defined in the reflection coding schema, the category 2ap was added to the schema. It represents the physical condition (e.g. pain, illness) related to own emotions and is thus defined as subcategory of 2a (own emotions). 94% of the reflective notes were assigned to the first stage and 6% to the second stage (see Table 6.6).

From the 103 statements inserted in KnowSelf, 33 statements were classified as non-reflective and for 11 entries there was no inter-rater agreement. The remaining 59 statements were classified as individual reflection items. Most of the notes, namely 47%, were assigned to the second stage of reflection, 22% to the first stage, and 27% to the third stage. For the latter, the diary entries included insights, learning outcomes, or conclusions drawn from reflecting. Examples can be seen in Table 6.6.

The coding schema could not be applied to the text entries inserted in response to the reflective questions in the quiz, because the text entries were too short, often consisting of one word only. Thus, for the quiz, we analysed the content of the answers regarding the most frequent words to get a general impression of participants' thoughts. For the questions at the beginning of the quiz the following keywords were used the most: repetition (40), learning (27), yes (19), practice (10), retain knowledge (7), but also nothing (17). Concrete answers given were *"strengthen my knowledge through repetition"* and *"check my knowledge status"*. Very short answers were given to the in-between questions as for example: yes (145), no (38), very relevant (9), very (4) and combine theory with practice (4). Some longer answers stated *"I can apply theoretical knowledge in practice"* and *"answer questions of patients"*. Questions posed at the

Table 6.6: Analysis schema: examples

App	Category	Example of notes
MoodMap call centre	1: experience or issue	Coach is now dealing with the horrible case and its Friday! :)
MoodMap call centre	2a: own emotions	Talk with manager, feeling a bit more positive.
MoodMap IT company	2a, 2ap: own emotions and physical condition	I have a little bit of stomach ache, but I am feeling positive. :-)
MoodMap call centre	1, 3: interpretation of actions	Back and forth we go, another day of getting nowhere with our control desks. Honestly not sure why the customer wants to stay with [company name] at this stage, no one.
MoodMap IT company	1,3: interpretation of actions	Emergencies that have distorted the work plan, overload of tasks and little fluidity (lack of feedback etc.).
MoodMap call centre	1, 7b: solution suggestion	Process for important job and customer did not have much of a clue and had unrealistic expectations. Will have to refer to sales to move.
KnowSelf	1: experience	Today I finished the references for the homepage.
KnowSelf	1, 8b: experience and insights	On the subjective experience, less fragmentation during the day happened. Tasks can be better performed in a blocked way.
KnowSelf	7b, 9: solution suggestion and conclusion	Store documents solely in sharepoint, easier for versioning and without multiplication of documents.

end of the quiz, were mostly answered with yes (55), practice (13), learning (11), no (7), very much (7), recognise progress (5). More concrete answers were: *"I can recognize my state of knowledge by answering the questions several times and enhance my knowledge accordingly."* or *"partly better understand medical orders"*.

6.6 Discussion

Usage. The evaluation of the reflection guidance components implemented in three different applications revealed that the components were perceived as useful and that reflective learning has taken place. Results from two out of

four field studies (Medical Quiz and KnowSelf) show a positive correlation between the extent of app usage and how users perceive the apps' support for reflective learning. This indicates that participants who used the apps more often, also dealt more intensively with their captured moods, working activities or the quiz questions, and consequently also reflected more about it. Therefore user engagement can be seen as a prerequisite for reflective learning. Without user engagement no reflective learning will take place independent of the application.

Perceived usefulness of the components. In the MoodMap App study at the call centre, the participants confirmed that the contextualisation of each mood point helped to better reconstruct past working experiences. Although the predefined contextualisation possibilities had been defined together with managers and users of the call centre and were based on the main call takers' activities, they did not cover all the situations in which participants used the MoodMap App. The "other" option was often chosen, which led to the assumption that participants used the app not only in typical recurring work tasks, but also in other work-related situations e.g. after dealing with a problem or successful event, start/end of day. Thus, contexts should be adaptable to individual preferences. Combining predefined context possibilities of reoccurring working tasks with free adaptable context in form of self-defined keywords will encompass all relevant situations, and would be still quick and easy to use. In the MoodMap study at the IT company, the study was conducted during a very stressful and work intensive time. This resulted in the fact that the participants stated lots of moods during the day, but did not really use the prompts to reflect. Nevertheless the statements of all interviewees confirmed the usefulness of the prompts for reflective learning. By integrating reflective questions at the beginning, during and at the end of the quiz, we were able to show that asking the right questions at the right moment can trigger reflective learning. Over 50% of the 1205 posed reflective questions were answered in a meaningful way. In KnowSelf, the general reminder to reflect about the data in the app and the notification about the most used resources were positively evaluated. This also confirms the usefulness of the prompts, when being presented at the right time.

Timing. The results of the field studies conveyed that the timing of presenting prompts needs to be carefully considered [152]. In the Medical Quiz, the willingness to reflect on the reflection questions was given more with the questions presented at the beginning and at the end of the quiz. Interviews

and workshop discussions revealed that the in-between reflective questions were perceived as more disruptive for the learning process. The results from the quiz are also in-line with the KnowSelf evaluation. Here, the participants perceived the notifications sometimes as disruptive because they popped up at times when they were working intensively on a task and were therefore seen as additional source of work fragmentation. Taken together, the users did not profit from the prompts as much as we have expected it, especially when interventions disrupted the natural work-flow. In other words, reflection guidance does foster reflective learning, but the time of interventions and amplifiers is crucial with respect to acceptance. If timing is 'messed up', users will not accept the reflection guidance components, and consequently not learn (but rather spend their energy on being annoyed at the interruption).

Stages of reflection. The analysis of the notes indicates that the participants reflected. Both MoodMap studies showed that reflection took place mainly on the first and second stage of reflection, while the notes of KnowSelf include all stages of reflection. Taking a closer look at both MoodMap App notes, they deal with work experiences, encompass mostly emotion-based notes including own emotions, emotions of others (e.g. customers) and some notes regarding interpretation and justification of actions. In the study of the MoodMap study at the IT company, additionally the own physical well-being was taken into account. This shows that the participants become aware of their own and others' mood and also reflected about them, which was the main purpose of the MoodMap App. Most of the notes in the KnowSelf study were related to the second stage of reflection. The participants did not only describe their experiences, but they were mostly explaining their experiences and suggested solutions to observed problems. Also more than a quarter of the reflective entries documented insights gained and conclusions drawn from personal experiences. These findings confirm that the participants gained new insights and a better understanding of their work experiences. These could then be used as a basis for changes in behaviour and thus sustainable improve related work processes, as e.g. time management. Although we were not able to apply the analysis schema to the answers given to the reflective questions within the quiz, some of the given answers showed evidence that reflective learning has taken place. However, participants inserted often only short answers. On the one hand, this was due to a lack of computer skills [37], on the other hand participants used the quiz especially to prepare themselves for the exam at the end of the workshop (log data show that they stopped using the quiz with

the date of the exam). From the interviews conducted in all four evaluations, we also learned that a great part of the reflection process takes place in informal face-to-face communications. Thus, it is not possible to conclude from the captured notes, on which stages reflection was actually triggered by the guidance components. Especially with respect to the third stage, it seems reasonable that insights, learning and conclusions from reflection rather develop in personal discussions with colleagues than while using an app.

Insights on reflective learning. Although we were able to show that the implemented in-app reflection guidance concept worked, further insights came up especially during the analysis of the questionnaires, interviews and workshop results with regard to reflective learning. For long-term adoption and from a technological point of view, the technology acceptance model [157, 156] postulates that both "ease of use" and "perceived usefulness" need to be available in order to successfully introduce new technologies. All applications were easy to use (confirmed by the questionnaires) and the reflection guidance components were perceived as useful for reflective learning. However, reflective learning itself was not always perceived as immediately useful with respect to the operational work processes, and organisational goals: better support of employees, increase and improve work performance by reflective learning. What is missing is a clear benefit with regard to reflective learning for all participating parties, management as well as employees. Especially answering the reoccurring question "What is in for me?" beforehand might enhance the applications usefulness with regard to reflective learning right from the beginning.

6.7 Conclusion

In this chapter, the in-app reflection guidance concept to facilitate technology-supported reflective learning at work was introduced. Reflection-in-action and reflection-on-action components have been implemented in three different applications. Due to the fact that the apps were very heterogeneous, chances are high that reflection guidance can be successfully added to any app designed to support reflective learning. It was observed that the users' perception of the apps' support for reflective learning positively correlates with the extent

of app usage whereas the achieved reflection stage varied among the different field studies. The correct timing of reflection interventions and reflection amplifiers is a crucial issue in order to avoid disturbing interruptions of the ongoing work process.

With regard to this thesis and especially for RQ2, it could be shown which technologies are most suitable for providing reflection guidance in order to trigger reflective learning.

By integrating reflective questions - a special form of reflection amplifier - at the beginning, during and at the end of the quiz, it could be shown that asking the right questions at the right moment can trigger reflective learning. In KnowSelf, the general reminder to reflect about the data in the app and the notification about the most used resources were positively evaluated. This also confirms the usefulness of the prompts, when being presented at the right time. As a consequence, the correct timing of reflection interventions and reflection amplifiers is a crucial issue in order to avoid disturbing interruptions of the ongoing work process. This is not trivial at all, as identifying interruptibility is an ongoing research challenge. As good practice from software design it can be recommended to "simply" give users control over the way they are notified and when this notification should take place.

The contextualisation in the MoodMap App work well, however limiting the possible options to only four choices is too restrictive. Therefore, combining predefined context possibilities of reoccurring working tasks with free adaptable context in form of self-defined keywords will encompass all relevant situations.

The reflection diary was only used in KnowSelf, in the MoodMap App no single entry was inserted in the available diary. The analysis of the diary entries of KnowSelf showed that the deepest level of reflection could be achieved, however, it is very difficult to motivate users to really use a diary during work. What is missing is a clear benefit or message for the individual, which keeping a reflective diary is worth for improving own work.

For long-term adoption and from a technological point of view, the technology acceptance model [157, 156] postulates that both "ease of use" and "perceived usefulness" need to be available in order to successfully introduce new technologies. All applications were easy to use (confirmed by the questionnaires)

and the reflection guidance components were perceived as useful for reflective learning. However, reflective learning itself was not always perceived as immediately useful with respect to the operational work processes, and organisational goals: better support of employees, increase and improve work performance by reflective learning.

7 Reflector: Conceptual Reflection Guidance Framework

7.1 Introduction

In order to be able to develop a general conceptual reflection guidance framework, the insights gained from the literature review (see Chapter 3) and the results acquired through the field studies of the applied in-app reflection guidance concept (see Chapter 5) needs to be taken into consideration.

From the literature review, the following key challenges emerged:
In order to develop an appropriate tool or application for guiding reflective learning, the time of reflection (reflection-in-action vs. reflection-on-action) needs to be taken into account. Prompts are powerful to guide learning activities in learning environments, for working environments it is rather difficult to present a prompt directly supporting the worker's current working task. Diary writing is a very time consuming but at the same time powerful approach to initiate reflective learning in formal learning environments, however, it is difficult to introduce and motivate users to regularly use such a tool in fast-paced and time pressured working environments. Visuals belong also to the tools necessary to consider when discussing tools for guiding reflective learning, however, representing work-related information might be a challenge with regard to tracking working activities, other work-related data or personal data. Certainly, it is of crucial relevance to take care that users have not the feeling of being permanently observed, when introducing such tools or techniques for guiding reflective learning at the workplace.

From the field studies, the subsequent insights could be derived:
Presenting prompts in form of reflective questions (like in the Medical Quiz), reflection interventions and reflection amplifiers (like in the MoodMap App

evaluated in the IT company), and time-triggered or event-triggered prompts (like in KnowSelf) during working or learning activities at the right time can trigger reflective learning. As a consequence, the correct timing of these various prompts is a crucial issue in order to avoid disturbing interruptions of the ongoing work process. This is not trivial at all, as identifying interruptibility is an ongoing research challenge. The contextualisation (applied in the MoodMap App at the call-center) worked very well, however, limiting the possible options to only four choices is too restrictive and asks for both possibilities to provide pre-defined context information adapted to the working environment as well as allow self-defined keywords to cover all other relevant work-related situations. The analysis of the diary entries (in KnowSelf) showed, that with this tool the deepest level of reflection could be achieved. However, it is very difficult to motivate users to regularly write short entries on the one hand because of an increasing workload and on the other hand because they cannot perceive the resulting benefit for themselves at one glance. In this relation it is also important to take the technology acceptance model by [157, 156] into account, that postulates that both "ease of use" and "perceived usefulness" need to be available in order to successfully introduce new technologies like a general applicable reflection guidance framework.

Using these gained insights from the literature research as well as the results of the conducted field studies as starting point, I will present in this chapter a conceptual reflection guidance framework called "Reflector". The goal of this framework is to introduce a technological concept that can provide app-independent reflection guidance.

7.2 Motivation

In literature, there exists already a lot of technological approaches how to activate and motivate people to reflect. Most of these approaches are applied in formal learning environments, for example in schools, at universities or in online courses by using reflection diaries [151], journals [161, 153] or e-Portfolios [2, 33]. In typical learning environment systems (LMS), reflection amplifiers [159] or prompts [28, 27], scripts [118], visuals [16, 14] as well as comparison possibilities like footprints [52, 53] are established to motivate learners to reflect. Reflective learning has also found its way into workplace

environments, where different approaches have been introduced to motivate knowledge-workers to reflect about work-related experiences in order to learn from them [39, 40, 115, 121, 103, 37, 119].

Beside these existing tools and applications, an underlying theoretical model needs to be considered for the development of the "Reflector" framework. As underlying theoretical model serves the "Computer Supported Reflective Learning" Model (CSRL Model) described in Krogstie et al. [87], which is based on the model of Boud et al. [11]. This model was developed to support reflective learning at work and encompasses the following steps: "Plan and do work" (capture and gather data), "Initiate Reflection Session" (Trigger), "Conduct a reflection session" (Guidance), and "Apply Reflection Outcome" (Capture outcomes or actions).

Because reflective learning is a cognitive process based on intrinsic and extrinsic motivation of the individual, it cannot be directly enforced. However, technologically provided triggers are a powerful way to initiate reflective learning. These triggers need to be based on individual user data, need to visualise the data in a sophisticated way and at the right time in order to motivate the user to reflect.

Although there exists several promising tools and technologies to trigger and support reflective learning as well as a number of theoretical concepts and models with regard to reflective learning, an underlying framework or architecture, serving as general basis for technologically supported reflection guidance is still missing.

Therefore, I will introduce a conceptual framework called *"Reflector"*, an underlying basic framework to promote general applicable reflection guidance, to overcome this research gap. The basic idea of the Reflector is to use data captured and stored by different applications in individual user profiles, generate reflection guidance in different variations, feed it back to the application and the corresponding device the user is working with and present it there in a meaningful and sophisticated way. A schematic presentation of how the Reflector should work is presented in Fig. 7.1.

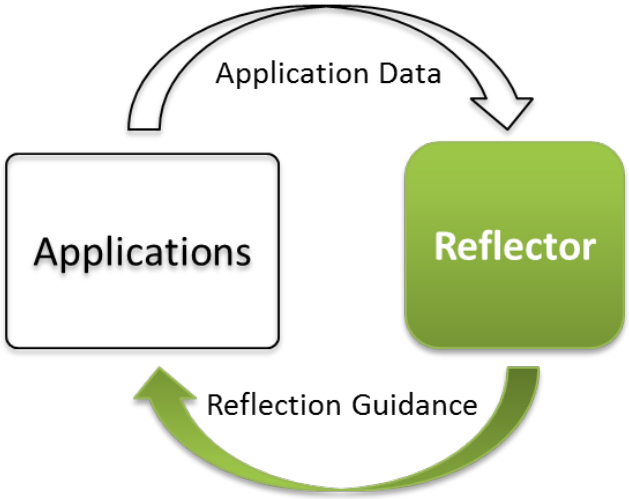


Figure 7.1: Reflector Schema

7.3 The Reflector Framework

The *Reflector* describes a framework of how technological reflection guidance can be provided. The Reflector's task is to analyse captured user data, to detect triggers worth being reflected on, to select the appropriate reflection guidance type and to visualize the trigger in a sophisticated way in the corresponding application. In order to achieve this, the Reflector consists of two main components: (i) *Reflection Engine* and (ii) *Reflection Guidance* as depicted in Figure 7.2. While the Reflection Engine is responsible for detecting triggers based on the available user data, the task of the Reflection Guidance is to present these triggers in a significant and essential way.

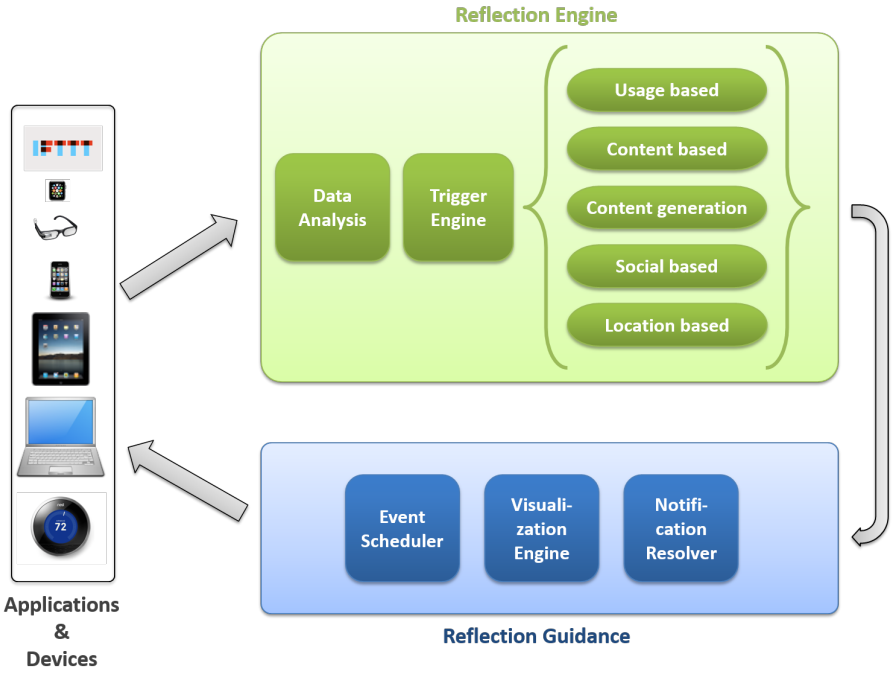


Figure 7.2: Reflector Architecture: Reflection engine and Reflection Guidance

7.4 Reflection Engine: Technical Concept

The major task of the reflection engine is to detect different types of triggers, which might be worth being reflected upon. Triggers can be anything e.g. discrepancies, anomalies, unusual user behaviour as well as situations, locations or social relations worth being reflected on. In the end, a trigger raises the user's awareness and motivates a user to stop the current activity and start to reflect upon it. These triggers can be very varied, manifold and different and are not limited or restricted to any topic or activity. Concrete triggers can be roughly divided into location based triggers, social based triggers, content based triggers as well as content creation triggers or usage based triggers.

These triggers are extracted from different data sources or application data an individual is using during work. In order to extract such a great range of triggers, different underlying technologies, methods and algorithms need to be applied including adaptive hypermedia systems, recommender systems, mobile sensing technologies, learning analytic techniques, and rule-based systems as well as comparing this new data to baseline or historical data. For each of these technologies, a short current state of the art is presented to show how they can contribute to the reflection engine.

7.4.1 Related Work

Adaptive Hypermedia Systems

Brusilovsky [13] investigated extensively Adaptive Hypermedia Systems in the area of education and training. In his work, he started with a literature research to show the development of adaptive hypermedia system over time. Then he explores the nature and mechanisms for adoption and provided several examples like QuizGuide [16]. Following the definition of Brusilovsky [13] *"adaptive hypermedia systems build a model of the goals, preferences and knowledge of each individual user; this model is used throughout the interaction with the user in order to adapt to the needs of that particular user"*. This as well as his work on user models [15] gave valuable insights for the development of the Reflection Engine with regard to user models and the adaptation of systems based on the user's activities.

Recommender Systems

There exists several different types of recommender systems, which use either collaborative filtering, content-based filtering, knowledge-based filtering or hybrid recommendation algorithms to provide users the most relevant documents, objects or persons according the user's current needs. Recommender systems play a crucial role in the area of technology enhanced learning (TEL). In this area, their goal is to support the learner during the learning process. Manoulesis et al. [106] provide a detailed overview on recommender systems in TEL. This overview includes the background of recommender system, related work regarding adaptive educational hypermedia (AEH) and learning

networks (LN), the current status of the development recommender systems in TEL and requirements for their evaluation. Typical recommender systems in the area of TEL recommend matching resources or people in order to support the user's learning goal. Adding context information to a recommender systems opens a new perspective as well as new challenges for the development of intelligent and context-aware recommender systems. Verbert et al. [158] provide a context framework for recommender systems. They analysed existing recommender systems against their framework and outlined directions for future research. Their context classification categories were computing, location, time, physical conditions, activity, resources, user and social relations. Beside classical recommender systems, there exist also approaches, where mobile devices and their integrated sensor data come into play to better personalize the recommendations. In Park et al. [124] they describe a map-based personalization recommender system, using context information captured by a mobile device and a Bayesian Network (BN) to meet the user's preferences. Another approach with the goal to provide more personal-based recommendations in combination with learning networks (LN) is described in Drachsler et al. [31]. They developed an initial model for personal recommender systems by using techniques from conventional recommender systems as well as context information, with the goal to increase the accuracy of personal recommendations.

With regard to reflective learning, there exists only view research approaches based on recommender systems. First approaches, where reflection and action are supported, are described in [24, 48]. Consolvo et al. [24] developed a tool called "Ubifit Garden", with which they try to encourage personal activities by using body sensors data and activity inference data with mobile devices. Their investigations include how the system affects the individuals' everyday lives as well as the interpretation and reflection on the captured physical data. Froehlich et al. [48] developed a tool called "Ubigreen", a personal ambient display providing feedback about sensed and self-reported transportation behaviours in order to make aware of eco-friendly behaviours. Both approaches use sophisticated visualisations to make people reflect about the different data with the goal to change their behaviour - in the area of health and eco-friendly transportation. Another approach how to motivate people to reflect and act with the help of a recommender system is described in Aseniero et al. [4]. They investigated how the stages *Reflection* and *Action* of Li's model [96] might be supported through UbiComp and HCI techniques. Therefore they

used augmented reality lenses which display recommendations for food items based on the person's profile and dietary goals.

From the literature of recommender systems, I assume beside the conventional task of recommender systems not only the ideas of taking into account the user's context information with or without mobile support, but also how visualisations and recommendations can motivate users to reflect.

Learning Analytics

Learning analytics approaches, methodologies and technologies are often closely linked to reflective learning. Learning analytics deals with methods for analysing and detecting patterns within data collected from educational settings or learning environments about the learner, and leverage those methods to support adaptation, personalisation, recommendation, and also reflection. Siemens [144] defined learning analytics as *"the use of intelligent data, learner-produced data, and analysis models to discover information and social connections, and to predict and advise on learning"*. The focus of learning analytics is on the learner support in formal learning settings, while in this work the focus is to support the knowledge worker in any informal learning setting. Approaches like learning dashboards for example described in [32, 141] present an overview of the learner's own learning activities and learning progress often in relation to colleagues at one glance. Such combined visualisations support self-monitoring of learners and awareness for teachers and empowers the learners to reflect on their own activity and that of their peers. Explicit traces (e.g. the learner's entries in a chat or a discussion forum) and implicit traces (e.g. the learner entering a course or clicking on a document or button) stored in the corresponding learner profiles serve here as basis for the aggregation and visualisation of the gathered data. Another idea is presented in Rivera et al. [138], who describe a framework of how quantified self tools can be combined with the theories of reflective learning in order to promote reflective learning and to support the reflective learning process.

As reflective learning and learning analytics are closely related to each other, it is obvious to consider the basic ideas of learning analytics for the development of the reflector.

Mobile Sensing

Mobile sensing is used to automatically track the user's activities with the help of the sensors implemented in mobile devices, wearables etc. For example, Choudhury et al. [22] have developed a Mobile Sensing Platform (MSP) for activity recognition with the help of on-body sensors. Other mobile sensing frameworks can be found in [133, 5, 19].

Mobile devices like smart-phones or tablets, equipped with more and more powerful sensors, are not longer used as communication devices only but are becoming rapidly the central computer of people's lives and can therefore also be used for activity or transportation tracking. Reddy et al. [134] focus in their work on determining the transportation mode of an individual outside with the help of mobile phones. They can distinguish whether the user is stationary, walking, running, biking or in a motorized transportation. Stenneth et al. [148] go one step further. They do not only distinguish between non-motorized transport vs. motorized transport, but they also distinguish between various motorized modes including car, bus, and aboveground train. Other approaches regarding transportation detection can be found in [126, 165, 57].

Other research in this area deal with semantic place detection, where mobile phone sensor data was used to predict the user's semantic place, as described in Lex et al. [95]. Current context information about the user's activities, location and transport detected via mobile devices, might be useful to find an optimal moment to motivate the user to reflect. Furthermore, the current interruptibility of the user has also be taken into account in order to find this suitable moment for starting a reflection process. Work presented by Ho and Intille [70] and Pejovic et al. [127] tried to reduce the burden of being interrupted in different ways (for details see Section 7.5.1). Mobile sensing technologies can also be used to detect people or colleagues nearby, participating in the same event. Miluzzo et al. [112, 113] present in their work the CenceMe application which is able to automatically infer the peoples sensing presence. Therefore they use the users activity, disposition, habits, and surroundings in order to inject the sensing presence in social networks like FaceBook, MySpace etc.

Mobile sensing approaches can be used to detect the right time and place to motivate a user to reflect with the right person on a topic of common interest.

Thus, mobile sensing approaches cover to central issues for developing the reflector frame work, the right timing and a matching person for reflection.

Rule-based Systems

Rule-based systems are one of several approaches of building expert systems and are used for *"codifying the problem solving know-how of human experts"* as defined in Hayes-Roth [65] with the help of rules. Rules are implemented with simple "IF - THEN - ELSE" statements in order to solve complex and well defined problems by applying and inferring rules with the goal to formulate conclusions. An overview of expert systems including the methodology and application of rule-based systems is presented in Liao [98]. Rule-based systems can also be applied in learning environments for adaptive purposes. For example, rules can be developed with the goal to facilitate the individualized access to learning materials according the learner's learning style as described in Karagiannidis et al. [77]. Additionally rule-based systems are also used in the area of intelligent tutoring systems, like described in Hatzilygeroudis and Prentzas [63]. They developed an intelligent tutoring system (ITS) where the knowledge of the expert system is presented in form of hybrid rules (called neurules). The ITS itself consists of a user modelling unit, a pedagogical unit and inference system used for decision making during the teaching process.

Rule-bases systems and especially clever and well defined rules can be used to decide when to motivate a user to reflect. Furthermore, rules provide an easy possibility to define own rules to represent the individual preferences with regard to when and about what to reflect.

Unusual Event Detection by Comparing Data

In literature, there exists different methods and approaches to detect unusual events, based for example on web mining techniques, mobile technologies as well as activity tracking in general.

For the Reflector, web mining techniques can be used to track usual as well as unusual events of a user when browsing the web. Web mining techniques, like described in Srivastava et al. [145], can be seen as *"the process of applying data mining techniques to the discovery of usage patterns from Web data"* and

can be used for content mining, usage mining, and structure mining. Out of these unusual web surfing behaviours or a change of interest in topics might be detected.

Different approaches for behavioural pattern detection exists with regard to mobile devices. Generally spoken, a lot of research from behavioural and social sciences exist that are interested in mobile phone data to better understand real-life phenomena, mobility as well as communication and interaction patterns [123]. For example, Paraskevopoulos et al. [123] studied in the work the call activity and mobility patterns, classified observed similarities aiming at discovering anomalous behaviour. The goal of their work is to identify exceptional situations, to monitor effects with regard to events in large areas. The work of Dong et al. [30] goes in the same direction. They investigated the detection of unusual events form mobile phone data, in particular the call detail records. To achieve this, they estimated the location of the users, observed users moving together or in the same direction in order to detect unusual events. In both cases they try to extract deviations or anomalies from baseline data, which might be worth being considered when developing the Reflector.

With regard to the work in this thesis, the KnowSelf points in the same direction [121, 122]. Tracking directly the activities and resources used at the desktop led to the recognition of deviations form baseline routines and resulted in showing reflection amplifiers. This approach was limited to the activities of one device, however it could serve as starting point and be extended to work not only application overlapping but also device overlapping.

Unusual event detection is also a research topic in the area of knowledge discovery, machine learning and artificial neuronal networks. As these topics are research areas on their own, they will not be elaborated within this thesis as this would go beyond the scope of this thesis.

For this thesis, there is a need to have one approach that is able to decide between the typical working baseline activities of the individual and unusual or anomalous events. And although there exists different approaches for unusual event detection in different scenarios, none of them perfectly matches for the development of the Reflector framework. Thus, this needs to be taken into consideration when developing the Reflector framework in the future.

7.4.2 Reflection Engine

The Reflection Engine consists of the following two components, a *Data Analysis* component and the *Trigger Engine*. The Data Analysis component uses different basic analysis algorithms in order to detect discrepancies, anomalies or unusual user behaviour as well as situations, locations or social relations, which might be transformed into a trigger worth being reflected on. This discovered data is then sent to the trigger engine. The trigger engine collects the data, classifies the data according available trigger types and prepares them as input for the reflection guidance component.

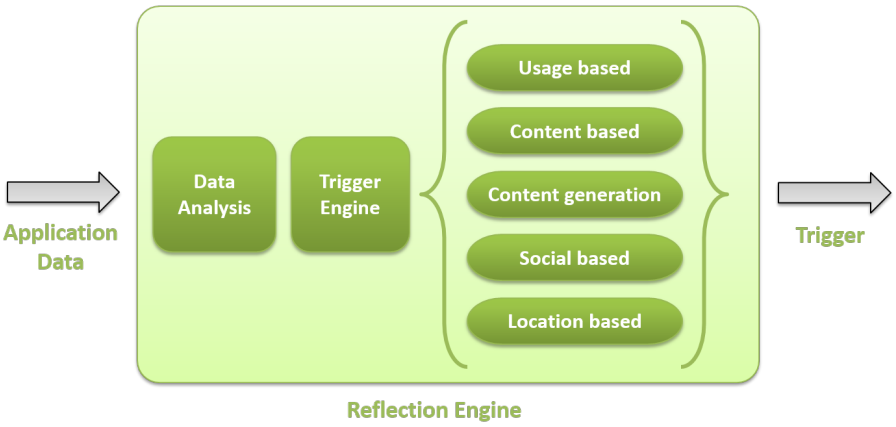


Figure 7.3: Reflection Engine Architecture

Data Analysis

In order to detect discrepancies, anomalies, unusual user behaviour as well as situations, locations or social relations worth being reflected on, the data can be captured and stored for example in an application overlapping user profile of the user, like suggested in Fessl et al. [38]. This data can be captured by different applications used during work, either on mobile devices or desktop computers and serves as starting point for the analysis. The data captured

needs to be analysed against the user's typical working baseline in order to decide between usual working behaviour and unusual events, that might be transferred into a possible trigger. Once the data analysis has detected such unusual events, different methods, approaches and algorithms from various research areas as presented above are used to further specify this significant data.

- *Recommender Systems & Adaptive Systems*: recommender systems are generally used to recommend documents, objects or persons which might be of interest for the current user. These recommendations depend on implicit or explicit traces or actions captured and stored within the user model of the user as well as on ratings or comments inserted by the user or by other users. In the area of technology enhanced learning for example with learning environments the recommendations include additionally the learning goals of the user. Within the reflection engine, a recommender system (using conventional recommendations techniques) might for example recommend documents, items, activities of colleagues worth being reflect on.
- *Learning Analytics*: although learning analytics focus more on formal learning in learning environments, some techniques and methods of how to motivate learners to learn might be also helpful to induce reflective learning in a working environment. Visualising own working activities or tasks during a day, comparing own working activities to the own calendar entries, comparing actual working state with the working goal, comparing own activities with activities of colleagues can be very motivating with regard to triggering reflective learning. Therefore using insights from the research area of learning analytics can lead to the detection of deviations or working patterns relevant for reflection.
- *Mobile Sensing*: mobile sensing technologies can be used to detect on the user's locations and the user's activity. Thus, mobile sensing technologies have the potential to detect the right location and time to make users reflect by using the current context as basis for the user's interruptibility. For example, good location or time for presenting a trigger are, if the user is on the way to work or waiting for an appointment with a physician. Furthermore, mobile technologies can automatically classify events (location, activity, habit, ...) people are taking part in, share this presence in social networks like Facebook or MySpace. Thus the presence of colleagues participating in the same events can be used

to motivate to reflect together about the event.

Beside detecting significant data for reflection automatically, rules can be defined to detect further relevant data:

- *Rule-Based Systems*: the basic technology of rule-based systems can easily be used for the creation of individual rules and thresholds, in order to define when and what kind of data might be worth being reflected on. Depending on the applications used, rules can be defined, for example: a mood switches from positive to negative mood within a specific percentage, the user has not inserted a comment for more than three days, activities of colleagues are higher in terms of percentage than the own ones as well as manually defining places or locations (with GPS data) where the user has usually time to reflect.

Independent of which technology, method or algorithm is used, the goal of all appraoches is to detect discrepancies, anomalies, unusual user behaviour as well as situations, locations or social relations etc. which can raise the awareness of the user and stimulate reflective learning.

Trigger Engine

The task of the Trigger Engine is to process the received data from the data analysis component with the task to create triggers. It categorises given data according one of the six trigger categories described below and depending on this category it chooses a suitable data format. This data format needs to be standardized for each trigger type, but also flexible enough so that the data can be presented in different suitable visualisations provided by the reflection guidance engine.

The detected triggers can be categorized in the following six different types:

- *Usage Based Triggers*: these triggers are based on the knowledge worker's usual interaction and usage of an application. Significant deviations from usual working routines e.g. from no interactions with an application at all until uncommon high activities can cause this triggers. The triggers task can for example be to bring the knowledge worker back to the application or make the worker aware of significant changes in the user behaviour.

- *Content Based Triggers*: in a learning environment these kind of triggers can make the learner aware of her learning progress. In a work environment setting, such triggers can make aware of pages often used by other colleagues working in the same areas, or of pages that are often updated in order to keep knowledge workers up-to-date. Other triggers make aware if a hot debate, which is ongoing in a blog or discussion forum, which might me worth being reflected on.
- *Content generation triggers*: these occur if a user has not inserted a content into an application for a some times. Such prompts can make the knowledge worker aware of thinking about inserting for example a new discussion entry, just entering a mood in the mood tracking application, inserting a new text document in a wiki or reminding of writing a new diary entry.
- *Social Based Triggers*: on the one hand, they make the knowledge worker aware of others' user behaviour or social activities, by for example comparing learning or working progresses or achieved quiz results. These triggers serve as a motivational cue to reflect on these social activities and take corresponding actions. On the other hand, Social Based Triggers can also make aware of other users or colleagues nearby for example attending together an event, and motivate to reflect together about a work-related topic.
- *Location Based Triggers (Interruptibility)*: mobile sensing frameworks use sensors in mobile devices (e.g. indoor and outdoor sensors) that have the task to find out when the worker has time (when the interruptibility is high) to take some actions in one of her applications. This could be for example on her way to work (e.g. using public transportation), while travelling (e.g. in a plane or bus), while waiting for an appointment at the doctor's or while having a coffee break in the office (e.g.indoor localisation). The upcoming trigger should make the worker aware of using one of the installed applications, to reflect on data, to create data or just compare own data with data of colleagues.
- *Manually Created Triggers*: these are triggers, which could be defined by the knowledge worker herself, when she wanted to be informed about significant changes or special events in one of her used applications. This could be drastically mood changes towards a negative mood within her team as well as a higher achieved high score in a quiz than the own score etc.

The detected and processed triggers have to be transferred to the reflection guidance component in order to be prepared and visualized to the user with in the Reflection Guidance.

7.5 Reflection Guidance: Technical Concept

The task of the Reflection Guidance component is to use the incoming triggers, decide which type of notification (e.g. prompt, script, feedback) is applicable for the trigger, select a corresponding visualisation style and decide which trigger is presented within which application used by the user.

7.5.1 Related Work

The literature research presented in Chapter 3 served as starting point for developing the Reflection Guidance component. It includes tools and technologies supporting reflective learning like prompts, journals/ePortfolios/diaries, visuals as well as miscellaneous approaches. In addition, scripts and feedback visuals as well as event scheduling approaches were considered. Furthermore, several design implementations were taken into account to ensure the success of developing a meaningful reflection guidance component.

Summary of Prompts, Journals/ePortfolios/Diaries and Visuals

Section 3.4.1 gives a detailed overview on prompts used to initiate reflective learning. In formal learning settings, there exists lot of literature regarding notifications in form of prompts in order to support students during their learning activities (e.g. for self-regulated learning). These prompts are used to organize or retrieve knowledge, monitor or evaluate knowledge as well as to reflect on student's learning, as presented in [80, 28, 27, 164, 74] to mention some of them. In contrast, in work-related settings, there exists little research on the usage of prompts and their implementation in tools or applications [42, 136]. In both settings, the timing of prompts plays a crucial role. In formal learning environments the perfect timing of prompts is necessary to optimize the learning process [152] of the students, in work-related settings the timing

needs to be adapted according to the user's interruptibility to not disturb the user's work-flow.

Journals/ePortfolios/Diaries are also common tools to foster reflective learning as described in Section 3.4.2. They were mainly used in formal educational settings, like for example in [161, 26, 58, 33]. The major goal of these approaches is to motivate the learner to reflect by asking them to write down their thoughts or to collect artefacts of past experiences for reflective purposes. These tools do mostly not really provide a guidance mechanism for the reflection process itself, but can be seen as relevant tools for reflection, since they save reflective thoughts and notes, which could be re-visited and re-experienced at a later point of time. Although these tools are very promising reflection supporting tools, however the time exposure to manually keep and maintain a reflection diary, journal or e-portfolio is often too high and needs to be carefully considered before being integrated in a work environment.

Scripts and Visual Feedback

Another approach to guide reflective learning can be provided in form of scripts. While prompts present hints, suggestions, reminders or active questions to promote reflection, scripts consist of step-by-step instructions on how to perform some tasks or activities or to collaborate together. In Mäkitalo et al. [104], they use epistemic cooperation scripts (scripts focussing on learning and knowledge construction) to investigate their influence on the amount of discourse, information seeking and learning outcomes in a collaborative learning setting. While learners with script support increased the amount of discourse and decreased information seeking activities, learners without script support achieved the better learning outcomes. Based on the work of Mäkitalo et al., Weinberger et al [162] use besides epistemic scripts also social scripts (scripts to guide and promote interaction of learners) to foster knowledge acquisition in a computer-supported and in a video-conferencing learning environment. The results showe that especially the social scripts are very valuable to support the knowledge acquisition, while the epistemic scripts were not that successful. In Morris et al. [118] they did not only present scripts and prompts for scaffolding collaborative engagement in computer-based learning environments, but they adapted the presented scripts and prompts

to the current role (e.g. predictor, summarizer, questioner and clarifier) of the learner within their team.

Other approaches to support learners with visual indicators focus on navigation support, in order to better guide students or learners through learning environments. This can be divided roughly in adaptive navigational support like in Brusilovsky et al. [16, 14] and in social navigation support described in the recent work Hsiao et al. [71]. In Brusilovsky et al. [16], the adaptive navigational support is provided by adaptive icons automatically selected depending on the user's current knowledge level and the learning goal in a tool called QuizGuide. The icons used a "target-arrow" metaphor meaning the more arrows are in the target, the higher the user's knowledge level. The intensity of the colour represents its relevance according the learning goal. In Brusilovsky et al. [14] they use QuizMap, a TreeMap-based visual interface to provide a combination of open social student modelling data and social navigation support. Two parameters, the colour and the size of individual tiles are used to present the learning performance of a student - orange tiles present the own performance, blue represents the colour of students of the same class. Based on [14], Hsiao et al. [71] provide another approach for learning guidance with social navigation support and open user modelling in order to help students to better find appropriate resources. The developed visualisation presents an easy to grasp view on the own learning progress and comparing own progress directly to the progress of students in the same class.

Event Schedulers

In order to provide meaningful scheduling of different types of notifications and corresponding visualisations, an underlying technology and architecture for sending push notifications has to be taken into consideration. The theses of Hauswirth [64] describe an architectural model and a reference implementation for auch a push system. It also discusses upcoming challenges regarding the widespread deployment of push systems including scalability to large numbers of users in terms of network bandwidth, timely notification of information availability, authenticity and integrity of information, etc. Cugola et al. [25] discuss in their work the publish/subscribe paradigm in relation to mobile computing. Within their research they derived eleven requirements for

a publish/subscribe middleware of large mobile systems, including movement of users while working with the mobile devices (online - offline), different network topologies, large number of information providers, manage high volatility of user's interest, and so on. Also Podnar et al. [128] propose an architecture for a mobile content delivery system including the different on- and offline stati of mobile devices and the handling of duplicate messages.

Another approach regarding automatic notifications in the area of classroom learning was presented in Martinez et al. [107]. In their work they defined a notifications generator, which provides automatically generated notifications for teachers during their lecture with regard to the current learning progress or activities of the students. The goal is to help teachers to better orchestrate the classroom learning by driving their attention and providing relevant feedback to the students on the fly.

While in the classroom setting the sending of automatic notifications is not a problem, especially when the teacher is there to support the students, in a working environment constantly receiving push notifications is by very disruptive during work. Therefore it would be very useful to find out, when there is a good moment for the user to receive a notification and when notifications should be avoided. Automatically measuring the interruptibility of users during work was and is still a challenging research topic. Earlier work focus on the estimation of interruptibility by developing models for interruptibility predictions. Hudson et al. [72] used the Wizard of Oz technique to simulate a wide range of plausible sensors through human coding of audio and video recordings. With the data, they build different models for the interruptibility prediction and are able to test them regarding their effectiveness and by combining different sensors. Based on the same study and the corresponding results, Fogarty et al. [46] present series of studies that quantitatively demonstrate how simple sensors can support the construction of models that estimate human interruptibility. Interruptibility plays also an important role for mobile devices and the related given permanent availability. Ho and Intille [70] tried to reduce the burden of interruption of notifications on mobile devices. Therefore they develope a context-aware mobile computing device to automatically detect activity transitions, in order to send notifications if the user is transitioning between different physical activities, which might indicate a task switch. In Pejovic et al. [127] they investigate suitable moments for interruptions with regard to the user's mobile context (location, movement and time) and the user's internal state (the engagement in a specific

activity, social environment and emotion). They developed and evaluated a smartphone library for intelligent interruption called InterruptMe. This library shows high potential to detect opportune moments for interruption, however the user's sentiment with regard to the interruption load needs to be considered as well.

7.5.2 Implications for the design

In order to be able to design useful and essential guidance for reflective learning, different design implications have to be taken into consideration.

The underlying architecture has to fulfil the necessary requirements to implement a push notification system for the notifications. Therefore an underlying architecture has to be chosen, which is able to deal with most of the conventional challenges regarding the publish/subscribe paradigm for mobile devices. These challenges include i) different on- and offline stati, ii) sending notifications at once to a multitude of devices, iii) save notifications in a queue for the user if the devices are offline, iv) avoid sending the same notification twice, v) choose a meaningful timespan between different notifications (do not bother the user with too many notifications).

Bannert et al. [7] have defined the following three general principles to design successful notifications for self-regulated learning, which needs also to be considered for the development of the Reflection Guidance component of the Reflector: (i) the notification should be integrated with the domain specific instructions for learning (and not be taught separately), (ii) the self-regulated learning strategies including their usefulness must be explicitly explained to the students, and (iii) the students need to have enough time to internalize these skills before they can be successfully applied. Further implications include that the sent notifications are i) easy to understand for the user at a glance, ii) manifold to make the user curious about the next one, iii) not sent too often and iv) sent at the right time (interruptibility).

7.5.3 Reflection Guidance

The detected triggers of the *Reflection Engine*, serve as input for the *Reflection Guidance* component. Based on these incoming triggers, the Reflection

Guidance has to perform the following three tasks.

First, the *Notification Resolver* has to decide with which type of notification the trigger can be presented. Second, the *Visualisation Engine* selects the style of presentation depending on the notification type and on the presentation device (mobile device or desktop pc). And third, the *Event Scheduler* decides which notification and visualisation type is shown depending on the timing (how often and when to present it), on the content of the trigger (keep it diversified) and on the interruptibility.

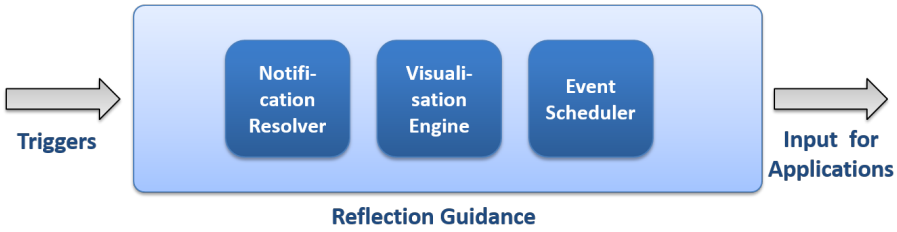


Figure 7.4: Reflection Guidance Architecture

The *Notification Resolver* decides, which trigger can be presented by using which type of notification out of the following list:

- *Reflection Amplifiers or Prompts*: are push messages, which consists either of questions, actions or motivational purposes regarding the available data e.g. making aware of significant mood changes in the MoodMap App.
- *Scripts*: are similar to prompts but contain detailed step-by-step guidelines for action and reflection, for example containing example scenarios or a kind of action script.
- *Reports with activities*: summarize gathered data of a specific period of time and provide suggestions on these data for improvement e.g. presenting a weekly overview of the applications and resources used like in KnowSelf.
- *Footprints and Comparison*: they present all explicitly and implicitly taken activities within a system for motivational purposes. The show own activities with regard to the activities of colleagues as motivational cue

to reflect e.g. present the own learning progress or own activities in comparison to others.

Depending on the notification type, the *Visualisation Engine* decides how to visualize the chosen notification. The visualisation depends on i) the application where the notification will be presented in, ii) the interruptibility, if a user has time to react on the scaffold or if the user is currently intensively working and iii) in the individual user settings, if specified.

The visualisations can be divided into the following four groups:

- *Push notifications*: these are simple pop-ups, which present some text or question or motivate to perform a direct action. Such an action could be to directly insert an answer to a posed question, open a specific view in an application and perform some activities there or just make aware of ongoing activities in the application worth being examined by the user.
- *Silent notifications*: these notifications are used to inform users about the same activities like with the push notifications, but in an unobtrusive way. These notifications are used when the interruptibility is very low. Silent notifications could be shown by inserting an image (e.g. a small animated image) or by changing the colour of an icon (e.g. in the task bar) depending on the urgency of the reflection guidance (e.g. red represented a very urgent notification, while blue represents an notification worth being reflected on in a later point of time).
- *Integrated graphical feedback*: is directly integrated in the visualisation of the applications. This could be navigational hints in form of colour or images making aware of changes in some areas or views of the application. This could also be presenting footprints and comparison views that make directly aware of situations worth being reflected on.
- *Customized recurrent notifications*: they can be defined by the user including the type and how often they should be presented for example at the end of the day or week. Also the information they should contain and the type of visualisation can be customized by the user.

The task of the *Event Scheduler* is to chose, which of the possible trigger, its notification type and its visualization, is shown to the user. This decision depends on the application, where the notification should be displayed in, on the interruptibility of the user as well as on previously presented notification, triggers and visualisations used. Furthermore timing, user behaviour and diversity play a crucial role for scheduling the right trigger at the right time.

It is important to not bother the user with notification. If notifications occur too often, they will be perceived as annoying and will therefore be ignored. Secondly if the interruptibility is low, a silent notification should be used, in order to not disrupt the user during the work. Disruption during work is a major reason to not follow the notifications and ignore them at all. And third, the presented triggers should be diversified in order to make and keep users curious and enthusiastic about the triggers.

7.6 Discussion

The discussion of the "Reflector" is structured along the two main components, the Reflection Engine and the Reflection Guidance components. Furthermore, to round up this thesis, the third discussion section - a self-reflection section - focus on the impact the "Reflector" might have on the first developed reflection guidance concept and its conceptualisation as adaptive components in the different applications.

7.6.1 Reflector Engine

For the data analysis, there exists a vast amount of algorithms from different research areas, which can be applied for analysing the data and detecting discrepancies, anomalies or unusual user behaviour as well as situations, locations or social relations, which might be transformed into a trigger. However there are two crucial questions which emerge when talking about data analysis for initiating reflection: *"How to cope with such a huge amount of data with regard to storage and analysis?"* and *"Which data might be worth being reflected on?"*

For the first question, the research area of big data analytics can provide solutions. On the one hand, there already exists corresponding hardware and software like Hadoop distriubted file systems (HDFS)[1], which is especially developed for distributed storage and processing of large data sets on computer clusters. In addition, there exists different frameworks for processing big data

[1] *http://hadoop.apache.org/*

like for example Spark[2], hadoop Map Reduce[3], Storm[4] or Flink[5]. On the other hand, there emerge systems like Splunk [6], who searches, monitors and analysis machine generated big data on the fly, to detect data patterns, providing metrics, diagnosing problems and providing intelligence for business operations. Especially the second approach might be of interest for data analysis with regard to reflective learning, because only aggregated data pointing at some significant or suspicious data might be worth being stored.

This leads to the second question, which data might be worth being reflected on. There is no single, unique answer to this question, however, there are several types of data, which have shown to be of relevance for users to reflect on. However, this list just name the three most important ones.

- *Discrepancies*: Data which shows deviations including unusual activities during work (compared to the baseline), new locations or social relations as well as deviations from routinised standard behaviour, significant increment or loss of work performance, successful as well as unsuccessful project meetings etc.
- *Comparison*: Motivational purpose to initiate reflection is to compare the own behaviour, progress, performance, mood, quiz results etc. with "best practices". Especially, revealing significant differences can result in a boost of motivation for reflection.
- *Recommendations*: Situations or data, which were relevant for many other users with regard to reflective learning, might also be recommended for reflection.

Although these types might be worth being reflected on, not all users will be attracted by all types of data in the same way.

7.6.2 Reflection Guidance

The Reflection Guidance component's task is to present the reflection guidance approach in a meaningful and sophisticated way to the user. However,

[2] *http://sparkjava.com/*
[3] *http://www.tutorialspoint.com/hadoop/hadoop_mapreduce.htm*
[4] *http://storm.apache.org/*
[5] *https://flink.apache.org/*
[6] *http://www.splunk.com/*

unobtrusive integration in working environments it not trivial at all and any automatically generated guidance needs to be very well and sensitively considered. There arise three major questions, which are closely related to each other: *"When should the trigger be presented during work?"*, *"How should the trigger be presented?"* and *"On which device should the trigger be presented on?"*.

At a first glance for the first question, the obvious answer would be: whenever the user has time. This sounds logically, however it is not very easy to find out when the user has time to reflect. Has a user time to reflect, when she is reading emails? Has a user time to reflect, when she is only seldom using the mouse or the keyboard (e.g. reading a paper)? Has a user time to reflect, when she is browsing through different web sites? Has a user time to reflect, when she is at a specific place? For all these questions the answers could be yes or no - depending on what the user is currently working on (or not).
Thus, the current user context plays a crucial role, and needs to be taken in consideration when establishing the timing for the presentation of guidance components. This refers to the investigation of the user's current interruptibility, which is still a challenging research question and for which no final or unique solution exits [72, 46, 70, 127]. However, the right timing of when to present reflection guidance components in form of triggers is of crucial relevance to successfully motivate users to reflect. If, for example, a prompt interrupts the user in an intensive working phase, the user will get annoyed and will ignore the prompts as a whole.

Second, not only the perfect timing plays a crucial role, but also how to present which type of notification. Prompts or reflection amplifiers, pushing directly up during predefined activities work very well in educational settings in combination with working environments. In such a case, the prompt can be associated with a specific task and thus perfectly match with the users activity (like for example in [28, 27, 74]). As tasks during work are often not exactly predefined, often depend on the current project or the use of various technologies, it is difficult to present notifications that are perfectly applied to the current working task.
During intensive working activities, silent notifications or integrated graphical feedback can be a good option for making the user aware that triggers for reflection were detected, but in an unobtrusive way. Silent notifications can for example occur in the task bar or in the working environment in form of a special icon or sign. When the user has time for reflection she can click on it and the trigger is shown. The advantage of such a silent notification is that

it does not interrupt the work-flow of the user and that the user can reflect whenever she has time to do so. This type of notification can be very successful if the user's intrinsic motivation for reflection is high and the user is actively involved in reflective learning. However, the user's intrinsic motivation to reflect has to be taken into consideration.
Integrated graphical feedback, automatically adapted to currently detected triggers, can make aware of discrepancies, changes, or significant situations etc. at one glance (like for example presented in [52, 53, 56]). The advantage is, that the visualisation is directly integrated in the working environment. Following this visualisation with peripheral awareness, does not disturb the user's work-flow, and the user can directly reflect on it if something significant happen. However, the visualisation must be very intuitive that changes or differences can be immediately recognized by the user.
Customized reoccurring notifications have the advantage that the user can specify them according her individual preferences and needs. On the one hand, the user can select the data or information she is interested in. She can define rules and thresholds when she wants to be notified about the trigger and the notification type. Additionally, she can determine how often (e.g. daily, weekly) and at what time of the day or week the notifications should occur. The advantage of the customisation is that the user defines herself what about and when to reflect. However, if the user allows only customized notifications, the presented reflection guidance components and the detected data will be very restricted and other new or relevant possibilities for reflection might be missed.
In order to keep the motivation for reflection high, triggers should not become annoying or boring. Disturbing the user regularly during work reduces the motivation to reflect in the same way as boredom, which occur when always similar triggers and recurring notification types are used. Triggers and notification types need to show variety, surprises, curiosity and tension in order to keep the joy and motivation for reflection high and to make reflection guidance components a successful tool.
To achieve this, statistical analysis of the usage of the reflection guidance components can help to find out, what worked well and which components were dismissed. Analysis of answers can be used to extract the achieved reflection level. User feedback in form of ratings or assessments can be requested and used for improving and adapting the presented reflection guidance components. In addition, to figure out if the reflection guidance components achieved some long-term changes or significant learning effects, some meta-reflection

questions asking explicitly for behavioural changes or perceived improvements taken in the last months or years need to be integrated and evaluated.

The third questions, where attention needs to be paid to, is the multitude of devices, where the reflection guidance can be presented on. Today, the work of a user is not limited to her desktop PC in the office alone, instead a user can work with several devices including notebook, smart phones, tablets or smart watches. On the one hand, this needs considerations on how to present triggers on the corresponding devices, because there exists various claims for different devices. On the other hand, there needs to be a sophisticated event scheduler in order to not present the same triggers on all devices at the same time, but to carefully distribute the triggers and the notification types to the devices the user is currently working with.

7.6.3 Self-reflection: Improvements on the First Developed Reflection Guidance Concept and its Components

The Reflector framework would have significant influence on the first developed reflection guidance concept presented in Chapter 5. This influence will be shortly discussed with relation to its positive influence on the presentented "reflection-in-action", "reflection-on-action" and "intertwined reflection" components.

For the "reflection-in-action" components, this influence can be summarized as follows:

Reflection Interventions: The reflection intervention can be better adapted to the user's needs as the framework collects a lot of information about the current user and the user's current working context. Thus, the task of the intervention is not longer to motivate the user only to use an application, but also to use different types of motivation perfectly matched to the user's preferences. Taking into account the user's answers to such prompts, the corresponding notification type (e.g. silent notifications, push notification) as well as the user's behaviour during or after a prompt and statistical analysis can lead to reflection interventions perfectly tailored to the user's needs and preferences.

Reflection Amplifiers: The reflection amplifiers can be enhanced in the same way as the reflection interventions. Furthermore, the reflection amplifiers, which make aware of deviations from standard behaviour, unusual working patterns or other significant situations, can be more effective as they can also be enriched with further information provided by the reflector framework. These enhancements include not only information collected within a single application but triggers emerging and created across data collected within different applications (e.g. combine MMA data with KnowSelf information) as well as providing individual information (e.g. individual knowledge level) in comparison to colleagues (e.g. knowledge level of colleagues).

In addition, for both types of prompts, the user can determine rules of when and how to present reflection interventions and reflection amplifiers. Furthermore, she can define topics, patterns or information, she would like to reflect upon and others she is not interested at all. Additionally, through the detection of different types of triggers, like usage based triggers, content based triggers, content generation triggers, social based triggers and location based triggers, the prompts will become more manifold and diversified. In the end, the combination of automatically created prompts and manually defined rules can lead to more efficient prompts, result in more reflective learning and as a consequence result in more beneficial outcomes for the user herself.

For the "reflection-on-action" components, this influence can be summarized as follows:

Reports: The framework provides much more information than the three single applications did. Therefore, the created reports can present much more information at a glance by combining the collected data to make aware on deviations, unusual behaviours or significant work patterns. Using visualisations like dashboards out of learning analytics, enriching it with information of mobile sensing technologies (e.g. which time was spent on which location and with whom) and recommender systems (e.g. recommending further literature for learning, colleagues attending similar events or working on similar work related topics), can provide the user a very detailed overview of significant working activities during a day, week or month worth being reflected on.

Reflection Diaries: a reflection diary on its own is not influenced directly by the framework. However, providing much more manifold and various triggers and more detailed reports with situations or experiences worth being reflected

on might raise the motivation of the individual to note down and store the insights within the diary.

For the "intertwined" components, this influence can be summarized as follows:

Contextualisation: The mandatory contextualisation, did work very well, however there was room for improvement. The framework, on the one hand, can automatically recommend further options directly extracted of the user's working context like for example project related context, the current user's location, or an event the user is participating in with a colleague. Additionally, adapting also the subsequent reflection amplifier questions to the selected context (if possible), can motiviate the user to additionally to add more reflective thoughts.

7.7 Conclusion

In this chapter, a general applicable reflection guidance framework called "Reflector" was presented. It consists of two major components, the Reflection Engine, which is responsible for data analysis to detect significant data out of which a trigger can be generated, and the Reflection Guidance, which has to present the detected trigger in a sophisticated and unobtrusive way.

The Trigger Engine needs to analyse a huge amount of data in order to detect discrepancies, provide comparison possibilities and suggest recommendations, worth being reflected on. To achieve this, the engine needs to be built upon big data analysis techniques and already implemented algorithms and techniques from well investigated research areas like recommender systems, learning analytics, mobile sensing as well as rule based systems. As a consequence, different types of triggers like usage based triggers, content based triggers, content generation triggers, social based triggers and location based triggers can be created to stimulate reflective learning.

The Reflection Guidance needs to visualize the detected triggers in an unobtrusive way. This means that a trigger should be presented at the right time, presenting the right content matching the users current work situation and use various way of notifying the user about the detected trigger. This will keep

the motivation and the curiosity of the user high and will boost the chances that the user will really reflect about the presented trigger.

Finally the impact on the first developed reflection guidance concept were discussed an resulted in the following assumptions for being improved: All components of the first developed reflection guidance concept would be improved and enhanced by collecting and analysing more data captured across different applications. As a result the motivation for reflective learning would be raised, as the presented components would be tailord to the users need and fulfil the users' individual preferences with regard to when to present which component.

8 Conclusion

This theses is motivated by the question on how to provide meaningful and sophisticated technologically supported reflection guidance in order to trigger reflective learning at the workplace.

The research method applied followed the design cycle approach by Hevner et al. [69, 67, 68]. Altogether fifteen field studies consisting of one focus group, two design studies, six formative field studies and and six summative field studies were conducted in different work-related settings. Field studies together with an extensive literature research led to the development of five iteration cycles for the developed applications. Finally the thesis resulted in 9 publications (6 accepted, 2 under major revision, 1 submitted). These empirical investigations in different working environments and with different applications lead to the development of a first applied in-app reflection guidance concept and subsequent to the development of the "Reflector", a general applicable reflection guidance framework.

8.1 Research Questions

In order to achieve the goal of this thesis, three main research questions were posed and their answers represent the main contributions of this work:

RQ1: What are the key challenges in order to provide meaningful technological support for guiding reflective learning at work?

Research Question 1 is answered in Chapter 3 and P8 ([36]) by doing an extensive literature on research technologies and tools supporting reflective learning. This analysis of the vast body of literature found according the

four dimensions - timing of reflection, participants for reflection, reflection guidance and success criteria for stimulating reflective learning - impacts mainly on the definition of guidelines and recommendations as prerequisites for successfully guiding reflective learning.

During the literature review the following main key challenges emerged:

- *Reflection-in-action vs. reflection-on-action*: The timing of reflection needs to be carefully considered with regard to selecting the right tool to trigger reflective learning. "Reflection-in-action" support can be provided by tools, which ask during an activity or task for reflection, while "reflection-on-action" tools ask for input after the action is over. As there exists a number of different tools supporting both types of reflection, it is a key challenge to select the right tools for initiating reflective learning. Especially, to choose the right tool at the right time strongly depends on the working environment, the current activity and the current context of the user.
- *Prompts or reflection amplifiers*: These tools are well investigated in learning environments. In such settings, prompts benefit from the fact that activities and tasks of the learners are known beforehand and that the prompts can easily be adapted according to these activities. In contrast, in a work-related settings the tasks are not always known beforehand or only vaguely known. Therefore it is a key challenge to present a prompt supporting the worker's working task with the right question at the right time.
- *Diaries, journals and ePortfolios*: These tools have in common that they are very time-consuming in being kept and maintained. In educational settings (e.g. education in nursing and medicine as well as athletics training), they showed evidence that these kind of tools can serve as powerful learning tools. In contrast, most workplaces are very stressful and work-intensive, thus the introduction of an additional, time-consuming tool like a journal or diary can increase the already existing workload of the individual knowledge worker. Therefore, it is a key challenge to detect, if and how time consuming approaches like diaries or journals can be applied in work-related settings.
- *Visuals*: Visuals of any kind are very well investigated in learning environments with regard to the individual learning progress or learning activities in learning environments. In contrast, in work-related settings,

visuals are rarely used to motivate knowledge workers to reflect on working tasks. On the one hand, it is a challenge to track working activities (e.g. application and resources usage during work), other work related data (e.g. who talks with whom) or personal data (e.g. health data like heart rate or blood pressure) during work, which might be worth being reflected on. On the other hand it is a challenge to present these data in such a meaningful way, that visuals motivate knowledge workers to reflect.

The key challenges derived from the literature, provide a theoretical underpinning, which need to be overcome in order to successful initiate reflective learning at the workplace.

RQ2: Which technologies are most suitable for providing reflection guidance in order to trigger reflective learning?

The second research questions is answered in Chapter 5 as well as in P6 ([42]) and P7 ([43](under major revision)). The newly developed applications and the implemented in-app reflection guidance concept were evaluated in different work related settings. Reflection-in-action and reflection-on-action components in form of prompts, mandatory contextualisation, as well as reflective diaries are successful technologies to guide reflective learning.

The four field studies give evidence that the different reflection guidance components were able to trigger reflective learning.

- *Reflection interventions and reflection amplifiers*: Reflection interventions as well as reflection amplifiers showed evidence to initiate reflective learning when being presented at the right time. By integrating reflective questions at the beginning, during and at the end of the quiz, the results confirmed that reflective learning could be triggered. In KnowSelf, the general reminder to reflect about the data in the app and the notification about the most used resources were positively evaluated. Thus the correct timing of reflection interventions and reflection amplifiers is a key challenge that needs to be fulfilled in order to initiate reflective learning in order to avoid disturbing interruptions of an ongoing work process and instead motivates to reflect. However, this timing is not trivial at all, as identifying interruptibility is an ongoing research challenge.

- *Contextualisation*: The contextualisation in the MoodMap App work well, especially with a combination of reflection amplifiers to motivate users to think on the selected context. The contextualisation possibilities were adapted the user's reoccurring working tasks of the user, however, limiting these possibilities to only four choices was seen as too restrictive. Therefore, combining predefined context possibilities of reoccurring working tasks with free adaptable context in form of self-defined keywords will encompass all relevant situations and make the contextualisation a powerful reflection tool.
- *Diaries*: The reflection diary was only used in KnowSelf. The analysis of the diary entries of KnowSelf showed that the deepest level of reflection could be achieved meaning that the users got insights from reflection and were able to derive conclusions for their work. Thus, using a diary is a real useful tool to trigger successful reflective learning, however it is very difficult to motivate users to really use a diary during work. What is missing is a quick apparent and obvious benefit for the user which immediately convince a users to keep a reflective diary as it can improve own work over longer period of time.
- *Technological Success*: For long-term adoption and from a technological point of view, the technology acceptance model [157, 156] postulates that both "ease of use" and "perceived usefulness" need to be available in order to successfully introduce new technologies. All applications were easy to use (confirmed by the questionnaires) and the reflection guidance components were perceived as useful for reflective learning. However, reflective learning itself was not always perceived as immediately useful with respect to the operational work processes and organisational goals. Thus, before introducing technologies to support reflective learning, there needs to be a motivational strategy that raises the user's intrinsic motivation to reflect and shows that reflective learning is powerful learning strategy to improve their own work.

RQ3: What are the core components and architecture for a general applicable reflection guidance framework?

The third research questions is answered in Chapter 7. The presented reflection guidance framework can be seen as kind of a technical summary of the insights gained from the implemented and evaluated reflection guidance concept. It

consists of a the Reflection Engine for data analysis and trigger creation and a Reflection Guidance presenting the detected triggers in the right time, in a sophisticated way and at the corresponding device.

The Trigger Engine needs to analyse a huge amount of data in order to detect discrepancies, provide comparison possibilities and suggest recommendations, worth being reflected on. To achieve this, the engine needs to be built upon big data analysis techniques and already implemented algorithms and techniques from well investigated research areas like recommender systems, learning analytics, mobile sensing as well as rule based systems. As a consequence, different types of triggers like usage based triggers, content based triggers, content generation triggers, social based triggers and location based triggers can be created to stimulate reflective learning.

The Reflection Guidance needs to visualize the detected triggers in an unobtrusive way. This means that a trigger should be presented at the right time, presenting the right content matching the users current work situation and use various ways of notifying the user about the detected trigger. This will keep the motivation and the curiosity of the user high and will boost the chances that the user will really reflect about the presented trigger.

These two components can be seen as the core components for developing a general applicable reflection guidance framework. While the first is detecting the triggers and the second presents the detected triggers, they are closely connected to each other through their mutual interplay they are a powerful framework to stimulate individual reflective learning.

In summary, this thesis presents an in-app reflection guidance concept, implemented in different new developed applications and evaluated in various heterogeneous working environments. Out of these a conceptual reflection guidance framework called “Reflector” has been elaborated, including requirements, lessons learned and necessary features for providing meaningful technologically supported reflection guidance. And although the “Reflector” has not been implemented yet, it promises to be a very well considered concept and serves as base for the generalisation of providing meaningful technologically supported reflection guidance.

8.2 Self-Reflection about this thesis: Lessons Learned

After having designed, developed, implemented, refined and evaluated the developed in-app reflection guidance concept in different applications and derived a general applicable reflection guidance framework, and after having written up this thesis, it is time to self-reflect about the development of the thesis and to summarize the most important insights.

Lessons learned with regard to the implementation of the different applications and the implementation of the concept can be summarized as follows :

- *On-site user studies*: In order to develop a tool or application tailored to the needs of the company and possible future users it is necessary to invite them to participate in the development and design process right from the beginning. To do so, first start with on-site user studies to find out how the target participants conduct their work and where the application might be effectively and efficiently introduced to support the participants during work. Conduct focus groups and workshops to find out what would make sense, which kind of tool is realistic to be developed and introduced in the targeted working environment. With regard to the development of the Medical Quiz for nurses working at a stroke unit, this approach has worked pretty well.
- *Participatory design for the applications*: When having a first idea of the application prepare paper-based mockups, and conduct design workshops on-site to discuss possible features, functionalities and integration scenarios for the application in the work-related setting. For the MoodMap App we conduced such a workshop after the first field study. It has been shown that doing the design workshop at first and conducting a field study afterwards is more efficient and effective for the application development. This was confirmed when preparing the summative field study of the MoodMap App for the call-center setting.

Lessons learned with regard to reflective learning and the conducted field studies can be summarized as follows:

- *Introducing reflective learning*: Reflective learning is a cognitive process based on intrinsic and extrinsic motivation of the individual. Thus reflective learning cannot be directly enforced, but tools and technologies

can provide guidance for reflection. When trying to evaluate such a cognitive process, it is of crucial relevance that all field study participants get a detailed introduction about the investigated cognitive concept, and should have afterwards a common understanding of what the concept of reflective learning is. Thus, the preparation of field studies needs to be done very thoroughly. Furthermore, it is highly recommended that the introduction to the participants is done by the responsible researchers. For the introduction it is also important to have enough time, to answer all upcoming questions and to provide all necessary information to take the participants on board for the evaluation. This approach worked well for the KnowSelf field studies.

- *Show a clear benefit*: In order to motivate participants to reflect about working activities, past experiences etc. and to conduct successful evaluations, provide them a clear benefit. As a researcher, try to answer the most often occurred question during the field studies right from the beginning as boost of motivation, namely *"What is in for me?"* as participant, in order to convince the participants that they really want to participate in the study.
- *Management support*: When setting up a field study, it is of crucial relevance that the management or the superiors are involved and convinced about the success of the the field study. To get the management or superiors on board, include them in the preparations, tailor the field study to their needs as long as it is in line with the planned research goal, develop together with them a clear benefit either for the individual participants, for the team/department or for the organisation.

Lessons learned with regard to scientific rigor can be summarized as follows:

- *Literature Review*: In order to build this thesis on the current state of the art, it is highly recommendable to do an extensive literature review in the beginning of the research. This will give the researcher a good overview on the research topic in general right from the beginning. When writing up this thesis, it crystallized that repeating such a review with focus on the own work supported the writing process of the thesis significantly. As the in-app reflection guidance concept evolved over time and crystallized rather late to be the core topic of my thesis after having been working on individual reflective learning for two years, such a first literature review on reflection guidance in general was not possible .

8.3 Future Work

The literature review (see Section 3) and the applied and evaluated in-app reflection guidance concept (see Section 6) resulted in insights and prerequisites for providing meaningful technological guidance for reflective learning. and led to the development of a general applicable reflection guidance framework called "Reflector'. The developed in-app reflection guidance concept can be seen as a first generalisable starting point on how to systematically initiate reflective learning at work. What is still missing is a kind of detailed step-by-step guideline which always leads to reflective learning. Thus, further investigations are necessary on how to make all components of the concept successful reflective learning components. This includes beside the perfect timing also the best matching content or data worth being reflected on and demands for the implementation of the "Reflector" framework.

At the moment, this framework is only available as a technological concept, the major open challenge it its real implementation. Out of literature, we know that most of the necessary technologies are already available, however, before being able to implement such a framework the following research topics need to be further investigated:

- *Baseline measurement vs. Discrepancies*: For the detection of discrepancies worth being reflected on, it needs to be defined, when a working behaviour can be seen as discrepancy and when it is a usual behaviour.
- *Interruptibility*: The right timing of when to motivate users to reflect with reflection-in-action components on working activities without interrupting the current workflow is still an open research challenge. This is not trivial at all, as identifying interruptibility is still an ongoing research challenge [70, 127].
- *Application Overlapping User Profiles*: Another open challenge, which needs further investigation before being able to develop the "Reflector", is the common storage of individual data created by different applications across different devices. Big data storage systems and algorithms on how to pre-process big data already exists. In addition, the research area of life-long user models is also well investigated [15, 17, 18, 78]. However, an application overlapping user profile is still an open issue, and needs to take into account data security and privacy.

The work of my thesis brought the research in the area of how to provide technologically supported reflection guidance at work one step further, however, there are still some challenges left, which need be addressed in future research.

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9 Appendix A

All application descriptions presented in this Appendix have been conducted within the EU Project "MIRROR - Reflective Learning at Work" and are taken out of the deliverable "D9.5 Part B - User Manuals of MIRROR Apps" [1]. The MoodMap App and the Medical Quiz were written under notable participation of the author. The description of KnowSelf was not written by the author and is added to complete the description of all applications. This appendix covers a detailed description of the final prototypes of the MoodMap App (V3.0) and the Medical Quiz (V2.0), both developed and evaluated with regard to reflective learning and the implemented reflection guidance concept. For KnowSelf, which was not developed by the author, only a short description will be provided encompassing the main functionality of the application and the implemented reflection guidance components.

9.1 MoodMap App V3.0

9.1.1 Introduction

The MoodMap App was motivated by the needs of addressing emotional aspects in reflective learning. As we know from Boud et al. [11], emotions play a powerful role in the reflection process, as they are used to attend to feelings when revisiting past situations. These feelings, positive as well as negative, could lead to a re-evaluation of past experiences and in the end to a change of behaviour. The MoodMap App provides the user with the possibility to capture and contextualize her mood during a working day or within specific situations like meetings. Exploring the captured moods, on an individual as well as on a collaborative level, could initiate the reflective learning process. In collaborative settings, the MoodMap App allows seeing

the mood of others in an anonymised manner, which in the end could also be a starting point for reflective learning. The mood representation within the MoodMap App (called mood map) is based on the Circumplex Model of Affect by Russel [139]. This model distinguishes between valence (negative to positive feeling) and arousal (low to high energy). Each mood can be understood as a linear combination of these two dimensions, or as varying degrees of both valence and arousal. The mood map has as background a gradient of colours, which are associated to the main moods placed in each of the quadrants of the map. This representation is based on Itten's colour system [76], which was adjusted to fit Russell's Circumplex Model of Affect (see [147]). This mood representation was chosen because it offers a simplified way of assessing mood (based in two numerical components) but it does not limit users offering only a set of discrete mood variables (e.g. taxonomies or smileys). A theoretical derivation of the mood representation in the MoodMap App is given in Mora et al. [116].

9.1.2 Overview of the Main Functionalities

The main functionalities of the MoodMap App are:

1. *User Administration*: Registration of new users and login functionality.
2. *Capturing Mood*: In the MoodMap App a two-dimensional colour coded representation called mood map is used directly for mood capturing and is carried on throughout all representations of recorded mood as well. In the moodlist, next to the mood map, the user has the possibility to add and edit notes about her moods. Additionally, a smiley representation mirrors the last selected mood status.
3. *MoodMap Views*: With the individual views, users can review their own mood by replaying the sequence of mood entries in the My Mood section or along a timeline. There exist two collaborative views, Compare Me and Collaborate, where the user has the possibility to compare her individual mood to the average moods of her colleagues.
4. *Team Views*: Three TeamViews visualise the individual mood stati in an non-anonymized way. TeamViews are only accessible for superiors.
5. *Meetings and Meeting Reports*: Before capturing a mood, the user has the possibility to select a meeting, to which the mood will be attached. Two

types of meeting reports are available to let users re-experience past meetings.

6. *Reflection Guidance Concept*: Different components of the developed reflection guidance concept were implemented in the MoodMap App. They encompass Reflection Amplifiers, Reflection Interventions, Contextualisation as well as a Reflection diary. item *Other features*: The About button covers general information about the MoodMap App, the Info button contains more concrete information for the MoodMap App usage.

9.1.3 User Administration

When entering the MoodMap App for the first time, the user has to register (see register form in Figure 9.1). User's full name, email address, MIRROR participant code, username as well as password are required for the registration. Additionally, the user can state her email settings concerning meeting reports. She can decide if she would like to receive emails or not, and if yes, which information about the meetings an email should contain. With the sharing settings, the user can decide if she wants to share her stated moods and in which way. Finally, the user has to select which team(s) she belongs to and which is her team role. After doing the registration, the user is automatically redirected to a welcome page and then to the MoodMap App where she can start capturing her mood. If a user has already an account, she has to log in before being able to capture her mood.

9.1.4 Capturing Mood

In the MoodMap App, a two-dimensional colour coded representation called mood map is used directly for mood capturing and is carried on throughout all representations of recorded mood as well. When entering the MoodMap App, the "Capture Mood" view is opened, so that the user can express her mood by clicking at the appropriate area of the mood map. If it is the first time that the user enters the application in a certain day, she receives an invitation (called reflection intervention) to insert the first mood of the day (Figure 9.2a). Because no mood was inserted yet, a neutral smiley is presented.

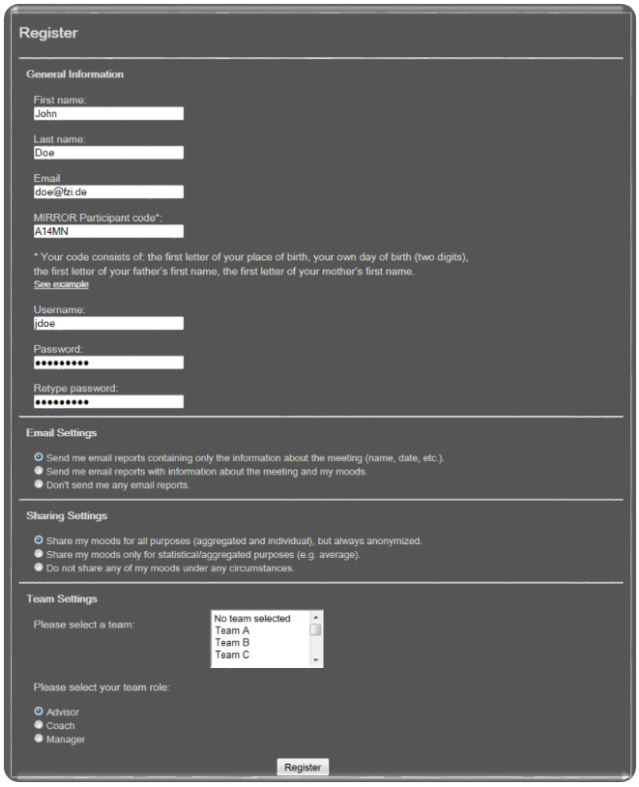
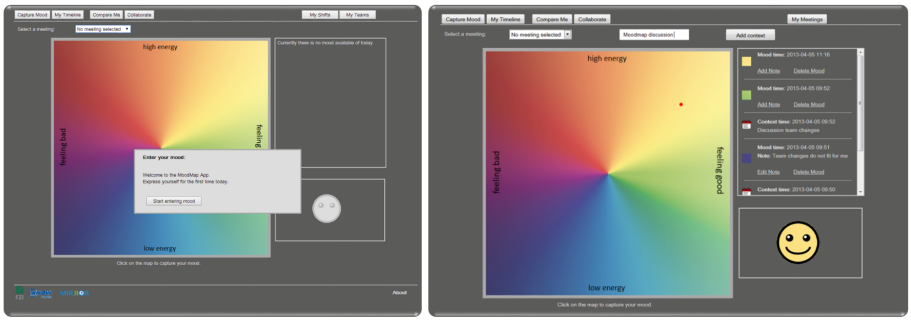


Figure 9.1: User administration: Registration form for a new MoodMap user.

As soon as the user expresses a mood within the MoodMap App, it appears in the moodlist (see Figure 9.2b on the right). An entry in the moodlist has a timestamp and shows the colour of the captured mood. Notes can be added to any mood in this moodlist, e.g., to comment on the mood or add any appreciation. Below the moodlist (see Figure 9.2b on the right), each inserted mood is also represented in form of a smiley. The bigger the smiley is, the more energy the user has, and the more it smiles, the better the user is feeling. The colour of the smiley corresponds to the colour of the point in the mood map that the user has clicked before.



a) MoodMap App when entering the app for the first time

b) MoodMap App after having captured several moods

Figure 9.2: Capturing Mood

Above the mood map, four buttons allow to switch between the different visualisations of the MoodMap App. If the logged in user is a manager or coach, an additional button “My Teams” is presented beside the Meetings or Shift functionality (Figure 9.2a).

9.1.5 Individual and Collaborative MoodMap Views

Apart from the moodlist, which shows the user’s moods, comments and context information chronologically, users can also review this data along a timeline (see Figure 9.3). Each mood point is split into its two values, the feeling and the energy value (formally known as valence and arousal respectively). The blue line in the figure represents the feeling level, whereas the red line shows the energy level. The value of the y-axis goes from 0 to 1 representing the state from very low to very high feeling and energy values. The x-axis represents the time. If a mood point has an attached note, it will be shown when the mouse moves over the point in the timeline. If context information was added in the “Capturing Mood” view, it is added to the bottom part of the timeline. By moving the mouse over the context symbol, the context information is displayed. If numerous mood points are shown in the timeline within a short time span (e.g. a minute), the user can zoom in by

selecting the according points in the timeline visualisation (holding the mouse while selecting the fragment of the timeline that should be zoomed).

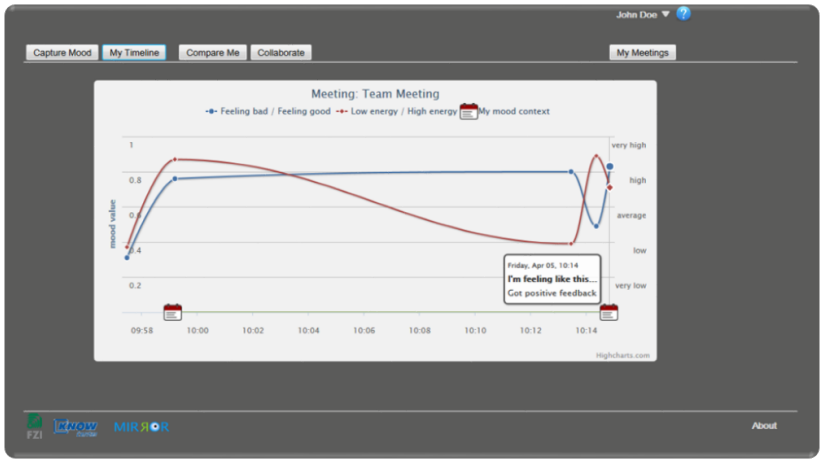
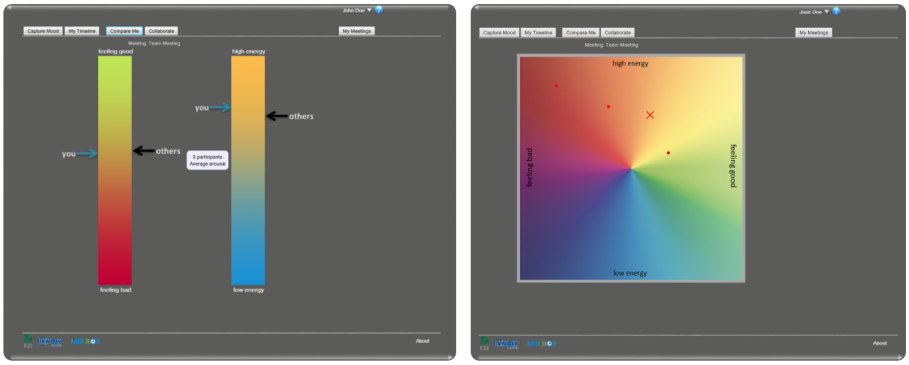


Figure 9.3: Timeline View: Users track their own mood and review it along a timeline

Besides the individual views, the MoodMap App provides also two views at collaborative level. Every user can compare her own mood with the mood of other colleagues or team members using the "Compare Me" visualisation (see Figure 9.4a). In order to facilitate this comparison, both feeling and energy values are represented separately through bars. The bar on the left shows your feeling levels (from good to bad) whereas the bar on the right shows your energy levels (from low to high energy). The vertical bars represent the range of values. On each bar, the blue arrow on the left represents the individual user's value, whereas the black arrow on the right shows the average value. The average values for both consist of the average over all latest entries from all users (calculated separately for feeling and energy values). In case the user is in a meeting, the average mood considers all participants in the meeting. By passing the mouse over the arrows, the user will get more information about the current number of participants. In the "Collaborate" view (see Figure 9.4b), a large red cross placed on the mood map shows the average of the latest mood entries of all users. By clicking this cross, the distribution of the anonymous individual entries (small red dots) is shown. With this view,

users can get an overall impression of the team's mood, besides seeing in a more precise way, if all participants have similar moods.



a) Compare Me View: Every user can compare her own mood with the average team mood on the feeling as well as the energy level

b) Collaborate View: Users see the average mood and distribution of individual moods in the two-dimensional colour-coded mood map

Figure 9.4: Collaborative Views: Users track their own mood and review it along a timeline

9.1.6 Team Views

If a user is logged in as a manager or a coach, there are three team visualisations available: "Team Day", "Daily Timeline" and "Weekly Timeline". These views give the manager the possibility to gain more insights about the mood of each individual team member and at the same time get an impression of the team as a whole. Figure 9.5a presents the "Team Day" visualization with the current mood of each team member in form of a smiley. The size of the smiley represents the energy level i.e. the bigger the smiley the higher is the energy value. The expression of the smiley represents the feeling level i.e. the more a smiley smiles, the better is the feeling of the individual whereas a sad smiley represents a negative feeling of the user. Additionally, the colour of the smiley is the same as the corresponding point in the mood map. When clicking on a smiley, the timeline is opened representing the energy and feeling development of the selected user of the corresponding day (see bottom part

of Figure 9.5a). The visualisation "Daily Timeline" is shown in Figure 9.5b, with all single mood points of each user on the timeline and the average development of the team moods (continuous line). This view gives the manager a possibility to see how the single mood points developed during the whole day according to the energy and the feeling levels of the whole team.

a) Team Day view: Smiley visualisation of each individual team member.

b) Daily Timeline: Development of the moods of all team members.

Figure 9.5: Team Views: Team Day (left) and Daily Timeline (right)

The third team view "Weekly Timeline" (Figure 9.6) shows the mood development of each single team member along the whole week. By clicking on the "Feeling" and "Energy" of each member team in the legend, the energy and feeling levels of each person can be added or removed of the timeline as required. When clicking on the "Hide all" button, all individual energy and feeling lines are removed and only the average energy and feeling lines of the whole team is displayed. Below the timeline visualisation a pie chart visualisation per team member is shown. Each pie chart represents the total number of captured moods and the percentage of moods that were attached to each type of context – according to the options available in the contextualisation of

moods.

b) Weekly timeline: mood development of each single team member during the whole week (up) and distribution of types of mood contexts for each team member (bottom).

Figure 9.6: Team View: Weekly Timeline

9.1.7 Meetings

Before capturing a mood, the user has the possibility to select a meeting or shift to which all captured moods will be attached. When clicking on the drop-down menu (see Figure 9.7), all available meetings for the current user are presented in a list. Only currently ongoing meetings and those which will take place in the future will be presented here. By clicking on one meeting title, the meeting is selected, and all further inserted mood points are assigned to this meeting. If no meeting is selected, the mood is stored in relationship to the current day. All other visualisations like "My Timeline", "Compare Me" and "Collaborate" will also show the information of the currently selected meeting or shift.

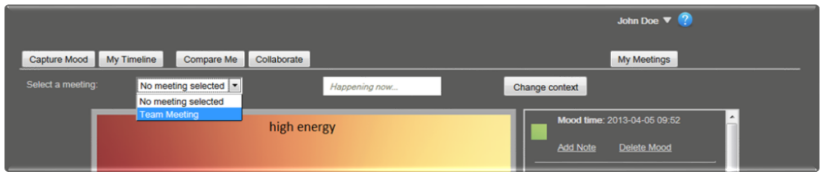


Figure 9.7: Capture Mood: Select a meeting to capture your moods

Every user has the possibility to create a meeting (see Figure 9.8). When entering the "My Meetings" tab, the user can create a new meeting, edit an existing meeting or create a new meeting based on the configuration of an existing meeting. A meeting can only be modified by its moderator and its creator. Users who are only participants of a meeting are not allowed to change the settings of the meeting. When creating a new meeting, the user should first define the type of the planned meeting and indicate the name of the meeting. Afterwards, different meeting place options are available, namely teleconference, video conference, web-based meeting, face-to-face and other. The next step is to define a beginning and end date and time. The user can also select a moderator for the meeting (per default the current user is set as moderator). The meeting creator can inform the moderator and the added participants via mail about the creaetd meeting. The creator of the meeting can also define two reflection settings: if the collaborative views are accessible during the meeting and if she wants that reflection interventions and amplifiers appear during the meeting.

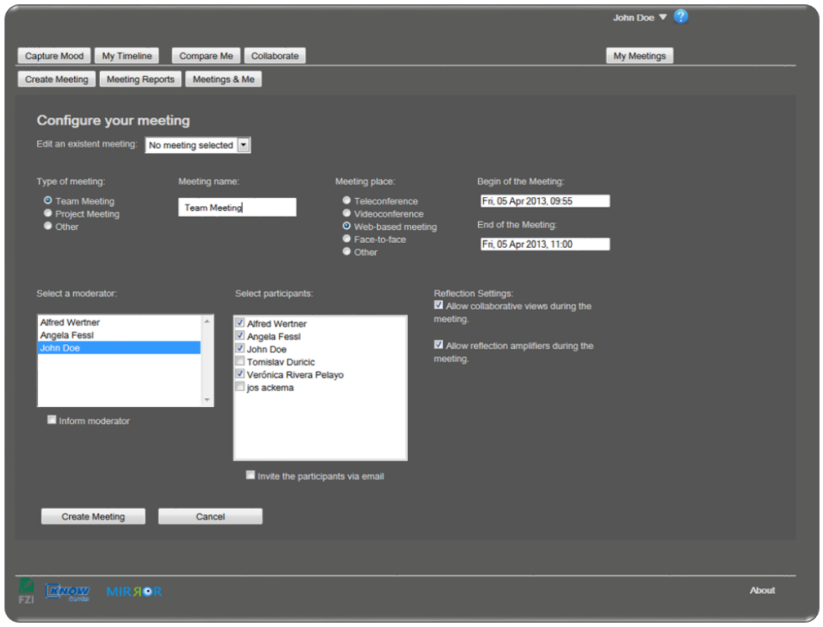


Figure 9.8: Create Meeting: Every user can create a new meeting, or update an existing one.

9.1.8 Meeting Report

When a meeting is over, the user has the chance to visit two types of meeting reports. The “Meeting Reports” and the “Meetings & Me” report, which are both accessible via the “My Meetings” tab. The “Meeting Reports“ provides you information about the past meeting and the captured moods of the participants, whereas the “Meetings & Me” offers a comparison of your mood during the meeting and that of your colleagues (team mood). The select box in the upper left part of Figur 9.9 provides all meetings you have ever participated in. The last attended meeting is automatically selected. General information of the meeting is presented including the meeting date, the duration, the moderator as well as the meeting type and place and the number of participants. The “Meeting Mood News” visualizes relevant mood changes, which were detected automatically during the meeting. These changes refer

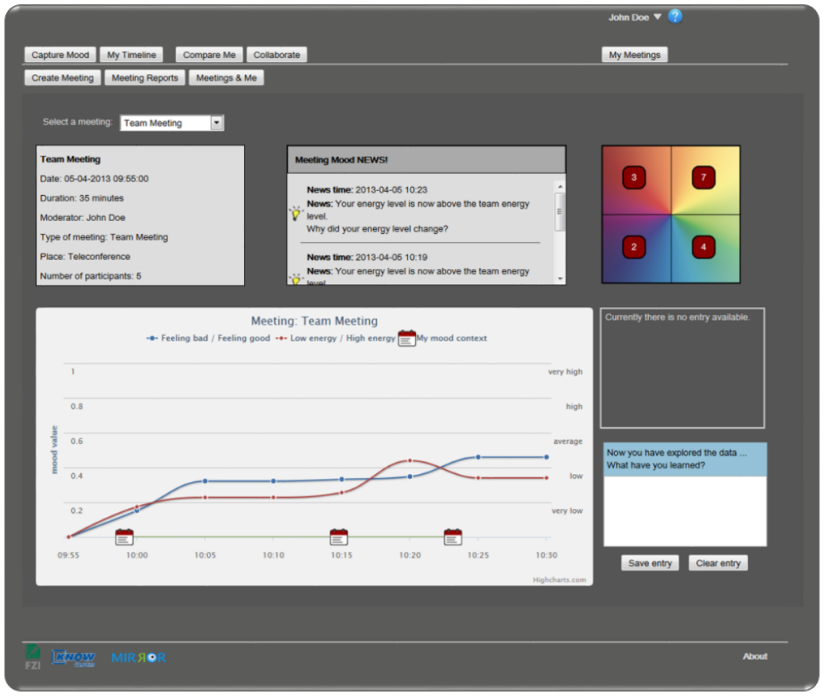


Figure 9.9: Meeting Report: Visit the meeting report after the end of a meeting, in order to reflect about the meeting mood development.

to significant individual mood changes, but also to noticeable deviations of the individual mood from the average team mood. The small picture of the mood map shows the number of mood points that were entered by the participants in each quadrant during the whole meeting. The timeline including the individual context information shows the average team mood development over the meeting time. Using this information, users can reflect about the whole meeting, e.g. bringing together the meeting mood news with the average mood on the timeline, or seeing the mood distribution of the whole meeting might lead to personal insights or thoughts. These thoughts could then be inserted into the Reflection Journal , which gathers all the insights that the user can gain by exploring the data.

The "Meetings & Me" report (see Figure 9.10) provides information about what happened during the meeting in relation to the user's individual mood. Through the select box with all the meetings a user has ever participated in she can select which report is visualized. In each report, the "Meeting Mood News" is shown, analogue to the previous "Meeting Reports". Additionally, two timelines with the corresponding context information are visible. The first timeline represents the feeling level, where the individual feeling development and the average collaborative feeling development are represented in two separated lines (light and dark blue respectively). The second timeline covers the energy values, showing the individual (light red) as well as the average energy (dark red) levels of the team are separately. These visualisations facilitate the direct comparison of the individual to the average collaborative mood development. Reflecting on the data and associating them with the "Meeting Mood News" might lead to new insights. These insights can also be stored in the reflection journal, which the user can revisit later.

9.1.9 Email Functionality

In the user settings there is the possibility to configure the email settings. The following three email settings are available:

- *Send me email reports containing only the information about the meeting (name, date, etc.)*: if an email is sent to the user, it will only consist of general information about the meeting e.g. the name of the meeting, the date of the meeting or the number of participants. Additionally a link will be available to go directly to the "Meeting Report" section in the MoodMap application. An example of this meeting is depicted in Figure 9.11.
- *Send me email reports with information about the meeting and my moods:* if an email is sent to the user, it will encompass besides general meeting information also information about the individual mood development during the meeting. This mail will also contain a link to the corresponding meeting within the MoodMap application.
- *Don't send me any email reports*: when selecting this option, the current user will not receive any emails of the MoodMap application containing reports about the meetings.

Figure 9.10: Meetings and Me: Visit the Meetings and Me report after the end of a meeting, in order to compare your mood development to the average meeting mood.

9.1.10 Reflection Guidance Components

All components of the reflection guidance concept (see Section 5.3) were implemented in the MoodMap App.

The **Reflection Interventions** (RIs) occur automatically when a user enters the MMA for the first time of a day or when the user enters a meeting for the first time (see Fig. 9.12a). After having inserted a mood, these types of prompts will not show up again, until the next day or another new meeting was entered.

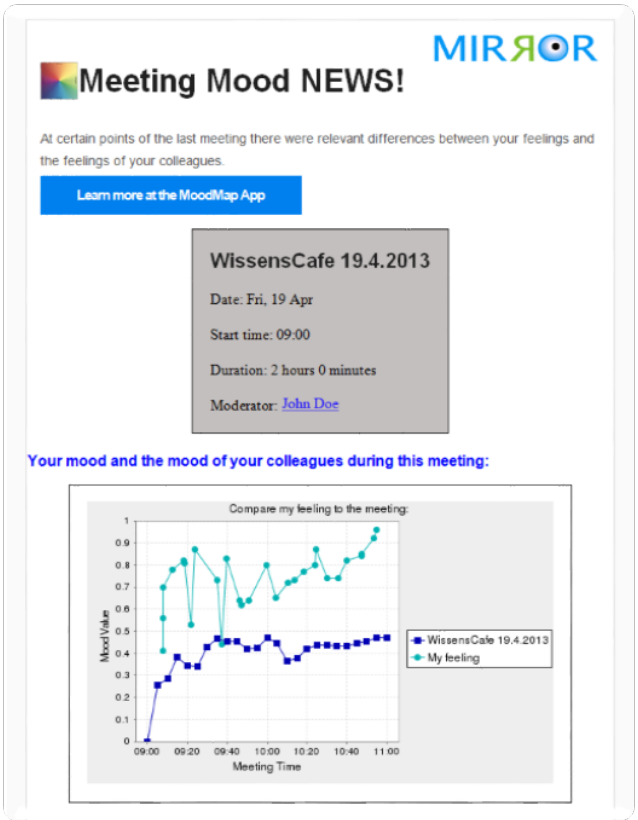


Figure 9.11: Email containing information a meeting and the mood of the participants

At the end of a meeting a prompt was shown, which motivates for reviewing the mood development of the past meeting either via mail including the most relevant summarized meeting information or by directly visiting one of the two available reports (as shown in Fig. 9.2a).

Reflection Amplifiers (RAs) automatically pop up during the application usage to motivate users to reflect about her current mood. This is done by making the user aware of a significant mood change of the own mood but

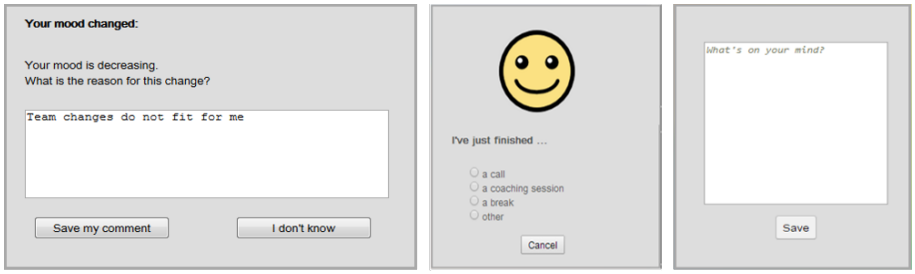


Figure 9.12: Reflection intervention, reflection amplifier and context

also in relation to the collaborative mood and by directly asking for input (see Fig. 9.12b). The changes on the individual level encompass significant increments or decrements of the valence or arousal level from one mood to the next one. Comparing the user's mood to the average team mood makes the user aware of significant deviations. In both cases, the user is asked for the reason of the change or deviation e.g. why the energy level raised, or why her mood is much better than the average team mood. Table 9.1 summarizes all RIs and RAs on an individual and team level implemented in the MMA.

Contextualisation was implemented in two ways. First, it was implemented in an optional way, meaning that whenever the user wanted to add a relevant context information to a stated mood, she could directly add the context in the text field directly above the moodmap (see Fig. 9.2a, left beside the "Add context" button). Second, it was implemented in a mandatory way. This means, that whenever a user stated a mood, a prompt for a context selection occurred as shown in Fig. 9.12c. After having selected the context, an reflection amplifier occurred asking questions like "What's on your mind?", "What are you doing?" or "Why do you feel like this?" as motivational trigger to reflect.

As mentioned before, two different types of **reports** with an integrated reflection journal wwere also included in the MoodMap App (see Section 9.1.8).

Table 9.1: Reflection Interventions (RI) and Reflection Amplifiers (RA) on an individual (I) and collaborative (C) level implemented in the MoodMap App

Type	Level	Prompt text
RI 1	I	Welcome to the MoodMap App. Express yourself for the first time today.
RI 2	I	Welcome to the meeting: "nameOfTheMeeting". Express yourself for the first time of the meeting.
RI 4	I	Add your thoughts to your last inserted mood.
RI 3	I	The meeting is over now. I want to have an email notification with the most relevant meeting information. I want to see the meeting report now.
RA 1	I	You are more energized now, but you are not feeling very good. What happened?
RA 2	I	Your energy level decreases, but your feeling is quite good. Why did it change?
RA 3	I	Your mood is decreasing. What is the reason for this change?
RA 4	C	Your feeling is more positive than the average team mood. What is the reason for this?
RA 5	C	Your feeling is more negative than the average team mood. Why do you feel so bad?
RA 6	C	Your energy level is now above the team energy level. Why did your energy level change?
RA 7	C	Your energy level is now below the team energy level. What happened?
RA 8	C	Your mood changed to a more positive mood than the team mood. What was the reason for this change?
RA 9	C	Your mood is much more energized than the team mood. What is the reason for this?
RA 10	C	Your mood is much more positive than the team mood. What happened?
RA 11	C	Your mood is significantly below the average team mood. What is the reason for such a bad mood?

9.1.11 Further Features

Two further buttons containing general information about the MoodMap App are available, namely the Info button on the top right corner and the About button on the lower-right-hand corner. Whereas the About button covers general information about the objectives and the development of the MoodMap App, the Info button contains more concrete information for the

MoodMap App usage. Whenever the Info button is selected, the content of the opening dialog box is adapted to the current MoodMap App view, explaining the usage and meaning of the concrete visualization.

9.1.12 Implementation

The MoodMap application is based on a client-server architecture (see Figure 9.13). The client is implemented as an AJAX Web application. The server consists of several services for data management and the database containing all the data. Client and server communicate via remote procedure calls (RPC).

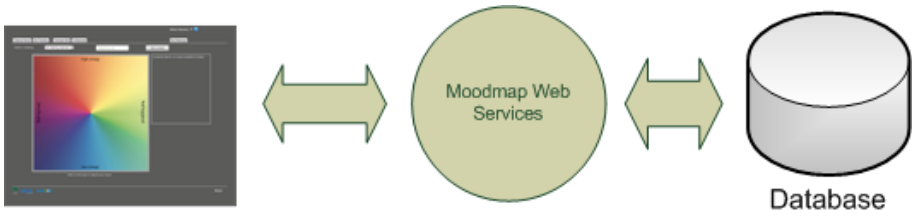


Figure 9.13: MoodMap App Architecture

Client Server Interface

The MoodMap App Interface defines the GUI that allows users to interact with the application. The Google Web Toolkit (GWT) offers the necessary methods for the execution of requests made by the client and their routing to the right service hosted by the server. RPC mechanisms are completely transparent and handled by GWT.

Client

The MoodMap App client is implemented in Java. The Google Web Toolkit is responsible for the compilation of the Java code into a deployable Web

application based on JavaScript and CSS. From a developers' point of view, this facilitates the process of building a Web application, as only Java code is written. The Web application is hosted by Apache Tomcat .

Server

The MoodMap App server takes care of the data management. Therefore it provides the necessary services as well as the database. Each service provides methods which carry out a specific task. Each task communicates with the database to read and write data. The database used to manage the MoodMap data is Virtuoso, which is an open source database engine. Virtuoso provides data management based on the RDF and SPARQL query language standard. Virtuoso offers everything common relation databases can do. Additional benefits include the reuse of existing vocabulary (sioc, foaf) when designing the MoodMap App data model as well as easy installation and maintenance.

9.2 Medical Quiz V2.0

9.2.1 Introduction

The Medical Quiz is an application especially developed for nurses working at a stroke unit. It is intended to support individual reflection on basis of the nurses' knowledge relevant for their work. The goal of the Medical Quiz is to initiate individual reflection or at least motivate players to think about their experiences or significant situations during their work. The quiz questions should bring the users to reflect about the content of the question, how easy it was to answer the questions, if they would need further information about the addressed content etc. To facilitate the reflective learning process itself, several reflection questions were integrated into the quiz.

9.2.2 Overview of the Main Functionalitiess

The Medical Quiz consists of four different quiz types:

- "Quiz-against-time" (German title: "Quiz gegen die Zeit")
- "Quiz-of-20" (German title: "20er Quiz")
- "Quiz-of-10" (German title: "10er Quiz")
- "Quiz-of-5" (German title: "5er Quiz")

In the first quiz type, the players have five minutes time to answer as many questions as possible. In the other three quizzes, twenty, ten or five quiz questions were posed in a randomized order. In the background we have two different databases, one for the content (medical) questions, one for each of the reflection questions (at the beginning, during and at the end of the quiz). For all quizzes 142 content-based questions will be randomly chosen out of the data base and are presented in random order to the player. The content questions are multiple-choice or single-choice questions, whereas all the reflection questions are text based questions.

9.2.3 How to Use the App

The Medical Quiz is accessible at "http://moodle.know-center.tugraz.at". After entering the page, please login with your account. Then the user is redirected to the welcome page of the quiz.

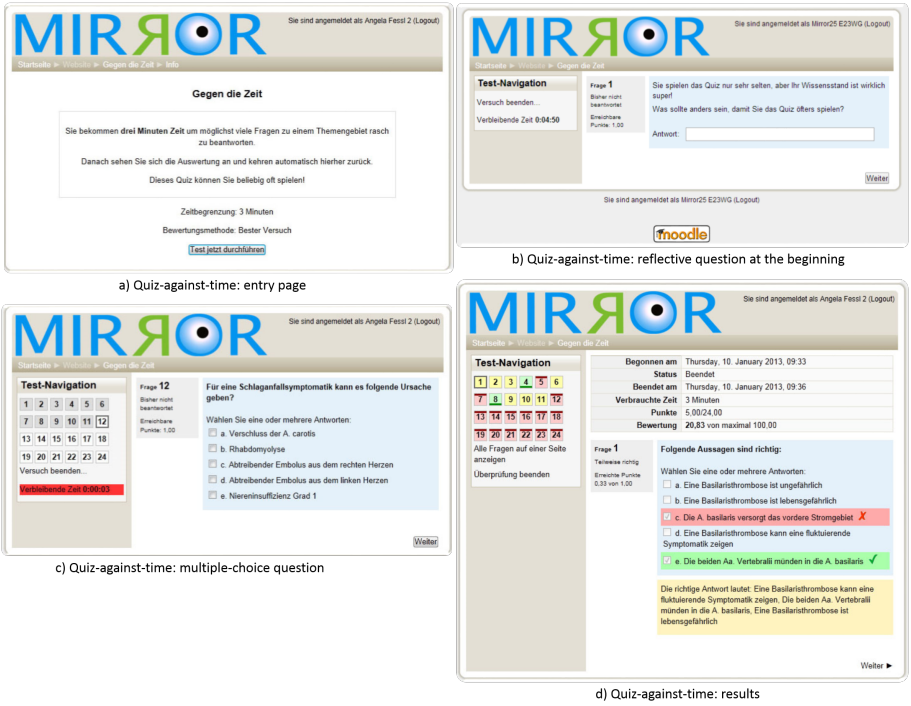
On the "Welcome Page" (see Figure 9.14), the left side presents the four quizzes and on the right side there is the navigation bar. The navigation bar consists of two different discussion forums, one for feedback for the quiz itself and one for the discussion of work related topics. Additionally a "Hilfe" page is available, describing the most relevant features of the quiz. The page "Einstiegsfragen" was only relevant for the evaluation of the quiz and will not be described further.

9.2.4 Quiz-against-time

Figure 9.15a shows the starting point of the "Quiz-against-time". Is gives you an overview about the quiz and that there are five minutes left, to answer as many questions as possible. If a user has already played this quiz, an overview of the achieved results is added to this page. By clicking on the "Test jetzt durchführen" Button, the quiz is started as shown in the left upper picture.

Figure 9.14: Medical Quiz Welcome Page

After having started the quiz, the quiz questions are presented as shown in Figure 9.15c. In left part of the figure, the "Test-Navigation" presents the number of the current quiz question. Below this "Test Navigation" the remaining time to play the quiz is displayed. The less time is left the timer changes the background colour from white over light-red to red (see lower left screenshot). After the time has run out, the player is automatically redirected to the results (see Figure 9.15d). She has then the possibility to see at once, which questions she got right, wrong or, in the case of questions that have multiple answers, partially correct. Green means, that the question was correctly answered, yellow shows that the answer was partially correct and red means that either the answer is wrong or that the question was not answered at. All trials are stored, and before entering one of the quizzes the results are presented to the user, so that the user can consequently reflection on her learning progress.



a) Quiz-against-time: entry page

b) Quiz-against-time: reflective question at the beginning

c) Quiz-against-time: multiple-choice question

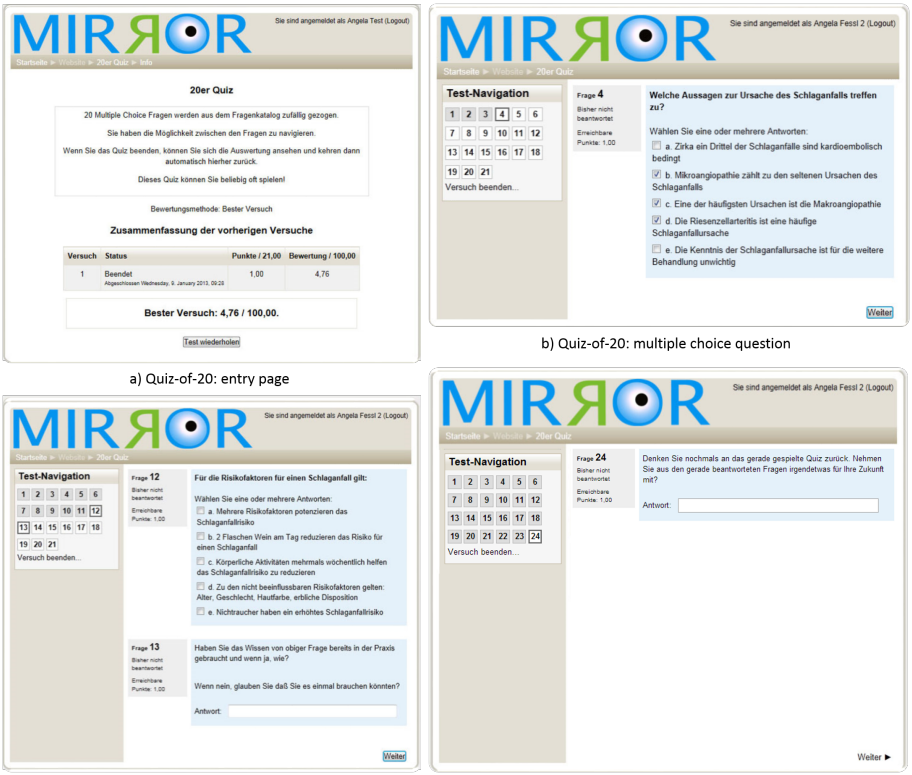
d) Quiz-against-time: results

Figure 9.15: Quiz-against-time

9.2.5 Quiz-of-20, Quiz-of-10 and Quiz-of-5

The Quiz-of-20 consists of 20 randomized questions relevant for work at a stroke unit. The Quiz-of-10 and the Quiz-of-5 work in the same way as the Quiz-of-20, but the Quiz-of-10 contains only 10 and the Quiz-of-5 only 5 randomly posed questions. In Figure 9.16a the entry point for the Quiz-of-20 is presented. After clicking on "Test wiederholen", the user enters the quiz, which is shown in Figure 9.16b. In the navigation part, you see the number of the currently presented question, so that you always know at one glance, which questions you have already answered. After having answered all questions, the player gets the result of all the questions. She has then the

possibility to see at once, which questions she got right, wrong or, in the case of questions that have multiple answers, partially correct. Green means, that the question was correctly answered, yellow shows that the answer was partially correct and red means that either the answer is wrong or that the question was not answered at. All trials were stored, so that the user can consequently see her learning progress, when playing a new quiz.



a) Quiz-of-20: entry page

b) Quiz-of-20: multiple choice question

c) Quiz-of-20: in-between reflective question

d) Quiz-of-20: reflective question at the end

Figure 9.16: Quiz-of-20

9.2.6 Reflection Guidance Components

The Medical Quiz was enriched with open reflective questions. These questions aim at triggering reflective learning at different points of time during the quiz play, thus they were posed at the beginning, during, and at the end of a quiz.

The reflective question at the beginning of each quiz motivate to reflect about the results achieved in previously played quizzes. This type of question is automatically adapted to the knowledge level (based on the results of the previously played quizzes) and the usage frequency (how often the user played the quiz) of the user (see Figure 9.15b). The question is composed of an introduction statement followed by a reflective question. Examples are: *"Your knowledge is very constant. Think about and describe shortly, how you could further improve your knowledge?"* or *"You are very motivated and you play the quiz at least once per week - you results are really very good. What is your success recipe?"*. Table 9.2 presents the all introduction statements depending on the knowledge level. Table 9.3 presents the all introduction statements depending on the knowledge level in combination with the usage frequency. Table 9.4 presents all reflective questions at the beginning of the quiz enrich one of the selected introduction statements.

Table 9.2: Introduction statements only depending on the knowledge level.

Knowledge Level Status (KL)	**Introduction Statement**
Increase high (h)	Congratulations, your knowledge level is very high.
Constant	Your knowledge is very constant.
Constant high (c)	Congratulations, your knowledge level is very good.
Decrease	Unfortunately your state of knowledge is very low.

The in-between questions (only available in the Quiz-of-20) are presented together with a content-based question (see Figure 9.16c). They aim at focussing on the content-based questions and how these content-based question refers to past working situations and working experiences. Examples are *"If you reflect with the help of the above posed question about a situation during work or the*

Table 9.3: Introduction statements depending on the knowledge level and the usage frequency.

Knowledge Level Status (KL)	User Frequency Status (UF)	Introduction Statement
high	high	You are very motivated and you play the quiz at least once per week - your results are really very good.
medium	high	You are very motivated and you play the quiz at least once per week - you results are rather good, but can be further improved.
low	high	You are very motivated and you play the quiz at least once per week – your results are not yet so good, but can be improved for sure.
high	medium	You play the quiz only from time to time, but your results are really very good.
medium	medium	You play the quiz only from time to time, but your results are rather good and can be improved for sure.
low	medium	You play the quiz only from time to time, and your knowledge level is rather low.
high	low	You play the quiz only rarely, but your results are really very good.
medium	low	You play the quiz only rarely, but your results are rather good and can be improved for sure.
low	low	You play the quiz only rarely, and your knowledge level is rather low.

qualification programme, could you gain any relevant knowledge to you?" or *"To what extent is the question stated above relevant to your work?"*

The questions at the end of the quiz (Quiz-of-20, Quiz-of-10 and Quiz-of-5) ask explicitly for gained insights or new knowledge with regard to the currently played quiz. Examples are: *"Reflect on the currently played quiz. Have you perceived any special insights for yourself?"* or *"Reflect on the currently played quiz. In what regards are the quiz questions related to your work?"*. Table 9.5 presents all possibilities for the reflective question during and at the end of the quizzes.

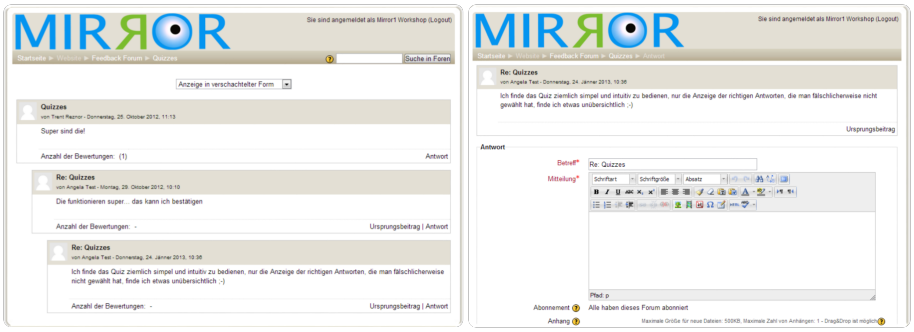
9.2.7 Discussion Forum

The two different discussion forums provide the users a possibility to give directly feedback to the quiz, or to discuss with other colleagues the content of the quiz questions. Figure 9.17a shows the discussion forum of the quiz, one

Table 9.4: Reflective Questions at the beginning of the quiz.

Knowledge Level Status (KL)	**Reflective Question**
Increase	What is your success recipe?
Increase	In what respect does the quiz help your to learn?
Constant high (>85%)	Think about and describe shortly, how you could improve your knowledge?
Constant high (>85%)	How could the quiz help you to improve your knowledge?
Constant (<85%)	Think about and describe shortly, how you could further improve your knowledge?
Constant (<85%)	How could the quiz help you to further improve your knowledge?
Low	What is the explanation, that you didn't play the quiz more often to improve your knowledge?
Low	What could help you to play the quiz more often (e.g. once a week)?
Low	What should be different, so that you play the quiz more often?

entry with two answers. Figure 9.17b presents the form of writing an answer to an entry within the forum.



a) Discussion forum: tree with two entries

b) Discussion forum: Insert an entry

Figure 9.17: Medical Quiz: Discussion forum

Table 9.5: Reflective question randomly posed during and at the end of the quiz

Reflective questions during the quiz
If you think back regarding the question above to the qualification programme or a situation during work, which knowledge can you gain out of it?
If you reflect with the help of the above posed question about a situation during work or the qualification programme, could you gain any relevant knowledge to you?
Could this question help you to learn? If yes, how? If no, how should this question could be modified in order to help you to learn?
Does this question give you some hints about your learning progress in relation to the related topic?
Does the question posed above remind you on an interesting situation or discussion during work (during the qualification programme) and if yes, on which one?
If you have a look at the question stated above, would it help you to have more information about the related topic e.g. direct access to a medical book or to an internet page? If yes, which information would you like to have? If no, why don't you need any further information?
How important is the question above for your work?
Have you already needed this information in practice and if yes, how? If no, do you think you could use this knowledge in future for your work?
To what extent is the question stated above relevant to your work?
Reflective questions at the end
Reflect on the currently played quiz. Have you perceived any special insights for yourself?
Reflect on the currently played quiz. In what regards do the quiz questions support you to learn for the qualification program?
Reflect on the currently played quiz. In what regards are the quiz questions related to your work?
Reflect on the currently played quiz. Do you take something with you for the future with regard to the currently answered questions?
Reflect on the currently played quiz. What did you particularly like with regard to the quiz?
Reflect on the currently played quiz. What do you intend to do with regard to the quiz results?
Reflect on the currently played quiz. How satisfied are you with your quiz result and do you want to change something?
If I reflect on the currently played quiz, would the quiz be more suitable for me if I would change
If I reflect on the currently played quiz, I would find the quiz more useful if ...

9.2.8 Technical Implementation

The Medical Quiz was developed with the free Course Management System called Moodle[1].The existing quiz module in Moodle was used and adapted according to the needs of the quizzes. Two databases were created for the quiz, one for the content questions and one for the reflective questions. Both of them were integrated in the four quiz types in order to enrich content questions with the reflective questions. Moodle is a web application written in PHP and is implemented as a client-server architecture. Moodle is open source under GPL licence.

9.3 KnowSelf V1.2

The author was not involved in the development of KnowSelf except the implementation of the reflection guidance components in form of time-triggered and event-triggered prompts. Thus the description of KnowSelf will be kept rather short with focus on the implemented prompts and the reflection diary.

9.3.1 Introduction

The KnowSelf App is intended to support reflective learning regarding time management and self-organisation. The current version provides an "AS IS analysis" of how a user spends his/her time, and is targeted towards knowledge workers that work mainly on a (Windows for technical reasons) PC.

9.3.2 KnowSelf Views

The Day View of KnowSelf as depicted in Figure 9.18 is the main entry point of the application. The Navigation Bar on top of the application is always visible to the user and provides the possibilities to pick a date the user wants to reflect about. It also contains a stopwatch to start a manual activity/project

[1]http://moodle.org

recording. There are also additional buttons on the top right for accessing additional functionalities like data export, reload and further information.

The Time Line presents all the resources used during this day. The same resource is always marked with the same colour, to easily differentiate between the resources a user worked with. Resources can be Office documents, Web pages, folders, etc. Since the whole day is shown, it can easily happen that resources are shown within a small time range (usually the working hours). The blue selection border provides the possibility to zoom into some time range. This selection border can be moved to the left or right by just clicking and holding the left mouse button and moving to the left or right. While changing the blue selection border, the time is shown as additional assistance. The lower part of the Time Line zooms to the time range selected above. If no resources are within the selected blue border, no visualisation is shown below.

The left area of the Content View lists all the applications recorded during the selected day. This list specifies all applications used during a particular hour of one day. Expanding an application node shows all the resources of the chosen application for the given hour. For each selected resource, the list of applications with detailed resources information is displayed in right area of the Content View; e.g., window title, begin and end date/time, duration, path to file etc. In addition, a timeline chart shows the usage of the selected resource over time.

Recorded applications and corresponding resources are the basis for statistical analytical services used for daily reflection. The pie charts in the statistics tab visualize the total usage time of applications e.g., how much time you have spent editing or reading WORD files. By clicking on the different sectors of the pie chart, detailed statistics about duration, number of visits and average time for each visit, etc. are presented for each application. In the Application resources table (right side) all used resources including their total time of usage and the number of visits are displayed. In the bottom part of application statistics, an application timeline chart is shown, which gives an overview of how long and when the given applications were used.

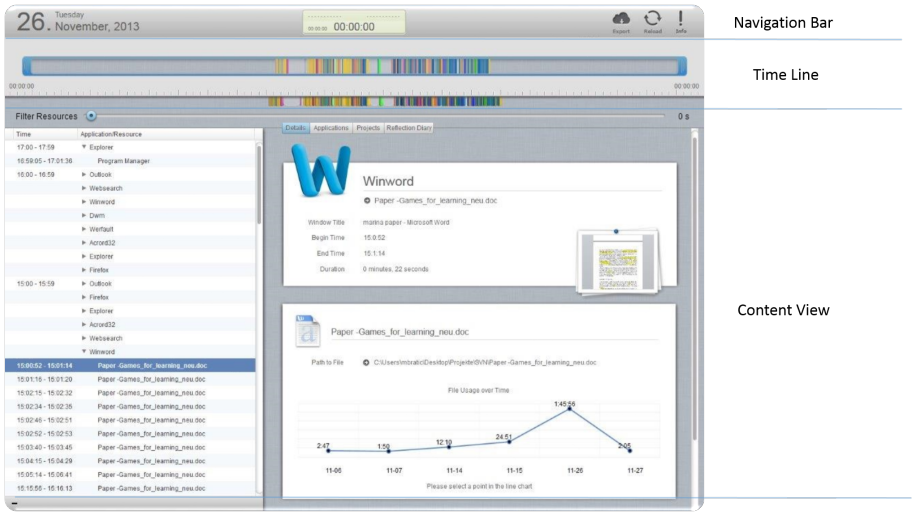


Figure 9.18: KnowSelf Web Application Day View

9.3.3 Reflection Guidance Components

The reflection process is supported in KnowSelf with reflection prompts. There are two kinds of prompts, time-triggered and event-triggered. The time-triggered prompts are shown on a specific day at a specific time which can be adjusted by the user and remind the user to reflect with the help of the app by offering feedback on various topics regarding user's behaviour. The second type of prompts are the event-triggered prompts which are generated when a significant change has been detected (e.g. when the number of switches is higher than usual or after unusually long periods of idle time). In order to determine whether the value is statistically higher, the interquartile range rule is applied to check whether the current value is an outlier in comparison with other historical values. These prompts don't have any time schedule and are independent from the regular prompts. Figure 9.20 shows how a prompt is presented in KnowSelf, while Table 9.6 gives a summary of all implemented prompts.

Beside the implemented reflection prompts, also a reflection diary is imple-

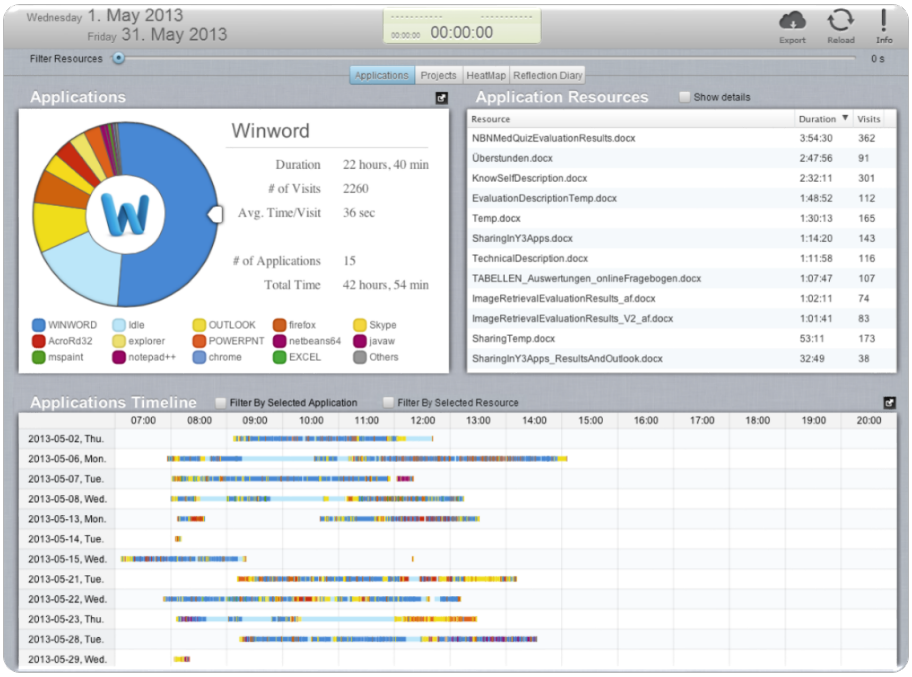


Figure 9.19: Monthly Statistics About Application and Resources

mented in KnowSelf as depicted in Figure 9.21. After inspecting the used applications and resources of a day, and having a look at the statistics, personal feelings, experiences and insights or plans for the future can be stored with the diary. To motivate the users creativity, some inspiring questions can be displayed below reflection diary.

9.3.4 Technical Implementation

KnowSelf is orchestrated by three software components: the KnowSensor, the KnowServer and the KnowSelf Web application. The KnowSensor is responsible for capturing user interaction data. It creates an event whenever the user

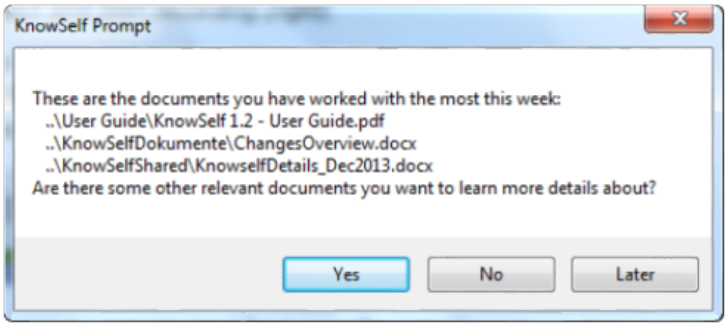


Figure 9.20: Prompt making aware about the most used documents

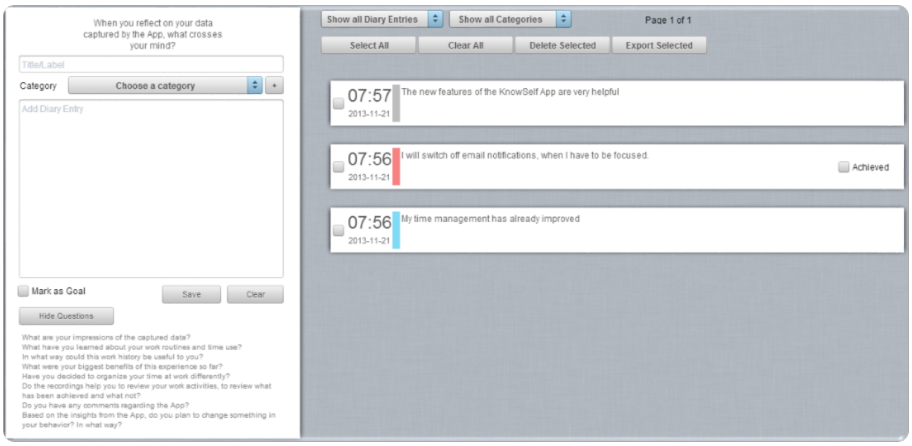


Figure 9.21: KnowSelf Reflection Diary

changes from one window to another. Such an event contains information such as date and time of occurrence or the title of the window for example. If available, the event contains information about the document displayed within the window. The KnowServer is receiving and storing events from KnowSensor. KnowServer also hosts the KnowSelf Web application files and conducts data analysis and aggregation tasks. KnowSelf visualises the knowledge base

Table 9.6: Reflective question randomly posed during and at the end of the quiz

Topic		**Timing**
Number of switches	On _DATE_ you reached the highest level of switches between _FROMTIME_ and _TOTIME_. Do you have an idea what is the reason for it? Would you like to see your recordings in the App which could help you to reflect on it?	On Wednesdays
	In the heatmap you can see the number of switches per hour and per day. Do you want to learn new valuable information about your time use with help of the KnowSelf app?	On Tuesdays
	On _DATE_ between _FROMTIME_ and _TOTIME_ you had higher switches than you usually have in that time. Do you have any idea why? Would you like to take a look at your captured activities in the App and reflect on it?	When number of switches during a 15 min interval gets unusually higher comparing to his/her usual switches.
Idle time	ON _DATE_ you had more idle time than you have on average. Do you have any idea why? Take a look at your idle times in the App and reflect on it.	When the daily idle time (whole idle time of the day) is unusually higher than usual
Projects recorded	You have recorded these projects so far: _____ (list up to 3 project names) Are there any additional projects or activities you would like to record to keep track of your work?	On Fridays
	You haven't recorded any project so far. Are there any projects or activities you would like to record to keep track of your work?	In case a person hasn't record any projects so far
Top 3 most used documents	These are the documents you have worked with the most from _FROMTIME_ to _TOTIME_: ___, ___ and ___. Are there some other relevant documents you want to learn more details about?	On Thursdays
Reflection diary	Do you have any goals regarding your time management you would like to accomplish? Would you like to write them down in your reflection diary and mark them as goals? This could help you to follow up on them!	On Fridays

about the user interactions. A timeline based approach supports a comfortable way to browse through history and reflect on it.

10 Appendix B

10.1 Introduction

All summative field studies presented in this Appendix have been conducted within the EU Project "MIRROR - Reflective Learning at Work" and are taken out of the deliverable "D10.3 - Summative Evaluation of MIRROR Appsphere usage and effectiveness at test beds" [135]. All of them were written under notable participation of the author, except the KnowSelf field study. All field studies follow a similar approach and are based on the tools and methods developed within the project with focus on reflective learning. All field studies are presented in its full length, including all participants and results. For the development of the in-app reflection guidance concept presented in Chapter 5 and the corresponding field studies presented in Chapter 6, only those participants and results were used, which contributed to the concept (those who used the applications and filled in the post-questionnaire).

The results of all field studies are presented along the four levels of the of Kirkpatrick's model [81]. This allows us assess relevant indicators for reflective learning and their impact for individuals and teams. The following four levels were considered for all summative field studies (as described in the MIRROR Deliverable D1.5 [82]).

- *Level 1: Reaction*:
  RQ: To what degree participants react favourably to the MIRROR apps? The usage/application of the corresponding application can be measured by recording how often reflection process is performed and what applications are used. In addition the user experience can be evaluated through subjective field studies.
- *Level 2: Learning*:
  RQ: To what degree participants acquire knowledge, skills, attitudes, confidence, and commitment?

The reflection sessions can result in either:
a. Change in knowledge/skills by understanding how specific competencies or processes can be improved
b. Behavioural Intentions indicating how the reflection outcome may be applied in daily work. For some applications learning could be assessed by analysing logfiles (e.g., serious games). Furthermore, learning can be accessed by specific evaluation forms that ask for documentation of learning outcomes. Quantity and quality of learning outcomes can be examined.

- *Level 3: Behaviour*:
  RQ: To what degree participants apply what they learned?
  It is now possible to measure the conversion rate of behavioural intentions into actions. In addition the impact on the specific actions on the respective processes by monitoring the related KPI's of the process can be measured. Furthermore, more intangible outcomes could be measured "before" and "after" the field studies.
- *Level 4: Results*:
  RQ: To what degree targeted outcomes occur as a result of MIRROR?
  The potential impact of actions on the business should be considered during definition of the action. Theoretically change of business related KPI's (sales revenue, profit, and customer satisfaction) could be impacted by action. However, in many cases it will be difficult to isolate the effects of the specific action, when more parameters are impacting a business KPI. Furthermore, the success of the applications in supporting reflection can be measured by using a loyalty metric like the Net Promoter metric. It can also be measured how often the MIRROR approach is referred to others and ask for ratings as it is now used in some of the App stores.

10.2 MMA FS5: Summative Field Study at BT Call Centres

10.2.1 Setting: BT Call Centres: Dundee and Alness

Two call centres of the large telecommunication company British Telecom (BT) in Great Britain served as test-bed for the long-term summative field studies of

the MoodMap App. The two call centres are situated in Scotland and together they have about 450 people. British Telecom is a large telecommunications company, serving customers in more than 170 countries. BT employs more than 300 people (divided in 19 teams) in its Dundee centre and 157 people (divided in 7 teams) in its Alness centre in a range of functions from directory enquiries to residential and business broadband. Such call centres can handle an average of 27.000 calls from all over the UK every day – almost 10 million calls over a year. The task of the call-centre staff is to support incoming product support or information inquiries from customers in an efficient, professional and friendly way.

Users and their job roles

In the field study at BT three job-roles were involved namely call-takers, coaches and managers. The call-takers are responsible for taking the calls and solving any issues directly with the customers. Their main task is to provide customer service with a high quality, which increases the company's reputation and boost sales. Thus, call-takers have to handle complex calls and situations, need to have excellent listening and problem solving skills as well as excellent communication skills. Generally it is a stressful job and they face high demanding situations with a daily occurrence. The task of the coaches is to support and train the call-takers for their work, mainly in terms of behaviour and sales psychology. The coaches regularly conduct coaching sessions with their call-takers. They ensure that the call-takers have the necessary skills, knowledge and behaviours to deal with any aspect of a customer call and resolve queries first time. Coaches play an important role on the improvement of the call-takers' performance and satisfaction. Through their coaching, problems and challenges of the call-takers can be identified and accordingly actions to improve this can be taken. To this respect, call-takers' mood can be a very good indicator. The manager's task is to ensure that the call-takers are performing against targets, they are reviewing the call-takers' performance and they supervise the call-takers' coaching and training sessions. Furthermore the manager has to provide feedback back to his/her superior about his/her team as well as has to transfer to the call-takers important organisational decisions and instructions he/she receives from his/her superiors. They additionally monitor multiple key performance

indicators (KPIs) regarding the performance related to customers and call-takers.

10.2.2 Design and Procedure

The MoodMap App was used by BT employees having all three roles i.e. call-takers, managers and coaches. The call-takers were asked to fill in their individual moods after a call, after a coaching session, after a break or whenever they thought their mood was relevant for them or has changed in a significant way. Additionally, they were compulsory asked to insert a note to each of the captured moods. The coaches used the inserted moods to better support the call-takers during their work and to improve and/or adapt the coaching sessions to the call-takers' needs. The managers also followed the mood development of each single call-taker to directly contact them if necessary. On the other hand the managers also kept an eye on the mood development of the whole team in order to arrange one-to-one meetings (i.e. a meeting between a manager and a single call-taker) or huddles (whole team meetings) to discuss about any issue and improve the whole team spirit. Additionally managers and coaches were also asked to capture their moods and use the MoodMap App for themselves with the goal to reflect on their own mood development and how they were influenced by their emotions. The summative field study of the MoodMap App started on the 20th of November and lasted until the 20th of December. The MoodMap App was introduced by the responsible project manager of BT to six different teams (encompassing 103 participants) and four of these teams were selected to pursue with the field study. During this introduction phase the team members were asked to fill in a pre-questionnaire including the MIRROR consent form. Regarding the application usage, all types of participants (call-takers, coaches and managers) of the trial were asked to insert their moods during all days during the field study period. They were also asked to reflect about their inserted moods and notes individually. The coaches and managers were additionally instructed to use the team visualisations in order to reflect about the mood development of their teams and take actions if necessary. At the end of the trial, they were requested to fill in a post-questionnaire.

10.2.3 Participants

Altogether 67 employees participated in this field study, belonging to four different teams of two call centres namely Team AMc (Dundee), Team AMo (Dundee), Team GMa (Alness), Team STh (Alness). The demographic questionnaires were filled by 43 participants, thus the information of the demographic data is referring only to this 64% of the participants. These 43 participants consisted of 26 men and 17 women. Participants in the field study were between 20 and 59 years old, with 56% of them aged between 20 and 29, 26% between 30 and 39, 14% between 40 and 49 and 5% between 50 and 59. The participants had on average M = 3.47 (SD = 3.66) years in their current position, ranging from participants with less than one year in that position and to a maximum of 15 years. The average number of years in their current team was M = 1.76 (SD = 2.28) and the average years in a similar position were M = 5.21 (SD = 4.32).

10.2.4 Evaluation Methods

Besides capturing log-data, two questionnaires were used: a pre-questionnaire, which gathered demographic information and contained the short reflection scale (SRS) and questions about participants' expectations with regard to the use of the MoodMap App. The post-questionnaire contained all questions concerning the evaluation levels 2 through 4.

Level 1: Reaction: all usage data, including for example the number of clicks per visualisation, can be obtained from the logs of the MoodMap App. The database of the application itself stored the information about the data captured, i.e. mood values, notes and context data. In the post-questionnaire, questions regarding usage (USE) and user satisfaction (SAT) were added.

Level 2: Learning: The short reflection scale (CR) was included in the pre- and post-questionnaires. Additionally, the post-questionnaire contained 8 app specific reflection questions (CA) which fitted best to our approach as well as the two Learning Outcome questions (CL).

Level 3: Behaviour: We used the core behaviour question (CB) with regard to work performance. Additional questions regarding behavioural intentions (BI) were used, depending on the role of the participant, including questions

about work improvement in general, employee satisfaction, and improvement of work performance or customer satisfaction (WP).

Level 4: Data on Key Performance Indicators (KPI) was provided by BT at individual and team level. At individual level volume and average rating were available. The KPIs at team level were Net Promoter Indicator, Call-Taker Satisfaction and Recap. The post questionnaire consisted of further questions with regard general application effects (GAE), long-term usage (LT), benefits and insights as well as the impact of reflection in their daily work.

After the trial, two managers and one call-taker took part in an interview over the phone. The posed questions covered the following topics: feedback to the overall experience, subjective feeling of the application's acceptance within the team, capturing mood, benefits and insights as well as general comments.

10.2.5 Results

Level 1: Reaction (Usage)

The participants used the MoodMap App on 31 consecutive days. Except for 5 days in which the app was not used at all (corresponding to days off), the app was used by all users for 8 hours and 42 minutes (SD = 0.09) on average every day. In that time users where entering the MoodMap App repeatedly and using the different available features.

In total, 991 moods were captured during the whole evaluation period. On average, users captured 17.39 moods (SD = 24.50) during the whole evaluation period, with a range of 1 to 136 moods per user. Considering the moods captured in each team, on average 23.72 (SD = 34.45) moods were captured per person in GMa Team, 21.00 (SD = 24.52) in STh Team, 10.62 (SD = 11.91) in AMc Team and 9.25 (SD = 10.95)in AMo Team. These results show that users in teams GMa and STh captured on average twice as many moods than teams AMc and AMo.

Regarding the notes attached to the moods, a total of 946 non-empty notes were captured by the users and served as annotation for their affective states.

Users also had to enter a context to each captured mood i.e. in which situation the mood was captured. Figure 10.1 shows the distribution of all captured

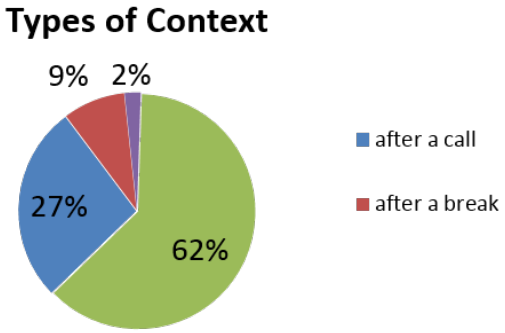


Figure 10.1: Distribution of context among all users

contexts (N = 991) among the four available categories i.e. after a call, after a break, after a coaching session and other. In order to get more insights about this 62% of "other" situations, the notes of those moods were analysed. This analysis revealed the following context as the most common ones: start or end of shift, before break/lunch, back from lunch or a certain event, problem or issue (crash, waiting for other departments), feeling better after dealing with a problem, successful events, feeling tired or having finished a certain task.

Figure 10.2 shows the distribution (absolute numbers) of captured moods and context as well as notes for each team that participated in the field study.

From all the participants that were registered in the MoodMap App, 53 used the available visualizations during their working shift and a total of 1914 interactions were logged (see Figure 10.3). Each of these users had on average 36.11 interactions with the application (SD = 60.63) during the whole field study period. Such a high standard deviation also shows that the usage of the app was very polarized, having users who were very active, whereas others almost did not use the app at all. As shown in Figure 10.3, the three features that were most used were the Capture Mood, Timeline and Compare Me visualizations. This was also confirmed by the interviews and the questionnaires. From the available visualizations, users were mostly using the timeline of the day, were they could review their mood development during

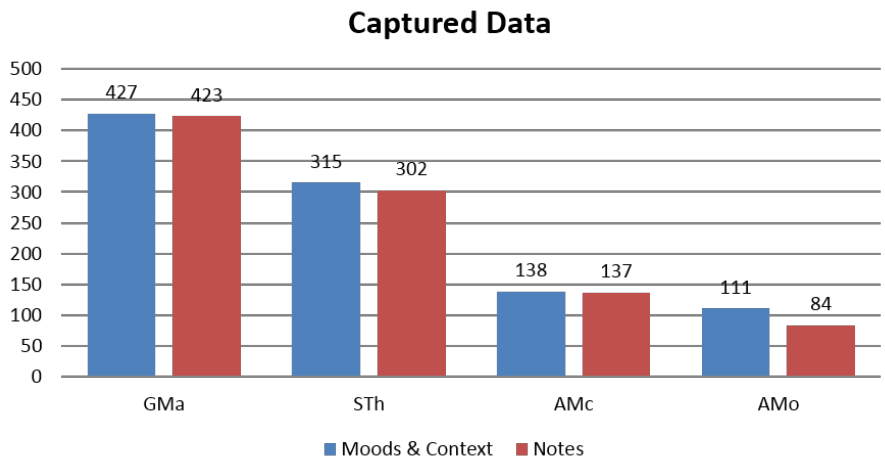


Figure 10.2: Absolute numbers of moods and context and notes captured by each team.

the present day. The preferred visualization for the users was the Compare Me visualization, where employees could compare their own mood with the mood of their colleagues. This confirms our hypothesis that comparing themselves to the team in a quick and intuitive way may be supportive and useful, both in terms of creating curiosity in the users as well as allowing users to detect discrepancies that can initiate a reflective process.

Overall Impression

The answers (N = 38) to the open questions of the post-questionnaire that referred to the usage of the MoodMap App and participants' reaction to it showed that the users' opinions were very ambiguous – from very positive over neutral to negative. Regarding the situations in which it was useful to capture a mood, the responses range from *"It was interesting to capture moods at the start and end of shifts, dependent on how much work was left to do etc."* to *"difficult to use an app when calculating mood because I FEEL. I do not need a technology to validate it"*. If the users would or would not share their moods with managers was also very diverse. Some would especially share their mood about an awful call or a bad situation others would not share such a mood

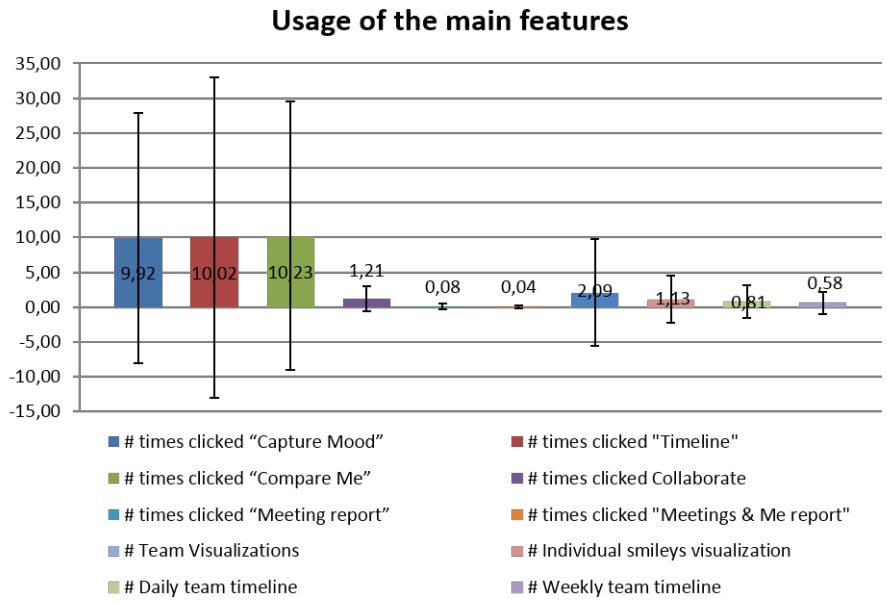


Figure 10.3: Usage of the main features of the MoodMap App. For each feature, average and standard deviation are depicted

at all. The final comments regarding the MoodMap App of the participants in general showed up again their different attitudes towards the application. Four participants provided positive feedback like *“The mood map was fun to use and did lift team spirit for those that used it but I wouldn’t say it has impacted on my day to day work / performance”* or *“I really enjoyed it. To make it more fun, we would use a # in the same way as twitter. Helped improve mood further.”*. Five of the participants provided neutral statements and four of the participants’ opinions were rather negative e.g. *“I think BT should spend their money more wisely.”* The following items were all rated on a 5-point Likert Scale (strongly disagree – strongly agree). Figure 10.4 (blue bar) shows that the participants (N = 38) stated that they have slightly agreed to be satisfied with the MoodMap App. If we consider this score for each individual team, it shows that the teams,

who have used the MoodMap App at most Team GMa, Team STh agreed to be more satisfied with the MoodMap App, than those who have not so intensively used the application Team AMc, Team AMo.

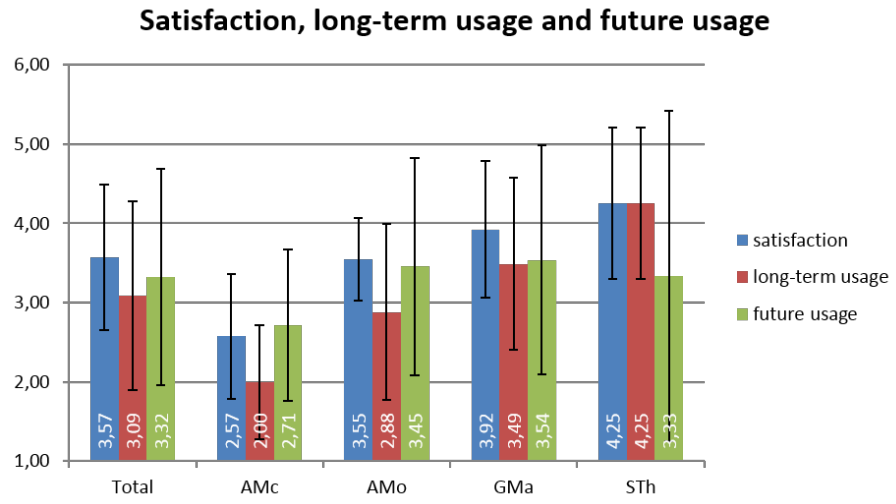


Figure 10.4: Mean scores of satisfaction, long-term usage and future usage in total and per team

The overall score regarding the long-term usage of the MoodMap App during work (Figure 10.4, red bar) is rated rather neutral. Again here the two teams Team GMa and Team STh, who have intensively used the application agreed that they would like to continue using the MoodMap App. In contrast, the scores of the two teams with the lower usage namely Team and Team AMo rated the long-term usage neutral or slightly disagreed to it. The future usage was rated neutral or slightly positive. In this case the mean score represents also three of the individual teams except Team AMc.

A Pearson product-moment correlation coefficient was computed to assess the relationship between several variables from Level 1. Concretely, the number of captured moods, interactions with the application, subjective usage, self-expressiveness of feelings and social media attitude were investigated. Due to the difference between the data available for each participant, it has to be

taken into account that only a selection of the users could be considered in this analysis i.e. the users who had data available for each of the variables involved and mentioned below.

There was a very strong positive correlation between number of captured moods and number of interactions in the MoodMap App, r = .870, p = .002, for N = 64. That means that users who captured more moods were also using the visualizations more often. Also a significant moderate positive correlation between number of interactions and subjective usage (r = .496, p <.001, N = 35) was found. Finally, a strong positive correlation between captured moods and subjective usage was determined, too (r = .626, p <.001, N = 35). This result indicates that all three variables are correlated. This outcome is the expected result, as a higher usage of the app produces the capturing of more moods. It also shows that users could properly assess how often they used the app during their work and were aware of the introduction of the app in their daily practices. We also found that comfortableness of users with expressing their feelings at work is correlated with captured moods and app interactions. There is a moderate positive correlation between interactions and expression of feelings (r = .411, p <.014, N = 35) and a weak positive correlation between captured moods and expression of feelings (r = .384, p <.023, N = 35).

We found no correlation among the other Level 1 variables mentioned above e.g. social media attitude, which we expected to correlate with the usage of the app. This was also confirmed by an interview, where a highly active user in the MoodMap App stated not having any account in social media platforms.

Barriers

Figure 10.5 shows the scores of the possible barriers of using the MMA including general barriers such not having time, not having physical space, not having seen any advantage or not having motivation to use the app. Users rated these barriers with neutral to slightly disagreement, which also corresponds to each single team. The social media attitude (Figure 10.5, social attitude) i.e. how likely it is that they use social networking platforms (e.g. Facebook, Twitter, LinkedIn, Google+, MySpace...) was rated slightly positive, which means that the social media attitude is no barrier for using the MoodMap App. The social privacy concerns (Figure 10.5, social privacy concerns, rated with a 4-point Likert scale: not at all – high) shows that the participants are only little to somewhat concerned about their social privacy.

Regarding their comfort with the self-expression of feelings (Figure 10.5, self-expression) in general and during work, the participants rated it neutral or slightly agreed. Having a look at this aspect at team level, only one team slightly disagreed with being comfortable in expressing their mood (Team AMc: M = 2.50, SD = 0.80), all other teams stated their self-expression rather positive. Sharing of emotions (Figure 10.5, sharing) with managers and coaches was not seen as a significant problem.

From the open questions of the post-questionnaire we received many different responses regarding the barriers of the MoodMap App usage. Responses from 13 participants, who have answered this question show, that they either do not see any direct barriers for using the MoodMap App, that they perceived the MoodMap App as easy-to-use, that the app could become part of their normal working day, or that the app has only a clear benefit for the coaches and managers but not the call-takers, or that they do not think that the MoodMap App is useful for them.

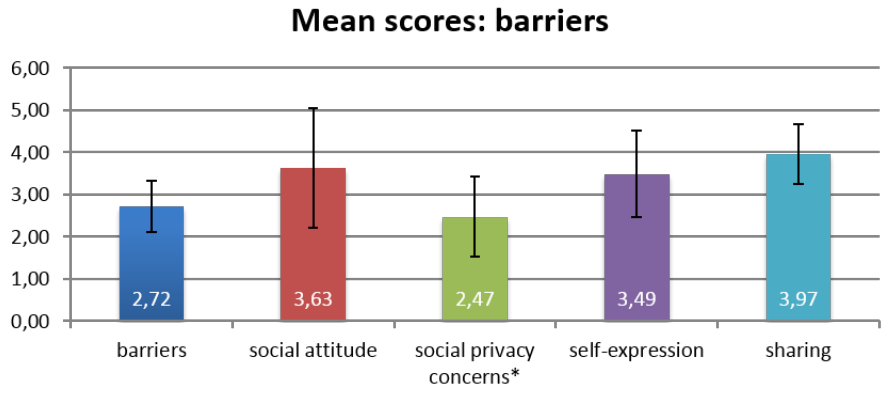


Figure 10.5: Mean scores for possible barriers including general barriers, social attitude, social privacy concerns (*rated on a 4-point Likert scale), self-expression and sharing

Level 2: Learning

The goal of the MoodMap App is to provide users' an easy and integrated tool to track their mood during work. Thereby the participants should become aware of their mood and how their mood influences their daily working tasks. Reflecting on their own mood development as well as on the development of their team's mood during a working day and establishing a relationship with their work, can give them explicit awareness and new individual insights about their attitude to work, confidence as well as skills. Not only the individual mood can help them acquire new insights, but also the mood of the team colleagues can contribute to detect discrepancies and consequently acquire new knowledge.

Learning Process

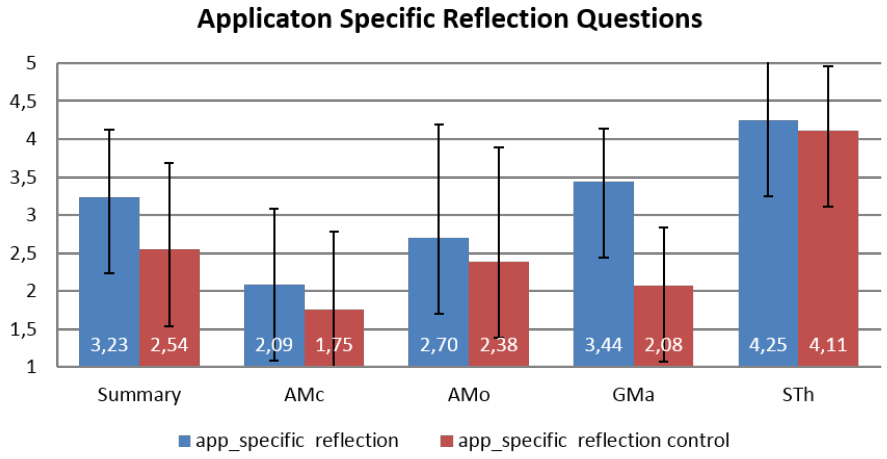


Figure 10.6: Mean rating for 7 application specific reflection questions per team

App-specific reflection questions: Altogether eight app-specific questions were included in the post-questionnaire, seven regular questions and one control question. Figure 10.6 presents the mean ratings (from 5-point Likert scales) of the app-specific reflection questions and the corresponding control question

of the whole field study and per team. The overall mean shows that the participants slightly agreed that the application has potential to initiate reflection by capturing data relevant for reflection and visualizing data to reconstruct working experiences as well as capturing learning outcomes. Very interesting is the rating of the single teams. While Team AMc (M = 2.09 (SD = 0.99)) and Team AMo (M=2.70 (SD = 1.48)) rated the app specific reflection questions rather neutral or slightly disagreed, the other two teams Team GMa (M = 3.44, SD = 0.69) and Team STh (M = 4.25, SD = 0.96) rated it very positive. Considering the app-specific reflection ratings of the most active teams showed that the teams with higher MoodMap App usage had higher ratings concerning the app's potential to support reflection.

The "app specific reflection control" question asked if the application is able to show how many calls a user had had during a day. With the mean ratings of the summarized value M = 2.74 (SD = 1.15) the participants clearly disagreed. Only Team STh with M = 4.11 (SD = 0.85) agreed, although there is no direct technical connection of the MoodMap App and the call-centre's calling system.

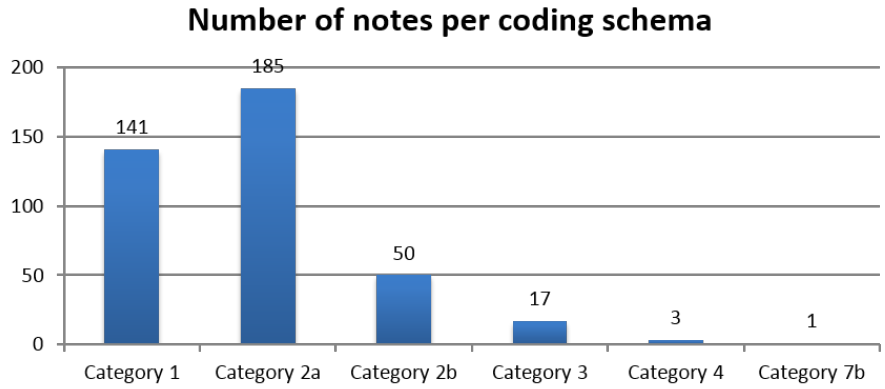


Figure 10.7: Number of notes per category

Analysis of notes: All together the participants have captured 991 moods and attached 983 non empty notes. After analysing the notes against the reflection-coding schema (as presented in Prilla et al. [132]), 239 notes could be identified

as individual reflective items, the remaining notes were not work related and could therefore not be addressed to any of the categories. Three different researchers conducted the first rating of the notes independently. The inter-coder reliability exceeded an average compliance with regard to the following categories: Category 1: Experience or issue/problem report: 87%, Category 2a: own emotions: 91%, Category 2b: emotions of customers: 93% and Category 3: interpretation and justification: 92%. Category 4 and 7b were not mentioned here because only very view notes were assigned to these categories. After the first categorisation round, the researchers discussed all the notes where their ratings differed in a second round, which resulted in 100% accordance. Each note could be assigned to more than one category. Most of the notes were rated with Category 2a, which describe own emotions of the participant. Figure 10.7 shows a summary of the notes to the corresponding categories and Table 10.1 presents some examples.

Table 10.1: Examples of categories and corresponding notes

Category	**Example of notes**
1: experience or issue	"Coach is now dealing with the horrible case and its Friday! :)"
2a: own emotions	"Talk with manager, feeling a bit more positive"
1, 2b: customer emotions	"Got customer information and he is happy"
1, 3: interpretation of actions	"Back and forth we go, another day of getting nowhere with our control desks. Honestly not sure why the customer wants to stay with BT at this stage, no one."
1, 4: linking of experiences	"Oneview crashed during my 1st call. Second morning in a row. Emailed screen shot to my manager"
1, 7b: solution suggestion	"KCI 2 for important job and customer did not have much of a clue and had unrealistic expectations. Will have to refer to sales to move"

Short Reflection Scale (pre- and post)

Figure 10.8 shows the mean ratings obtained for the Short Reflection Scale (SRS) as well as the two subscales concerning individual and team reflection. Comparing the scores on all three levels, we found no significant differences between the SRS of the ratings of pre-questionnaire to the ratings of the post-questionnaire. For the overall comparison (N = 26, here we used only those answers of the participants, who have filled in both questionnaires) of the

SRS the mean in the pre-questionnaire was M = 3.98 (SD = 0.49) and in the post-questionnaire M = 3.89 (SD = 0.53).

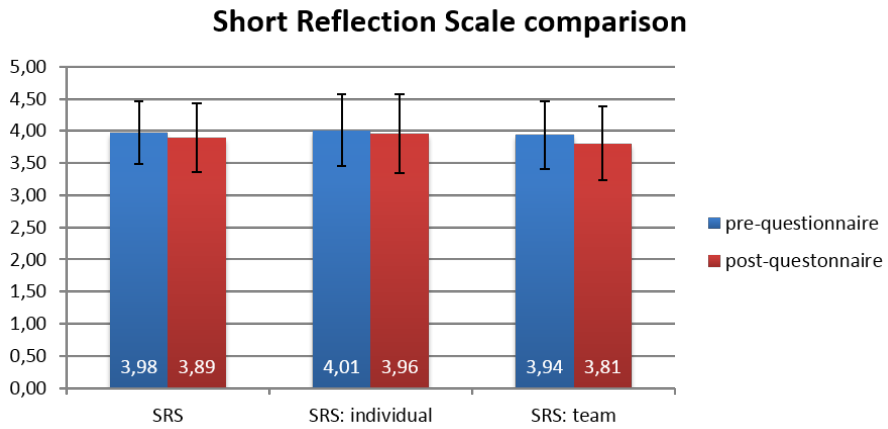


Figure 10.8: Short Reflection Scale before and after the usage of the MoodMap App

Furthermore, we conducted a Kruskal-Wallis-Test in order to compare the four different teams to each other, but no difference was recognizable (all p $>$.05), neither within the pre- nor within the post-questionnaire. Additionally, we also conducted a related t-test across all teams (N = 26), which also shows no significant neither between the overall scores nor the individual or collaborative scores.

Learning Outcomes The learning outcomes stated within the post-questionnaire (N = 38) were seen as nearly neutral M = 2.87 (SD = 0.99), i.e. participants could not decide whether they gained a deeper understanding of their work life and what to change about their work behaviour with or without regard to the coaching session. Having a closer look on each team, the mean score mentioned above also represents the scores of Team AMc, Team AMo and Team GMa. Only Team STh with M = 4.00 (SD = 0.72) agreed to have gained a deeper understanding with regard to their work-life and what to change about their work behaviour. This polarized result may also be influenced by the fact that only four participants of this team have filled in the post-questionnaire.

The analysis of the open questions from the post-questionnaire provided more details about their understanding of their work life and their conscious decisions of what to change in the future. Only five participants agreed to have made a conscious decision on how to behave in the future. On the one hand they would try to be more positive regarding distressed customers and on the other hand they mentioned the decision to let things at work affect them less. Five participants agreed to have gained a deeper understanding of their work lives. It was mentioned that a larger work load causes more stress at different times of the day. Another statement said that they would be more prone to remember the things that went wrong rather than what went right. The MoodMap App was unfortunately not used in the coaching sessions; therefore no change in behaviour can be mentioned with regard to the coaching sessions. From the coaches and the managers we received only four ratings M = 2.5 (SD = 1.73) with regard to making a conscious decision about how to behave in future in coaching sessions or team meetings.

Level 3: Behaviour

Behavioural change (measured by question CB1) was rated by the participants with M = 2.77 (SD = 1.27), which implies that the participants tend to state neutral or slightly disagreed that the MoodMap App helped them to improve their work at the call centre (e.g. during the shift, after customer's calls, during and after coaching sessions, during team meetings or in other situations). 35% of the participants agreed with the MoodMap App helping them to improve their work performance and mentioned that their work is improved by becoming aware through the app. They stated that that if their mood was low, they tried to lift it, that they would try to have a more positive attitude towards negative situations. A participant also mentioned that he/she would use the MoodMap App to state how much work they had completed.

We also asked the participants if they had recognised any improvements in the attitude of their managers and coaches. Most of the answers stated that the attitude of the four managers and their coaches was already great, being approachable, supportive and easy to interact with, so they had not noticed any further improvements. Nonetheless, in Team AMc a participant recognized that their manager had shown little more concern about their current

moods and in Team AMo another participant confirmed having recognized improvements, but unfortunately did not give any further details.

Further questions on work improvement were divided according to the participant's role. Coaches and managers were asked if they had noticed any improvements in the work performance of their call-takers since they started using the application. Answers to this question were available from teams AMo and GMa, both from the manager and a coach respectively. Although the opinions differed (one coach and one manager agreed by rating 4, whereas the other coach and manager disagreed by rating 1), we could appreciate a direct relationship with the question on making a conscious decision about how to behave in future mentioned above (Learning Outcomes). The manager or coach that agreed with having made a conscious decision and behaving differently also noticed improvements in the work of his/her call-takers, and vice versa.

Table 10.2 shows the mean and standard deviation for several questions related to participants' behaviour. For the comparison of the pre-test and post-test situation, only the answers of the 26 participants whose data for both questionnaires is available were taken into account. As the results show (see coaching_sessions in Table 10.2) the perception of the participants was slightly improved. Average rating to the question whether being aware of own emotions during customer calls helps to reduce the call-takers customer repeats (number of times a customer has to call again to solve an issue, which should be always solved "Right First Time"; see customer_repeats in Table 10.2) was also slightly reduced. Participants were also asked whether reflecting on their work and on their emotions helps them to improve their customer satisfaction. The comparison between the answers before and after the field study (see work_customer and emotions_customer in Table 10.2) show that participants were more confident after the field study regarding reflection on, but they were less confident with reflection on their moods getting to affect customer.

Accordingly, we asked coaches and managers at the beginning and at the end of the field study if they are aware of the coaching needs of their team. From the answers of 2 coaches whose data for both questionnaires is available, no changes were produced in that direction, having both a pre- and post-value of M = 4.00 (SD = 1.09).

Table 10.2: Results to questions regarding participants' behaviour with a 5-point likert scale (N = 26)

	Pre-questionnaire	**Post-questionnaire**
coaching_sessions	M = 3.87, SD = 1.45	M = 4.00, SD = 1.26
cover_coaching	M = 3.87, SD = 1.45	M = 3.87, SD = 1.45
customer_repeats	M = 3.80, SD = 1.16	M = 3.43, SD = 1.43
feedback_processes	M = 3.68, SD = 1.03	M = 3.68, SD = 1.03
reflect_feel	M = 3.40, SD = 1.34	M = 3.40, SD = 1.34
work_customer	M = 3.32, SD = 1.33	M = 3.80, SD = 1.16
emotions_customer	M = 3.74, SD = 1.54	M = 3.32, SD = 1.33

Additionally, the conducted Pearson correlation showed that there is a positive correlation between the customer's average rating of the participants after the usage period of the MoodMap App and the user's comfortableness with expressing feelings in general ($r = .635$, $p < 0.026$ for $N = 12$). This shows that the usage of the app may have a positive impact on better communication with emotions and call-takers' empathy, resulting in a better rating of the services by the customers. Regarding the Short Reflection Scale score of the participants and the customer's average rating of the participants, it could be also proved through a Pearson test, that they positively correlate with a score of 0.586 ($p < 0.035$) for $N = 13$. This implies that, for these 13 participants the ratings for this KPI is higher when the user has a higher reflection score. That means that the usage of the app has a positive impact in both parameters, although this interpretation can only be confirmed for those 13 participants whose data was available.

Additionally further insights and behavioural changes were collected through several interviews. Interviews with two managers and one call-taker were conducted. Feedback from both managers was very positive, especially regarding the insights they gained about their teams and how this positively affected the teams' work. Also the call-taker from Team Sth perceived the experience with the MoodMap App as very positive and he learned some insights when comparing himself to the team.

Level 4: Results

A paired-samples t-test was conducted to compare the individual KPI metrics before the usage of the MoodMap App and after it. Concretely, the metrics were provided for three reporting periods:

- Before using the app: 1st August – 21st October (81 days)
- While using the app: 21st October – 19th December (59 days)
- After having ceased using the app: 6th January – 7th February (32 days)

The provided KPIs were *volume*, number of customers that delivered a rating to the call-taker after the call, and *average rating*, which indicates the customer satisfaction rating (0-100). Data was available for the Teams GMa and STh. A comparison of the time period before the app was used with the period, in which the MoodMap App was used (during: from 21st October until 19th December) was conducted with paired-samples t-tests for the Teams GMa and STh. The results are shown in Table 10.3 below.

Table 10.3: Descriptive Statistics and t-test Results for Volume and Ratings for Teams GMa and STh before and during the usage period

	before		during					
Outcome	M	SD	M	SD	n	t	df	p
GMa Volume	18.68	4.08	10.05	3.95	19	.55	18	0.59
GMa Avg. Rating	82.79	7.98	89.58	5.81	19	-3.39	18	0.003
STh Volume	27.65	17.00	24.41	17.91	17	1.00	16	0.33
STh Avg. Rating	82.82	8.24	83.00	11.86	17	-0.06	16	0.95

As displayed in Table 10.3, there are statistically significant differences, at the .01 significance level, between the periods before and during app usage scores for the average ratings in Team GMa, but not for the volume. The results show that the average rating delivered by the customers increased on average 8.20% during the period where the MoodMap App was used, which is a very positive result. However, the impact of the application in their work environment cannot be totally isolated and other factors may affect the development of the KPIs. As some interviews with the managers of the call centres revealed, other changes in the company due to measures they are taking simultaneously may also affect the KPIs.

Regarding Team STh, *volume* was slightly reduced in that period whereas the average rating slightly increased. However these results are statistically not significant.

The data of the period of app usage was also compared to data of the period after the usage of the MMa was ceased (19th December to 7th February). The intention of these measurements was to follow up if the identified improvement in the KPIs could be maintained for longer period of time after the usage of the app.

Table 10.4: Descriptive Statistics and t-test Results for Volume and Ratings for Teams GMa and STh during and after the usage period

	before		during					
Outcome	M	SD	M	SD	n	t	df	p
GMa Volume	10.05	3.95	3.47	2.01	19	6.30	18	<.001
GMa Avg. Rating	89.58	5.81	89.33	13.46	19	0.013	18	.99
STh Volume	27.00	17.46	10.27	5.81	15	4.06	14	<.001
STh Avg. Rating	84.27	8.20	77.00	21.69	15	1.27	14	.23

As displayed in Table 10.4, there are statistically significant differences, at the .01 significance level, in scores for the time in which the MMA was used compared to follow-up scores for volume in both teams. According to the managers at BT, the period in January was affected also by extremely bad weather, which made leak times increase and therefore there were less resolutions of cases. This also causes more stress in the call-takers and less satisfaction in the customers. The significant reduction in the volume metric was on average 65.45% for GMa Team and 61.98% for STh team. With regard to the average rating of the call-takers during the period after the app usage, it was slightly reduced in both teams, but the reduction was not significant according to the t-test (Team GMa -0.06% and Team STh -8.62%).

For the teams GMa and STh data regarding Key Performance Indicators at team level were provided (see Table 5.3.6) at the same three reporting periods mentioned above. These metrics are provided by the customers through SMS message once they have spoken to the call-taker. The available KPIs are the following:

- Net Promoter Indicator (NPI): it is based on customer advocacy and reflects the answers to the question "How likely are you to recommend

our services to others based on your recent experience with us". In terms of percentage can range from -100 to +100.
- Advisor Satisfaction (Advisor Sat): indicates the customer overall satisfaction with the call. Customers answer in a scale 1-10 and the percentage is calculated dependent on how many customers score the call-taker and what the score is.
- Recap: indicates whether the call-takers proactively summarized the call to the customer, in order to help assist with lowering the amount of repeat calls they receive as a business. The question that the customer answers is "Did the last advisor recap what had been agreed?"

Table 10.5: Results for change in percentage of team KPIs during and after the app usage period, for teams GMa and STh.

Team	NPI		Advisor Sat		Recap	
	during	after	during	after	during	after
GMa	40.00	17.14	7.14	-1.11	4.71	-3.37
STh	16.67	-34.29	1.19	-3.53	3.80	-1.22

The metrics from Team GMa show that NPI increased 40.00% (from a score of 25 to 35 points) during the app usage period, whereas its improvement afterwards was only 17.14% (from 35 to 41). The metrics from Team STh show a similar behaviour. However, the difference between the usage period and the period after usage regarding the NPI is major, having an improvement of 16.67% with the MoodMap App and a decrease of 34.29% during the period after the cessation. Regarding Advisor Sat and Recap, both metrics were slightly improved during the MoodMap App period, but they decreased minimally after the usage cessation. This same behaviour was detected in both teams (see Table 10.5 for details).

10.2.6 Discussion & Conclusion

As a result, the interpretation of the gathered data within the application itself, the usage of the MoodMap App derived from the log files as well as the pre- and post-questionnaires was rather difficult. The prime reason is that the users who used the application most and the users who filled in the pre- and post-questionnaires were partially not the same. Therefore we had to decide,

which available combination of data can be meaningfully used for which type of evaluation result and interpretation purposes. Due to this fact, only 26 participants delivered answers for both questionnaires and therefore analysis of pre- and post- situation was rather limited.

From Team STh only 4 out of 18 participants have filled in the post-questionnaire, although this team was one of the two most active ones. Due to the low number of participants the obtained results might not completely mirror the whole team. On the other hand we had conducted two very positive interviews with the manager and one call-taker of the team. The positive attitudes of these two participants as well as the low numbers of filled in questionnaires let us suspect, that significant positive results regarding the benefits of the MoodMap App were lost. The fact that teams GMa and STh captured twice as many moods as the other two teams is also remarkable. In general we perceived ambiguous attitudes towards the usage of the MoodMap App. We have statements from finding the MoodMap App very useful and that it could be easily integrated into BT's daily working routines to comments that BT should spend their money more wisely. This shows that some of the participants really liked and accepted the application, while others could not do anything with it. This disagreement is also mirrored by the very high standard deviation values shown at reaction level analysis. When inserting a mood in the MoodMap App, the users were compulsory asked to insert a context and a note. Therefore we predefined three types of context relevant for a call-centre namely "after a call", "after a break" and "after a coaching session", and one neutral in form of "other". Our hypothesis was that especially the first one might be chosen the most. In contrast, the results showed that the moods were not captured in the expected situations, as 62% of the contexts were classified as "other" (see Figure 1). Secondly this fact also showed that it is important to leave users space for freedom in order to find out in which situations the moods were really captured during work.

Additionally we analysed the notes according to the reflection coding schema. We received a high number of moods describing a working experience, moods with emotions of the participant him/herself and moods of the customers. There were also some notes regarding interpretation and justification of taken actions. Participants did not introduce notes regarding linking an experience to different pieces of knowledge, responding to interpretation of action, working on a solution (only 1 note was rated to this category), insights/learning from reflection, or drawing conclusions and implications from reflection. This can

be explained with the fact that the compulsory insertion of notes was directly related to the currently inserted mood of the participant. No further questions with regard to reflective learning at all were posed anywhere in the MoodMap App, which leaves room for improvement to this regard.

The questions of the Short Reflection Scale (SRS) were posed in the pre- as well as in the post- questionnaire with the goal to find out, if the usage of the application contributed to improve the reflective practices of the participants (N = 26). The values of the pre-questionnaire show that the willingness to reflect was rather high right from the beginning and did not show any significant improvement after the field study. An explanation of this phenomenon is that most of the participants see themselves as reflective persons, and for the initial value was rather high it is more challenging to show an improvement. Another possible explanation for this would be the relative short field study period, as we have no evidence how likely it is that the answers to these questions significantly change in 4 weeks.

The result with regard to reflective learning showed, that some of the participants could recognize a clear benefit for themselves but especially for the coaches and managers, if they can see how each individual call-taker of the team is feeling and react to it. Some of the call-takers, coaches and managers mentioned that they have gained a deeper understanding with regard to their work-life and what to change about their work behaviour. The call-takers stated that they try to be more positive regarding distressed customers and to the decision to let things at work affect them less. Two of the managers and coaches also confirmed having taken conscious decisions to change their work behaviour, but unfortunately they did not report the actions taken. With regard to the Key Performance Indicators that allow us to measure the targeted outcomes, we could show a significant improvement both at individual and team level during the period where the MoodMap App was used. In the case of Team GMa, these results were even statistically significant. Although we are aware of the other factors affecting the measured Key Performance Indicators, these were very positive results for the field study.

During the preparation phase of this field study as well as during the field study itself we could derive several lessons learned. First, there has to be a clear goal or benefit for all parties involved. Second it is important to have the full support at the organisational level as well as from the manager's level in order to conduct such a big field study successfully. It is also important that

the stated goal will be implemented and established by the management or the organisation. Third, each single participant needs to see a clear goal or benefit for him/herself when using such an application and have the feeling that there will be actions taken towards the goal from the side of the management. The actions which could be taken, present the following success story reported by one manager:

"I sit in a little corner of the office so I don't actually get a chance to interrupt with all of my team all the time. So I find the MoodMap App very useful to see how everyone was feeling cause not everyone obviously comes to tell you how they are feeling and I had one guy, he sits quite far away from me and he was on a really hard time with a very difficult customer. Off site and all by the way he made a comment on the MoodMap App of having a really hard time and that he was not feeling like that he was getting any help. So straight away I went over to him and asked what I could do to help him and an hour later his mood had gone from like really low to really high because I had gone over to helped. [. . .] I would have never known about that and he would have probably struggled on, so there sitting without me knowing anything."

The successful field study of the MoodMap App as well as the described success story at BT also contributed to the organisation of another field study at another MIRROR testbed, namely REGOLA. The good practices and examples that emerged from this field study also facilitated the initialization of the field study as well as increased the interest of the organisation itself.

Concluding, we see that the MoodMap App has the potential to trigger reflective learning and especially to facilitate the improvement of coaching sessions in a call-centre setting like the one described above, although further efforts at organisational level will be needed to this respect.

10.3 MMA FS6: Summative Field Study at Regola

10.3.1 Setting: IT Company Regola

Regola is an Italian company who is leading in the development of software-technology and cloud services in the emergency domain, including ICT systems for emergency centres and volunteering associations. The company is

located in Turin and consists of altogether 35 employees distributed over 5 departments.

Users and Their Job Roles

Regola consists of five different departments, from development, service desk and support to sales as well as management. Therefore, there are several teams and profiles, according to their competences i.e. system technicians, developers, project managers, call takers from service desks, sales consultants and marketing staff. In the following we describe all these departments.

- *Department Am*: consists of four staff members. Their daily main tasks include controlling, finance, accounting, secretary activities, personnel management, banks relationship and registration trademarks.
- *Department Co*: consists of one sales director and three staff members. Their daily working tasks encompass scouting, tender, conferences, exhibitions, fairs attendance, preparation of events, social management, project and opportunities evaluation, assisting clients and partners by clarifying and documenting objectives, account management and contact (B2B) as well as the preparation of demos.
- *Department Qu* consists of one operational director and six staff members. The employees consist of software skilled operators, application specialists, system technicians and network security specialists. Their main tasks are to provide first, second and third level support and assistance to clients. These activities are mainly performed via mobiles, web instructions, remote connections and eventually on-site actions to investigate and solve critical issues, according to predefined Service Level Agreements (SLA).
- *Department Pm* consists of one chief technical officer (CTO) and five project managers. The major tasks of the CTO are to plan the global activities, design global projects, choose the right technologies and organise coordination meetings. The CTO receives a huge amount of input from each of the projects. Additionally he keeps control on the global design of the projects in terms of integration, choosing and deepening new technologies and he is also interacting and handling requests from sales department. The project managers deal with team leading and

organize the corresponding meetings. Furthermore they are responsible for the requirements engineering processes.
- *Department Sv* consists of the same CTO as Department Pm and of 16 developers. Their main tasks are new developments, bug fixing and testing of the produced code.

10.3.2 Design and Procedure

The summative field study of the MoodMap App at Regola started on the 12th of February and lasted until the 31st of March 2014. The MoodMap App was introduced by a responsible project manager of Regola to all five departments. During this introduction the project manager described on the one hand the MoodMap App itself and what it should be used for and on the other hand he presented a success story which emerged during the MoodMap App usage at BT (see Section 10.2) in order to show them a meaningful insight and a clear benefit. During this introduction phase the department members were asked to fill in a pre-questionnaire including the MIRROR consent form. During the application usage period, all participants of the trial were asked to insert their moods during their working shifts and to reflect about their inserted moods and notes individually. The managers were additionally instructed to use the team visualisations in order to reflect about the mood development of their departments and take actions if necessary. At the end of the trial, all participants were requested to fill in a post-questionnaire. Additionally, seven participants of the field study took part in an interview with the researchers with the aim of gaining more insights about the field study and the usage of the MoodMap App at Regola.

10.3.3 Participants

Out of 38 employees of Regola, 35 have participated in the MoodMap App field study. The reasons for not participating were not related to the field study itself, but it was due to personal or professional reasons. The 35 participants were split over the five following departments: Department Am, Department Co, Department Qu, Department Pm and Department Sv. The 35 participants consisted of 27 male and 8 women. Participants in the field study were between 20 and 59 years old, with 9% of them aged between 20 and 29, 77% between 30

and 39, 11% between 40 and 49 and 3% between 50 and 59. They had worked on average M = 6.77 (SD = 1.52) years in their current position, ranging from participants with less than one year in that position and to a maximum of 15 years. The average years in a similar position were M = 4.14 (SD = 2.96). 80% of the participants are working full-time, 17% are working part-time and one participant has not stated his job scope. All participants have filled in the pre-questionnaire and the post-questionnaire. Two of the participants have filled in the pre-questionnaire after the trial, so only demographic data was used for analysis (questions regarding reflection practices and expectations were not considered). One participant has filled in the post-questionnaire with invalid data; therefore these answers were also removed from the dataset. Altogether 32 participants have filled in both questionnaires and their answers constitute the dataset used for comparisons of pre- and the post-questionnaire variables.

10.3.4 Evaluation Methods

Besides capturing log-data, two questionnaires were used: A pre-questionnaire, which gathered demographic information , contained the short reflection scale (SRS) and questions about participants' expectations with regard to the use of the MoodMap App. The post-questionnaire consisted of all questions concerning the evaluation levels 2 through 4.

Level 1: Reaction: all usage data, including for example the number of clicks per visualisation, can be obtained from the log files of the MoodMap App. The database of the application itself store the information about the data captured, i.e. mood values, notes and context data. In the post-questionnaire, questions regarding usage (USE) and user satisfaction (SAT) were added.

Level 2: Learning: The short reflection scale (CR) was included in the pre- and post-questionnaires. Additionally, the post-questionnaire contained 8 app specific reflection questions (CA) which fitted best to our approach as well as two Learning Outcome questions (CL).

Level 3: Behaviour: We used the core behaviour question with regard to work performance (CB).

Level 4: As KPIs could not be provided by Regola, concrete questions about their KPIs were asked to the different departments before and after the field

study (e.g. number of bugs per week or number of hours dedicated to a certain task). The post-questionnaire included additional questions about employee satisfaction as well as improvement of work performance at individual and collaborative level (WP).

Additionally, the pre-questionnaire contained questions about expectations (EXP) the participants might have with regard to the use of the MoodMap App. The post questionnaire consisted of further questions referring to usage (USE) and user satisfaction (SAT), general application effects (GAE), long-term usage (LT), benefits and insights as well as the impact of reflection in their daily work.

After the trial, two managers and five employees of different departments took part in an interview over Skype. The posed questions covered the following topics: feedback to the overall experience, subjective feeling of the application's acceptance within the team, capturing mood, benefits and insights as well as general comments. Several concrete hypotheses were investigated during this field study at different evaluation levels:

- Reaction (Usage): The long-term usage of the App is influenced by the willingness to share moods, the motivation to reflect about moods, the dealing with emotions in general and the loyalty metric and vice versa.
- Learning: Comparing one own mood to the team mood creates curiosity in the users and allows users to detect discrepancies that can initiate a reflective process.
- Behaviour and Results: Participants, who learned due to the usage of the MoodMap app and also changed their behaviour, have rated the KPIs (reflect on feelings to improve individual and collaborative work performance) with a higher value.

10.3.5 Results

Level 1: Reaction

The participants used the MoodMap App on 48 consecutive days. Except for 12 days in which the app was not used at all (corresponding to days off), on average 10 hours and 32 minutes (SD = 0.129) lie between the first and the

last logged event of every day. In that time users were entering the MoodMap App repeatedly and using the different available features.

In total, 2250 moods were captured by the 35 participants during the whole field study period. On average, users captured 64.29 moods (SD = 33.27) during the whole field study period, ranging between 12 and 143 moods per user. Considering the moods captured in each department, on average 41.50 (SD = 39.71) moods were captured in Department Am (N = 4), 38.75 (SD = 21.20) in Department Co (N = 4), 59.17 (SD = 29.17) in Department Qu (N = 6), 79.20 (SD = 38.62) in Department Pm (N = 5), and 73.63 (SD = 30.54) in Department Sv (N = 16). These results show that participants of the departments Pm and Sv captured on average approximately twice as many moods per member than the other three departments.

Regarding the notes attached to the moods, a total of 226 non-empty notes were captured by the users and served as annotation for their affective states. The contextualization of moods was not used regularly, as only 31 contexts were captured in total by all participants. Figure 10.9 shows the distribution (absolute numbers) of captured moods, notes and context for each department that participated in the field study.

All 35 participants, who were registered in the MoodMap App, used the app during their working shift and used the main features of the app a total of 1767 times. Each of these users had on average 50.49 interactions with the application (SD = 101.56) during the whole field study period. Such a high standard deviation also shows that the usage of the app was very polarized, having users who were very active, whereas others almost did not use the app. Figure 10.10 shows the average usage of each feature of the MoodMap App. The three features that were most used were the Capture Mood, Timeline, and Compare Me visualizations. This was also confirmed by the interviews and the questionnaires. The preferred visualization for the users was the Compare Me visualization, where employees could compare their own mood with the mood of their colleagues. This confirms our Hypothesis 1, that comparing themselves to the team in a quick and intuitive way may be supportive and useful, both in terms of creating curiosity in the users as well as allowing users to detect discrepancies that can initiate a reflective process.

Overall Impression

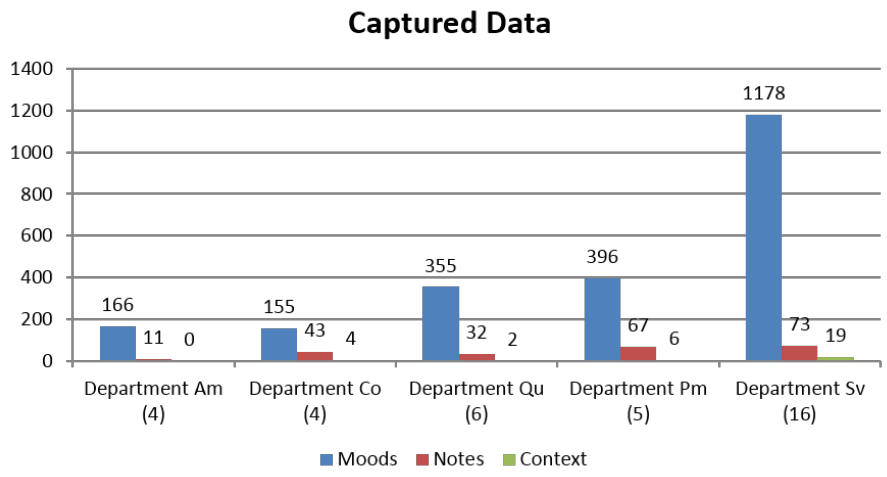


Figure 10.9: Absolute numbers of moods, notes and context captured by each department (with number of members of each department).

Summarizing the answers (N = 34) of the open question of the post-questionnaire about the usage of the MoodMap App showed that the users' opinions were very ambiguous – from very positive over neutral to negative.

The final statements of the participants revealed again their different attitudes towards the MoodMap App. On the one hand, we have several positive statements which refer mainly to the managers' perspective and that they could use the MoodMap App to better support their team e.g. *"To be useful it should be used by managers to check the mood of its staff and possibly implement appropriate corrective actions."* Another positive statement was *"It's a great project but maybe the effectiveness was a bit limited by the lack of time to make meetings on the subject."* Another very interesting statement was that *"MMA and the concepts in which it is based are intelligent. But the Italian culture and mentality, especially in working environments, do not give any importance to feelings / energy / health / stress of people so the use of MMA has showed little profit and 'was seen as a loss of time'."* This statement was very interesting because it is Italian law that dictates that companies have to verify the level of stress of their

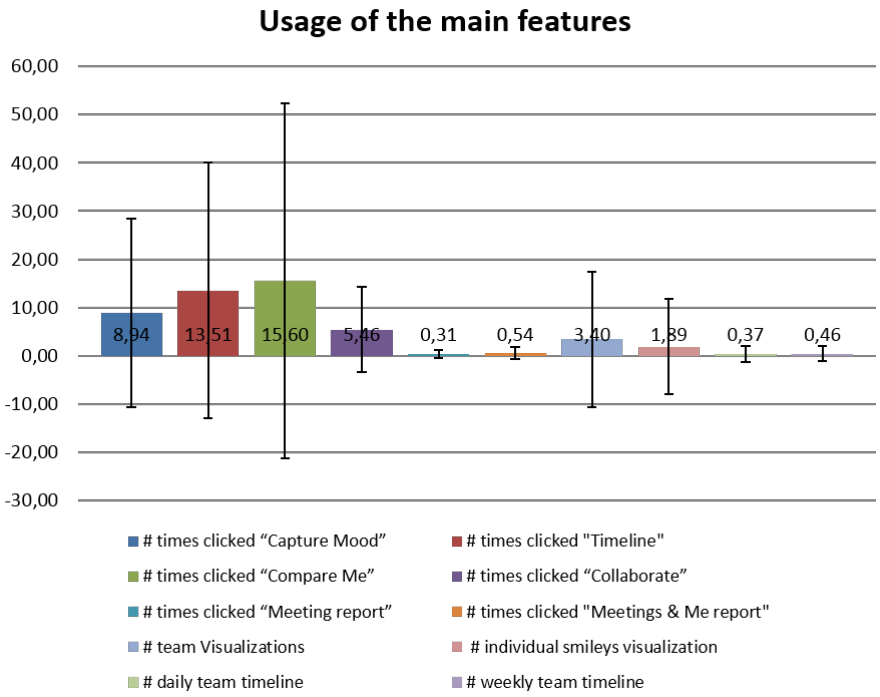


Figure 10.10: Usage of the main features of the MoodMap App. For each feature, average and standard deviation are depicted

employees, but it seems that this has not been included in their organisational culture yet. Additionally we also received some ideas for improvement e.g. *“The app should be made much more streamlined and straight forward [...] use a faster realization, maybe a widget on your desktop”*. In contrast, there were also some critical statements regarding the usefulness of the MoodMap App, especially one from a manager: *“The objectives of the MoodMap are unrealistic. The idea of thinking about the own mood is good, but I just consider it inapplicable [. . .]”*. He also stated several reasons why users would never state their real mood into such a tool (e.g. ethical reasons, non-work-related personal bad feeling or depressions) and questioned what one should do if mood is not optimal

"What happens if an employee is going through a bad time?". This fact suggests that this participant may have not understood the purpose of supporting reflection with the MoodMap App and the goal of the whole field study, where such findings should help people improve their work and collaboration.

Satisfaction, Long Term usage and future usage

The following mean scores were all rated on a 5-point Likert Scale (strongly disagree – strongly agree). In Figure 10.11 (blue bars, satisfaction) the participants (N = 34) stated that they are neutral or have slightly agreed to be satisfied with the MoodMap App M = 3.24 (SD = 0.85). Four departments mirror the overall mean scores. Only Department Pm was not satisfied with the application, although they have captured most of the moods per participant during this trial. This could be explained with the fact that they have neither used the available reports in the application nor that they have conducted any meetings to reflect about their moods within their team to gain explicitly any insights or benefits. Furthermore many of them did a lot of travelling during the field study period and seemed to be the most stressed ones, therefore they just captured the mood and kept working, but could not perceive any benefit for themselves. The overall score regarding the long-term usage of the MoodMap App during work (Figure 10.11, red bar, long-term usage) is rated rather neutral M = 2.94 (SD = 1.00). While Department Co agreed to continue using the MoodMap App, the other four departments rated the long-term usage neutral or slightly disagreed to it. The future usage (Figure 10.11, green bar, future usage) of the MoodMap App was rated with an average value of M = 2.76 (SD = 1.35). Especially Department Co agreed to use the MoodMap App also in the future. The other departments Department Am, Department Pm and Department Sv slightly disagreed to use the application in future. For all values, the standard deviations are rather high; this shows that the participants diverge in their opinion regarding the future usage of the app.

A Pearson product-moment correlation coefficient was computed to assess the relationship between several variables from Level 1. Concretely, the number of captured moods (notes and context), interactions with the application, subjective usage, self-expressiveness of feelings and social media attitude as well as sharing, satisfaction, long term usage, the motivation to reflect alone or in the team, learning outcomes, change in behaviour and KPI's were investigated. There was a positive correlation between number of captured moods and number of interactions with the visualizations in the MoodMap

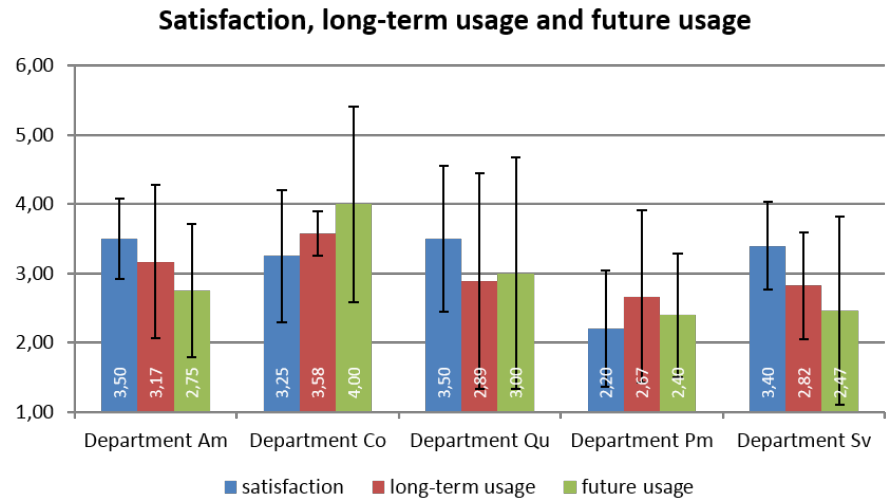


Figure 10.11: Mean scores of satisfaction, long-term usage and future usage

App, r = .489, p = .003, for N = 34. This analysis reveals that most active users (e.g. the ones who visited the visualizations) were also the ones who captured more moods. Self-expression of feelings in general and during work clearly emerged, r = .710, p <.001, N = 34. This reflects, that people who are usually comfortable to express themselves, don't encounter additional barriers to do it at work, and vice versa. Additionally we see a strong positive correlation between the motivation to reflect on work in general and the opinion that the app helped them to deal with their emotions (r = .720, p <.001, N = 34). This result indicates that the MoodMap App could help them to deal with emotions, especially for people who are more motivated to reflect on work. A strong positive correlation exists between the number of captured moods and the subjective application usage (r = .489, p <.001, N = 34). This suggests that users were aware of their activities done in the MoodMap App regarding the capturing of moods. Participants who were more comfortable with sharing their moods with managers also inserted more notes in the MoodMap App, as it is shown by the positive correlation between these two variables (r = .488,

p = .006, N = 30). Finally, we also found a positive correlation between moods and notes (r = .395, p = .019, N = 35) and notes and context (r = .377, p = .025, N = 35).

Barriers

Figure 10.12 shows the scores of the possible barriers (Figure 10.12, blue bars) in relation to not having time, not having physical space, not having seen any advantage or not having motivation to use the app, which were rated with neutral to slightly disagreement M = 2.66 (SD = 0.58) by all departments. The social media attitude (Figure 10.12, red bars) i.e. how likely it is that they use social networking platforms (e.g. Facebook, Twitter, LinkedIn, Google+, MySpace) was rated on average with M = 3.50 (SD = 1.08). This means that they slightly agreed to use such platforms, and that the social media attitude is mostly not a barrier to use the MoodMap App. While four of the departments mirror the average score, Department Co rated this item with M = 4.50 (SD = 0.58). This shows that the participants of Department Co strongly agree to use social networking platforms. In contrast, the social privacy concerns (Figure 10.12, green bars, rated with a 4-point Likert scale: not at all – high) are rated with M = 2.68 (SD = 1.17). This shows that the participants are only from a little bit to somewhat concerned about their privacy on social networking sites in general, which is therefore not seen as a major barrier to use the MoodMap App. Department Qu and Department Sv are more concerned about their privacy than the other three departments. Department Cu is least concerned regarding privacy which again matches with their overall social media attitude. Regarding the self-expression of feelings (Figure 10.12, purple bars) in general and during work M = 3.41 (SD = 0.84), the participants rated it neutral or slightly agreed, that they feel comfortable with this fact. While Department Co rated the self-expression very high, Department Pm rather low. The other three departments stated their self-expression rather neutral. Sharing of emotions (Figure 10.12, cyan bars) with managers or department members was rated with M = 3.53 (SD = 0.86), which means that sharing of individual moods was not seen as a significant problem. In this case the average value represents the scores for all five departments.

Additionally, the participants mentioned several situations when they would share their moods with their managers, for example *"Upon the occurrence of important working events that make my mood change considerably"* or *"In the situations where a manager is able to listen constructively the issues/problems identified*

in the work processes". One manager refused to share his moods at all *"Never. The moods are extremely personal and depend on thousands of factors. I would not want to share it to work."* Situations where the participants would not share their moods with their managers encompass mostly non-work related private issues or situations where users are discontent or dissatisfied with their work. Again, from a manager we have the following sentence *"Never. It is not ethical to ask to share the mood in the workplace."*

From the open questions of the post-questionnaire (N = 34) we received many different responses regarding the barriers of the MoodMap App usage. 26 participants did not answer this question. Three of the participants did not see any barriers to use the MoodMap App at all. Four of the participants mentioned that they have no time to use the MoodMap App because of urgent and tight timelines. One participant stated that he would like to have a faster approach to insert his moods e.g. in form of a widget. And one participant stated that that *"The graphical interface is not usable"*.

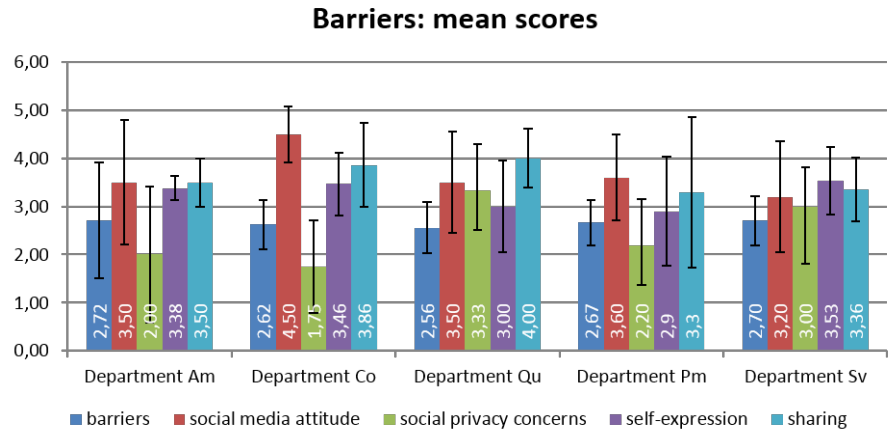


Figure 10.12: Mean scores for possible barriers including general barriers, social attitude, social privacy concerns (*rated on a 4-point Likert scale), self-expression and sharing

Level 2: Learning

Learning Process

App specific reflection questions: Altogether nine app-specific questions were included in the post-questionnaire, eight regular questions and one control question (N = 34). Figure 10.13 presents the mean ratings (from 5-point Likert scales) of the app-specific reflection questions and the corresponding control question of the whole field study and per department. The overall mean M = 2.86 (SD = 0.80) shows that the participants were neutral, that the application has potential to initiate reflection by capturing data relevant for reflection and visualizing data to reconstruct working experiences as well as capturing learning outcomes. While Department Pm disagreed that the application has potential to initiate reflection, the other four departments answered this question neutrally. These ratings are also very interesting with regard to the application usage and how many moods per participant per department were captured during the whole field study period. The results show that departments having captured less moods slightly agreed that the application has potential to trigger reflective learning, departments with higher app usage stated the opposite. These results are also aligned with the insights gained from the interviews: especially the managers did not use the application for other purposes than for capturing moods. Therefore they could not exploit the capacity of the different visualizations regarding reflective learning about their own moods nor on the moods of their department. Furthermore, they did not include the application in their meetings, so in those situations the potential to trigger reflection was also missed. The "app specific reflection control" question asked if the application can help to simulate their work process. With the summarized mean ratings M = 2.82 (SD = 0.97) the participants answered this question rather neutral. This rating is rather too high, because the application does no simulation of any work processes at all.

App specific questions: Figure 10.14 presents the mean scores of the applications specific questions (N = 34) contained in the post-questionnaire. We will only mention the values of the single departments, when they clearly differ from the average scores.

All eight items were on average rated neutrally (see Figure 10.14) covering mean values between 2.71 and 3.29. Department Co M = 4.50 (SD = 1.67) strongly agreed to become aware of their own mood (Figure 10.14, own mood

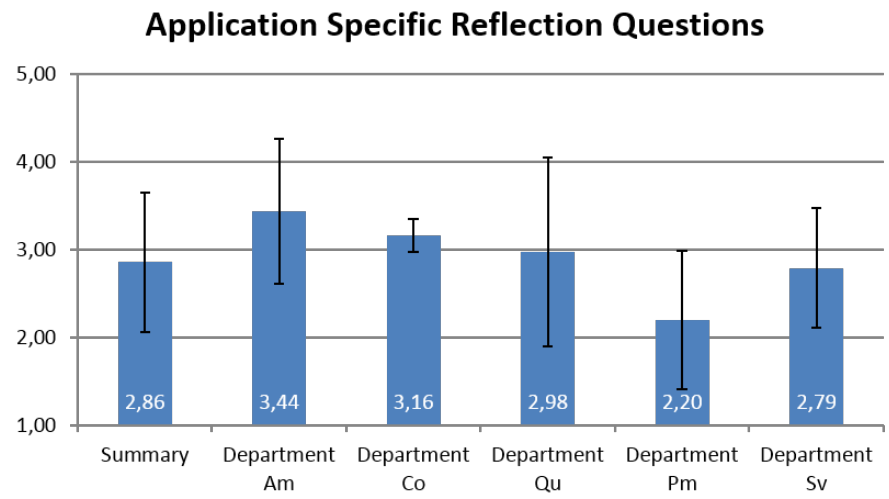


Figure 10.13: Application specific reflection questions for the whole field study and per department

awareness) and also stated to become more aware of their colleagues mood M = 4.00 (SD = 1.17) (Figure 10.14, colleagues mood awareness). Regarding the identification (Figure 10.14, identification) of significant situations, significant mood changes or topics worth reflecting upon was positively rated by Department Am M =.47 (SD = 0.42) and Department Co M = 3.59 (SD = 0.89) and negatively rated by Department Pm. In addition, only Department Am M = 3.50 (SD = 0.58) agreed that the MoodMap App guided them to reserve space for reflection (Figure 10.14, space for reflection).

Regarding the question if the MoodMap App helped the participants to gain a better understanding of the department and its members (Figure 10.14, department understanding) was agreed by Department Am M = 3.75 (SD = 0.50) but disagreed by Department Pm M = 2.00 (SD = 0.71). Only Department Am M = 3.58 (SD = 0.79) agreed that the app helped them to better understand their emotions, how their emotions affect their work or to deal better with their emotions (Figure 10.14, emotion understanding).That the capturing of

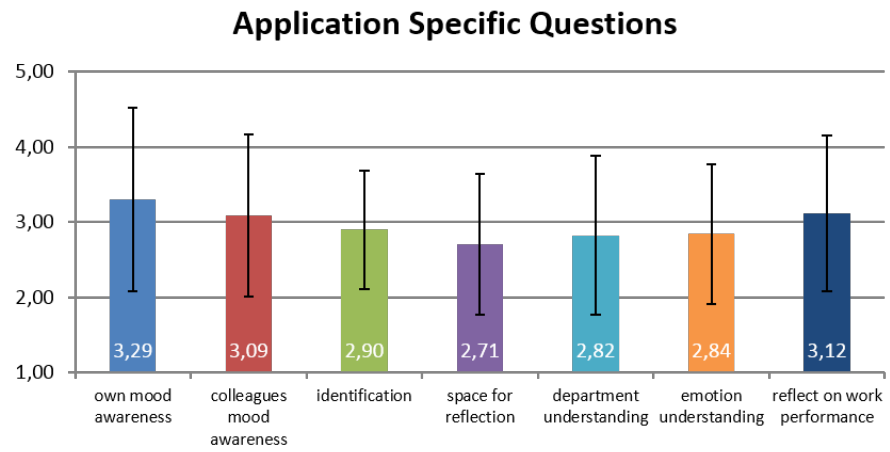


Figure 10.14: Mean scores of the application specific questions

moods during their daily work is useful to reflect and think about their work performance (Figure 10.14, reflect on work performance) was confirmed by Department Am M = 3.75 (SD = 0.50) and Department Co M = 3.75 (SD = 1.41).

The participants were asked to capture their mood during the day. The usefulness of capturing the mood at the beginning of the day was rated with M = 3.50 (SD = 1.05), in the middle of the day with M = 3.62 (SD = 1.10) and at the end of the day with M = 3.59 (SD = 1.10). Regarding further situations in which it was useful to capture a mood, the responses range from during or after meetings until stressful situations, including "moments of tension" or "during / after the execution of tasks that require concentration and accuracy" and in phases where the user was feeling particular fatigue or tiredness.

Analysis of notes:

The participants have captured all together 2250 moods and 225 non empty notes. After analysing the notes with the reflection-coding schema (section 2.2), 207 notes could be identified as individual reflective items (see Figure 10.15). In the first round, two researchers categorized the notes independently. In a

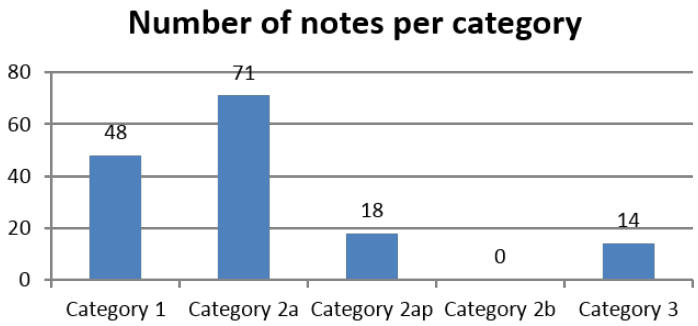


Figure 10.15: Number of notes per category according to the Reflection Coding Scheme

second round they analysed the notes together in order to get full accordance. Beside the categories defined in the reflection coding schema, a new category "Category 2ap" was added to the schema. It is a subcategory of "Category 2a" (own emotions) and represents the physical condition (e.g. pain, illness) related to own emotions. Table 10.6 shows examples of notes and the corresponding categories.

Table 10.6: Examples of categories and corresponding notes

Category	**Example of notes**
1: experience or issue	"Positive call with a customer"
2a, 2ap: own emotions	"I have a little bit of stomach ache, but I am feeling positive :-)"
1, 2a: experience and own emotions	"I feel better, but I just finished a call about analysis with the customer .."
1, 3: interpretation of actions	"Emergencies that have distorted the work plan, overload of tasks and little fluidity (lack of feedback etc.)."

Short Reflection Scale (pre- and post)

Figure 10.16 represents the mean ratings for the Short Reflection Scale (SRS) as well as the two subscales concerning individual and team reflection. Comparing the scores on all three levels, we found no significant differences

between the SRS of the ratings of pre-questionnaire to the ratings of the post-questionnaire. For the overall comparison we used the answers of those participants who have filled in both questionnaires on time and with meaningful content (N = 32). Figure 10.16 shows means and standard deviations for the SRS and the subscales individual reflection and team reflection in the pre- and post-questionnaire.

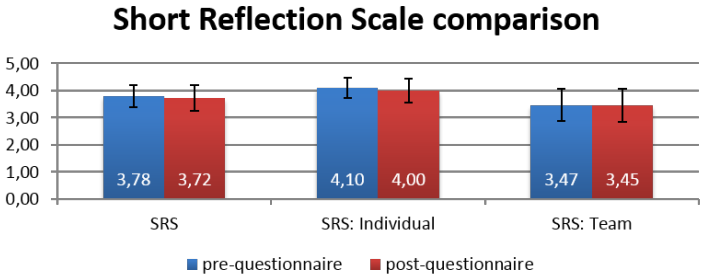


Figure 10.16: Short Reflection Scale before and after the usage of the MoodMap App

A two-way ANOVA with the factors time (pre- vs. post-questionnaire) and type of reflection (individual vs. team) revealed no effect of time but a significant effect of reflection type ($df = 1\ (31)$, $F = 60.52$, $p < .001$). Post-hoc related t-tests show that individual reflection scores are significantly higher than team reflection scores at both times (pre/post-qu: $t(31) = 6.2/5.7$, both $p < .001$).

Long term usage: Several variables from Level 1 and Level 2 correlate regarding the long-term usage in general. The long-term usage covers questions with regard to the long-term advantage of using the application (long-term 1), the wish to continue the usage of the app as part of the work-life (long-term 2) and to being practical to continue using the application during work-life (long-term 3). Sharing of moods with managers positively correlates with all long term variables which indicate that following moods over a longer period of time might positively influence the collaboration between managers - and employees. Also the motivation to reflect on work in general as well as to deal better with emotions are increased by a longer usage of the App. Additionally recommending the App to others would increase if the App is used longer and more clear insights and benefits are gained on an individual

level. These correlations confirm our Hypothesis 2 that these 4 factors influence the long-term usage of the MoodMap App. Table 10.8 presents the detailed correlations.

Table 10.7: Correlation between long-term usage and sharing, motivate to reflect, deal with emotions and loyalty metric (N = 34)

	long-term advantage (LT1)	**continuation of usage (LT2)**	**practicality during work-life (LT3)**
sharing	r = .605, p <.001	r = .702, p <.001	r = .590, p = .001
motivation to reflect	r = .464, p = .006	r = .507, p = .002	r = .467, p = .005
deal with emotions	r = .647, p <.001	r = .566, p <.001	r = .516, p = .002
loyalty metric	r = .711, p <.001	r = .645, p <.001	r = .488, p = .003

A moderate positive correlation between the user's satisfaction with the application and seeing the long-term advantage of using the application was also found, r = .494, p = .003, N =34. With regard to the user's satisfaction with the application we also saw a strong positive correlation to the motivation to reflect on work in general (r = .729, p <.001, N = 34), to deal with emotions (r = .592, p <.001, N = 34) and the recommendation of the application to others (r = .704, p <.001, N = 34).

Learning Outcome

The learning outcomes stated within the post-questionnaire (N = 34) were seen as nearly neutral to slightly disagree M = 2.66 (SD = 0.95), i.e. participants were not in agreement whether they gained a deeper understanding of their work life and what to change about their work behaviour with or without regard to their work within their department. While four of the departments mirror the average values Department Pm M = 2.10 (SD = 0.89) clearly stated that they did not perceive any deeper understanding of their work life or did not consciously made a decision about how to behave in the future.

The analysis of the open questions from the post-questionnaire provided little more details about their understanding of their work life and their conscious decisions of what to change in the future. Only 2 to 4 participants answered the open questions regarding their learning outcomes. Regarding the conscious decision of what to change in future one participant stated to *"focus/concentrate on a certain working outcome"* while a manager mentioned that he will *"give a greater attention to the mood of the staff in my team"*. With respect to getting a

deeper understanding of the own work life, one participant stated to take care about *"appropriate moments in which to do a break"*. Other participants gained deeper understanding about the *"importance and influence of encouragement from the team of colleagues and especially the superiors (managers)"* and *"in the management of the business in relation to the moods, especially in times of stress"*.

Level 3: Behaviour

Behavioural change (through question CB1) was rated by the participants with M = 2.53 (SD = 1.02), which implies that the participants tend to slightly disagree that the MoodMap App helped them to improve their work. While the four departments Am, Co, Qu, and Sv represent the average score, Department Pm M = 1.60 (SD = 0.89) strongly disagreed that the MoodMap App has helped them to improve their work. From the post questionnaire we only get confirmed that they have not noticed any improvements regarding their work.

A Pearson product-moment correlation coefficient was computed to assess the relationship between the variables from Level 2 and 3. Strong positive correlations (see Table 10.8) were found between making a conscious decisions of how to behave in future (CL1)[1], gaining a deeper understanding of the work life (CL2)[2], the improvement of work performance (CB1)[3] and Level 1 variables like the user's satisfaction with the application, the long-term advantages, the motivation to reflect on work, better dealing with emotions and the recommendation of the application to a colleague (loyalty metric).

Additionally to the feedback gathered with the questionnaires, gained insights and behavioural changes were also collected through several interviews. Seven interviews were conducted with the following participants: the manager of the Department Am, the manager and one of the two staff members (who coordinated this field study from Regola's side) from the Department Pm, two staff members from the Department Co, one staff member from the Department Am, and another staff member from the Department Sv. Below some representative statements of the conducted interviews are presented.

[1] CL1: After using the MoodMap App, I made a conscious decision about how to behave in the future.

[2] CL2: After using the MoodMap App, I gained a deeper understanding of my work life.

[3] CB1: The MoodMap App helped me to improve my work performance.

Table 10.8: Correlation between Level 2 and Level 3 variables (N = 34); *: Significant at p <.001

	satisfaction	long-term advantage (LT1)	continue usage (LT2)	practicality during work-life (LT3)	reflect motivation	deal with emotions	loyalty metric
CL1[1]	$r = .613^*$	$r = .619^*$	$r = .569^*$	r = .487 p = .003	$r = .665^*$	$r = .809^*$	$r = .659^*$
CL2[2]	$r = .524^*$	$r = .718^*$	$r = .737^*$	$r = .736^*$	$r = .669^*$	$r = .773^*$	$r = .608^*$
CB1[3]	$r = .685^*$	$r = .526^*$	$r = .572^*$	r = .457 p = .007	$r = .754^*$	$r = .775^*$	$r = .679^*$

Generally, the feedback from managers and staff was very positive, as it is shown for example in the following statement from a manager *"... interesting experience as a user because in a way it is my company that becomes interested in my work. They try to be aware of my goals during my work activities and I think that it is a really positive thing..."*. Also statements from the staff showed the positive experience: *"Yes it is an positive experience ... I think it was a useful tool to access this state of mind at any given time of the day and particularly during work and activity"* or *"I thought that the usage of the MoodMap App could help and support the entire company and team work"*.

Level 4: Results

In order to detect differences between the situation before and after the usage period, we asked participants in both questionnaires (pre-test and post-test) about their job satisfaction and the impact of reflection in their job.

Regola could not provide KPIs from their organisation and the results regarding the KPIs collected with the post-quesitionnaire could not be obtained due to a technical problem. Therefore we focus our results on the job satisfaction, and the work improvement on an individual as well as team level, which were collected in the pre and post questionnaires.

Participants' rating about job satisfaction was improved during the app usage (see Job satisfaction in Figure 10.17). Participants were also asked whether

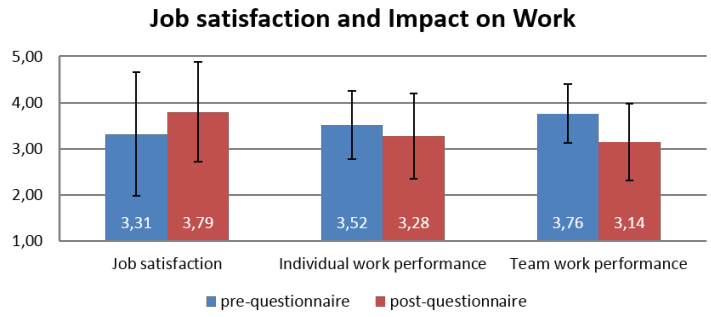


Figure 10.17: Job satisfaction and impact of reflection on work before and after the usage of the MoodMap App

reflecting on how they feel could both individually and collaboratively help them to improve their work performance. Expectation before the field study ("Reflecting on how I feel could help me to improve my work performance.") was compared with the actual experience during the field study ("Reflecting on how I feel improved my work performance."). This comparison (see Individual work performance and Team work performance in Figure 10.17) shows that participants were slightly less confident after the field study regarding reflection on own individual work. This was also the case with reflection and discussion on their moods getting to improve their team performance.

As shown above, job satisfaction was on average improved after the field study. Therefore, job satisfaction at department level was analysed. Figure 10.18 below shows the average work satisfaction of each department, before and after the app usage. All departments except for Department Qu reported an improvement of their work satisfaction. Results show an increase in the average satisfaction value as well as a decrease of the standard deviation for each department (see Figure 10.18). Department Qu has shown a very low satisfaction both before (M = 2.25, SD = 1.71) and after the field study (M = 2.00, SD = 1.41).

Average rating to the question whether individual reflecting on how an individual feels, helps to improve the own work performance slightly varied among departments (see Figure 10.19). Whereas the agreement to this question

Figure 10.18: Job Satisfaction of each department before and after the usage of the MoodMap App

decreased in 4 teams (Am, Co, Pm and Sv), in the case of the Department Qu it was increased. Details about the analysis of the answer given by each department are depicted below in Figure 10.19.

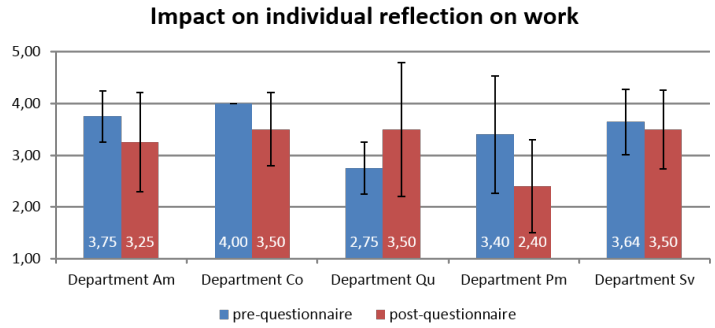


Figure 10.19: Impact on individual reflection on work improvement per department before and after the usage period

The results of the loyalty metrics (N = 34) looks as follows: 3% are promoters, 26% are passives and 69% are detractors. That implies a computed Net Promoter Score (NPS) of -68%. This low score reflects the difficulties unfortunately experienced at Regola to introduce the MoodMap App as a support for reflective learning.

A Pearson product-moment correlation coefficient was computed to assess the relationship between the variables from Level 4 and variables from other levels, which may have had an impact on the subjective KPIs. KPI 1 representing the satisfaction with own work, was not correlated with any of the variables investigated below, however, this was the case for the KPIs related to the impact of reflection on work (post-questionnaire answers).

There are positive correlations between KPI 2[4] (reflecting on how own feelings helps to improve work) and both, expression of feelings in general ($r = .464$, $p = .007$, $N = 33$) and expression of feelings at work ($r = .684$, $p < .000$, $N = 33$). This fact shows that there is a strong influence of self-expressiveness of the participants and their trust on reflection to improve their work performance.

A significant moderate positive correlation between two of the subjective post-questionnaire values of the KPIs and the average value of the app specific questions was found. The believe of reflecting on how one feels helps to improve work (KPI 3[5]) has a moderate correlation with the app specific mean ($r = .505$, $p = .003$, $N = 33$). This is also the case for reflection and discussion on their moods getting to improve their team performance in relation to the app specific mean ($r = .499$, $p = .003$, $N = 33$).

By calculating the correlations between the KPIs and the variables from Levels 2 and 3 we can investigate the Hypothesis 3 that people who learned due to the usage of the MoodMap App and also changed their behaviour thanks to it also rated the KPIs with a higher value. This hypothesis was confirmed, as it can be shown in the following Table 10.9, as both KPIs improvement of individual work performance and team work performance correlate positively with questions of making a conscious decision about how to behave in future (CL1[6]), of gaining a deeper understanding of once own work life (CL2[7]) and

[4]KPI2: Reflecting on how I feel could help me to improve my work performance.

[5]KPI3: Reflecting and discussing on how we feel could improve our team performance.

[6]CL1: After using the MoodMap App, I made a conscious decision about how to behave in the future.

[7]CL2: After using the MoodMap App, I gained a deeper understanding of my work life.

of improving the own work performance (CB1[8]).

Table 10.9: Correlation between post-values of the KPIs and variables from Levels 2 and 3 (N = 33)

	CL1[6]	**CL2**[7]	**CB1**[8]
KPI2[4]	r = .488, p = .004	r = .360, p = .040	r = .588, p <.001
KPI3[5]	r = .456, p = .008	r = .407, p = .019	r = .583, p <.001

Strong and moderate correlations were also found with variables that had an influence on the app usage and the reflection on the data. These variables include the satisfaction with the MoodMap App (App satisfaction), the motivation to reflect on work in general (Motivation to reflect), and the belief, that the app helped them collaboratively to deal with their emotions (Dealing with emotions). Table 10.10 shows an overview of these correlations. Finally, the loyalty metric has a strong and moderate correlation respectively with the KPIs referring to the impact of reflection on work (see Table 10.10).

Table 10.10: Correlation between post-values of the KPIs and app satisfaction, motivation to reflect, help to deal with emotions and loyalty metric (N = 33)

	App satisfaction	**Motivation to reflect**	**Dealing with emotions**	**Loyalty metric**
KPI2	r = .698, p <.001	r = .480, p = .005	r = .452, p = .008	r = .721, p <.001
KPI3	r = .589, p <.001	r = .602, p <.001	r = .507, p = .003	r = .573, p <.001

10.3.6 Discussion & Conclusion

The use of the MoodMap App was initially identified by the human resources manager of the company with the goal to provide a possibility for self-reflection, self-development and especially for stress detection during work. However, the field study did not reveal the goals expected for several reasons.

[8]CB1: The MoodMap App helped me to improve my work performance.

First of all, the whole summative field study was conducted in a time when Regola was in a very busy period (e.g. a lot of hard project deadlines fell into the trial period) which adds additional challenges to the introduction of a new application. The introduction of the field study was organized within a one hour lasting workshop for all employees together. After the field study, the project managers on site mentioned that it would have been much better to organize different meetings with each single department in order to give a more detailed and better suited introduction for the corresponding participants and their job roles, by analysing also their work processes and embedding the MoodMap App on them. Additionally they might have also given support on how to reflect on the data and how they could derive some benefits or insights for themselves. We see this as one of the major lessons learned. It is of crucial relevance to prepare the introduction of such an field study very well, to show all participants a clear benefit and accompany all departments during the whole field study process. This is necessary to guide them to include reflection in their working processes but also to support them to gain all benefits of the MoodMap App usage.

The employees of all departments have declared that their job is very stressful and that they currently have to meet many project deadlines. Nevertheless a high number of moods were captured during their working days, but they had nearly no time and/or space to reflect about the captured data. Therefore, on the one hand they did not see a real benefit for themselves but on the other hand it was not mentioned after the field study that the capturing of moods was seen as "waste of time", as one participant stated in the expectations asked in the pre-questionnaire.

As part of the field study, very short meetings with the corresponding managers were planned in order to find out how mood or particular things according to the results of the MoodMap App can be improved. However, these meetings to conduct reflection sessions about the captured moods with their managers or within the team could not be scheduled. Such planned sessions with the project responsible would have shown the managers how to deal with the captured data and might have given them some insights regarding their whole team or single team managers. From the managers side the staff members did neither receive any feedback nor did the managers take any direct actions with regard to their team members. This could be also explained with the fact that the managers had no time to deal with the moods

of their team members and to try out the whole functionality of the MoodMap App, because this in the end would have increased again their work load.

Another barrier, which did not make the field study as successful as we expected it to be, was that some participants were afraid to state their mood in such a tool honestly, as it may affect their working position in the company. This suggests that it is important to convince the participants that the goal of the application is not to use the data inserted against them, but to support them. Such a conviction is only possible if the managers as well as the organisation are committed to such principles. Another factor that may have influenced the usage of the application is the low number of members that some departments had. From the experience gained in other field studies, bigger teams see an additional advantage when the manager can attend to each member individually and the MoodMap App could help to increase this awareness. However, in the case of Regola, having small teams may have led to a sense of controlling, instead of support and also in Department Sv (N=16), which is a bigger team, this result was not confirmed due to the lack of actions taken by the manager.

Regarding the MoodMap App features, the participants were very satisfied with it and they had no technical problems at all. They stated that the capturing of moods was very easy and they thought the application was complete. The favourite visualisation was the CompareMe view, because there they could directly compare their mood to the mood of the whole department at one glance. The reflection interventions and reflections amplifiers were sometimes ignored, but most of the times they were mentioned as very positive and useful. Besides having captured 2250 moods, participants only introduced 225 notes, 207 of which were categorized as reflective items. The analysis revealed that only 14 of these notes achieved category 3, where the learner interprets or justifies an action. Therefore, the potential for reflection while capturing their moods, by immediately identifying the cause of it or relationship to work tasks, could not be totally exploited.

Summarizing the progress of the field study, participants were very active in capturing their moods but it seems that the purpose of this capturing was not understood. Time and space for reflection was not facilitated and reflection on the data was not achieved. As the usage data reveals, some users who were very active in capturing moods only visited the visualizations a few times, so

they may have considered the capturing more as a reporting to the company instead of a way of reflecting on their work.

10.4 MQ FS5: Summative Field Study of the Medical Quiz

10.4.1 Setting: Neurologische Klinik Bad Neustadt

The Neurological Clinic Bad Neustadt (NBN) is one of the largest neurological centers of excellence in Europe. NBN is a specialty hospital for neurological acute and rehabilitation medicine. Located in the middle of Germany the clinic has in total 284 beds. The teams are specialized in the wide range of neurological diagnostic and therapy to provide our patients the best care. For the MIRROR Project the NBN selected the Stroke Unit as testbed. The Stroke Unit is a specialized entity of NBN that deals with acute cases of strokes. The time pressure and the daily work with emergencies and their results are a burden for all employees on a stroke unit.

The Stroke Unit at NBN has 10 certified beds, and employs 50-80 mainly female staff, and part-timers. At the Stroke Unit there are working about 40 nurses, split up into three shifts (morning, afternoon and night shift). Their task is to care for the patients and the patient's special needs after a stroke.

The summative field study of the Medical Quiz was carried out during the qualification course "Spezielle Pflege auf Stroke Units", which is organized by NBN.

The qualification course takes place once a year. In 2013/2014 about 21 nurses have participated in this course. The course started in October 2013 and ended in February 2014. In each month one course week has taken place, so the course consisted of altogether 5 weeks. The field study started with the beginning of the course in the middle of October 2013 and ended with a workshop during the course week, which was held in the middle of January.

Users and Their Job Roles

The work of nurses in the stroke unit is generally divided into three shifts comprising early, late and night shifts. While during early and late shifts, usually about six to eight nurses are on duty, in the night there are only up to four. The responsibility of nurses is to ensure medical treatment of patients as well as assuring their physical and mental well-being. The tasks they perform in order to fulfil these responsibilities are manifold and include the implementation of directives e.g. for medication given by physicians, the organization of patients' days including their transport to examinations and the documentation of both care given and physiological data measured during the day.

The early shift of nurses is structured by the day structure of patients, including tasks such as waking them up and serving them meals, and physicians' needs such as the ward round. Other influences they have to react on are unforeseen incidents such as emergencies and external influences such as therapists entering working with patients or patients being collected for external examination.

In the morning and late shifts, each nurse usually is responsible for patients in two rooms. One nurse per shift is responsible for the emergency ward and carries around a telephone to be informed about people being moved to this ward.

uring the workshop the nurses were learners who wanted to become more qualified for their work at a stroke unit, including the special needs of stroke patients. In this setting the Medical Quiz gave the nurses the possibility check their newly gained knowledge, to think about their learning progress and to establish a relation between the newly gained knowledge and their own working experiences with the help of the posed reflection questions during the quizzes.

10.4.2 Design and Procedure

The Medical Quiz was introduced to the participants of the qualification course "Spezielle Pflege auf Stroke Units" in the first week of the course. The presentation for the introduction was prepared by KNOW and the introduction

was held by the NBN project leader of MIRROR in the mid of October 2013. During the introduction the participants were asked to fill in the consent form, the demographic questionnaire and general questionnaire. Afterwards the participants got an introduction to the quiz itself including a neutral account. From the introduction of the quiz to the next qualification program week (middle of November 2013), the participants were asked on the one hand to play the different quizzes as often as possible and on the other hand to create new questions for the quiz. During this time all quiz attempts including all quiz results and answers to the reflection questions were logged. In the second week of the qualification course, the clinic representative presented the results of the first filled-in questionnaires and the number of quiz accesses. Then participants filled in an in-between questionnaire and were asked again to play the quiz and create questions for the quiz until the third course week (first week of December 2013), in which the same procedure was repeated. In the fourth week of the course (middle of January 2014) two researchers from the KNOW visited NBN and conducted a workshop with the study participants. During the workshop the overall statistics were presented to the participants, group discussions and some interviews were conducted and a final questionnaire was distributed. Altogether the field study lasted from October 2013 to January 2014. The quiz itself was played from the middle of October until the beginning of December. Participants used their spare time to play the quiz and create questions.

10.4.3 Participants

21 nurses participated in this field study, 2 men and 19 women; 66% were aged from 20-29 and 33% between 30 and 59. 95% were nurses and 5% were head nurses. The average time in the current position was 4 years.

10.4.4 Evaluation Methods

We used for this field study the following procedure: Demographic Information: The pre-questionnaire contained all demographic questions from the toolbox, except for date and Team-ID, because there were no teams in this setting.

10 Appendix B

Level 1: Reaction: all usage data can be received from the logs of the Medical Quiz.

Level 2: Learning: The short reflection scale (CR) was presented in the pre- and post-questionnaires. Additionally, the post-questionnaire contained 8 app specific reflection questions (CA) which fitted best to our approach and the two Learning Outcome questions (CL1).

Level 3: Behaviour: We adjusted the core behaviour question (CB1) to the Medical Quiz by asking how much the Medical Quiz helped to improve one's work at the stroke unit.

Level 4: KPIs were measured by several questions, encompassing work improvement in general, employees' work satisfaction (KPI), improvement of work performance (WK), patient satisfaction (KPI), and loyalty metric.

Additionally, with the pre-questionnaire we measured IT attitude (TI), learning strategies (LS), and posed questions about the work at the stroke unit in general (4 questions asking how participant perceive their work-relevant knowledge, problem solving abilities, patient satisfaction, and the quizzes' potential to improve their knowledge), and upcoming expectations regarding the quiz. The two in-between questionnaires covered subjective usage of the quiz and experiences with the quiz. The post questionnaire contained – in addition to the core questions - learning effect (GAE), self-efficacy, and questions regarding the future of the quiz.

Furthermore, the workshop at the end of the field trial was used to get deeper insights in participants' experiences with the app by means of interviews and group discussions. The gained insights concern for the main part field study levels 3 and 4, covering the following topics: for the interviews usage barriers, awareness of knowledge and behaviour change, transfer to job, satisfaction, and quality of work; and for the group discussions reflection guidance, influence into the organisation, potential for the future, and the quiz's relation to the CSRL model.

10.4.5 Results

Level 1: Reaction

The introduction of the quiz took place at the 14th October 2013. From this date on until the 2nd of December 2013, the quiz was regularly used by the participants. Based on the collected log-data, Figure 10.20 shows the application usage during this period. The four bar groups refer to the four different types of quizzes offered to the participants.

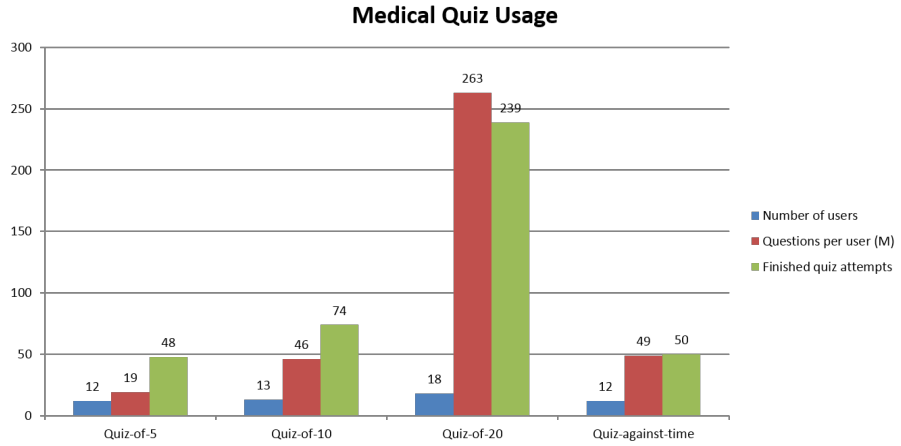


Figure 10.20: Medical Quiz Usage

The "Number of users" shows, that the Quiz-of-20 was played by 18 different users, the other quizzes by only 12 or 13. "Questions per user" represent the average number of questions each user has answered per quiz type. This value varies from 18.5 (SD = 27.8) questions for the Quiz-of-5 to more than 263 (SD = 290.9) questions for the Quiz-of-20. The average questions answered for the Quiz-of-10 and the Quiz-against-time were nearly the same (M = 45.5 (SD = 61.3) – M = 48.8 (SD = 70.5)). The "Finished quiz attempts" show how many quizzes per type have altogether been played and finished during the field study (summed up across all users). Three participants never played

the quiz due to different reasons discussed below. Thus, all users who have tried out the Medical Quiz have played the Quiz-of-20. Altogether for the Quiz-of-20 239 finished quiz attempts were counted, followed by 74 finished attempts of the Quiz-of-10. The finished attempts of the Quiz-of-5 and the Quiz-against-time are almost identical with 48 vs. 50. During this field trial, the participants have answered altogether 8314 questions. While one user answered more than 1120 questions by playing the Quiz-of-20, other users only answered 24 questions during the entire field study period. Overall, the results regarding the usage of the app show that most of the participants have played the quiz very often, which indicates that they perceived it as useful; otherwise they would not have played it that often.

Barriers

Two of the three participants, who have not used the quiz at all stated in the questionnaires that they had no internet access and one of the participants did simply not bring herself to try it out. The following other barriers for not using the quiz or for using the quiz in the beginning of the trial more than in the end were mentioned in the interviews: a lack of time especially in November and December, a loss of interest in the quiz after passing the exam and because of too many recurring questions and too little user-friendliness especially for nurses with lack of computational skills. On the other hand, several statements included the wish, to have the quiz directly available at their ward especially for the night shifts.

Mean ratings of Kirckpatrick's levels

Further data concerning level 1 have been gathered via the questionnaires. Figure 10.21 shows the mean ratings (from 5pt. scales) of summarized values of the post questionnaire. The red bars on the left hand side present the values for "Level 1: Reaction" of Kirckpatrick's model. The four blue bars represent the "Level 2: Learning". The green bars can be related to "Level 3: Behaviour", while the orange bar shows the result for "Level 4: Results" with regard to the measured KPI. Each of these values will be described in detail in the corresponding section of this deliverable. The first three red bars of Figure 10.21 relate to "Level 1: Reaction". Regarding the subjective estimated usage frequency of the application, the participants rated their individual usage frequency rather low (M = 2.5, SD = 0.92). If we compare the subjective impression of the participant's with the real usage retrieved from the log data, we are of the opinion that some of the participants underestimated their quiz

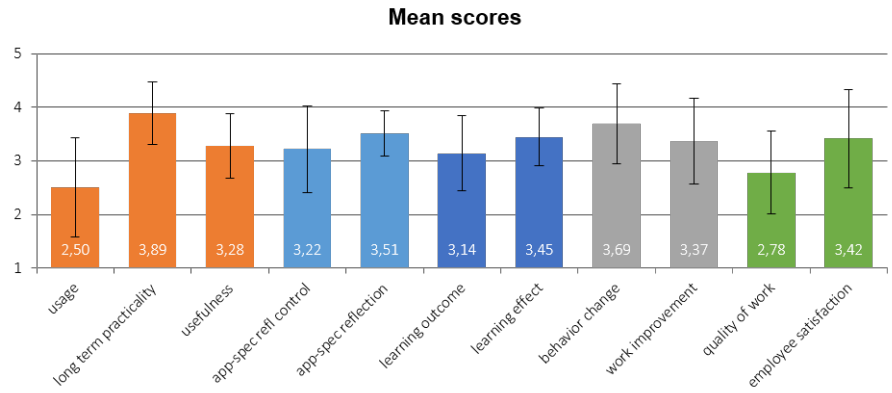


Figure 10.21: Medical Quiz Usage Mean ratings (SDs) after using the quiz (from 1-totally disagree to 5 – totally agree); different colours indicate different field study levels (starting with level 1 on the left hand side of the figure).

usage. Interestingly, there is no correlation between subjective and objective usage in terms of number of questions played (r=.324, p=.19, N=18). Most of the participants agreed to long-term practicality (M = 3.89, SD = 0.58), which means that the application can be used to complement professional training for nurses. The usefulness of the quiz (M = 3.28, SD = 0.60) was rated neutral or at least slightly positive from most of the participants. This attribute indicates that the users see the long-term advantage of the quiz during work as well as that they are interested in using the application during work. We found no correlation among the four "level 1" variables objective and subjective usage, long-term practicality, and usefulness.

Level 2: Learning

The goal of the Medical Quiz during the qualification program is to provide an easy possibility for the nurses to check their newly gained knowledge, to detect possible knowledge-gaps, to make them reflect about their current knowledge, and to relate the content of the posed questions to work-related situations or experiences. Within the qualification program the participants

used the quiz to be well prepared for the course's examination, which was explicitly stated by one participant.

With regard to the nurses using the quiz directly at the stroke unit, the quiz should make them aware about their current knowledge and refresh it if necessary, relate the content of the questions to work-related situations or experiences but also provide a possibility to keep-up-to date with new treatments and medications.

Learning Process

CSRL model and reflection questions: Relating the Medical Quiz to the CSRL model, playing the quizzes corresponds to the "Plan and Do work" stage with the goal to learn something or get insights for the practical work. Especially with the help of the implemented reflection questions, the "Initiate reflection" phase is triggered. By answering the posed reflection questions the "conduct reflection session" phase is covered including noting down any insights or outcomes. The last phase "apply outcome", is not covered directly by the Medical Quiz, because we have no possibility to check whether the gained insights our outcomes have been tried out or applied during work.

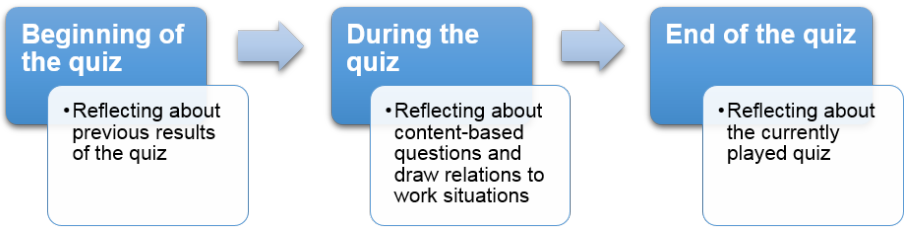


Figure 10.22: Reflection guidance components.

In order to better support the "initiate reflection" phase during the quiz play, we implemented a part of the reflection guidance concept. We added reflection

questions (open questions) additionally as well as on top of the usual content-related quiz questions at the beginning, during and at the end of a quiz. At the beginning of the quiz (implemented in all quiz types) the reflection questions make aware of the current knowledge status, depending on the gained quiz results on previously played quizzes. Additionally, participants are asked to think about the reasons for their past results and, in the case of low knowledge, levels how they can improve in the future (see Table 10.11 for some example questions). The in-between questions (only available in the Quiz-of-20), put the focus on the content-based questions and how they refer to past working situations and working experiences (see Table 10.13 for examples). The questions at the end (Quiz-of-20, Quiz-of-10 and Quiz-of-5) of the quiz asked explicitly for gained insights or new knowledge with regard to the currently played quiz (see Table 10.12 for examples). After having finished a quiz, the quiz results are directly presented to the players, which again is worth reflecting on.

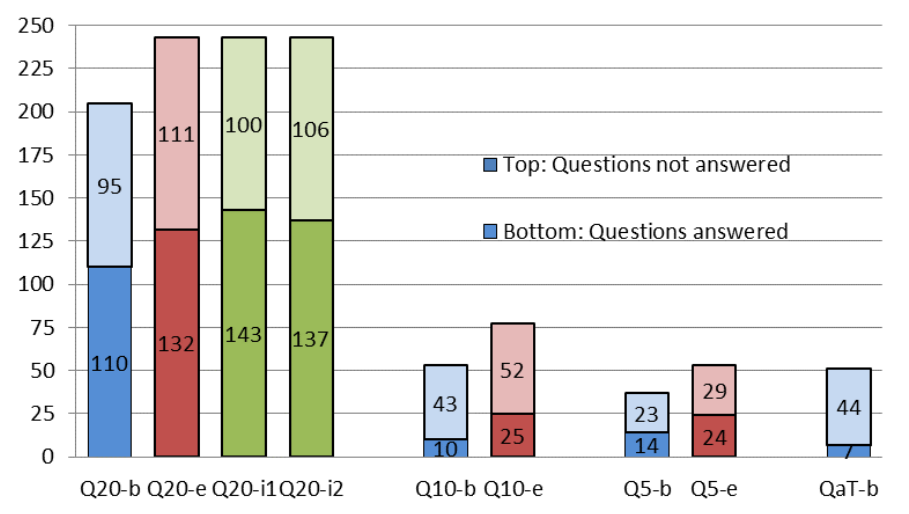


Figure 10.23: Number of presented (full scale bars) and answered (bottom part) reflection questions: split into questions shown at the beginning (b), during (i1, i2) and at the end (e) of the quizzes.

At the beginning of each quiz, one entry reflection question was automatically posed, which was based on the previous quiz results of the current user. These questions were displayed as soon as the user has played the corresponding quiz for three times. The questions referred to the current knowledge state of the user and motivated the user to think about how the quiz might influence or support the user's learning. Altogether we had 9 different reflection questions. Examples of these questions are presented in Table 10.11. For the Quiz-of-20, altogether 205 reflection questions at the beginning (blue bar) were shown and more than 50% were answered by the players (Figure 10.23, bar "Q20-b", bottom bar). For the Quiz-of-10 only 18% of the 53 posed questions were answered (Figure 10.23, blue bar "Q10-b"), for the Quiz-of-5 38% out of 47 questions (Figure 10.23, blue bar "Q5-b") and for the Quiz against time 13% were answered out of 51 questions (Figure 10.23, blue bar "QaT-b").

Table 10.11: Summary of the reflection questions posed at the beginning of all types of quizzes.

Question at the beginning	**Frequency of occurrence**	**Frequency of answers**	**Answers**
Your knowledge is very constant. How could the quiz help you to learn?	65	26	Practice, Nothing, Yes, Repetition
Unfortunately your state of knowledge is very low. In what respect does the quiz help your to learn?	59	37	Learning, Yes, Practice, Repetition, Retain Knowledge
Unfortunately, your state of knowledge is very low. What is your success recipe?	63	35	Yes, Learning, Repetition, Practice

Table 10.11 shows three possible reflection questions posed at the beginning of all quizzes. The "Frequency of occurrence" shows how often which of these questions were shown during the quiz and "Frequency of answers" shows how many of them were meaningfully answered. (Unfortunately some participants only inserted some letters, in order to get the question counted as correctly answered.). The "Answer" column shows a summary of the words most often occurring in the answers.

At the end of each quiz, except the Quiz-against-time, a reflection question was presented with the goal to motivate the users to reflect about the currently completed quiz and if they could gain any benefits or insights out of the currently played quiz. These reflection questions were chosen randomly out of altogether 8 questions. Examples of these questions are presented in

Table 10.12. At the Quiz 243 of these reflection questions were presented to the players and 54% of them were answered (Figure 10.22, red bar, Q20-e). For the Quiz-of-10 77 questions were presented and 32% were answered (Figure 10.22, red bar, Q10-e), and for the Quiz-of-5 the users answered 45% of the 53 posed questions (Figure 10.22, red bar, Q5-e). In the Quiz against time no reflection question was presented at the end.

Table 10.12: Summary of the reflection questions posed at the end of three types of quizzes.

Question at the end	**Frequency of occurrence**	**Frequency of answers**	**Answers**
Reflect on the currently played quiz. Have you perceived any special insights for yourself?	54	26	Yes, Retain Knowledge, No, Repetition
Reflect on the currently played quiz. What do you intend to do with regard to the quiz results?	53	30	Learning, practice, use theory in practice
Reflect on the currently played quiz. In what respect does the quiz questions support you to learn for the qualification program?	44	23	Yes, very much, recognise progress and repetition of the learned knowledge

Table 10.12 presents three of the posed reflection questions at the end of the quiz. "Frequency of occurrence" shows how often the question was posed at the end of the quiz and "Frequency of answers" presents how many of them were filled in. The last column contains often received answers.

The two in-between reflection questions were only added to the Quiz-of-20. Nine different reflection questions were randomly presented. Their task was to motivate the player to relate the presented content-based question to possible situations during work. Examples of these questions are presented in Table 10.13. For both in-between questions, the participants had also answered more than 50% of the presented questions (Figure10.23, green bars, Q20-i1 and Q20-i2).

Table 10.13 presents three of the in-between reflection questions posed during the 20-er quiz. "Frequency of occurrence" shows how often the question was posed during the quiz and "Frequency of answers" presents the number of how many of them were filled in. The last column contains reoccurring answers.

Table 10.13: Summary of the reflection questions posed during the Quiz-of-20.

Question during the Quiz-of-20	Frequency of occurrence	Frequency of answers	Answers
Does the question above remind you on an interesting situation/discussion during your work and if yes, on which?	51	23	Yes, No
In what respect is the above mentioned knowledge relevant for your work?	68	40	Yes, Very relevant
Could the question mentioned above support your learning? If yes, how? If no, how should this question be chanced, in order to support your learning?	60	35	Yes, No it's too easy

From the field study of the log data we saw that the guidance concept was accepted and more than 50% of the reflection questions were answered in a meaningful way. Nevertheless from the interview and group discussion conducted, we also received some further feedback regarding the reflection questions. Answering or not answering the reflection questions should not have any influence on the quiz result. Sometimes the questions were found as disturbing during the quiz play, referring especially to the in-between questions, because the randomly chosen questions did not always fit very well to the content-based question above. When introducing the quiz to the workshop participants, the sense of the reflection questions should be explained in more detail.

General and app-specific reflection questions: Referring back to Figure 10.21 (blue bars) one can see that the participants of the qualification program only slightly agreed that the application triggers reflective learning (M = 3.51, SD = 0.42). This is in line with the general impression that participants viewed the quiz mainly as learning support and that reflection was only of secondary importance. The result is not surprising considering that these participants played the quiz in the context of a training course. However, correlating the app-specific reflection ratings with usage data, shows that participants with higher objective (number of played questions) or higher subjective usage (rating) also showed higher ratings concerning the app's potential to support reflection (r =.712/.535, p=.001/.022, N=18 for objective/subjective usage). The "app-specific reflection control" question asked whether the sharing

of experiences is supported within the Medical Quiz. With a mean rating of M = 3.22 (SD = 0.81) participant also slightly agreed, which was rather surprising, because no sharing at all is implemented within the application. We believe that the participants misinterpreted the question by referring to sharing experiences "about the quiz" instead of sharing learning/working experiences "within" the quiz.

Short reflection scale:

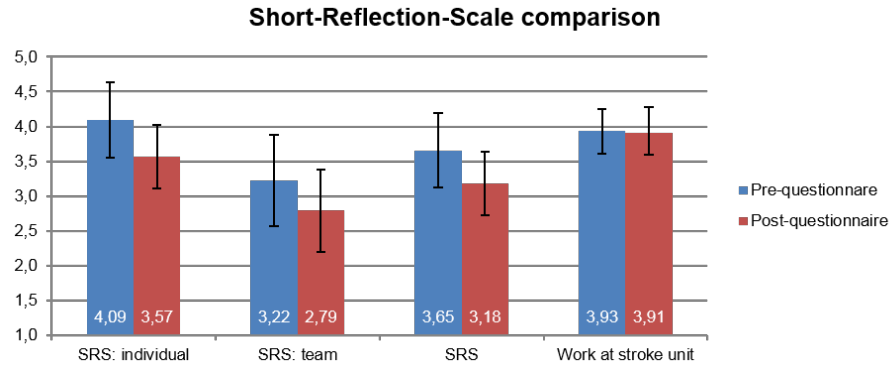


Figure 10.24: Short Reflection Scale and "Work at a Stroke Unit" before and after playing the quiz.

Figure 10.24 shows the mean ratings obtained for the Short Reflection Scale (SRS) as well as the two subscales concerning individual and team reflection only. Comparing the scores (SRS) of the pre- and post-questionnaires, Figure 10.24 clearly shows that the general tendency to reflect decreases significantly for the overall scale, as well as the two subscales (for all 3 comparisons, related t-test revealed significant differences with all $p \leq .003$ and N=18). One reasonable explanation of this phenomenon is, that at the beginning of this field study all participants thought that they were rather reflective practitioners. However, after becoming aware of how reflection is defined within the MIRROR project, they might have changed their understanding of the concept of reflection as well as their reflective practices. Further comparisons of the post-SRS values with usage data and other learning outcome scales (see below) show a positive relationship between high individual reflection and perceived

usefulness (r=.522, p=.026) as well as long-term practicality (r=.536, p=.022) of the quiz. Otherwise, there was no relationship between usage, learning outcome, or behaviour change.

Learning Outcomes

Regarding our implemented reflection guidance concept, by presenting reflection questions at the beginning, during and after a quiz play, we have evidence that reflective learning can be triggered. 52% of all posed reflection questions were answered in a meaningful way, which proofs that the quiz players have at least thought about the posed question. Some of the answers, which give more insights about the player's thoughts, show clear insights or benefits for the individual player. Answers like *"I can recognize my state of knowledge by answering the questions several times and enhance my knowledge accordingly"* or *"I partly better understand medical orders"*.

In the interviews participants also indicated, that they could change their state of knowledge and their learning behaviour with the help of the quiz. They liked that the quiz was integrated in the qualification program and it increased the motivation to learn. Referring back to Figure 10.21 (cyan-coloured bars) the learning outcomes stated within the post-questionnaire were seen as nearly neutral M = 3.14 (SD = 0.70), i.e. participants could not decide whether they gained a deeper understanding of their work-life and what to change about their work behaviour. The average learning effect, which was assessed by 12 questions, was rated as slight agreement (M = 3.45, SD = 0.45). Regarding the single question mean ratings range between M = 2.78, (SD = 0.81) for "talking about the quiz helps me to reflect upon my learning behaviour" and M = 4.22 (SD = 1.06) for "the quiz supported me when preparing for the exam". Again, the agreement was higher for questions concerning the gain of new knowledge than for questions concerning the reflective behaviour itself.

Level 3: Behaviour

The results presented in Figure 10.21 (green bars) show that the behavioural change was rated with M = 3.69 (SD = 0.75), which implies that the participants tend to agree that the quiz helped them to improve their work at the stroke unit. Also the 5 further questions on work improvement received an average rating of M = 3.37 (SD = 0.80). Inter-correlations between the scales from the

post-questionnaire show that ratings of app-specific reflection questions and learning effect (both on level 2 – learning) are positively related to behaviour change and work improvement (both level 3). Thus, participants who perceive the quiz as helpful for supporting reflection and learning are also more positive that it helps them to change their behaviour at work (all correlations show p- values $<.01$).

The interviews confirmed these values and showed that with the quiz behavioural changes have taken place and that these changes are very relevant for their future work. First, the nurses emphasized that they gained a lot of new knowledge during the qualification program and by playing the quiz, altogether too much at a first glance to be able to reflect on it. Bringing together the theoretical knowledge with their working practice was seen as very relevant for them, especially when they can use the new knowledge during work. What was also mentioned is that they have now much more background knowledge in general. And finally they reported that the more they know, the higher is their self-confidence during work. These statements are really promising results for the behavioural changes.

Level 4: Results

With the Medical Quiz we focused on the KPIs "employee satisfaction" and the improvement of "quality of work" (see Figure 10.21, orange bars). The employee satisfaction was rated with M = 3.42 (SD = 0.92) whereas the quality of work was rated with M = 2.78 (SD = 0.84) in the post-questionnaire. Regarding the first KPI the participants stated neutral and slightly agreed, that the employee satisfaction was positively influenced by the quiz. The quality of work, including the improvement of the medical care for the patients and to better solve problems occurring during work, was rated from neutral to slightly disagree, which means that it was nearly not influenced by the quiz play.

First, with this summative field study we can prove that the participants liked the Medical Quiz and gained a lot of new knowledge relevant for their work.

Second, we can prove reflective learning was initiated. With the help of the implemented reflection guidance in the form of reflective question we could

show that reflective learning was initiated, when analysing the answers of the reflection questions.

Third, by relying on the statements of the interview, we got first evidence that participants changed their behaviour according the newly gained knowledge and the insights they got from reflection. Unfortunately we have no further or deeper insights on this, neither in the quiz itself nor in the statements from the interviews.

The field study of the Medical Quiz within the qualification program has no direct influence on an organisational level, because the participants came from different stroke units spread all over Germany. But in the group discussion about the possible organisational influence they saw high potential for the quiz. Possible influence on the organisation was seen with regard to the optimisation of patient care, improvement of the quality of patient care and improvement of the employee satisfaction. Having more theoretical knowledge leads to a better understanding of their work, improves the quality and finally results in a better patient satisfaction. In order to achieve this with the Medical Quiz, there need to be more practice relevant questions within the quiz, real case studies with corresponding questions and more questions in general referring to practical work.

From the group discussion with respect to the future development or features of the quiz, we got a lot of suggestions. These encompass different difficulty levels, rewarding system, over knowledge battles nurse vs. nurse or clinic vs. clinic, until to the creation of a Facebook group or other type community. As prerequisite it is necessary to maintain the quiz by adding consequently new questions (removing outdated questions) and motivational features, in order to keep the motivational question to use and learn with the quiz constantly high. The results of the loyalty metrics looks as follows: 5.6% are promoters, 38.9% are passives and 55.6% are detractors. That implies a net promoter score (NPS) of -50%.

10.4.6 Discussion & Conclusion

In general, the results of the field study showed that the Quiz was well accepted by the workshop participants, most of them really used it very often, especially to prepare themselves for the workshop examination. They

perceived the quiz as useful and they also stated that, if the quiz would be extended and maintained, it would be great to have it available during the work especially during the night shifts. They also mentioned that the quiz brings in more motivation as well as fun aspects with regard to the learning of new knowledge. In contrast, they also had some ideas for improvements. Although we had in the end of the trial more than 150 different content-based questions, the participants stated that there were too few of them in the quiz and that they reoccurred too often. They also mentioned that they would like to have not only content-based factual questions but also case studies from real work situations and corresponding questions to it. And they also would like to have some difficulty levels, which might bring more motivational aspects into the quiz.

By integrating a part of the reflection guidance concept in form of reflective question at the beginning, during and at the end of the quiz, we are able to proof, that asking the right questions at the right moment can trigger reflective learning. The participants mentioned that they were able to gather new knowledge with the help of the quiz, which is in the end very useful for their work. As a result the participants mentioned that they feel more self-confident during work, because they were able to answer more of the questions posed by physicians, patients or relatives. They also stated that because of more available background knowledge, they understand the treatments and some conclusions taken by the physicians in a better way. They also confirmed by answering the reflection questions in the end of the quiz, that they gained clear benefits and insights for themselves but unfortunately these learning outcomes were not inserted into the quiz.

Clearly, there is also room for improvement with respect to the reflection questions. First, some participants stated, that the meaning of the reflection questions was not clearly evident in the beginning. Second, the questions posed at the beginning of the quiz, were sometimes inconsistently composed due to a bug in the quiz code. For example "Your knowledge is rather low. What is your success recipe?" does not really serve as a motivational question. Third, the reflection questions were randomly chosen out of a set of questions, which did not always fit especially to the content-based questions. The willingness to reflect on the reflection questions was given more with the questions presented at the beginning and at the end of the quiz. At the same time the in-between reflection questions were perceived as more disruptive during the learning process.

Some participants stated that they have tried to take some behavioural changes and applied them during their work as a consequence of using the quiz. However, since the quiz does not capture these data, we can only rely on participants' subjective reports.

Concluding, we see that the Medical Quiz has the potential to trigger reflective learning and to facilitate combining theoretical knowledge with practical experiences.

10.5 KS FS1: Summative Field Study at Infoman

The author of this thesis was neither directly involved in the development of KnowSelf, nor in its evaluation. The author's contribution with regard to Knowself focuses on the integration of the reflection guidance concept in form or time-triggered and event-triggered prompts as well as the reflective diary. Additionally the author supported the preparation of the field study with regard to these tools relevant for this thesis.

The following two sections will very shortly summarize the conducted evaluations of KnowSelf with regard to reflective learning and the reflection guidance components implemented.

10.5.1 Setting: IT Company Infoman

Infoman AG is a consulting company that consults, sells, and personalizes Microsoft Customer Relationship Management (CRM) Software to help analyse and optimise the marketing, sales and service processes of their customer companies (small and medium enterprises (SME)). People mainly work in small teams of two to three people. Altogether, the company has about 60 employees, most of them based in the headquarters. However, they have a lot of meetings with customers at the customers' site which require internal preparation and post-processing. Daily work is heavily focused on customers' needs which require a high degree of flexibility and the development of individual best practice. Consulting and sales thus involve a high degree of reflection on interaction with the customer. Therefore, knowledge management and sharing is considered to be a major challenge at this test bed.

Users and Their Job Roles

The study participants at Infoman were full-time employees working in six different departments (e.g. CRM consulting, Business Development & Innovation, marketing, etc.) mostly on the management level (e.g. research manager, marketing manager, team leader). They can be described as knowledge workers conducting a majority of their work using a computer. The rest of the time is structured by meetings, spontaneous or planned, organized with a calendar tool or by communication with customers by phone and e-mail.

10.5.2 Design and Procedure

An Infoman representative introduced KnowSelf at a kick-off meeting, providing the instructions for the study, installation files for the KnowSelf App, user guide and a 'cheat sheet' (a short overview of the planned activities, timeline, and the basic app information: installation, the main app functionalities, contact in case of problems).

They filled in the pre-questionnaire which served as a baseline measure before the intervention in order to compare it with the post-intervention measures. The participants were asked to use the app over a period of 6 weeks (January 16th – beginning of March 2014) and to reflect on the collected data on a daily basis.

During the field study, participants got a weekly reminder email with a link to an online questionnaire was sent (questions regarding app usage, reflection, learning effect) which on one side supported the regular use of the app reminding the participants to reflect on the captured data and to enter observations, and on the other side provided us with continuous feedback. At the end of the field study, the participants were asked to fill in the online end-questionnaire and were asked to send us their anonymised log files documenting their app usage. Finally, we also conducted follow-up interviews with some of the participants.

10.5.3 Participants

12 Infoman employees (4 females, 8 males) participated in the summative field study. The median age was 20 to 29 years, with the youngest participant younger than 19 and the oldest 40 to 49. All participants were employed full-time in different departments with three-quarter of them on the management level. On average the participants have been working in their current positions somewhat longer than one year with total work experience in this field of about 4 years.

10.5.4 Evaluation Methods

Core-questions from all four levels were chosen (reaction, learning, behaviour, results) including the following topics: demographic items, level of participation, short reflection scale, app-specific questions, learning outcomes, work-self assessment, and loyalty metric. Some questions beyond the Core Questions were as well used: Usage (USE 01, 03, 06, 07), Usefulness/Satisfaction (SAT 01, 03), Inclination Long-Term Usage (LT 01, 02), Knowledge/Skills (KS 01, 02, 04), Work (WK 01, 05, 06, 08, 09, 13, 14), and work satisfaction. Additionally, in the post-questionnaire we addressed the KnowSelf prompts with a few questions while usage and some learning and behaviour aspects were assessed throughout the evaluation by use of weekly questionnaires as well as by the analysis of the reflection diary entries.

As an individual KPI measure we used a self-assessment of their personal time management measured with the time management scale by Hansen [59] before and after our intervention. We also asked participants to assess their time wasters before and after the intervention to see whether this assessment will change. Time-wasters in the everyday work were identified using the scale by Seiwert [143].

With respect to the organisational impact of time management tool, the following KPIs were measured: subjective assessment of personal time management and time wasters as well as the job satisfaction in a pre/post comparison.

10.5.5 Results

In the following the results are presented according to four Kirkpatrick levels (Reaction, Learning, Behaviour, Results). Different number of participants provided answers to the evaluation tools we applied: pre-questionnaire (n=12), post-questionnaire (n=10), interviews (n=7) and app log data (n=7).

Level 1: Reaction

According to the self-reports of the users at Infoman they used the tracking tool on average 3.7 days per week and the time investment was about 25 minutes weekly (see Figure 10.25 for more detailed depiction of subjective usage of the app).

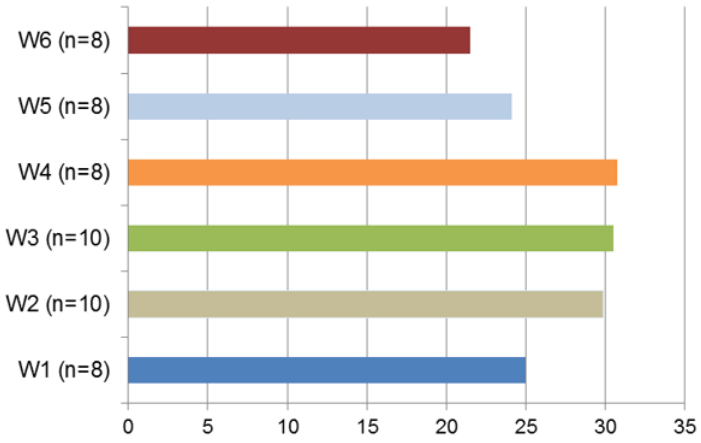


Figure 10.25: Subjective usage over time (week 1 to week 6) in minutes

Using the Friedman's ANOVA test we compared their weekly-questionnaire self-reports of the time they invested in the app and we found a decrease over time: the usage was significantly lower in the last two weeks than in the time before (χ^2(1,N=8) = 4.5, p=0.034).

Interestingly, the evaluation of the log data we received from seven out of twelve participants showed an average app usage of 1.14 days a week and an average weekly time investment of 6.42 minutes. In the Figure 10.26 we compared the subjective usage based on the self-ratings collected in the weekly questionnaires and the objective usage based on the log data we received. Different number of participants provided data for particular weeks (e.g. Week 1 (n=8/6): 8 participants provided their subjective rating while 6 participants shared their log data for that week).

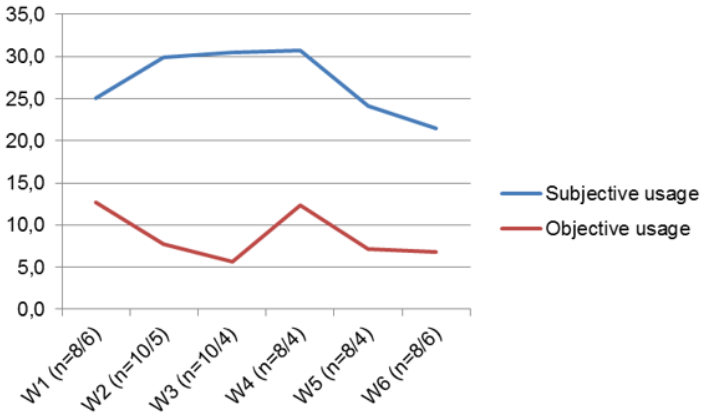


Figure 10.26: Comparison of subjective and objective usage (min/weekly)

One possible explanation for the discrepancy between objective and subjective usage could be that the evaluation duration was six weeks, but not all participants had the app running for the whole time frame (e.g. due to absence from work, etc.). Also some participants claimed in the interviews as well as in the questionnaires that the app didn't capture the data properly and that their recordings for several days were incomplete or missing completely. This was confirmed by a comparison of their activity log data to the reflection diary entries they entered.

Additional barriers for using the app were lack of time (USE1: I did not have the time to use the app; M=3.10 SD=1.2) for reflection during their busy working hours or lack of motivation because about a half of them did not

see a clear advantage for themselves from using the app (USE03: I did see no advantage in using the app; M=3.40 SD=1.08). Additionally, some of them felt uncomfortable with the fact that the tracking tool recorded "every move" on the computer (M=3.40 SD=1.27).

We collected also feedback to the app on a general level: what was good or what needs to be improved. The participants reported that the app has a good design and structure and they saw its potential for giving data overviews which trigger reflection and for supporting the awareness of their time management. However, they asked for some kind of help with the interpretation of the captured data in order to be able to draw some conclusions from it. What they really liked are the visualizations and having the overview of their work routine. And in general most of them stated they believe that time management apps can help improving one's time management to some extent mainly by raising the users' awareness for different aspects of their time management. In addition they confirmed that the app could help them to get an overview of their tasks and the time they invest in each of them an the corresponding projects.

Regarding the long-term usage, the majority was undecided whether the app can provide some long-term advantages in their work-life (LT01: M=2.90 SD=0.74). Only only one person would like to use the app continuously as part of his/her work life in the future (LT02: M=2.30 SD=1.01) mostly because of the possibility to track the computer activities and resources used for a specific project. Reasons for not using the app included having already enough knowledge about one's working behaviour, following a very structured work process, or having a job with high spontaneity and a lack of structure.

Level 2: Learning

The participants gained new insights regarding their time management on the one side through the usage of the app and on the other side because of the request to think about their time management on a regular basis.

Learning Process

The App-Specific Reflection Questions (CA statements) regarding the KnowSelf App showed that the app helped the participants the most by collecting information relevant to reconstructing experiences from work (CA1: M = 3.40,

SD = 0.96), by reminding them to reflect (CA10: M = 3.40, SD = 1.08) and by providing relevant content for reflection (CA40: M = 3.40, SD = 0.70). With the help of this relevant material they reflected about various issues, such as interruptions, work fragmentation and their working processes in general as well as the question how they could optimize those.

The control item where no change was expected (the app providing information about related experiences) was rated the lowest and hence confirmed the true effect of other statements (CA16: M = 2.10, SD = 0.88). Average of all five CA statements (M = 3.28, SD = 0.66) showed that the participants were moderately satisfied with the reflection support the KnowSelf App provided.

The short reflection scale was applied to measure the participants' tendency to reflect before and after the field study period. The ANOVA test for repeated measures showed that the main effect of type of reflection (individual vs. team) was statistically significant (F(1,9)=14.10 p=0.005); specifically, it showed that the participants' tendency towards individual reflection was significantly higher than towards team reflection in our data sample (Mind.=3.72; Mteam=2.91). However, the second factor (time: pre vs. post) was not statistically significant (F(1,9)=0.123 p=0.734) as well as the interaction between the two factors (F(1,9)=0.310 p=0.591).

The reflection tendency before and after the evaluation period did not significantly change over time. This was confirmed as well in the weekly questionnaires where we collected their subjective ratings of their tendency to reflect on time management and way of working, and these ratings remained stable during the evaluation period (Friedman test: $\chi^2(2,N=8) = 2.61$, p=0.88). However, in the interviews we found out that one third of them report they reflect more, mainly in the beginning and end of their work days as well as when interruptions or unusual events occur.

The reflection process was supported additionally by one reflection guidance component of the KnowSelf App: the KnowSelf Prompts. The current version of the KnowSelf App included an automatic notification system which reminded the participants to reflect at a particular time of a day or after some unusual event was recognised by the app (e.g. high number of switches or long periods of idle time). We asked the participants to what extent were these automatic notifications helpful for their reflection process (see Table 10.14).

The results show that the users did not profit from the prompts as we have expected it; they perceived the notifications often as disruptive during work and as additional source of work fragmentation. Most positively were evaluated the reminder regarding the most used resources and the general reminder to reflect about the data in the app. In the interviews it was suggested that the prompts could pop up each day at the same time or even better a summary of all notifications could be listed somewhere directly inside the app so a person could look at it when the time was right.

Table 10.14: Assessment of KnowSelf Prompts

Questions	**KnowSelf**	
	Mean	**SD**
Please indicate your agreement with the following statement		
The KnowSelf Prompts motivated me to reflect.	2.00	1.06
To what extent were the following categories of KnowSelf Prompts helpful to you?		
Reflection Intervention: Reminder for using KnowSelf generally (e.g. look at heatmap, write diary entries)	3.22	1.09
Reflection Intervention: Reminder of project recording	2.75	1.28
Reflection Amplifier: Notification about specific amount of switches	2.30	1.34
Reflection Amplifier: Notification about unusual amount of idle time	2.57	0.79
Reflection Amplifier: Notification about most used resources	3.30	1.25

Learning Outcomes

After using the KnowSelf, more than half of the participants indicated that they have improved their understanding in the area they wanted to improve (KS02: M=3.60 SD=0.52). Four of them improved also their work related skills in that area (KS04: M=3.40 SD=0.52). Further, six of ten persons agreed that they made a conscious decision about how to behave in the future regarding their time management (CL01: M=3.30 SD=1.06) and gained a deeper understanding of their work life (CL02: M=3.50 SD=0.71).

The participants reported in the post-questionnaire and in the interviews several 'lessons learned', such as: to daily set priorities, handle interruptions in a more conscious way, reserve time for the tasks with the highest priority and to plan some time for the unplanned occurrences etc. When talking about "time wasters" most of them mentioned that Outlook causes constant interruptions and that handling e-mails and appointments in Outlook consumes a lot of

their time. Other problems they identified were high work-fragmentation, high number of distractions and the need to frequently reprioritize tasks due to new unpredictable ones or bad planning.

Some participants claimed that gaining these insights motivated them to set goals for themselves and stick to these plans without getting distracted or switching to other tasks so often. The acceptance of documenting these goals with the help of the KnowSelf's Reflection Diary grew over the first half of the evaluation, as can be seen by only 16 diary entries stored during the first two weeks, but already 48 entries written during week three and four. This number then remained constant for the end phase of the evaluation with another 47 entries made in the last two weeks. Of course these numbers again refer only to the seven participants who made their log data available to us. In total we received 139 diary entries, but 28 of them were excluded from the following analysis, because they were stored after the end of the official evaluation time, while the participants still continued using the app.

We analysed those entries using the qualitative analysis schema described in Prilla et al. [132]. The content was analysed with respect to whether reflection has happened, how deep the reflection was and (if available) which app-specific aspects the content contains.

The coding was conducted by three independent coders who in the first round of coding had consistency regarding different categories of reflection elements between 62% (category 3) and 95% (category 4). A possible reason why the intercoder consistency varied between different categories up to 30% could be the relative novelty of this coding schema and overlapping of a few categories or different understanding of categories by different coders.

There were 103 statements by 6 participants, who were willing to share their explicit data. The reflection diary data of the seventh participant who shared their log data with us was hashed, so its content was not available to be considered in this analysis. In total 33 diary notes were classified as non-reflective (no reasons or critical interpretation; senseless or non-answerable content) while for another 11 entries the coders couldn't agree on whether they were to be interpreted as reflective or non-reflective (these items were excluded from the dataset for later analysis). The remaining statements (59) were classified as individual reflection items (no other actors involved) containing various reflective elements.

The final results are based on the coders' agreement: after independently coding the material the coders discussed the differences and tried to come to an agreement. The final codes are presented in the Table 10.15. It was possible to assign more than one code to one entry since some statements contained more than one reflection element (see Table 10.15: Column Frequency). This table only contains 57 of 59 reflective entries, because for two entries the coders could not reach an agreement. For each entry we also specified the highest category reached (the highest level of reflection reached by this entry) which was assigned to basic, medium or high level of reflection (see Table 10.15: Column Level of reflection containing learning).

Table 10.15: Analysis of reflective content

Categories of reflection elements	**Frequency**	**Level of reflection containing learning**
1. Description of an experience	54	Basic level (13)
2. Mentioning emotions	0	
3. Interpretation or justification of actions	33	Medium level (28)
4. Linking an experience explicitly to other experiences	1	
5. Linking an experience to different pieces of knowledge, rules, values, organisational documents	0	
6a. Responding to interpretation of the action (inquiry/different/alternate perspectives)	1	
6b. Responding to interpretation of the action (challenging or supporting assumptions / opinions / attributions)	0	
7a. Working on a solution based on assumptions, insights (explanation of reasons)	7	
7b. Working on a solution (giving suggestions without proposing to set them in practice/referring to an experience)	4	
8a. Insights / learning from reflection (different / better understanding of experience)	5	High level (16)
8b. Insights/learning from reflection (generalising from experiences, finding patterns across experiences)	6	
9. Drawing conclusions and implications from reflection	8	

Analysing the individual categories of reflection elements from Table 10.15 we can conclude that most of the participants in their reflection diary entries

described their work experiences and occurred issues (category 1). According to the qualitative analysis schema this corresponds to the basic level of reflection (provision and description of experience, but no (explicit) traces of reflection).

The second most documented category was "interpretation or justification of actions" (category 3): we found a lot of interpretations and reasons for their successful as well as problematic experiences.

As the assignment of more than one category to one diary entry was possible, for calculating the level of reflection containing learning only the highest category assigned to one entry was considered. Resulting from this, most of the reflection outcomes reported in the reflection diaries can be assigned to the medium level of reflection: participants didn't only describe their experiences, but they were mostly providing explanations of reasons for their experiences as well as solution suggestions to observed problems too. Also more than a quarter of the reflective entries documented insights gained and conclusions drawn from personal experiences.

These findings confirm that the participants gained new insights and a better understanding of their work experiences and provided possible reasons for those experiences. These new insights and conclusions could be then used as a basis for application of changes in order to improve their time management.

Level 3: Behaviour

As described above, the participants not only gained insights regarding their time management (level 2), one half of them also improved their time management with the help of the KnowSelf App (CB01: M=3.40, SD=1.08). Additionally, about 70% of the participants reported that they have used their learning regarding time management on the job (WK01: M = 3.5, SD = 1.18), focused more on their work tasks with the help of the KnowSelf App (WK09: M=3.90, SD=0.74) and kept up their change of behaviour (WK05: M = 3.67, SD = 0.50).

Although the participants reported numerous positive changes regarding their time management and the higher awareness for these topics we did not find a statistically significant change when analysing the pre- and post-measure of the Time management (pre: M=3.60 SD=0.6, post: M=3.58 SD=0.40; t(9)=-0.10

p=0.92) and Time wasters scale (pre: M=1.89 SD=0.33, post: M=2.10 SD=0.45; t(9)=1.30 p=0.23). This result means that they assess their time management and dealing with time wasters the same as before.

Asked about the effect of the applied changes on their work one quarter of the participants claimed in the interviews that the quality of their work had improved and two participants stated that the changes had at least enhanced their efficiency. In general most of them were convinced that a more structured and conscious way of working over longer periods of time will lead to a better quality of work.

Level 4: Results

When asked how likely is it that they would recommend the KnowSelf App to a friend or colleague we found out that one person out of 10 would actively recommend it (promoters: scores 9-10) and passively another 30% (scores 7-8). The rest 60% of the participants would not recommend it (detractors) which of course influenced negatively the Net Promoter Score (accounts to -50

Possible explanations why not more participants would recommend the app could be that some of the participants did not see a personal benefit in using the app because they missed guidance and some app features and therefore would not recommend it. However, asked about their future behaviour five participants claimed that they will try keep up the positive changes regarding their work behaviour and time management as effectively as possible in the future, too.

Asked about the effects on organizational level one third of the participants is of the opinion that all improvements achieved on individual level will aggregate to an improvement of the whole organization. Also four out of twelve participants stated that more employees should improve themselves by conducting reflection or participating in time management measures. Two participants pointed out that improving individuals' time management and efficiency is not enough, but that collaborative communication has to be considered too (e.g. handling of meetings and interruptions, expectance of constant availability).

10.5.6 Discussion & Conclusion

The intervention in this test bed included KnowSelf App usage by the 12 participants on a daily basis during 6 weeks. As the log data show the app was not used as intensively as expected which could be caused by technical problems in the first weeks or lack of clear benefits resulting from this experience.

In summary it can be said that the KnowSelf App supported the participants mostly by providing them relevant material for reflection and helping them to reconstruct their work history. These captured activity data served as trigger for initiating reflection and provided basis for the reflection session. This enabled the participants to reflect more profoundly on their work behaviour and time use which was shown by many examples of gained insights and implemented behavioural changes. The remaining phases were also supported to some extent, since some participants used the app's Reflection Diary to make plans about how to slightly change their working behaviour and several times also documented there the changes they had applied and the resulting experiences. In this regard our expectations were met and as well those of most of the participants.