Caring for Carers

Design and "in-the-wild" Evaluation of a Mobile System to Support Nurses in Applying Kinaesthetics

Master Thesis

by
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Abstract

Caregivers are at a higher risk to suffer from workrelated musculoskeletal disorders (WRMD) such as low back pain. One of the factors to be influencing is the daily transfer of patients. Kinaesthetics is one of multiple care concepts that try to communicate safe patient handling techniques to address this issue. Yet, the integration in the curriculum in Germany solely consists of a three-day basic course. A lack of follow-up support leads to a lack of knowledge and therefore appliance in practice.

This thesis examines how a mobile system, in the following called *NurseCare*, can be designed to face this lack of support in practice. NurseCare is a combination of two components: A wearable to provide real-time feedback on risky movements regarding the back and a smartphone application to supply additional support. Distributed Cognition, the Behavior Change Wheel Framework, and Participatory Design were taken into consideration to understand the theoretical background. The analysis of related work revealed a gap in research of systems that combine sensory and mobile technology to support safe patient transfer techniques during work. Thereupon, two conducted workshops could help to understand the design space in this complex work domain. The workshops' results guided the requirement analysis, as well as the design process of NurseCare. The first workshop involved nurses as end-users and the second workshop additionally HCI students as technical experts.

NurseCare was implemented as a prototype and evaluated "in-the-wild" with nine nursing students. Data of questionnaires, interviews, an e-diary, and log files were analysed to investigate how caregivers experience the usage of NurseCare in its natural setting. The findings reinforce the need for the support of Kinaesthetics in practice. Moreover, the design of NurseCare as a wearable and smartphone application was perceived as expedient and easy to use in everyday life. The findings indicate that an integration of a system like NurseCare is wished and revealed ideas for its realisation. The examined benefits and shortcomings were furthermore taken as a basis to generate implications for future work.

Zusammenfassung

Pflegefachkräfte sind einem erhöhten Risiko ausgesetzt an muskuloskelettalen Beschwerden insbesondere im Bereich des Rückens zu erkranken. Ein Risikofaktor ist unter Anderem der tägliche Patiententransfer. Ein Pflegekonzept, welches dieses Problem durch das Vermitteln von rückenschonendem Arbeiten zu adressieren versucht, ist Kinästhetik. Allerdings wird Kinästhetik in den Lehrplan der Auszubildenden lediglich in Form eines Grundkurses an drei unzusammenhängenden Tagen integriert. Der Mangel an Anschlussunterstützung führt oftmals zu einem Mangel an Anwendung in der Praxis.

Diese Arbeit untersucht, wie ein mobiles System, im Folgenden *NurseCare* genannt, designt werden kann, um dem Mangel an Praxisunterstützung entgegenzuwirken. NurseCare besteht aus zwei Komponenten: Einem Wearable, welches direkte Rückmeldung über rückenschädigende Bewegungen bietet, und einer Smartphone Anwendung, welche Unterstützung über weitere Features bereitstellt. Distributed Cognition, das Behavior Change Wheel Modell und Participatory Design wurden berücksichtigt, um den theoretischen Hintergrund zu verstehen. Die Analyse verwandter Arbeiten zeigte eine unzureichende Untersuchung von Systemen, welche Sensorik und mobile Technologie vereinen, um rückenschonende Patiententransfers in der Praxis zu unterstützen. Die Durchführung zweier Workshops sollte helfen, den Design Kontext dieses komplexen Arbeitsfeldes besser nachzuvollziehen. Die Ergebnisse der Workshops leiteten sowohl die Anforderungsanalyse als auch den Design Prozess. Am ersten Workshop nahmen KrankenpflegerInnen als End-NutzerInnen teil, am zweiten Workshop zusätzlich Informatik StudentInnen als technische ExpertInnen.

NurseCare wurde als Prototyp umgesetzt und mit neun Pflege-SchülerInnen "in-the-wild" evaluiert. Datenmaterialien der Fragebögen, Interviews, elektronischen Tagebücher und Log-Dateien wurden ausgewertet, um die Erfahrungen der Pflege-SchülerInnen mit NurseCare in seinem natürlichen Einsatzgebiet zu erforschen. Die Studienergebnisse bekräftigen die Notwendigkeit einer Praxisunterstützung von Kinästhetik. Des Weiteren wurde das Design von NurseCare als Wearable in Kombination mit einer Smartphone Anwendung als sinnvoll und im Alltag einfach zu handhaben empfunden. Die Ergebnisse zeigen weiterhin, dass eine Integration eines Systems wie NurseCare als Praxisunterstützung gewünscht wird und wie diese aussehen könnte. Basierend auf den erforschten Vorteilen und Schwachstellen der aktuellen Implementierung konnten zudem Implikationen für zukünftige Arbeiten abgeleitet werden.

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Declaration

I hereby declare that the attached master thesis on the topic

> Caring for Carers: Design and "in-the-wild" Evaluation of a Mobile System to Support Nurses in Applying Kinaesthetics

is the result of my own, independent work. Parts of this research is based on my masters seminar and project both entitled "NurseCare: Supporting nurses in applying Kinaesthetics into practice". Apart from that, I have not used any aids or sources other than those I have referenced in the document.

For contributions and quotations from the works of other people (whether distributed electronically or in hardcopy), I have identified each of them with a reference to the source or the secondary literature. Failure to do so constitutes plagiarism. I will also submit the term paper electronically to the lecturer. Furthermore, I declare that the above mentioned work has not been otherwise submitted as a term paper.

I am aware that papers that turn out to be plagiarized will be graded “insufficient” (5,0). Every suspected case of plagiarism will be submitted to the examination board, which will decide on further sanctions. The legal basis for this procedure can be found in the examination regulations. These rules also apply to students that study Politics and Public Administration as a minor subject.

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Carla Gröschel

Planned submissions

It is planned to submit parts of this research to the 2020 CHI Conference on Human Factors in Computing System:

> Dürr, Maximilian and Gröschel, Carla and Pfeil, Ulrike and Reiterer, Harald (2019). “NurseCare: Design and "in-the-wild” Study of a Mobile System to Support Nurses in Applying Kinaesthetics"

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CHAPTER 1

Introduction

Workrelated musculoskeletal disorders (WRMD) build a dominant proportion among work-related diseases in many countries. Especially caregivers are affected due to the daily transfer of patients often causing injuries. Various care concepts try to address this issue by providing ergonomic patient transfer techniques. One of those is the kinaesthetics care conception (in the following called Kinaesthetics). In the field of nursing, it contains safe patient handling techniques to disburden caregivers by involving the patients in the handling process. One might assume, that those provisions are an inherent part of nursing education. However, in Germany, the integration in the curriculum solely consists of a basic course over three nonconsecutive days. Hence, an internalisation and application of the concept often fail. Safe patient handling techniques remain in theory because of a lack of awareness for the topic and a lack of knowledge.

The following section 1.1 will outline the above-touched issue to underline the motivation for this work. Next, the proposed solution approach is presented in section 1.2 followed by the structure of this thesis in section 1.3.

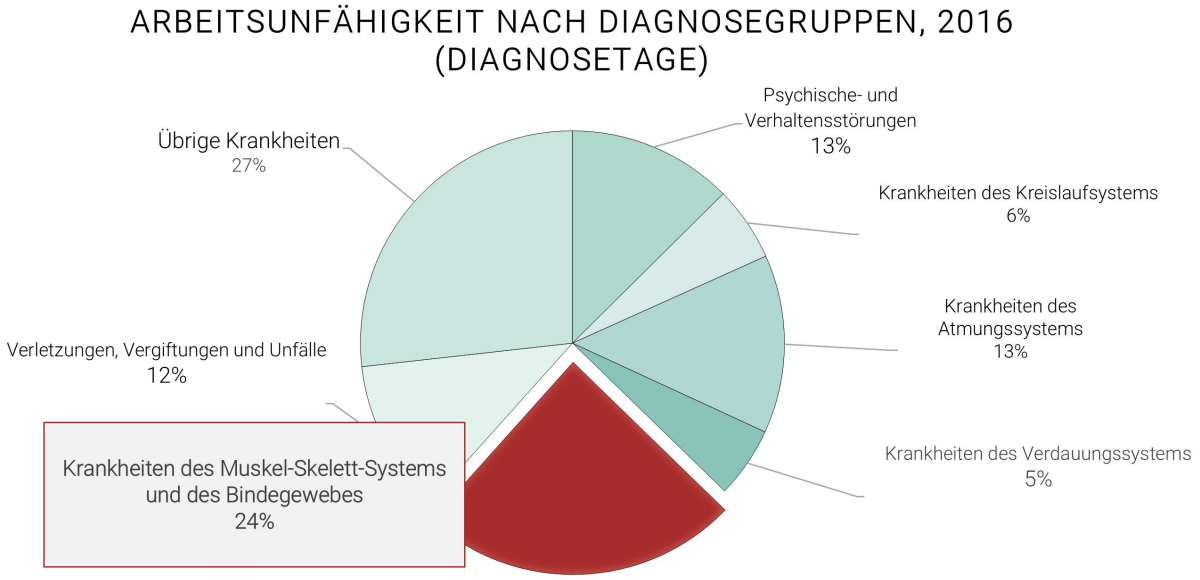


Figure 1 Major causes for unemployability in Germany, 2016 [German] [1]

1.1 Motivation

As mentioned above, WRMD is a widespread problem [1]–[3]. It comprises inflammatory and degenerative diseases of joints and bones. Very common are low back, shoulders and neck pain. In Germany, musculoskeletal disorders are one of the four most critical diseases [1]. It was the major cause for unemployability in Germany in 2016 as illustrated in figure 1. Among individual factors such as age or sex, factors found to be influencing are physical load at work or working in awkward postures [3], [4]. There is evidence that especially hospital nurses are likely to be

affected by WRMD in particular low back pain [5]–[8].

Previous studies examined risk factors related to WRMD among caregivers. One major risk factor is the transfer of patients. The transfers often comprise lifting heavyweight and working in awkward positions [9]–[13]. Ergonomic patient transfer techniques target at preventing injuries during the transferring tasks. One care concept comprising those techniques is Kinaesthetics. Briefly summarised, its idea is the communication of movement competence and body awareness. This approach should help nurses to manage patient handling situations in a less exhausting manner. Injuries should be prevented and reduced through an understanding for the own motion. As previously stated, some institutions in Germany integrate Kinaesthetics as a preventive method in their curriculum. Its theoretical background will be further explained in the following chapter 2. Kinaesthetics is taught in the form of a three-day basic course. Figure 2 visualises two nursing students practising a patient transfer during such a course. Nevertheless, research has shown that there is a lack of follow-up support [5], [14]. Fringer, Huth, and Hantikainen [5], for instance, conducted focus groups to investigate the experience of Kinaesthetics training among nurses. After the basic Kinaesthetics training, the participants still "reported a further need for practical and theoretical support". This hampers the internalisation of the concept and its realisation during work.

Figure 2 Practical training during a Kinaesthetics course

The ERTRAG project tries to investigate how technology can address this issue. It aims to develop a virtual trainer for ergonomics, addressing the lack of possibilities to learn and train ergonomic patient transfers [15]. Caregivers should be supported in learning individual ergonomic movements with a particular focus on Kinaesthetics. The trainer should be set up in a special room where nurses can practise during their free time. An initial contextual inquiry in Kinaesthetics courses, as well as interviews with nursing-care students and teachers, were conducted to define the system requirements. The results are consistent with those of Fringer, Huth, and Hantikainen [5]. Various students expressed a lack of material for self-educated learning. Furthermore, they stated that they feel insecure applying the learned techniques during work. Besides the possibility to learn in a self-determined manner, it appeared that the apprentices wished better support directly in their work routine [16]. Kinaesthetics coaches are only rarely available in a clinic. If they are available, they are often responsible for multiple hospital stations simultaneously. Hence, Kinaesthetics coaches are often hard to contact and cannot provide consistent support. Even though a virtual trainer offers the possibility to practise Kinaesthetics in a lab setting, it cannot support nurses directly while working.

1.2 Solution approach - NurseCare

This thesis intends to investigate how mobile technology can bridge the gap between learning movements with the virtual trainer in a lab and realising these movements "in-the-wild". Hence, the overall goal of this thesis can be summed up as follows:

> Determine how to design a mobile system that supports nurses in applying Kinaesthetics into practice during work.

The presented research emerged from the participation as a student researcher in the ERTRAG project. For that reason, it makes use of some content that was generated during this work. To examine the above listed central goal, a concept for a mobile system, in the following called

NurseCare is proposed. NurseCare should not replace the traditional basic courses. Rather it should leverage technological possibilities to supply sufficient follow-up support and complement current practices.

Instant feedback is considered as promising in the field of motor learning [17]. Hazardous movements regarding the back can be detected and real-time feedback provided with the help of sensory features. The sensors could be implemented as a wearable. Wearable devices or wearables are electronic devices that can be worn on the body such as glasses or watches. The approach of motion tracking and real-time feedback has already been investigated in other work fields prone to WRMD [18], [19] and in general for posture correction to reduce low back pain [20], [21]. Consequently, NurseCare is planned as wearable to take advantage of the previously described benefits. As patient transfers go beyond simple posture correction regarding their movement complexity, additional support should be provided by an application. The design of necessary features in the application and the design of the wearable is expected to be driven by insights from the nurses as end-users. Therefore this work takes advantage of methods from Participatory Design. This approach should ensure the compatibility of NurseCare with the nurses' complex work-field. Besides the development of an interaction concept, the conducted "in-the-wild" study of the constructed prototype provides further knowledge of how nurses experience the systems' usage in the hospital context and how it can be extended in the future.

1.3 Outline

This thesis is structured into eight parts. The first chapter already depicted the motivation for this work and the proposed solution approach. Next, chapter 2 deals with theories and methodologies that help to set the right focus during the overall design process. In chapter 3 requirements for NurseCare will be gathered based on a future workshop with caregivers. Next, we move on to chapter 4 where the previously extracted requirements are integrated into an interaction concept. The conduction of a second workshop is described as well as the further design process. The implementation of this interaction concept as a prototype is thereafter the focus of chapter 5. The succeeding chapter 6 is dedicated to the conducted "in-the-wild" user study. It seeks to elaborate on whether the proposed design of NurseCare can support nurses in applying Kinaesthetics. Based on the study results, chapter 7 deals with redesign ideas and further research questions. Finally, chapter 8 gives a summary of the findings and the contribution of this work.

CHAPTER 2

Theoretical background

Before proceeding to gather the requirements of NurseCare, it is necessary to understand the theoretical background of the system context. At first, one needs an initial understanding of the subject in which NurseCare is supposed to support the nurses. Hence, a short introduction in Kinaesthetics is given in section 2.1. Considering the issues that hamper the appliance of Kinaesthetics, two aspects are of big interest. At first, the nurses must have the necessary knowledge to apply the concept. NurseCare should support by providing the opportunity to continuously learn Kinaesthetics. To understand the context of this learning process, the learning theory Distributed Cognition was consulted and is briefly outlined in the first section 2.2. Secondly, NurseCare seeks to foster nurses to change their behaviour towards a more ergonomic work routine. For that reason, the Behaviour Change Technique Taxonomy is described in section 2.3. As a theoretical framework, it should help to work out which measures trigger the applying of Kinaesthetics in the long-term. Finally, NurseCare will support nurses directly in their work context. Only the end-user themselves know this context the best. Therefore, Participatory Design, applied as methodology, is outlined in the concluding section 2.4 to make use of domain-relevant knowledge.

2.1 Kinaesthetics

> *"The sensitisation of the movement perception and the Development of movement competence can make a lasting contribution to the promotion of health, development and learning in people of all ages." - translated from German* ([22])

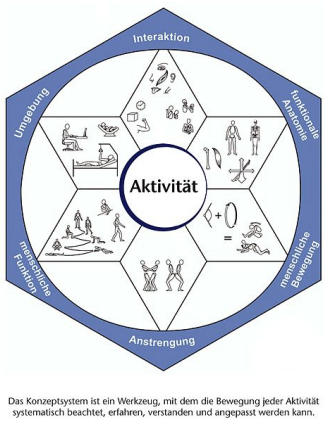


Figure 3 Kinaesthetics: The six dimensions [German] [23]

Kinaesthetics was developed during the 80s by F. W. Hatch and L. S. Maietta [24]. As kinematics, it focuses on the perception of the own body movements. With a sophisticated movement competence, the own health can be influenced positively. The theory of Kinaesthetics is structured in six different dimensions as illustrated in figure 3. Each dimension comprises different subtopics regarding activity. The main area of application is the domain of healthcare and welfare. Caregivers are supposed to learn how they can manage patient transfers with less physical effort making use of their gained movement competence.

For more than 20 years professionals are trained with different Kinaesthetics programs to learn new movement patterns in various European countries. The basic Kinaesthetics-courses integrated into some nursing institutions in Germany are organised in three nonconsecutive days. Trained coaches communicate the quality of movements in everyday life to increase the own body awareness. In addition to theoretical knowledge, the basic-course comprises safe patient handling techniques. The techniques should rather be seen as an indication

of how the Kinaesthetics dimensions can be linked to ergonomic patient transfers, than as strict instructions.

2.2 Distributed Cognition

> *"The emphasis on finding and describing 'knowledge structures' that are somewhere 'inside' the individual encourages us to overlook the fact that human cognition is always situated in a complex sociocultural world and cannot be unaffected by it."* ([25])

The Distributed Cognition Approach was already used in previous research. It helped to guide the design process and elicit specific requirements for novel systems [26]. Likewise in the case of NurseCare, this approach can be fruitful to understand the learning context of Kinaesthetics.

When computers became ubiquitous and systems became more complex, human-computer-interaction challenged more complex interaction questions. To provide suitable interaction methods to handle complex tasks, it is necessary to understand the organisation of cognitive systems. In the past years also in cognitive science, a shift occurred. Cognition was now considered as an embodied process instead of a process limited to the brain of an individual. In contrast to traditional cognitive theories, Distributed Cognition extends the view of cognition to the interaction between the individual, the environment and the artifacts the individual uses to perform certain tasks at his workplace. It was originally developed by Edwin Hutchins in the mid-80s.

Distributed Cognition is based on two theoretical principles that delimit it from other approaches [27]. At first, the boundaries of the unit of analysis are defined by all cognitive processes that might occur and its functional elements interacting with each other during this process. Thus it is not limited to the individual but observes cognition also as an external process. The second theoretical principle concerns the class of cognitive events. Where traditional views focus on cognitive events operated by an individual actor, Distributed Cognition widens this view. Cognitive events outside of the individual actor are likewise able to reorganise the distributed cognitive system.

Hollan, Hutchins, and Kirsh [27] propose analysing the unit of analysis "in-the-wild" and refer to three kinds of distribution of a cognitive process: Socially Distributed Cognition, Embodied Cognition, and Culture and Cognition. Socially Distributed Cognition reflects the idea that cognitive processes are distributed in interactions between members of the society and the structure in their environment. Embodied Cognition means that the cognitive process cannot lock out the sensorimotor system but must consider complex interactions between internal resources such as attention and external resources such as artifacts. Finally, Culture and Cognition describes the idea that cognitive processes are influenced by the cultural system and vice-versa.

Overall, it is important to understand that learning processes are not limited to the individual as actor. Likewise, the learning process of Kinaesthetics is not limited to the individual. A mobile system offers the opportunity to provide holistic support. Based on the above-described principles one can depict various questions to focus on during the requirements analysis. The concrete reference to the use case of NurseCare will be part of the section 3.2.1 in the succeeding chapter.

2.3 Behaviour Change Technique Taxonomy

> *"A well-specified intervention is essential before evaluation of effectiveness is worth undertaking: an under-specified intervention cannot be delivered with fidelity and, if evaluated, could not be replicated."* ([28])

The previous section dealt with the Distributed Cognition approach to comprehend how learning as a cognitive process unfolds. Besides the learning process, it is important to investigate which features can trigger nurses to apply Kinaesthetics into practice and change habits. Smith, Salas, Schüz, *et al.* [29], for instance, criticise the lack of theory-based interventions among mobile health applications. The authors refer to various reviews. To be able to gather theory-based requirements, this section briefly introduces the idea of Behavioural Change Theories in general and the Behavior Change Wheel as a framework in particular.

Behavioural Change Theories aim at explaining what factors influence human behaviour and why it changes. Those theories can be applied to different sections in which a change of behaviour is pursued. In healthcare, the idea to change people's behaviour already existed before digital health tools were on the market. Changing a behaviour such as smoking can be a crucial part of disease prevention [30]. Michie, Richardson, Johnston, *et al.* [28] claim a lack of consistent specifications for reporting the content of behaviour change interventions. To address this issue, the authors developed a taxonomy of behaviour change techniques (BCTs). BCTs are defined as "an observable, replicable, and irreducible component of an intervention designed to alter or redirect causal processes that regulate behaviour".

BCTs can be used alone or in combination and in a variety of formats [28]. They are grouped into ten clusters. For each BCT, Michie, Richardson, Johnston, *et al.* [28] provide a clear definition and even an example of how the BCT could be realised within an intervention strategy. For instance, the BCT "2.2: Feedback on behavior", included in the cluster "Feedback and Monitoring" is defined as "Monitor and provide informative or evaluative feedback on performance of the behavior (e.g. form, frequency, duration, intensity)". The provided example is the following: "Inform the person of how many steps they walked each day (as recorded on a pedometer) or how many calories they ate each day (based on a food consumption questionnaire)". Related to digital health tools there are already examples in research that used the Taxonomy to define useful behaviour change interventions [31], [32]. Examples are even listed on the BCT Taxonomy web-page [33].

Michie, Stralen, and West [34] additionally developed the Behavior Change Wheel framework to support researchers in designing powerful interventions. To design an effective intervention, the authors propose the proceeding based on the Behavior Change Wheel. They also published a practical guide about it in the form of a book [35]. The BCT Wheel framework is based on a synthesis of 19 behaviour change frameworks from variant disciplines. Michie, Stralen, and West [34] emphasise especially the relevance of the context in which the behaviour takes place in. Behaviour interventions cannot work if the behaviour is not examined in its context. The practical guide of the BCT Wheel offers a framework based on three stages each including different steps [35]. The steps and the concrete appliance will be covered in section 3.2.2. This approach will permit the gathering of requirements based on theory-based interventions.

2.4 Participatory Design

> *"User involvement is something that needs to be structured, facilitated and interpreted into directions for future design."* ([36])

Besides the correct theoretical foundation in mobile health applications, there is evidence that the involvement of the end-user is often underestimated. The miss of the users' needs or a lack of Usability can lead to a non-usage in long-term [37], [38]. To avoid a system that is finally not usable for nurses, the Participatory Design methodology seems beneficial to involve the end-user directly in the design process.

Participatory Design (PD) was born in Scandinavia in the 1970s and 1980s originally designed to empower workers [39]. During this time, the stake of computers to increase efficacy started. Yet, workers were often not familiar with technology and, furthermore, not involved in the

development process of the tools they were supposed to use. Hence, the tools rather hampered than supported them. The developers knew little about the organisational context and workers had no power to be part of the design process. Scandinavian researchers as Pelle Ehn or Morten Kyng tried to bridge this gap and democratise workplaces. They proposed a new approach: managers, designers, and workers were involved in the design process cooperatively [40]. Readers with an HCI background might see similarities to User-Centered-Design focusing on the users' needs in every design step. However, PD not only focuses on the users' needs, but involves the users directly in the design process as early as possible. The involvement usually unfolds in the form of workshops combining different techniques such as the generation of mock-ups or story-boarding [41].

The concrete techniques will be outlined within the description of the two conducted workshops in section 3.2 and 4.1.

CHAPTER 3

Analysis and requirements gathering

With a sufficient understanding of the theoretical background described in the previous chapter, we move on to the initial analysis, outlined in this chapter. It is a first step towards the interaction concept of NurseCare. The focus of the analysis was a better understanding of the users' needs, the systems usage context and the derivation of system requirements.

The first section 3.1 provides an overview of related work to investigate the design space of similar systems. In section 3.2 the organisation, procedure, and results of a conducted future workshop are outlined. The workshop allowed the derivation of theory-based requirements with the end-user. The concluding section 3.3 summarises the requirements that will be taken as a basis for the further design process in the succeeding chapter.

3.1 Related Work

This section outlines related research and related commercial systems regarding two main directions. Firstly, NurseCare is supposed to detect risky movements regarding the back. To do so, it should use sensory features. Furthermore, NurseCare should make the user aware of risky movements in real-time. Hence, research in the field of wearables pursuing a similar goal was examined, described in section 3.1.1. Secondly, NurseCare aims at providing sufficient assistance to apply Kinaesthetics into practice. Consequently, research on mobile systems that support caregivers in applying safe patient transfer techniques is outlined in section 3.1.2. In the final section 3.1.3, we draw conclusions regarding the presented research.

3.1.1 Wearables to prevent hazardous movements

As mentioned in the introductory chapter 1, motion tracking is applied in various fields to detect risky movements and provide feedback in real-time.

Yan, Li, Li, *et al.* [18], for instance, developed a prototype to prevent WRMD among construction workers (see figure 4). They often hang in hazardous postures that can lead to lower back and neck pain during their work. The presented prototype uses the Inertial Measurement Unit (IMU) sensors of two smartphones. One sensor is attached to the worker's helmet and one to the back of the worker's vest. As soon as a hazardous movement is detected, a smartphone application supplies audio feedback and displays a warning message. The results of the conducted laboratory and field experiment indicate the reduction of hazardous movement patterns among the participants during the study.

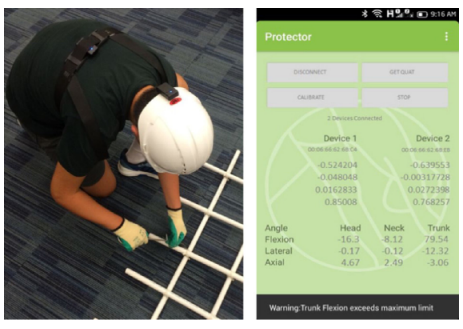


Figure 4 Wearable and application of Yan, Li, Li, *et al.* [18]

Another example is the work of Soenandi [19]. The author focuses on the specific use case

of workers in the cottage industry of Emping Melinjo. As the workers perform their tasks manually on the floor often in an unhealthy position, they are at a higher risk suffering from WRMD. Soenandi [19] proposes a system compound of four position sensors integrated into a cushion. A buzzer provides real-time feedback in case of bad postures.

Among commercial products, a company worth mentioning is DorsaVi. Their sensor technologies aim at companies, clinics, and athletes with various wearable sensors and application types [42]. The MyViSafe application for instance targets specifically at the injury reduction of construction workers. If a high-risk movement is detected, the application provides real-time feedback in the form of vibration. In addition to that, the user can check his performance within the application. He even gets recommendations for different handling techniques. The directors can make use of the tracked data to prevent hazardous movement patterns by adapting operating processes.

Besides research on use cases for specific work-groups, a large amount of literature focuses on posture correction in general. Back pain becomes more and more common which can be explained by the increasing time spent in a sitting posture [43]. Carvalho, Queirs, Moreira, *et al.* [20] developed a vest to correct the user's spine posture. Five modules containing IMU sensors are used to detect the user's state. The idea is to embed the prototype later-on in a serious game scenario to educate correct postures. Based on the API for the device, a smartphone and a desktop application offer the monitoring of the user's spine profile. In the case of a hazardous posture, audio, as well as tactile feedback, is supplied. The authors evaluated the performance and efficacy of the system with ten participants in a within-study design. The study design comprised two different sessions one week apart. In each session, the participants sat in a classroom for one hour. They wore the device that collected posture data. Where the first day served as a baseline condition, during the second session the feedback systems were activated. Overall, the authors state a decrease of bad postures among the participants on the second day. Additionally, in more than 60% of the cases, the participants corrected their posture 2 – 4 seconds after the real-time feedback. Similarly, Shanmugam, Nehru, and Shanmugam [21] measure the lumbar spine position with an accelerometer. Feedback in case of a bad posture is provided by a vibration motor and a notification in the smartphone application. Furthermore, the smartphone application offers the possibility to define certain settings and thresholds. During their study with ten participants, the authors focus on investigating the accuracy of their wearable. Regarding the back, they were able to measure the angle of the back bending with an accuracy of 95%.

Recently in 2018, Du, Wang, Baets, *et al.* [44] investigated how wearable technology can prevent shoulder pain prevention of office workers. A smart garment to detect a bad posture was designed and evaluated. The system gathers data with IMU sensors and provides haptic feedback in real-time via integrated vibration modules. An additional Android application supplies a shoulder tracker and a shoulder trainer with several shoulder exercises.

Figure 5 Posture correction as commercial product: UprightGo [45]

Interestingly, Du, Wang, Baets, *et al.* [44] specifically claim that previous research does not go beyond real-time feedback like simple audio or vibrotactile notifications. The authors refer to Schmidt and Lee [17] who claim that two types of feedback are relevant for motor learning. At first real-time feedback, so-called knowledge of performance, and secondly, summative feedback, so-called knowledge of results, should be provided. Du, Wang, Baets, *et al.* [44] implemented the second type of feedback as day and hour scale of the posture that can be accessed in the Android application.

Tactile feedback is also widely spread among commercial products that focus on posture improvement. Lumo-Lift, for instance, consists of a small sensor that connects to a smartphone application [46]. The sensor can be attached to the T-shirt and tracks your posture and activity. As soon as the user starts slouching it vibrates to remind the customer to sit up straight. Upright Go uses a similar

concept where a sensor connected to a smartphone application is attached to the upper back (see figue 5) [45].

In the field of healthcare, motion tracking is mainly applied to focus on the at-home monitoring of patients. Novel systems might detect falls [47], [48] or monitor posture [49]. Muckell, Young, and Leventhal [50] support this view. The authors combine a motion tracking system with computational analysis to detect risky patient transfer behaviour in nursing. They argue that "there has not been any significant published work that leverages full-body motion tracking data to automatically assess injury risk for lifting and patient transfers". During an exploratory study in an assisted living faculty, they determined, that risky patient transfers are diffused in this faculty and can be detected using wearable motion sensors. In contrast to the work of Muckell, Young, and Leventhal [50], our work does not target the evaluation of the system from a technical perspective. However, the work is germane as they pursue a similar goal as NurseCare. At long sight, they aim at constructing a full motion tracking system to support caregivers performing safe patient transfers and reducing WRMD.

3.1.2 Mobile systems supporting the application of safe patient-transfers

Previous studies investigated how technology can support caregivers learning core-skills in care. Especially the field of simulation training with patient-dolls was examined [51]–[53]. Wu, Hwang, Su, *et al.* [54] developed a context-aware mobile learning system for caregivers. During the learning experience in a simulation training, the mobile system provides summative feedback on the performance and instant feedback on incorrect behaviour. Specifically concentrating on patient-transfers, Huang, Nagata, Kanai-Pak, *et al.* [55] describe the development of a self-help training system for nurses and a robot patient [56]. They report a significant skill improvement in patient-transfer techniques.

With a focus on Kinaesthetics, it exists two mobile solutions as commercial products. Both target at people who nurse their family members at home. "Kinaesthetics Care" was developed by Henriette Hopkins, a German nurse [57]. The mobile application provides instruction-videos that try to teach Kinaesthetics approaches. The user can watch different videos about specific topics annotated with textual information. The second mobile application "MH Kinaesthetics" was developed on behalf of a German clinic [58]. For each of the six Kinaesthetics principles, it provides textual information.

3.1.3 Findings

Overall, the presented literature in section 3.1.1 suggests that wearables providing instant feedback and allowing direct support during work can play an important role in the reduction of WRMD. Yet, to our knowledge, the field of application mainly concentrates on factory workers, which asks for different requirements than a clinical setting, or posture correction in general, which does not involve complex movement patterns such as patient-transfers. In addition to that, the research has tended to focus on quantitative methods and the sensor accuracy rather than qualitative methods investigating how users perceive the support. Concerning mobile systems to support patient-transfers described in section 3.1.2 most studies concentrate on the acquisition of core-skills in nursing. Research on the specific case of patient transfers is limited to the support in the lab setting.

Together, the studies presented in this section indicate that there has been no research on a system that leverages mobile and sensory technology to support the transfer of patient-transfer skills directly during work. The requirements for such a system are vague especially to meet the nurses' needs in their complex-work domain. To survey this design space a Workshop was conducted which will be part of the succeeding section.

3.2 Workshop 1.0

As previously outlined, the literature on the specific use case of supporting safe patient-transfers in practice is limited. Thus, further insights in the work-domain are of big interest to investigate requirements. Moreover, the involvement of the end-user is advantageous to increase the efficacy of mobile interventions as discussed in section 2.4. One common technique to involve the end-user is workshops.

For the requirements analysis of NurseCare, a Future Workshop with five nurses was conducted. Its organisation, procedure and the results are depicted in this section. Besides requirements gathering, its goal was to validate issues in current practices and the context where support is needed.

In the first section 3.2.1, it is described how Distributed Cognition influenced the leading topics in the workshop. Next, section 3.2.2 includes the appliance of the BCT-Wheel framework to identify evidence based intervention techniques. Those were, in a later step, used as the basis for the future workshop. At first, its organisation will be described in section 3.2.3 followed by the procedure of the workshop in section 3.2.4. Finally, the purpose of section 3.2.5 is to sum up the workshop results.

3.2.1 Guiding topics based on Distributed Cognition

The Distributed Cognition approach, previously outlined in section 2.2, should help to understand the important aspects of learning. This understanding can further clarify which aspects should be supported by NurseCare. Based on the described principles, questions were elicited to guide the workshop.

According to the idea of *Socially Distributed Cognition* the cognitive learning process of Kinaesthetics cannot be understood in isolation within the caregiver. It must rather be investigated within the whole socio-technical system it takes part in. The Future Workshop should give insights on how nurses interact with other social members and how the learning process is influenced by that. The social interaction between the nurses with each other and also with other members has to be taken into account.

Based on *Embodied Cognition* several factors should be taken into account during the design process of NurseCare. At first, the use of the system directly "in-the-wild" can be seen as an additional possibility for practise. Consequently, it is of big interest by what means the nurses can be supported "in-the-wild". Moreover, the artifacts that they use to transfer patients should be kept in mind. During the workshop, it can be investigated which kind of feedback or instruction the nurses consider as beneficial and how they wish to interact with the system "in-the-wild". Further one might ask how they interact with assisting technologies such as lifters or the electric bed of the patients.

Culture and Cognition is important in our case as the environment of the clinical-setting influences the nurses' possibility to put Kinaesthetics into practice [59]. The contextual inquiry of the ERTRAG project already gave some insights into the clinical system. It further revealed the contexts where the learning process of Kinaesthetics can or could unfold. The advantage of a mobile system is that it can support in all of the contexts. The workshop should clarify how a novel system can be integrated into the sociocultural system of the hospital but also in the private life of the nurses. The school context of the basic-course is the first context, where the students are introduced into the topic. During the workshop, the current practice of learning Kinaesthetics in the basic courses can be further elaborated. To internalise the learned content, movements should be applied directly in the clinical context. Repeating the movements and reflecting on the own performance could strengthen the awareness of ergonomic work manners and happen also after work in the home context. Whether nurses consider support at home as beneficial and how that could look like should be explored during the workshop.

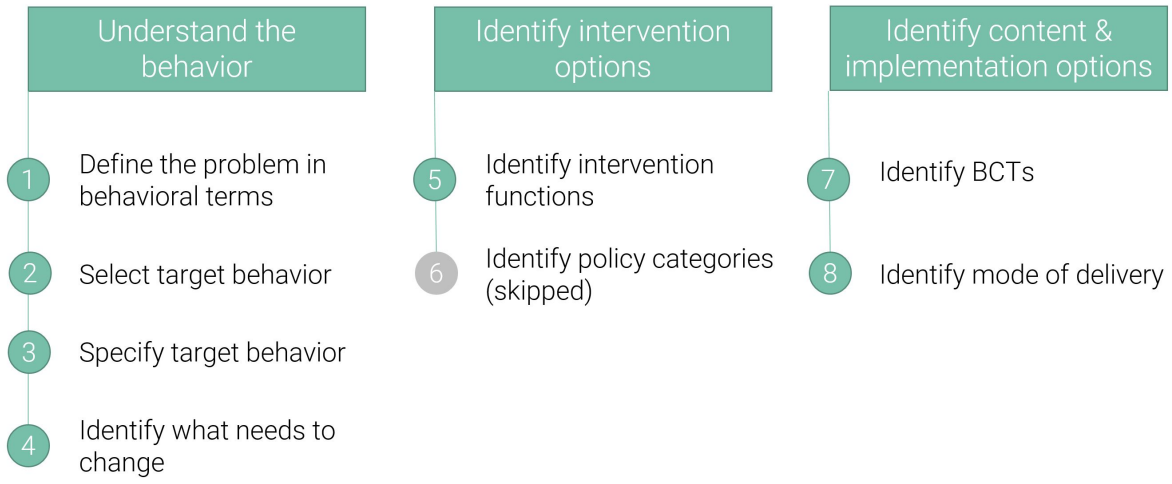


Figure 6 Steps of the BCT Wheel framework

3.2.2 Appliance of the BCT Wheel Framework

To ensure a theoretical grounding for the requirements, the BCT Wheel Framework was applied. It has already been briefly introduced in section 2.3. It comprises eight steps in three stages as illustrated in figure 6.

Stage 1: Understanding the behaviour

During the first stage, the behaviour of the user including the problem and target behaviour should be completely comprehended. As a first step, the problem needs to be properly defined in behavioural terms. This includes the individuals related to the problematic behaviour and the location where it takes place. In our use case, the problem has already been described in detail in section 1.1. Summarised, some work-fields for instance nursing are more likely suffering from WRMD due to non-ergonomic movements during their work. Although in some places nurses learn Kinaesthetics at the beginning of their education it is often not applied to everyday situations during their work.

Next, the target behaviour and the circumstances that currently hamper the target user group from applying it should be elaborated in step two, three and four. In their paper "StopApp: Using the Behaviour Change Wheel to Develop an App to Increase Uptake and Attendance at NHS Stop Smoking Services" Fulton, Brown, Kwah, *et al.* [60] classify the target behaviour by means of several questions:

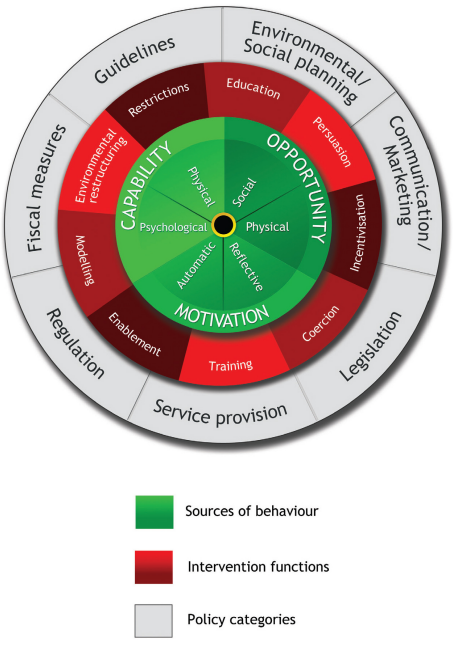


Figure 7 The Behavior Change Wheel

Target behaviour Apply Kinaesthetics during risky work situations.

Who needs to perform the behaviour? Nurses.

What do they need to do differently to achieve the desired change? The nurses need to be aware of the consequences of non-ergonomic movements. Furthermore, they need to be

aware of a risky situation to apply Kinaesthetics. In addition to that, they need to be capable to apply the Kinaesthetics movement. This implies that they need time and knowledge.

When, where and how often do they need to do it? During work in the clinical setting they should apply Kinaesthetics in all fitting situations (like patient handling). To create awareness they also should repeat the principles at home or ergonomically lift things in their free time.

With whom do they need to do it? If possible and necessary together with other nurses and the patient.

Stage 2: Identify intervention options

Once the current behaviour and the target behaviour is understood, the second stage is about identifying intervention possibilities. In step five one seeks to identify suitable intervention functions. Figure 7 illustrates the BCT Wheel which is supposed to support this process. The grounding of the Behavior Change Wheel contains three conditions necessary for the target behavior: Capability, Opportunity or Motivation (COM-B). The nine intervention functions (red in the wheel) are proposed to address specific deficits in those conditions. Furthermore, seven categories of policy are proposed, which are not of interest in our use case. To avoid confusion the following terms should not be mixed up:

Conditions Capability, Opportunity or Motivation (COM-B) They influence each other and the behavior as well as vice-versa. An intervention aims to change one or more of them to reach a specific behavior.

Intervention functions Those are functions an intervention can have to change conditions of the COM-B system. For instance Michie, Stralen, and West [34] define "education" as "Increasing knowledge or understanding".

Behavior Change Techniques (BCTs) Those are 93 specific components of an intervention such as "feedback" or "self-monitoring".

The results of this step and step seven described in the succeeding stage are summarised in the appendix A. In the following, the procedure is exemplified. The identified problems from the previous stage were mapped to the specific condition in which a deficit exists. For instance, it was elaborated that the nurses are often not aware of risky situations where Kinaesthetics could be applied. This issue was mapped to the Com-B "psychological capability". Next, the BCT Wheel provides information on which interventions are suitable for which Com-B deficit. In our example "Education, Training or Environmental Restructuring" can be helpful. This was executed for all revealed Com-B conditions. Step six in the second stage was skipped because this is not directly relevant for the implementation of NurseCare.

Stage 3: Identify content and implementation options

In the last stage, content and implementation options were examined. Step seven includes, therefore, the identification of the proper BCTs using the above mentioned Behaviour Change Technique Taxonomy. Just to remember: BCTs are specific components of an intervention such as "feedback" or "self-monitoring". The Behaviour Change Technique Taxonomy comprises 93 BCTs with descriptions and examples. The most suitable ones for the chosen interventions in step five were selected. Referring back to our previous example, ten BCTs were identified as suitable to address the identified deficit in the "psychological capability", for instance, BCT "2.2. Feedback on behaviour". After selecting the proper techniques, one usually defines the content of the techniques and how they should be implemented in the system. In our case this procedure

was realised during the future workshop and will, therefore, be part of section 3.2.5. The BCTs were used as grounding for the requirements. They were verified during the workshop with the nurses. This procedure is outlined in the succeeding section. The last step of the framework includes choosing the right mode of delivery which will be likewise defined after the workshop.

3.2.3 Organisation

The workshop was organised with the help of partners of the ERTRAG-project. It was held in German. All data has been translated into English. To recruit participants, an invitation mail has been sent to all nursing (pedagogy) students of the Hochschule Ravensburg-Weingarten. Figure 8 gives an overview of the demographic data.

Figure 8 Workshop 1.0: Demographic overview

Six students signed up for the workshop that was planned for 2,5 hours. One participant was not able to join caused by illness so the workshop was finally conducted with 5 participants. They were all female and between 22 and 50 years old. Four of them studied nursing pedagogy in the 8th semester, one in the 6th semester. They all have finished their education in nursing and are already working in this profession. Thus they were all familiar with Kinaesthetics because they participated in the Kinaesthetics basic-course.

The workshop took part in a room in the Hochschule Ravensburg-Weingarten equipped with a projector, a whiteboard, and a blackboard. Beforehand the room was prepared to fit the needs of the workshop. A row of chairs and tables was placed in front of the black- and whiteboard where the first session of the workshop took part. In the middle of the room two groups of tables were placed with sketching materials such as pens, large white paper, markers and scissors. The documentation was realised by notes, a video of the whole workshop was taken, and the artifacts created by the participants were collected. The compensation was 25€.

3.2.4 Procedure

Several questions were of great interest during the workshop. Do the participants consider the appliance of Kinaesthetics as problematic at all? Do they wish the support in different contexts? Would they themselves come up with the same pre-selected BCTs as interventions? And which BCTs do they consider as most relevant?

To get answers regarding those questions, a Future Workshop was considered as suitable structure. The Future Workshop format was introduced by Finn Kensing and Kim Halskov Madsen and groups a workshop in three phases, namely the "Critique Phase", "Fantasy Phase" and "Implementation Phase" [61], [62]. During a Future Workshop end-users are urged to evolve innovative solutions for concrete problems during their work. Figure 9 illustrates the three phases of the workshop and the goal for each phase.

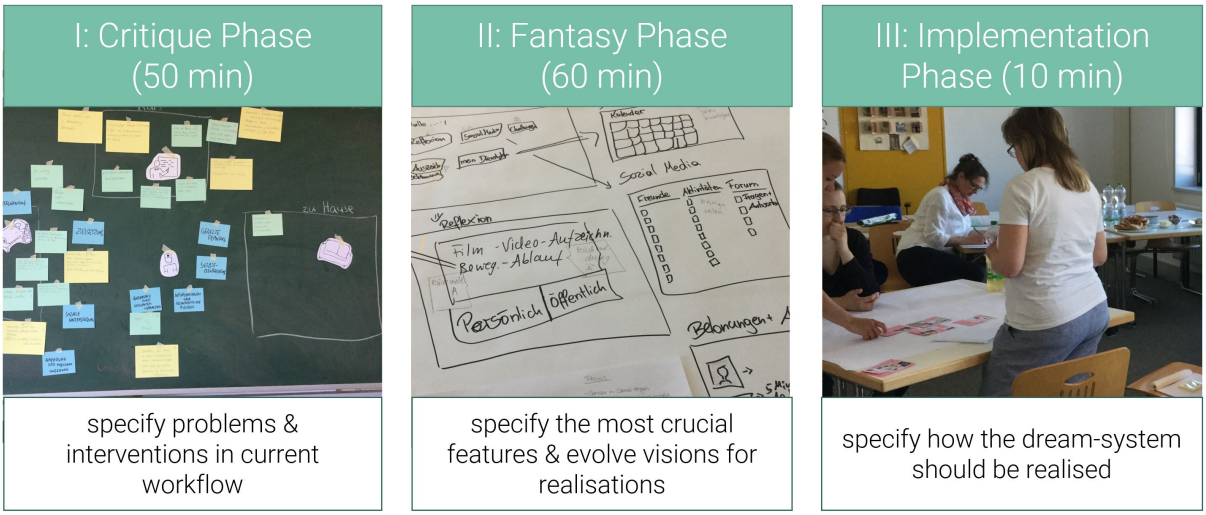


Figure 9 Workshop 1.0: The three phases

After the participants have been welcomed, they were asked to fill out the consent form and a demographic questionnaire. Next, they were introduced into the topic and the agenda:

15 min Consent form and introduction to the topic and the agenda

50 min Structured brainstorming - Which problems hamper nurses from working ergonomically and how can a system intervene? (*Critique Phase*)

15 min Short recap

60 min Sketching - Create your dream-system! (*Fantasy Phase*)

10 min Discussion (*Implementation Phase*)

Phase I: The Critique Phase

The Critique Phase aims to uncover specific problems. It often comprises brainstorming as common activity [62]. In our use case, two aspects were of big interest. Firstly, it should be investigated whether the issues, that were depicted in the introductory chapter 1, are likewise existing for the workshops participants. This would reinforce the relevance of the topic. Secondly, it was examined which solution approaches the participants regard helpful to address the issues. The solution approaches could then be compared to the pre-selected BCTs. After the workshop, system requirements could then be extracted from BCTs that match with the participants' solution approaches.

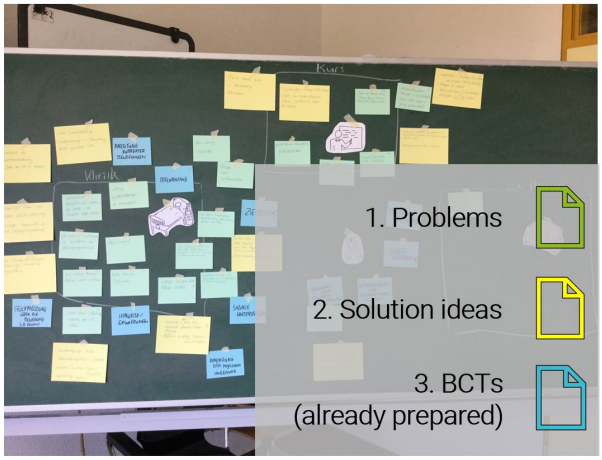


Figure 10 Workshop 1.0: Structured brainstorming

A blackboard was used to structure all ideas (see figure 10). As outlined in section 3.2.1, the learning process unfolds in various contexts. To keep that in mind, the blackboard was prepared with areas for the home, school and hospital context. Each participant was provided with ten empty green "problem" and ten empty yellow "solution" cards. In a ten minutes brainstorming session, they were asked to note down aspects that hinder them in applying Kinaesthetics on green cards. On yellow cards, they wrote down ideas that a novel system could supply to

address those issues. Thereafter each participant presented their results and stuck their cards in the specific context on the board.

In a second step, we grouped similar issues and solutions. Blue "requirement" cards with the pre-selected BCTs were introduced by the researcher. The BCTs were beforehand translated into more general German expressions and presented rather as support possibilities instead of strategies of a theoretical framework.

Phase II: The Fantasy Phase

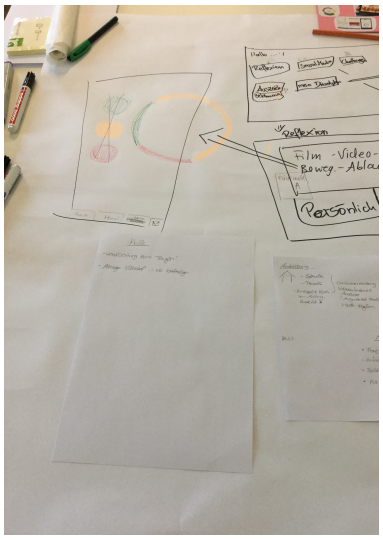


Figure 11 Workshop 1.0: Sketches during the Fantasy Phase

The Fantasy Phase targets the generation of ideas regarding a possible dream system. The participants worked in two smaller groups. At first, each group was asked to select three of the blue "requirement" cards that seemed most crucial to them. Using pen and paper, the participants sketched initial ideas for how the requirements could be realised (see figure 11). As they did not have any technical background, additional input regarding systems and technical opportunities should be provided. "Inspiration Cards" were considered a valuable method [63]. The "Inspiration Card Workshop" serves as a method to design new digital tools. "Technology Cards" are combined with "Domain Cards", both containing an image of the technological application or domain finding, a description, and space for participants' comments. Based on this method "Technology cards" for this workshop contained an image and a description of technical terms like "QR-Codes" or "Augmented Reality". "Domain cards" were not taken into account as the cards were supposed to mediate the technological possibilities to the participants with a non-technological background.

Phase III: The Implementation Phase

The last phase was the shortest. Each group presented their "dream system". A group discussion led to a mutual agreement of the most important BCTs or later-on requirements for a novel system.

3.2.5 Results

Overall the Workshop was successful in aiming the previously defined goals. It was possible to gain insights on the relevance of a novel system and a ranking of interventions and features. Furthermore, it was possible to get a better understanding of the work context where NurseCare will be used. The attitude about the idea of NurseCare was overall positive. The participants were even interested in further involvement in the design cycle. They agreed to be contacted for the next workshop which should bring up a more concrete idea of the design.

The previously examined issues and the need for such a system were confirmed. To analyse the results of the structured brainstorming during the Critique Phase, all cards were digitised and counted. The results are included in the table 2 in the appendix B. Aspects such as a lack of practice of Kinaesthetics during work routines were mentioned as well as a lack of awareness

for the health risks. It appeared that the prepared BCTs can function as labels for the solutions proposed by the participants as they matched with regards to contents. The selected BCTs merged with the participants' proposals led to the following requirements:

R1: Real-time feedback
BCT: Feedback on behavior [2.3]
NurseCare should provide the user with individual adjustable real-time feedback during unhealthy postures as well as positive feedback after performances without risky movements. Vibrotactile feedback without audio is preferred to not irritate patients.

R2: Reflection in everyday life
BCT: Self-Monitoring of Behavior [2.4]
NurseCare should provide the user with evaluative, summative feedback on his daily performance regarding hazardous movements. Furthermore, it should support the user to reflect on this data.

R3: Instruction / demonstration
BCT: Instruction on how to perform a behavior [4.1] / Demonstration of the behavior [6.1]
NurseCare should provide instructions and demonstrations on correct Kinaesthetics movement patterns for instance in the form of videos or Augmented Reality.

R4: Rewards
BCT: Nonspecific reward [10.3]
NurseCare should motivate the user in applying Kinaesthetics in the form of digital rewards.

R5: Reminder:
BCT: Prompts/Cues [7.1]
NurseCare should provide prompts to increase the awareness of the topics' relevance and remind the caregivers to mind their back.

R6: Social interaction
BCT: Social Support (unspecified) [3.1]
NurseCare should provide a platform for nurses to exchange knowledge among each other and with experts about Kinaesthetics.

3.3 Conclusion

This chapter illustrated how the conduction of a future workshop in combination with a theoretical framework can guide the derivation of requirements. The question which features the novel system is supposed to supply was thereby clarified. Yet, those requirements still need to be implemented in an interaction concept. Moreover, the interaction concept must fit the complex hospital context in which it will be used by the nurses. Further involvement of the end user in the form of a second workshop seemed helpful to generate relevant knowledge. Its procedure and influence on the design process will be part of the succeeding chapter 4.

CHAPTER 4

Design of the interaction concept

After the derivation of requirements, this chapter is dedicated to the design process of NurseCare. The first section 4.1 deals with the organisation and conduction of the second workshop bringing together nurses and HCI students. The results will comprehend insights on how requirements are wished to be realised as features in the novel system. Keeping the results in mind, we then move on to the further process of design thinking described in section 4.2. At the end of this chapter, we will have a concrete idea of the interaction concept for NurseCare which will be thereafter implemented as a prototype.

4.1 Workshop 2.0

As the participants of the first workshop all agreed on being contacted in case of further activities, this opportunity was taken. A second workshop was planned. Its goal was to generate an interaction flow to understand when and how the nurses want to be supported. The domain knowledge of the nurses was supposed to be valuable to design a system that is usable in the complex hospital context. The idea appeared to conduct this codesign workshop not only with nurses but also with HCI students. Thereby domain and technical knowledge were combined.

4.1.1 Organisation

An invitation email was sent to the nurses from the first workshop. Computer Science students, who work likewise as student researchers in the chair of Human Computer Interaction (HCI) at the University of Constance have been invited face-to-face (in the following called HCI students).

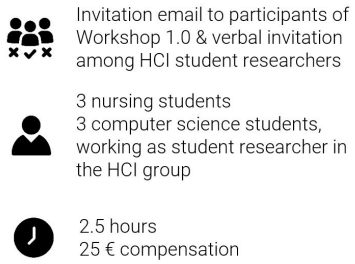


Figure 12 Workshop 2.0: Demographic overview

Finally, three HCI students and three participants from the first workshop were recruited (see figure 12). They were between 22 and 28 years old, five female students and one male student. The nursing students from the first workshop were still working while studying nursing at the Hochschule Ravensburg-Weingarten in the 8th semester. Out of the HCI students, one participant was a bachelor student in Computer Science in the 6th semester, two were master students in Computer Science, one in the 4th and one in the 6th semester. Due to the tight schedule of the nurses, the workshop was again planned solely for 2,5 hours. To document the results, the workshop was video recorded, notes were taken and the produced artifacts were collected. The participants received 25€ as compensation each.

The organisation of the workshop structure included choosing appropriate tools and techniques. Sanders, Brandt, Binder, *et al.* [41] summarise common tools and techniques and propose a framework for structuring those. Based on the use case of NurseCare the proposed tools and techniques were filtered leading to a selection of various methods. Methods considered as

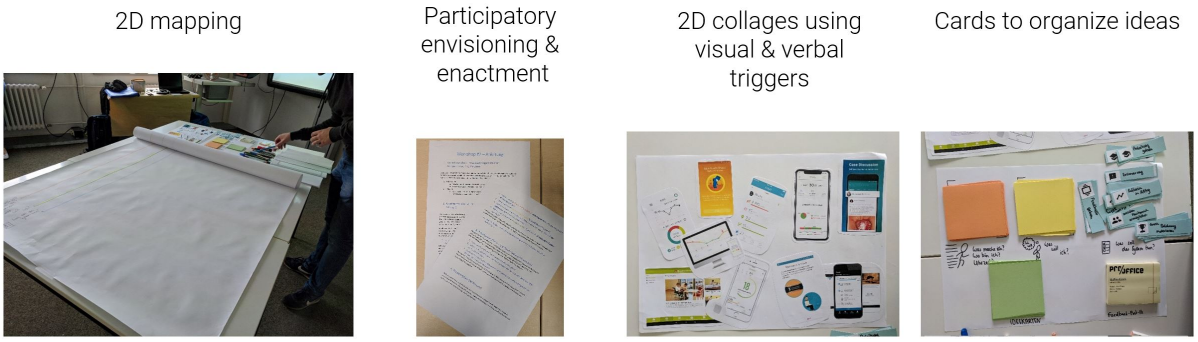


Figure 13 Workshop 2.0: Prepared material

beneficial were the following: 2-D collages using visual and verbal triggers, 2-D mappings using visual and verbal components, stories through writing, cards to organise, categorise and prioritise ideas, and participatory envisioning and enactment. In the next step, those techniques were mapped to the knowledge that the participants can contribute to and the desired output. Figure 13 visualises how the methods were finally realised as prepared materials. This iterative process led to the final procedure of the workshop described in the succeeding section.

4.1.2 Procedure

The workshop started with a general introduction into the topic and agenda guided with a powerpoint presentation. Next, the participants were divided into three groups, one nurse and one HCI student each. A group table for each group has already been prepared with the required materials: A large piece of paper that shows a yellow, orange and blue "timeline" from the morning until the evening, a "toolbox" with various cards, a collage with design input from related work as inspiration and different sketching utensils (see figure 13). Moreover, sketching templates of tablets, smartphones and desktops were provided. This served the purpose to leave the selection of the output device up to the participants. Additionally, a printed version of the workshop activities was provided to them as instruction. The agenda was the following:

20 min Introduction to the topic and agenda, explanation of the exercises

40 min Development of a dream scenario

10 min Coffee break

60 min Sketching the dream systems screens

20 min Group presentation

To facilitate collaboration, the groups were initially asked to introduce themselves for two minutes guided by domain-specific questions. After that, the main activities started.

Development of a dream scenario:

The focus of this activity was the nurses' domain knowledge. The input of the nurses should address the following question: At what time during their day do the nurses want to be supported by the system and how? The groups should capture their ideas on the provided large piece of paper with the three timelines. The nurses were asked to think about the usual workday. For each action during the day, they were supposed to think of possible support by the system. If they think the novel system could support them by applying Kinaesthetics either indirectly or directly, they should reflect on the following questions together with the HCI-student (see figure 14): What am I doing? What do I want? How can NurseCare support?

To ensure a common structure of the groups' works, cards seemed an advantageous method to frame the different inputs.

Cards in different colours should make the results distinguishable for the analysis afterward. For instance, to answer the first question, the participants were supposed to write the response on an orange card and stick it to the orange timeline. The first two questions should be answered by the participants and generate new input. To answer the last question, the participants were asked to take a blue card which contained the different requirements derived from the first workshop. Green "idea" cards could be used to capture first ideas that might be relevant for the succeeding activities.

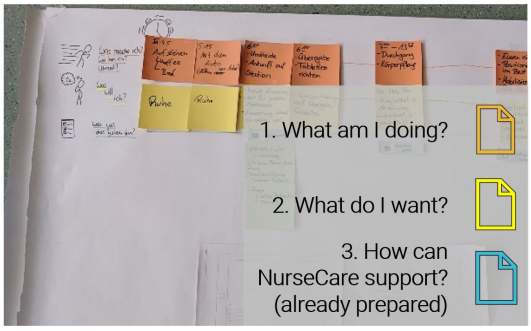


Figure 14 Workshop 2.0: Development of a dream scenario

Sketching the dream systems screens:

The focus in this activity was the HCI students' knowledge. The groups were asked to iterate their timeline. For each "step", the groups should reflect on how the specific requirement could be represented in the novel system. They should take empty templates, sketch out ideas and pin them among the step.

4.1.3 Results

The analysis of the workshop results unfolded in two parts. At first, all group artifacts were summed up in written form individually. Secondly, similarities amongst the groups should be identified. The detailed results of both steps have been documented in the project paper. In this work, solely the second step is summarised with a focus on the overall results.

A Windows Surface Hub at the University of Constance was used to get an overview of the different group artifacts (see figure 15). The images were loaded to a whiteboard session and arranged one above the other. Just to remember: The images contained timelines with situations where the nurses like to be supported by NurseCare. The cards in one column describe how the group wants to be supported in this situation, why and during which activity. To give an example, group 2 noted that after work between 15.30 and 19.00 o'clock, they like to see an overview of their daily movement performance. This refers to "R2: Reflection in everyday life". The cards forming one situation were circled. This was solely done for the first group. Thereafter the cards from the other groups were inspected for similar visions. Referring back to the previous example, similar to group 2, group 1 and 3 likewise wished the support to reflect on their daily performance after work in the evening. Those similarities regarding the requirements were then summarised in digital post-its. This step aimed at facilitating the elicitation of implications for the design. In the last step, additional aspects were marked that might be interesting regarding the interaction concept.

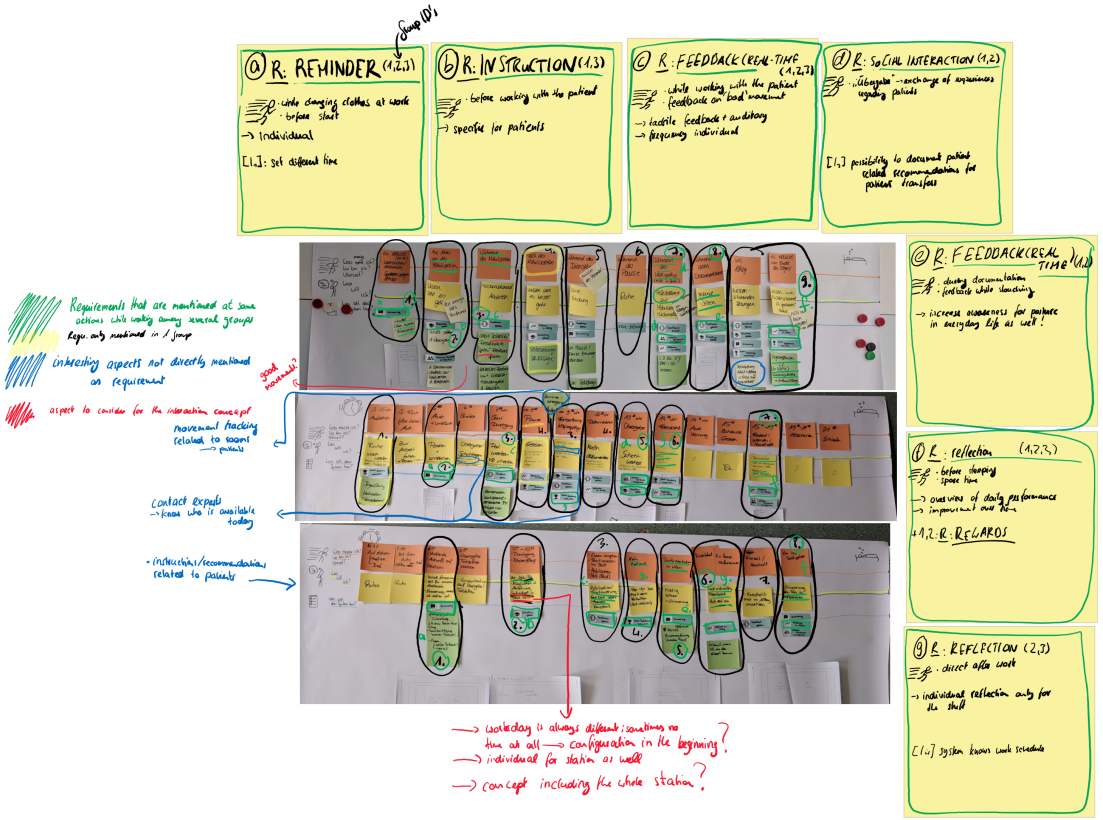


Figure 15 Workshop 2.0: Step 4 of the identification of similarities

Based on this analysis and the detailed summary of the groups' results several implications regarding the requirements have been recorded. The statements below refer to the yellow post-its illustrated in figure 15. To clarify the reference to the Requirements, the number in brackets indicates the corresponding requirement.

(a) **Reminder (R5):** The reminder is imagined as a notification before the shift starts by all groups. A good time slot would be while changing clothes in the changing room. The time could be set individually.

(b) **Instruction (R3):** Two of the three groups considered instructions regarding Kinaesthetics movements as helpful before they enter the patient's room. Getting recommendations based on specific patient's characteristics was imagined as helpful as well. The instructions were proposed as videos with textual step-by-step instructions. Yet, one must consider the different time constraints in different parts of the hospital. Watching video instructions while working with the patients might be possible for some (for instance group 1), but not for others (for instance group 2).

(c) + (d) **Feedback (R1):** Vibrotactile feedback on "bad" movements should be provided in real-time. On the one hand, it should be provided while working with the patients. On the other hand, it can increase the awareness for the own posture also during the paperwork when the caregiver starts slouching. One group added optional auditory feedback as an idea. In any case, the feedback should be individually adjustable.

(e) **Social interaction (R6):** Two of the three groups visualised support during the change of shift to exchange and document experiences with the patients regarding Kinaesthetics.

(f) + (g) **Reflection (R2):** The possibility to reflect on daily movements should be provided at the end of the day and in the spare time according to all groups. An overview of the daily performance, as well as the improvement over time should be accessible. Two groups wanted to reflect directly after work, they imagined an individual overview specific for the finished shift.

Among specific indications regarding the requirements, some general insights on relevant factors for the further design process were gathered as well.

Caring for the carer It appeared, both during the first and the second workshop, that the participants tend to focus on the patients' health, more than on their own. They disregard their own health due to time pressure or other structural circumstances such as a lack of assisting equipment. NurseCare should increase the awareness of the user for his own health. The application might address the user directly to create a supportive ambience. This should be considered for instance by greeting the user with his name on the start screen or embed reflective questions.

Individuality of working conditions The working conditions differ among various hospitals as well as among the wards within the same hospital. The system must be unobtrusive on stressful days and provide features that can be assessed when the working conditions allow a more extensive usage of the application.

Mode of delivery One aspect needs to be mentioned regarding the mode of delivery of the application. The groups appreciated the possibility to use the future application on their own smartphone. This allows the usage in various contexts, for instance at home. However, some of the groups chose tablets as an output device in the hospital. The decision was based on the doubt that smartphones - for now - are still forbidden in German hospitals. Yet, there is evidence that more and more hospitals will allow the usage of smartphones due to the digitisation of healthcare [64]. Thus in the following, this work focuses on smartphones as output devices for NurseCare.

4.2 Design Thinking

Although the workshop delivered valuable insights on how the interaction with the system can unfold, the user interface is still vague. Among others, Hartson and Pyla [65] propose various methods that support the concretion of the interaction concept. Methods that seemed convenient for our use case have been applied to narrow down the first screen ideas. The knowledge that was gathered during the workshops framed the design process. A selection of the applied methods will be outlined in the following. The entity of methods used is described in detail in the master project paper.

4.2.1 Essential Use Case

Essential use cases are one type of task interaction models common in User Centered Design. Originally introduced by Constantine and Lockwood in 1999, Hartson and Pyla for instance mention this way of describing tasks in their UX book [65]. An essential use case is a "simple, general and abstract task description, independent of technology or implementation". In contrast to step-by-step task models, essential use cases do not focus on how interaction is performed. They rather help to concentrate on specific tasks and therefore core functions of the novel system. Three essential use cases for NurseCare emerged from the results of the first

workshop. Each one refers to different requirements. The essential use cases not only help to focus on the further design process, but they will also be revisited in the analytical inspection described in section 4.3. The second essential use case is presented as an example.

Essential Use Case 2: Getting instruction regarding a specific patient handling technique.
This second essential use case covers the requirement *R4: Instruction / demonstration*

User intention	System responsibility
The user wants to know how an immobile patient can be transferred to the wheelchair.	
	The system offers video instructions for patient handling techniques based on Kinaesthetics.
	The system offers the possibility to search for specific cases.

Figure 16 Essential Use Case 2

4.2.2 Persona

In their book "Rapid Contextual Design" Holtzblatt, Wendell, and Wood [66] describe personas as a method that "bring users alive and focus the stakeholders on the relevant issues". Usually, they contain a textual description of a typical user. A fictional character based on the initial contextual inquiry of ERTRAG and the first two workshops was created within the master project. Out of several alternative personas, a primary persona was selected. This persona is presented in the following.

Background: Marie is 24 years old and lives in Ravensburg where she works as a nurse in the hospital Sankt Elisabeth. She lives in a flat together with her boyfriend Tim. Besides working, she decided to start studying nursing pedagogy in the Hochschule Ravensburg-Weingarten. During her spare time she likes to meet friends, go to the cinema or take a walk.

Technical background: Like many others of her age, Marie is quite familiar with smartphones and tablets. She mainly uses technology for social interaction or taking pictures. She has seen other digital devices such as activity trackers before, however, never used.

Kinaesthetics experience: Within her education as a caregiver, she attended the basic Kinaesthetics course at the beginning of her second year of education. The course took place in a school and was arranged in three days. During this course, a professor taught the principles of Kinaesthetics in a theoretical part as well as by the means of role plays. Marie was supposed to learn different safe patient handling techniques practicing them with other students performing patients. After this course, there was no follow-up education. In the evening, Marie often suffered from low back pain. She is aware of the fact that patient handling and many

Figure 17 Persona: Marie [67]

lifting movements during work are the reason for her pain. Although she sometimes is aware of hazardous movements, she is unsure about the correct appliance of Kinaesthetics transfers because she never practised those movement patterns again. Moreover during the course, the patients were lightweight students so she does not know which principles to apply in specific individual patient cases. Even though a Kinaesthetics coach is part of the staff in the hospital, the coach is responsible for the whole clinic and therefore often not directly available.

Goals: Marie likes her profession and imagines working as a head-nurse one day. Yet, she is aware of the fact that many of her senior colleagues suffer from WRMD. She hopes to find a solution for avoiding low back pain in her future carrier, working directly with patients as long as it is possible.

4.2.3 User-scenario

After clarifying the question who is going to use the system, two scenarios were created to document how NurseCare could be used. At first, the present-based scenario specifies the current situation without NurseCare:

Present-based user-scenario: Its Thursday morning and Marie starts her shift at 7 am. The last days she often suffered from back pain after her working shifts. After a while, she is supposed to help in room 134 where a 45 years old man is recovering from his stroke. The man is quite heavy and partly paralysed. Her colleague explains to her that the patient needs to be moved up within his bed as he feels uncomfortable. Marie remembers that there are movement patterns in Kinaesthetics to move patients up within their bed in an ergonomic way. Yet she is not sure about the correct way neither about the aspects to consider for especially heavy patients that are partly paralysed. Due to a lack of staff, she knows that all of her colleagues are busy. Equally the Kinaesthetics coach is in the other part of the hospital right now. As she has no one to ask she enters the patient's room and somehow tries to manage the situation without keeping track of her own back.

The future-based scenario aims to clarify how the end-user will interact with the novel system to solve the problems faced in the present-based scenario. It was written based on the implications of the second workshop described in section 4.1.3. The numbers in brackets refer to the different requirements introduced in section 3.2.5.

Future-based user-scenario: Its Thursday morning and Marie starts her shift at 7 am. The last days she often suffered from back pain after her working shifts. In these days a novel system called NurseCare was introduced on her station. It comprises a T-shirt with a sensor and an application for the smartphone for the nurses as well as an application for the tablet in the nurses' room. Arriving at work at 6.30 she enters the clothing room to change her clothes. She already wears the sensor and takes a glance at her phone. A notification reminds her trying to apply Kinaesthetics during work *(R5: Reminder)*. She starts working and after a while, she is supposed to help in room 134 where a 45 years old man is recovering from his stroke. The man is quite heavy and partly paralysed. Her colleague explains to her that the patient needs to be moved up within his bed as he feels uncomfortable. Marie remembers that there are movement patterns in Kinaesthetics to move patients up within their bed in an ergonomic way. She opens the NurseCare application and selects the section with the patient in room 2. Based on his characteristics NurseCare recommends a specific alternative for moving patients up. She watches the video and feels ready to enter the patient's room *(R3:Instruction / demonstration)*. It works out and she moves on to the next patient. Soon she forgets about Kinaesthetics as the stress level increases. At some point she feels a vibration while transferring a Parkinson patient

from the bed to the wheelchair *(R1: Real-time feedback + R6: Social interaction)*. After her work in the room, she notices a notification on her phone telling her that a harmful movement was detected. NurseCare provides her with sufficient recommendations for the transfer technique she applied if needed. As she has not much time she decides to accesses the recommendations later. During the change of shift in the nurses' room each patient is discussed. Talking about her Parkinson patient she mentions that she felt a vibration and had problems with transferring him. The head nurse selects the patient in the NurseCare application on the tablet in the nursing room. The system recommends several patient handling strategies. Marie additionally adds a note, that using a lifter might be appropriate for the patient *(R3: Instruction / demonstration)*. Her shift finishes and she drives home. Arriving at home she opens NurseCare again and checks how many harmful movements she performed today. Quite a lot but there is time to improve, maybe she can achieve a badge the next days for reducing her rate of harmful movements *(R2: Reflection in everyday life)*. It crosses her mind that she is still unsure about how to apply Kinaesthetics in case of one patient who just had an operation on his hip. She posts the question in the forum and hopes for an answer before going to bed.

4.2.4 Sketches

How can the requirements, the groups' sketches and the participants' ideal scenarios melt together to an appropriate design concept? Hartson and Pyla describe sketching as a beneficial method for ideating a novel design concept: "Sketching is a direct part, not an after-the-fact part, of the process of invention" [65]. The sketches that have been created for the ideation of NurseCare are documented in the appendix of this paper (see appendix C). Two examples are supposed to illustrate how the workshop results framed the process of sketching.

Figure 18 demonstrates how the navigation structure was influenced by the results of the second workshop. It was examined which requirements were wished as always and directly accessible. Those include *R2: Reflection in everyday life*, *R3: Instruction/Demonstration* and *R6: Social Interaction*. Thus the screens where those requirements are implemented as features should all be at the same level of the hierarchy. Googles Material Design provides an overview of different types of navigation [68]. Furthermore, the page comprises recommendations for adequate navigation components per type of navigation. The primary navigation component of the app should allow the user to access all top-level destinations. Providing lateral navigation for two or more top-level destinations is recommended [68]. As we have three screens, which are all at the same level of the hierarchy, the bottom navigation was considered suitable for the project. It is recommended for mobile devices with 3 – 5 navigation elements that should be always accessible [69].

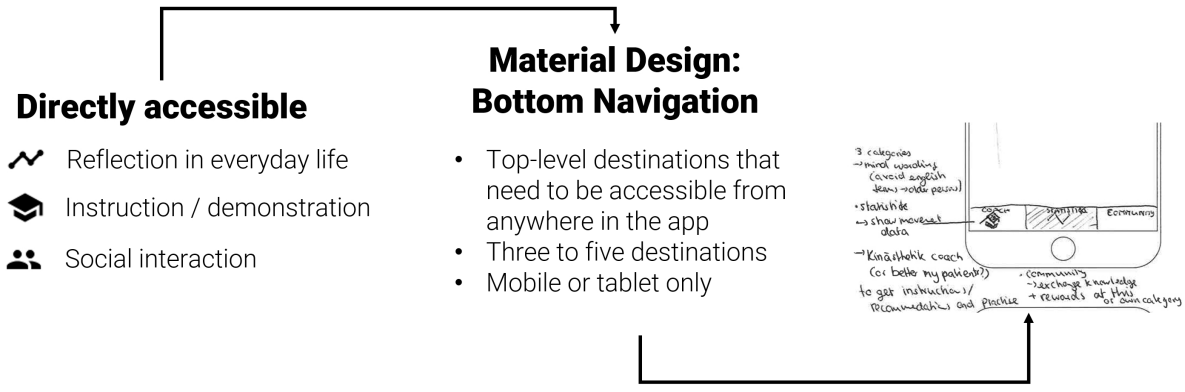


Figure 18 Combining workshops' results with design recommendations - navigation structure

A second example is the realisation of instructions regarding specific patient transfers. Par-

ticipants considered videos with step-by-step textual instructions as helpful. The sketches were kept in mind, transferring it to match the dimensions of a smartphone. The sketch was then digitised (see figure 19 below).

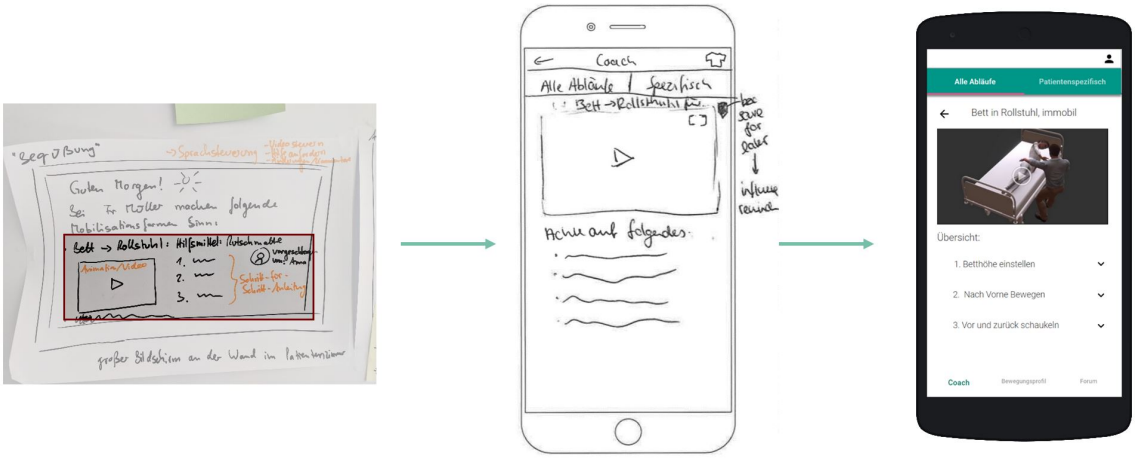


Figure 19 Transferring workshops' results to analogue sketches and a digital prototype - video instructions

4.3 Analytic Inspection

Prior to the implementation, the sketches still needed to be narrowed down to a more concrete concept. As Hartson and Pyla stated, the lifecycle of UX design is an iterative process [65]. To identify possible usability issues in these initial conceptual ideas, an analytic inspection in the form of a Cognitive Walkthrough was conducted. The participants were two HCI students who already participated in the second workshop.

To communicate the design, a click-through prototype was built based on the sketches using Atomic.IO as tool. The participants were asked to perform four previously defined tasks with the digital prototype. The tasks were based on the Essential Use Cases stated in section 4.2.1 and supplied as printed instructions (see appendix D). Additionally, the participants were asked to speak out all thoughts out loud regarding the system.

Although both students were able to solve all tasks, some issues regarding the navigational structure could be revealed. To facilitate the interaction flow, two adjustments were performed. The first aspect concerns the adding of an independent start screen. As outlined in the previous section 4.2.4, our three top-level destinations derived from the requirements *R2: Reflection in everyday life*, *R3: Instruction/Demonstration* and *R6: Social Interaction*. In figure 20 one can see the bottom navigation with the sections *Coach (R3)*, *Bewegungsprofil (R2)* and *Forum (R6)*. Throughout this paper, the term movementprofile will refer to the German term Bewegungsprofil. In how far the requirements have been implemented will be illustrated in detail in chapter 5. Just briefly explained, the movementprofile is the section where the summative feedback in the form of statistical overviews of the movement data is provided. In the tested digital prototype, this section was the home screen. Moreover, it comprised the possibility to connect to the sensor in a top bar. P02 mentioned that she was irritated that the starting point of the application is part of the movementprofile. She proposed to implement a separated home screen. Furthermore, P01 criticised the top bar where the user can directly connect and disconnect the sensor. To address this issue, the navigation structure was modified. The movementprofile was separated from a completely new *Start*-screen. This seemed additionally beneficial as the user can be welcomed here, he can connect his sensor, and get a daily hint.

In addition to that, figure 20 illustrates that within the coach section, the user can navigate between two tabs. One tab includes all movement transfers leading to instruction-videos. The other tab includes specific profiles of patients with recommendations for appropriate transfers. During the Cognitive Walkthrough, none of the participants recognised the tabs. Furthermore, it was claimed, that the kind of information regarding the patients was not the same as in the movement transfers. Thus it was decided to add another top-navigation layer for specific patients.

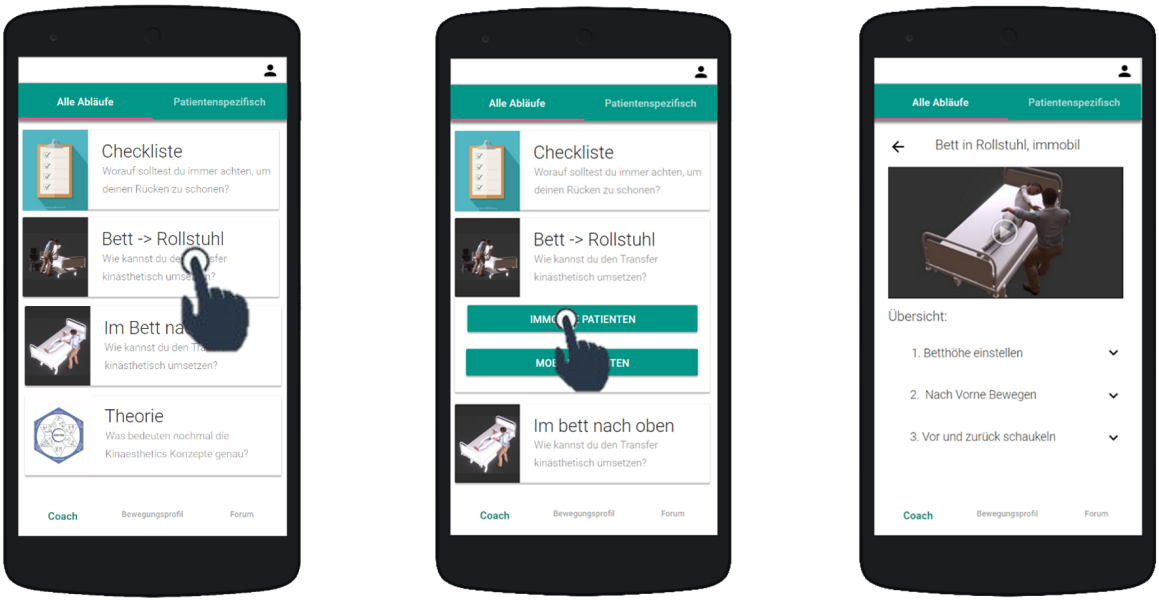


Figure 20 Digital prototype example

4.4 Conclusion

In this chapter, the planning, conduction, and analysis of a codesign workshop have been presented. Moreover, the further design process was outlined and how the workshop results additionally framed this process. Overall, the results provided useful insights on a concrete idea of how the previously derived requirements can be integrated into the user interface. To evaluate the interaction concept later-on, the next chapter moves on to the implementation of the concept in the form of a prototype.

CHAPTER 5

NurseCare

After visualising the user interface, the interaction concept of NurseCare was realised in the form of a prototype. This chapter deals with the implementation process of the components illustrated in figure 21. At first, the hardware that will track the user's movement data needs to be defined and implemented as wearable. This aspect is discussed in the following section 5.1. Secondly, the digital prototype needs to be realised as a smartphone application that can communicate with the sensor, which will be described in section 5.2.

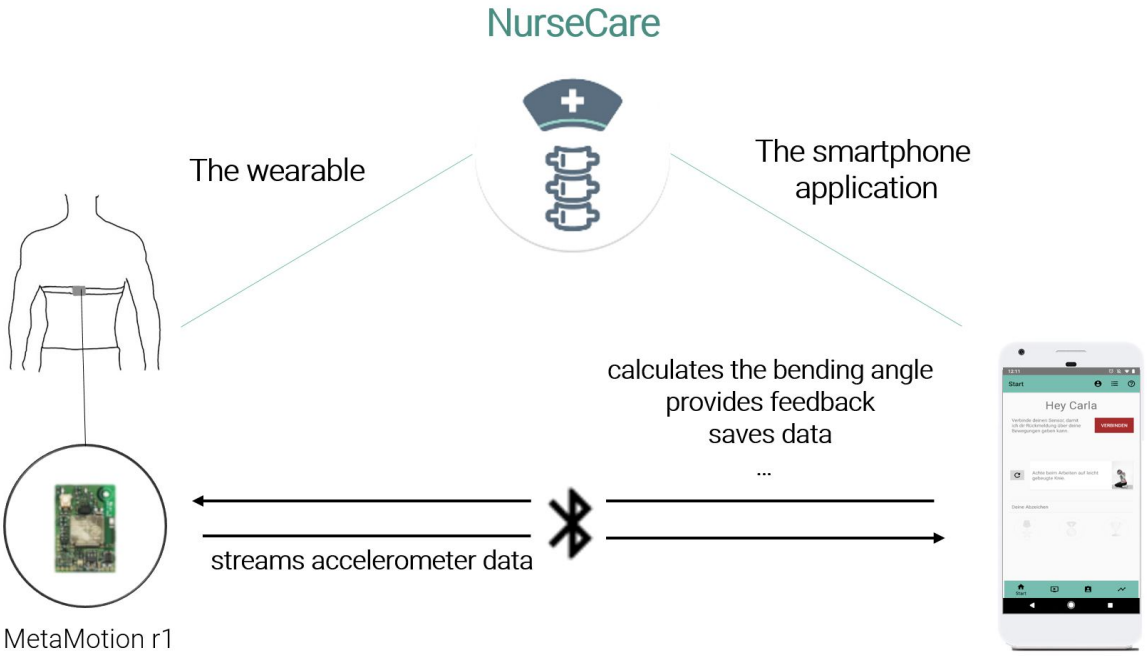


Figure 21 Overview of the NurseCare components: The wearable and the smartphone application

5.1 The wearable

In section 3.1, several prototypes were presented that aim to reduce hazardous movements for the user. Some of them used IMU sensors to detect risky movements and the smartphone or a vibration motor to provide simple vibrotactile feedback [18], [20], [44]. These papers mainly focused on the accuracy of measurements. In contrast, this paper concentrates on the development of a holistic concept to support nurses. Real-time feedback is only one of several requirements. It should be implemented to inquire whether real-time feedback is perceived as helpful at all in the clinical context. Therefore, the detection of "risky movements" is limited to the calculation of the bending angle using the accelerometer data of one IMU sensor. The selection of the sensor was based on previously defined technical requirements.

As the sensor should be worn during work, it must be mobile to not disturb the users workflow.

Additionally, it should be easy to take it on and off to not influence the nurses tight schedule. Moreover, NurseCare is supposed to supply real-time data during the day. Hence, it should stream real-time data and have a solid battery life to support long-term monitoring. This ensures that the nurses do not need to charge the sensor during the day. Finally, the sensor has to communicate with our smartphone application thus it should provide an API for smartphone development. The technical requirements (TR) can be summed up as follows:

TR1: Mobility The input wearable should be mobile.

TR2: Ease of use The input wearable should be easy to take on and off.

TR3: Real-time data The input wearable should stream real-time data.

TR4: Long-term monitoring The input wearable should have a sufficient battery life for long-term monitoring.

TR5: API The input wearable should provide an API.

Figure 22 summarises the final pre-selected devices mapped to the technical requirements (as of November 2018).

	mbientlab	 Notch	 UprightGo	 LumoLift	 LilyPad	 bitalino
TR1: Mobility	✓	✓	✓	✓	✓	✓
TR2: Ease of use	✓	X	✓	✓	✓	✓
TR3: Real-time data	✓	✓	✓	✓	X	X
TR4: Long-term monitoring	✓	X	✓	✓	✓	✓
TR5: API	✓	✓	X	X	✓	✓

Figure 22 Comparison of the devices according to the technical requirements: mbientlab [70], Notch [71], UprightGo [45], LumoLift [46], LilyPad [72], bitalino [73]

Finally, the mbientlab sensor was selected as it fulfills all technical requirements. Additionally, there have been prior experiences with this sensor. Mbientlab is a platform, which focuses on wearable technology for healthcare [70]. Wearable kits allow researchers or physiotherapists to obtain motion data of their patients. Apart from the mbientlab's own application, third-party app development is supported by developer APIs for IOS, Android, Windows and Linux. The MetaMotionR r1 sensor was used with the firmware version 1.4.4.

Still, the hardware needed to be integrated into some kind of wearable that can be easy to take on and off. In an iterative process, two prototypes were created.

First version Inspired by the work of Yan, Li, Li, *et al.* [18], who attached a smartphone at the back of the worker's vest, the idea came up to integrate the sensor in the clothes. A case was printed for the sensor with a 3D printer. In the next step, a pocket was sewed on the backside of a sports T-shirt at the upper part of the back (see figure 23).

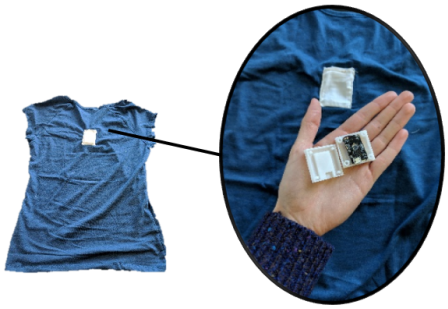


Figure 23 The waerable - version 1.0

Figure 24 Final version: The sensor integrated into a chest strap with a case

Wearing the T-shirt was comfortable and a good option to integrate the sensor. Yet, a possible evaluation over multiple days with multiple participants would lead to a large demand for T-shirts. Therefore, the idea for the second prototype came up.

Second and final version A chest strap that is often used along with fitness trackers seemed a more convenient alternative. It can be worn for multiple days. A pocket was sewed at the chest strap to fix the sensor as illustrated in figure 24.

5.2 The smartphone application

In the first step, it was necessary to define the framework for the smartphone application. As Android is the market leader, it was decided to develop an Android application [74]. The app was developed in Android studio for at least Android 4.4 (SDK 19) which covers 96,5% of the devices on the market [75].

The following sections help to get a better understanding of the final application structured along the requirements that have been defined in section 3.2.5.

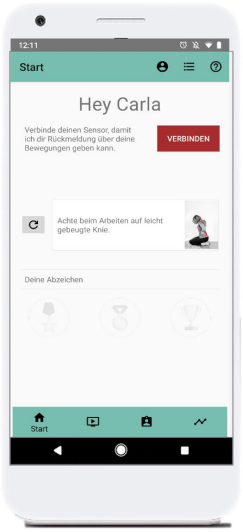


Figure 25 The application: Start screen

5.2.1 R1: Real-Time feedback

The first requirement included vibrotactile feedback on risky movements as well as positive feedback. To provide feedback, the application needs to gather movement data from the previously described sensor in a first step. On the start screen, the user can press a connect button followed by feedback whether the connection was established or not (see figure 25). In the case of an established connection the sensor starts streaming raw accelerometer data.

The connection with the sensor can be handled with the help of the mbientlab SDK. To prototype feedback on risky movements, the application calculates the average angle of the users back bending forward for one second. If the angle exceeds a certain threshold, the smartphone starts vibrating and the user gets a push notification (see figure 26). The initial idea was to provide on-body vibrotactile feedback. The mbientlab sensor even comes with a vibration motor. Yet, it appeared that in the first version of the wearable as T-shirt the vibration on the back could hardly be noticed. Consequently, a vibration via the smartphone was preferred.

The threshold was set to 50 degrees. It was selected based on Muckell, Young, and Leventhal [50]. Their work was also presented in section 3.1. The authors use the performance of a physiotherapist while transferring a patient as gold standard. As the paper provides gold standards for two kind of transfers (45 and 55 degrees), the mean of 50 degrees was chosen. The user is free to switch the vibration off in the settings. That might lead to a non-usage of this kind of real-time feedback during the study but the application must not distract the caregiver from the working routine. Thus he should have the option to disable the vibration.

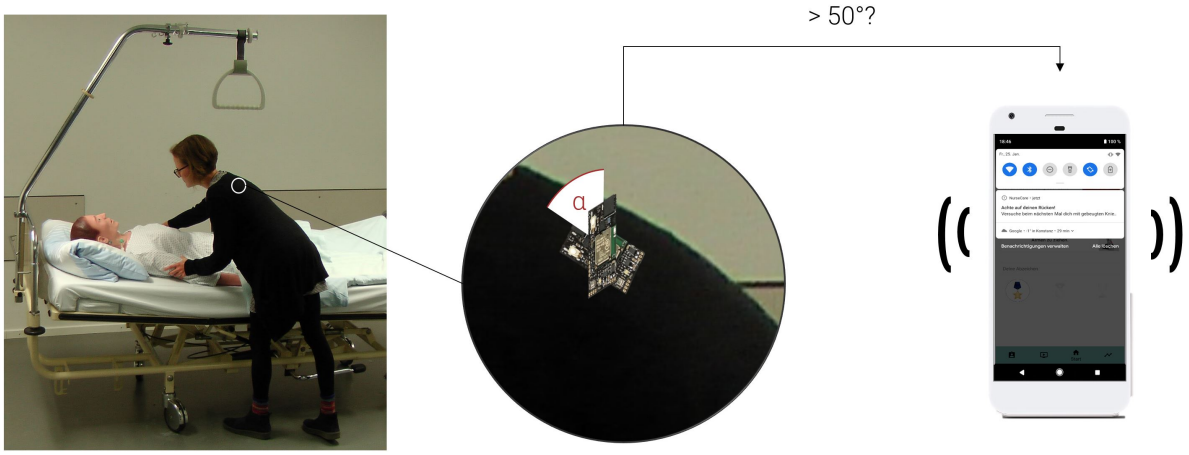
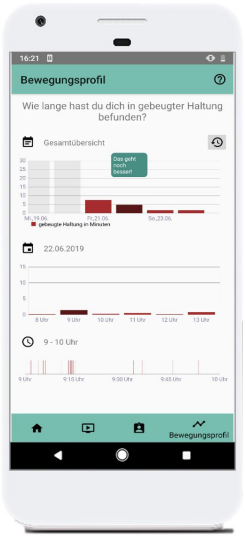


Figure 26 Abstract visualisation of the implementation of instant feedback

5.2.2 R2: Reflection in everyday life



Besides formative feedback in real-time, summative feedback should help the user reflecting on his movements. To make the data accessible, accelerometer raw and processed data is saved in a local database. The Room Persistence Library was used as an abstraction layer for SQLite [76]. The data is visualised in various charts. The library MPAndroidChart was used for that purpose [77]. The visualisation illustrated in figure 27 is the final version of several iterations. The first barchart summarises the minutes in bent posture per day. Grey bars mean that the sensor has not been connected on this day. Tapping on a bar for a specific date lets the two detailed charts appear below. The idea follows the third step details-on-demand of the Information-Seeking Mantra introduced by Shneiderman [78] "Overview first, zoom and filter, then details-on-demand". One chart summarises the data for the selected date split up in hours and the other visualises data for a specific hour on that day.

Figure 27 The application: Movementprofile

5.2.3 R3: Instruction / Demonstration

As explained earlier, instructions were conceptualised as step-by-step video instructions. They were realised making use of the content that was generated as part of the ERTRAG project. During the contextual inquiry, three relevant types of patient transfers have been derived. 3D animations of multiple alternatives how those transfers can be performed based on Kinaesthetics have been captured. Finally, eight videos were produced. In a second step, the videos were divided into different steps and complemented with textual instructions. Once the content has

been generated, it was corrected by a Kinaesthetics coach. All necessary information was saved in a JSON file and a 3D animation video.

The JSON file included several information: Textual annotations per step, related hints for Kinaesthetics concepts, and the timestamps for each step. To visually connect the steps and the video, the current step in the video is highlighted in the timeline of the video as well as in the list of textual annotations (see figure 28). Moreover, some of the steps are connected with specific concepts of Kinaesthetics. Whenever a concept is relevant for a specific step, an icon is visible below the textual annotation. Tapping on the icon opens a dialog with additional background information.

ExoPlayer2 was used as a library for the video player as it offers the possibility to customise the design of the video controllers. The native Android media player, which was used initially, was quite limited regarding this aspect. Taking advantage of this feature, it was possible to add visual references for each step below the timeline.

If the planned shift from analog to electronic medical records is realised, the information regarding the patients could be used for specific transfer recommendations. Additionally, the nurses could save notes if the patient asks for the use of a specific assisting technology for instance. The section *patients* (in German "Patienten") was implemented to mimic this idea. It offers the possibility to add profiles for patients comprising the name, a room number and the capacity of mobility. Naturally speaking this step would drop out if the data is accessible in electronic medical records anyway. For each patient, it is further possible to get a transfer recommendation and to save notes.

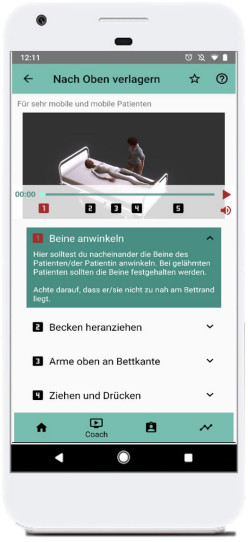


Figure 28 The application: Coach

5.2.4 R4: Rewards

Rewards aim to motivate the user keeping an eye on his own health. They were implemented as so-called "badges" as integrated into common fitness apps and sketched out by participants of the first workshop. In figure 25 one can see the three badges greyed out in the lower part of the start-screen. After one, two or three hours with less than 60 risky movements the user is informed via push notification. Additionally, the specific image of the badge which is initially greyed out is colourised on the start-screen.

5.2.5 R5: Reminder

The reminder is implemented as push notification provided at a specific time daily repeated. The time for the alarm can be set by the user individually in the settings. It can also be turned on and off.

5.2.6 Caring for carers

In section 4.1.3, the workshop's results suggested that NurseCare should communicate the idea to "care for carers". Consequently, the design should, for instance, directly address the user to create a friendly atmosphere. This aspect was implemented within various parts of NurseCare. To give an example, the user has the opportunity to choose the name with which he is welcomed on the start screen (see figure 25). Furthermore, the push-notifications of the reminder and the real-time feedback always directly address the user. When the user taps on the feedback-

notification, NurseCare is opened with a dialog saying: "Keep in mind to focus on ergonomic work, even if it starts to get stressful. Do not disregard your own health!" (translated from German).

5.3 Limitations

Although it was sought to integrate as much as useful input from the workshops, the implementation of the prototype underlies certain limitations. All requirements have been integrated into the interaction concept, yet during the implementation, the requirement "social interaction" was shifted to future work. A forum was imagined by the nurses to exchange knowledge. This idea might be implemented in future scenarios where more people use the system at the same time and an active exchange of knowledge is possible.

Another potential limitation of the prototype is the detection of risky movements. The threshold for the angle data is not based on any official standard as this does not exist to our knowledge. Therefore, an approximate value based on the work of Muckell, Young, and Leventhal [50] was chosen. Furthermore, the calculation is limited to the accelerometer data of one sensor. Naturally speaking, the classification of a movement as risky depends likewise on other factors such as the rotation of the spine or the weight that is lifted. Though, this thesis focuses on the design of a holistic concept and not on the quantitative analysis of movement data. Hence, detecting risky movements is primarily implemented to investigate whether this kind of feature is perceived as useful at all. Ideas how future work can address this limitation will be further discussed in chapter 7.

CHAPTER 6

User Study

After implementing the novel system in the form of a prototype, a summative "in-the-wild" study was conducted to investigate how nurses experience the use of the system in their everyday life. In the succeeding section 6.1, the study design is outlined. Next, section 6.2 summarises how the collected data was analysed leading to the relevant findings presented in section 6.3. Those findings will be discussed in section 6.4. The concluding section 6.5 deals with limitations regarding the study. At the end of this chapter, we will have a better understanding of how nurses experience the usage of NurseCare. Based on those results, implications for future work can be derived which will be outlined in chapter 7.

6.1 Study Design

This section depicts the study design, starting with the application of the DECIDE framework in section 6.1.1. Thereafter, the participants in section 6.1.2 and the final procedure of the study in section 6.1.3 is described.

6.1.1 DECIDE Framework

To guide the evaluation, the DECIDE framework was applied. It was introduced by Preece, Rogers, and Sharp [79] in their book "Interaction design: beyond human-computer interaction". The framework aims to help to decide on the evaluation paradigms and techniques in the following six steps.

Determine the overall goals that the evaluation addresses.

As outlined in the introductory chapter 1, the overall goal of this thesis is the following:

> Determine how to design a mobile system that supports nurses in applying Kinaesthetics into practice during work.

To pursue this goal, NurseCare has been designed based on an iterative design process. Nurses as end-users and HCI students have been involved in the requirement analysis and the design process. Subsequently, NurseCare was implemented as a prototype which will now be the subject of the evaluation. Out of the overall goal, it emerges three subgoals, at whose investigation the summative evaluation will aim at:

SG1: User Experience Investigate and understand how users experience the use of NurseCare.

SG2: Application Investigate and understand if and how NurseCare can help nurses to continuously learn and apply Kinaesthetics into practice.

SG3: Preference Investigate and understand if and why users prefer or do not prefer NurseCare in contrast to existing support and learning materials.

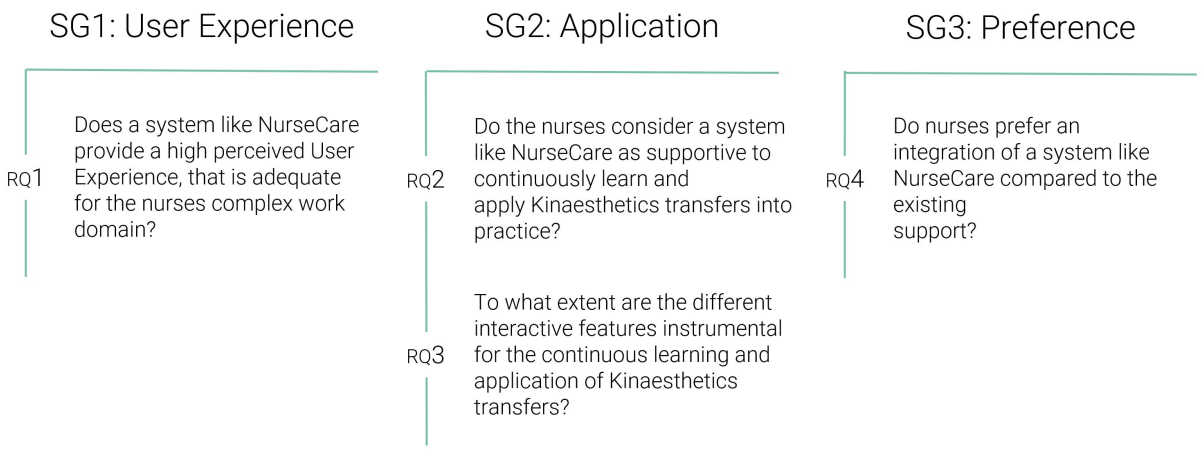


Figure 29 The research questions related to the subgoals of the study

Explore the specific questions to be answered.

Out of the previously presented subgoals the following research questions arise as illustrated in Figure 29. Moreover, each of them comprises several subquestions:

RQ1: Does a system like NurseCare provide a high perceived User Experience, that is adequate for the nurses complex work domain?

- Do the caregivers perceive the usage of the system meaningful or not?
- Is the system in the clinical context usable?
- How does the usage of NurseCare differ between stressful and stress-free days?

RQ2: Do the nurses consider a system like NurseCare as supportive to continuously learn and apply Kinaesthetics transfers into practice?

- Does NurseCare help to increase the knowledge of the nurses about Kinaesthetics and why?
- Do the nurses perceive NurseCare as supportive to accomplish patient-transfers based on Kinaesthetics in practice and why?
- If not, which factors, system-related or external, hamper them?
- Does the awareness for the topic of ergonomic work change over time?

RQ3: To what extent are the different interactive features (e.g. real-time feedback or video instructions) instrumental for the continuous learning and application of Kinaesthetics transfers?

- Do the nurses consider the integration of the features as helpful or not?
- Which features do the nurses use more, which less?
- Which features do they miss?

RQ4: Do nurses prefer an integration of a system like NurseCare compared to the existing support?

- What are shortcomings and benefits of a system like NurseCare, when compared to the current situation?
- How can a system like NurseCare be extended and improved in the future?
- If perceived as helpful, how could NurseCare be integrated into current practices?

Choose the evaluation paradigm and techniques to answer the questions.

To investigate the research questions, it is necessary to choose a sufficient evaluation paradigm that frames the selection of techniques. As the selection of requirements was based on the BCT Wheel framework, one might argue to measure a behaviour change in applying Kinaesthetics in a longitudinal comparative study. To gather quantitatively relevant results, this approach asks for a lot of participants, financial resources and time. Due to the practical and time constraints of a thesis, those resources could not be sufficiently provided. Hence, the results of this study design could be subject to restrictions. Moreover, in their paper "How to Evaluate Technologies for Health Behavior Change in HCI Research", Klasnja, Consolvo, and Pratt [80] propose a shift from the classical evaluation of behaviour change to a focus on *how* a system reaches a behaviour change and *why*. Consequently, the evaluation of NurseCare will take the form of a User Study. The study design is supposed to disclose profitable insights on how useful nurses perceive the interaction with the system and how it can be extended in the future.

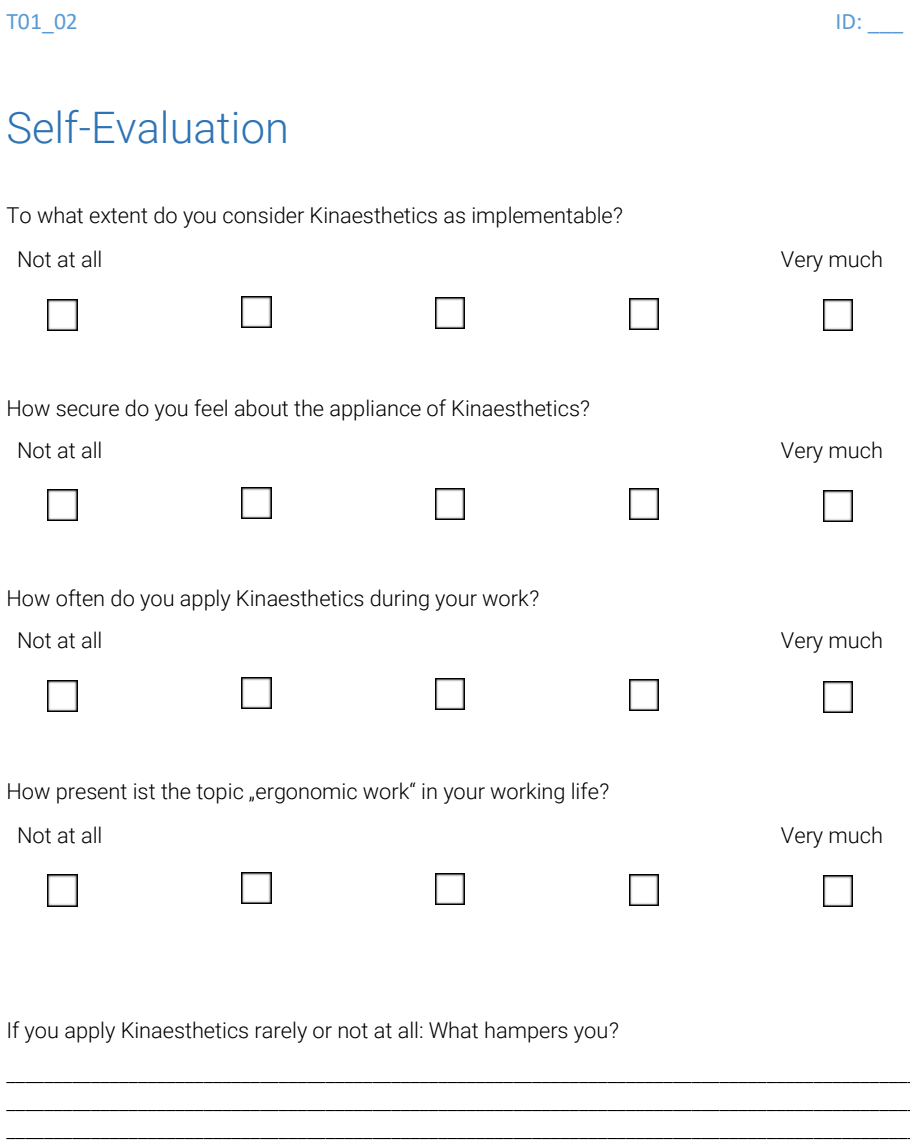
Still, it must be determined whether to conduct the study in the lab or in the field. In 2014, Kjeldskov and Skov [81] discussed their findings of a review regarding ten years of field and lab evaluations in mobile HCI. The starting point was their paper "Is It Worth the Hassle? Exploring the Added Value of Evaluating the Usability of Context-Aware Mobile Systems in the Field", published in 2004 [82]. In a comparative study between a lab and a field study, the authors discovered that the field study identified fewer usability issues than the lab study. The field study even needs more organisational and often financial resources. They concluded, that field studies are often not "worth the hassle". Ten years later, they argue that nowadays evaluations in mobile HCI should explore a broader range of questions than only usability issues. For instance, it is often necessary to include the context where the mobile system is used. If that cannot be mimicked realistically, a field study might be the preferred method, even if it is often more time-consuming to conduct. In our use case, the usage of NurseCare in the clinical setting is of main interest. In the lab setting, aspects like time pressure or various types of patients are hard to mimic. Thus, if possible, the evaluation should take the form of a user study, conducted "in-the-wild".

Common techniques for field studies are interviews and surveying techniques [81]. To triangulate data, the following methods, both qualitative and quantitative, are used during the investigation.

Questionnaires In total four questionnaires were generated to gather relevant information regarding the research questions. All original documents in German can be found in the appendix E.

The *demographic questionnaire* was supposed to gain general information about the participants like the age, gender and current year of education. It also included questions about their technical experience, which Kinaesthetics course they participated and if they had any prior back injuries caused by their work in the hospital. Furthermore, the questionnaire investigated the ward, on which the participants currently work in and their work schedule during the study. To get information on the current support of Kinaesthetics in practice, the participants were additionally asked to list available means of support.

A *self-evaluation in Kinaesthetics questionnaire* was developed to get insights regarding the participants' current appliance of Kinaesthetics. Five-point Likert scales should inquire as how applicable the participants perceive Kinaesthetics and how secure they feel about the concept. The custom questions regarding those aspects are illustrated in figure 30. They were translated from German. Those were supplemented with questions from the *Kinaesthetics Competence Self-Evaluation questionnaire*. It was introduced by H. Gaittinger in 2017 as an instrument to assess nursing staff's competence in Kinaesthetics [83]. The completion before and after the usage of NurseCare should measure a potential influence on the caregivers self-evaluation in Kinaesthetics.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Self-Evaluation

To what extent do you consider Kinaesthetics as implementable?

Not at all Very much

How secure do you feel about the appliance of Kinaesthetics?

Not at all Very much

How often do you apply Kinaesthetics during your work?

Not at all Very much

How present ist the topic „ergonomic work" in your working life?

Not at all Very much

If you apply Kinaesthetics rarely or not at all: What hampers you?

Figure 30 Custom questions in the self-evaluation questionnaire [translated from German]

Two questionnaires should measure the participants' User Experience. A custom generated *system-evaluation questionnaire* allowed questions that target at the specific use case of NurseCare. Five-point Likert scales measure, for instance, to what extent the participants perceived NurseCare as supportive to apply Kinaesthetics and ergonomic work in general (see figure 31, translated from German). This distinction between Kinaesthetics and ergonomic work should inquire differences in the perceived support of Kinaesthetics transfers compared to simple ergonomic hints such as adjusting the bed's height. The results of the custom questionnaire were complemented with the standardised *System Usability Scale*. This 10-item questionnaire was introduced by Brooke [84] to measure user satisfaction. These quantitative data gathering methods were supposed to usefully supplement and extend the qualitative data gathered during the semi-structured interview.

Semi-structured interview A post semi-structured interview was planned to gain insights about the users' interaction with the system. It concentrates on how the participants perceived the usage of NurseCare. The semi-structured approach was chosen because it can be

T02_02 ID: ___

System-Evaluation

To what extent did NurseCare help you to apply ergonomic work?

Not at all Very much

☐ ☐ ☐ ☐ ☐

Can you imagine using NurseCare in your everyday life?

Yes No

☐ ☐

Would you recommend NurseCare to a colleague?

Not at all Very much

☐ ☐ ☐ ☐ ☐

How desirable do you consider an integration of NurseCare in current practices as support?

Not at all Very much

☐ ☐ ☐ ☐ ☐

To what extent did NurseCare help you to focus more consciously on ergonomic work?

Not at all Very much

☐ ☐ ☐ ☐ ☐

To what extent did NurseCare help you to apply Kinaesthetics in practice?

Not at all Very much

☐ ☐ ☐ ☐ ☐

Figure 31 Questions in the system-evaluation questionnaire [translated from German]

structured according to the topics of the research questions. At the same time, it leaves enough room for specific questions regarding individual aspects of the participant. A document with relevant topics was prepared beforehand. The topics derived from the research questions presented in 6.1.1.

Diary Although in interviews and questionnaires one can refer to experiences during the "in-the-wild" usage, it might happen that data is missing as users forget about aspects [81]. Liu, Liu, and Wang [85], for instance, propose a combination of logging and e-diary. In their book "Research Methods in Human-Computer Interaction", Lazar, Feng, and Hochheiser [86] discussed recently in 2017 the application of diaries. Among various application fields, they consider diaries as "good for studying the use of a technological device in a real-world setting, where a controlled setting would not be able to provide ecological validity". Therefore, it seemed expedient to integrate a diary during the study. However, diaries can differ concerning the kind of information that is inquired and the time the users need to capture the information.

Roto, Väätäjä, Jumisko-Pyykkö, *et al.* [87] collected best practices for capturing the context in User Experience Studies "in-the-wild" based on a literature review and five use cases. They recommend to "capture the context with multimedia" such as audio recordings, video snippets or photos. The idea of capturing media might be helpful to gather relevant information in-situ. Nevertheless, artifacts such as photographs might involve ethical issues because relevant events such as specific interactions with NurseCare occur during the work in the hospital. Thus the privacy of the patients might be threatened. The diary for NurseCare is therefore limited to simple question-and-answer based annotations. As the participants already use an application, it was decided to integrate the diary questions directly in there. Figure 32 illustrates an extract of the implemented diary questions. The questions are a shorter version of the system evaluation questionnaire and are the same for each day. Additionally, one open question regarding the features and a field for notes leave space for experiences the participants want to keep on record. The full list of questions is also listed in the appendix E. Moreover, an overview of relevant interactions is provided above the diary as clues. For instance, the participants can check at what time they watched an instruction video.

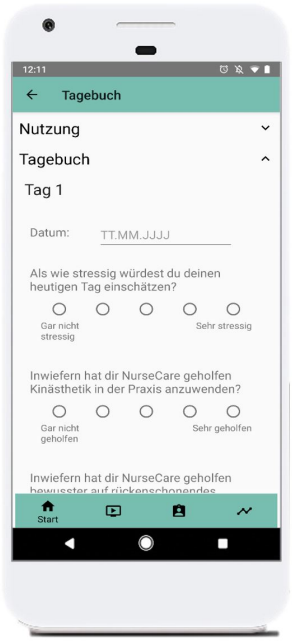


Figure 32 The application: Implementation of the e-diary

Still, it should be ensured that the participants do not forget to answer the questions. Event-based prompting might be one solution [88]. Though, the nurses use the system during work and event-based prompting might disrupt the work-routine. A repeating alarm in the form of a push-notification was considered a beneficial alternative to remind but not disrupt. As during the workshop the participants stated that the late shift ends at 21.00 o'clock, the alarm was set to that time.

Data logging Automatic logging was implemented in the application to supplement the qualitative results on the usage of NurseCare with quantitative values. It mainly targets at validating the outcomes of the qualitative techniques, such as if and how long various features of the system have been used. An extract of a log file is available in the appendix in section G.

Identify the practical issues that must be addressed.

After the selection of suitable techniques to gather data, possible practical issues, especially in field studies, must be examined. The major practical issue for the evaluation of NurseCare is

the recruitment of the participants. As for now, it exists certain regulations regarding the usage of smartphones in German hospitals, it is not easily possible to recruit participants from any institution. To address this issue, one of the project partners in the ERTRAG project, a local nursing school, was asked for assistance. The head considered a possible "in-the-wild" study with apprentices as feasible. Hence, prior to the investigation, we applied for a permit to the workers' council. The submitted document is available in the appendix F. Additionally, it appeared that an approval by the data security officer was necessary which extended the permission process. After one month, the study was finally approved by all necessary instances.

Scheduling the participants is another practical issue. Nurses work in shifts. Thus a defined duration of the study in days does not ensure, that each participant works the same amount of shifts during the study. Furthermore, in Germany, the nursing education occurs block-wise. This means that for apprentices a phase of working in the clinic is succeeded by another phase of school. The conduction of the study must conform to the practical block of the nursing class. In contrast, the school block before can be used to recruit the participants face-to-face. However, the apprentices only receive their roster one month in advance. Although the first recruitment can take place face-to-face, further scheduling must occur via email or phone calls, as the participants are then already in their practical block. Those aspects increased the effort to organise the study's time schedule.

Even though a field study promises relevant insights into the usage of the system in its natural setting, one drawback of this study approach is the lack of control. It might be, that participants are not motivated to use the system or forget it. Nevertheless, a non-usage would also reveal information on possible issues of the system, that might not be gathered during a lab study. Furthermore, potentially occurring technical issues cannot be fixed as easy as in a lab setting. As a first step, this potential problem should be addressed by providing the participants with the researcher's mobile phone number. They are supposed to contact the researcher in case of any problems.

Finally, conducting a field study involves the question of whether to provide the participants with loaners or install the application on their own devices. On the one hand, using loaners decreases the probability of technical issues. On the other hand, it might prevent the participants from interacting naturally with the devices as they fear to break them. This aspect was stated during a previous conducted "in-the-wild" study in the frame of the ERTRAG project by multiple participants. As the natural interaction with the application is of main interest it was finally determined to install the application on the participants' devices. Solely participants without Android devices were provided with a loaner.

Decide how to deal with the ethical issues.

Ethical issues concern the privacy of the participants as well as the patients' privacy. Although an e-diary with photos and video snippets would provide beneficial information, this is not feasible in a clinical setting. The privacy of the patients must be ensured. Thus the informed consent explicitly comprises that the participants cannot record any data that can be used to identify patients of the hospital. This aspect was likewise included in the permission of the workers' council.

Moreover, it was important to inform the participants about the logging of the interaction data and the collection of the accelerometer data during the study. The participants additionally were informed that their devices will be connected with the evaluator's laptop to install the NurseCare application and later save the logging data. All of that information was part of the informed consent, that was signed by all participants.

Evaluate, interpret, and present the data.

In the final step, the gathered data needs to be evaluated and analysed to investigate the previously defined research questions. This step will be outlined in section 6.2.

6.1.2 Participants

As outlined in the above section, the usage of smartphones for nurses is still officially forbidden. Therefore the recruitment of participants needed to be properly planned. A local nursing school offered the possibility to recruit apprentices of a nursing class. On the last day of the school block, the nursing class was visited and introduced to the idea and procedure of the study. Interested apprentices were asked to leave their email addresses for further contact. A list of potential time slots was presented. A final arrangement of time slots was only possible for the first two weeks of the study's period because for the remaining weeks the nursing students did not have their roster yet. Therefore the remaining times were scheduled via email or phone.

Figure 33 User study: Demographic overview

Finally, ten apprentices signed up for the study. As one participant got sick, the data of nine students were finally analysed. Figure 33 gives an overview of the demographic data. The participants were 4 male and 5 female nursing students, aged between 18 and 31 years ($M = 23$, $SD = 4.33$). Six students were in the second year of education where three were already in the third year. They have all participated in the basic course of Kinaesthetics in their first year of education. Three participants were provided with a Google Pixel 3 as a loaner. The others used the application on their own devices. Their level of technical knowledge was inquired with a five-point Likert scale ($M = 4.1$, $SD = .80$, 1 = no knowledge, 5 = high level of knowledge). Other Likert scales were used to capture the participants experience with Kinaesthetics, for instance as how implementable they consider Kinaesthetics ($M = 3.3$, $SD = .70$, 1 = not at all, 5 = very much) or how confident they feel in applying the care concept ($M = 2.3$, $SD = .70$, 1 = not at all, 5 = very much). An open question gathered aspects that hamper the participants in applying Kinaesthetics. Most stated aspects were a lack of time by seven participants (p_{01} – p_{05}, p_{07}, p_{09}) and a lack of knowledge in Kinaesthetics by three participants (p_{01}, p_{04}, p_{06}). One participant also wrote down that one forgets to apply Kinaesthetics (p_{08}). This validates the issues investigated in the introductory chapter 1 and the first workshop described in section 3.2.5.

In addition to that, it was captured on which ward the participants worked during the time of the study as working conditions differ between the stations. Two participants worked in the children's medical unit, two in the maternity ward, two in the accident surgery, one in the internal medicine, one in the oncology and one in the intensive care.

6.1.3 Procedure

The study was planned for five consecutive days as depicted in figure 34. An introductory and closing session in the lab bordered the usage of the system "in-the-wild". It was ensured that the participants worked at least three shifts in between.

To test the procedure of the study, a pilot test was conducted. Unfortunately, it was not possible to pilot test the whole procedure in the clinical setting, as the approval for the study was limited to a certain time frame. To avoid a loss of potential participants, the study procedure

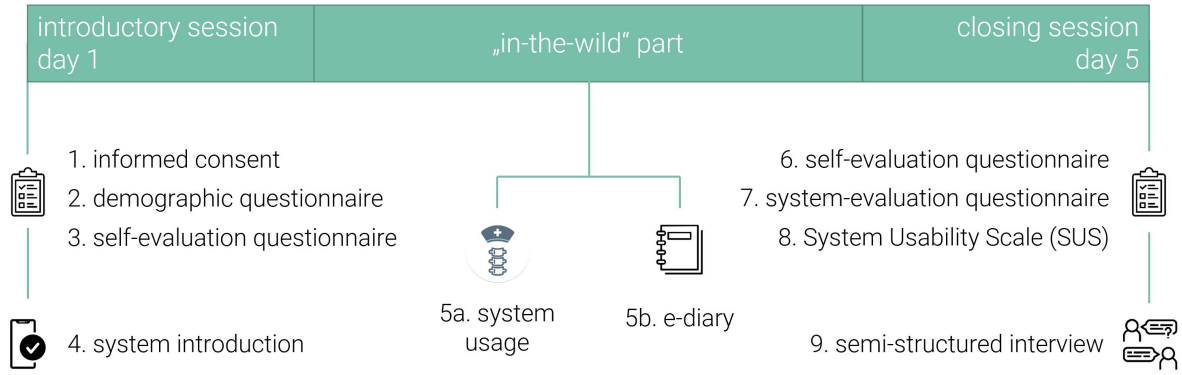


Figure 34 Overview of the study procedure

was pilot tested in two parts. At first, the "in-the-wild" part, which could not be tested in the clinic, was tested with a HCI student. This targeted at testing the usage of NurseCare over multiple days with an external device. The e-diary, the automatic logging and the battery of the sensor were tested. The automatic logging and the saving of the e-diary answers worked out as expected. Likewise, the battery life of the sensor was suitable for daily usage.

Secondly, the lab sessions should be tested to identify issues in the understanding of the procedure and the questionnaires. Especially the questionnaires should be tested by someone with the same background as the participants. Thus a small pilot test over one day was conducted with a 29 years old male nurse. The "in-the-wild" session was replaced by a mimed patient transfer with the researcher. Based on the results, the documents were refined.

The final study procedure started with the introductory session that took roughly 45 minutes. The participants were at first welcomed and informed about the study procedure, the data collection, and its usage. After the signing of the informed consent, they were asked to fill out the demographic questionnaire and the self-evaluation questionnaire regarding the appliance of Kinaesthetics. Thereafter, the participants' smartphones were connected to the researcher's laptop. The developer mode was enabled to install the custom NurseCare application. The application requests the authorisation to use Bluetooth to connect to the sensor and writing permissions to allow data logging. During the installation process, the chest strap with the sensor was presented to the participants. Moreover, they were provided with an additional waterproof neck punch for the smartphone. The workers' council requested the bag to ensure that the smartphone can be worn inconspicuously under the caregivers' work-wear. Finally, the participants were briefly introduced into the main features of NurseCare. During the succeeding days, they were asked to focus on working in a manner based on Kinaesthetics using NurseCare as a helping tool. Additionally, they were asked to fill out the e-diary after each shift when they used NurseCare.

In the closing lab session, which lasted roughly 60 minutes, the participants were again welcomed and returned all loaned materials. They were asked to fill out the self-evaluation questionnaire, the system-evaluation questionnaire, and the System Usability Scale. Next, the semi-structured interview was conducted. The interviews varied in length depending on the interviewee but took on average about 30 minutes. In the end, the participants got a compensation of 30€ and signed the confirmation of payment.

6.2 Data Analysis

During the study, both quantitative and qualitative data was collected which asked for different analysis approaches.

6.2.1 Qualitative data

A thematic analysis was conducted to construe the semi-structured interview. The procedure followed a step-by-step guide described by Ditte Mortensen based on an interview with Ann Blandford [89]. She refers to Virginia and Clarke [90] who introduced the following procedure:

1. Familiarise yourself with your data
2. Assign preliminary codes to your data in order to describe the content
3. Search for patterns or themes in your codes across the different interviews
4. Review themes
5. Define and name themes
6. Produce your report

In the first step, all audio recordings of the semi-structured interviews were transcribed in written form and saved in Excel. During this process, initial ideas about potentially interesting aspects could be revealed. The transcription was not performed word-by-word but summarising the statements of the participants to keep all relevant information for the further analysis process.

In the second step, codes were assigned to the transcribed data. According to Virginia and Clarke [90] codes "identify a feature of the data (semantic content or latent) that appears interesting to the analyst". Codes do not contain any interpretation but they are descriptions.

Next, the third step included the comparison of all codes within the dataset to generate themes that may combine multiple codes.

In the fourth step, the gathered themes were reviewed in an iterative process. Some themes did not contain enough codes and were omitted where others were split in multiple themes or combined with sub-themes.

After sufficient refinements of the themes, step five comprises the definition of appropriate names for the themes. To get a better overview, step four and five were conducted on paper. The themes were printed, cut and could then be rearranged. Figure 35 illustrates an extract from this procedure. The organisation in themes helped to answer the research questions.

Step six comprises the documentation of the analysis results in a coherent manner that will be covered in the succeeding section.

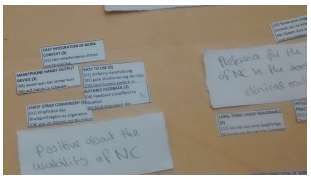


Figure 35 Analog arrangement of the themes

6.2.2 Quantitative data

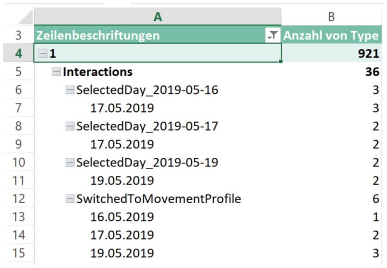
To supplement the qualitative data, the quantitative data were analysed. All custom questionnaires and the answers of the e-diary were analysed with Excel to gain knowledge about the arithmetic means and trends among the participants. Concerning the results of the e-diary, the mean score was firstly formed for each participant and then the mean of these values among all participants was calculated.

The self-evaluation questionnaire was completed before and after the usage of NurseCare. To survey a statistically significant difference between the means, a paired sample T-Test was conducted. Beforehand, the Kolmogorov-Smirnov test attested the equality of distribution ($p > 0.05$).

The System Usability Scale was analysed following the proposed procedure by Sauro [91]. calculating the mean score. For each of the odd-numbered questions, 1 was subtracted from the score. For each of the even-numbered questions, their value was subtracted from 5. The new values were added up and multiplied by 2.5.

The logging data mainly served the verification of the interaction with the application of the participants. Did the participants use the features as they stated? Which features did they

use more or less? And did they connect the sensor? Using Excel the data was analysed in three steps. At first, the logging data from all participants were combined in one excel sheet supplemented with the ID of the users. Secondly, a pivot table was created, to get a better overview. The table summarises the interactions of each participant. An extract of the table in figure 36 demonstrates an example for participant 01.



	A	B
3	Zeilenbeschriftungen	Anzahl von Type
4	1	921
5	Interactions	36
6	SelectedDay_2019-05-16	3
7	17.05.2019	3
8	SelectedDay_2019-05-17	2
9	17.05.2019	2
10	SelectedDay_2019-05-19	2
11	19.05.2019	2
12	SwitchedToMovementProfile	6
13	16.05.2019	1
14	17.05.2019	2
15	19.05.2019	3

Figure 36 Extract of the pivot table to get an overview of the interactions with NurseCare

In a third step, the data were filtered according to the coach section and the movementprofile section. With the help of the timestamps, it was possible to calculate the time difference between when the participants opened and closed the specific screen. This time difference functioned as value to understand if and how much time the nursing students interacted with the features. As the demographic questionnaire contained questions regarding the work schedule during the study, it also permits to analyse whether the interactions took part during work or outside the hospital context.

The data of the sensor was saved in a local database to provide the user with summative feedback. Yet, this work does not comprise a quantitative analysis of the sensor data for two reasons. On the one hand, this kind of comparison was not the focus of the investigation. It would ask for a different study design as outlined in section 6.1.1. On the other hand, the working conditions differ not only between the participants but also between the days for each participant. This aspect in combination with the short usage time would not lead to reliable results.

6.3 Findings

After the data analysis, this section is dedicated to the study results. They are presented structured along the subgoals of the study listed in section 6.1.1. The findings are based on the qualitative analysis of the interviews supplemented with quantitative results from the questionnaires. All presented quotes were translated from German to English.

6.3.1 SG1: User Experience

The "in-the-wild" usage of NurseCare revealed insights on how the end-users experienced the usage of the system in its natural setting.

Finding 1.1: NurseCare as a meaningful approach for an important issue

In the demographic questionnaire, none of the participants reported that they had any previous back injuries due to work. Yet, a recurrent theme in the interviews was the relevance of the addressed issue. Four participants explicitly stated that ergonomic work is an important issue, especially among caregivers.

> *"[...] I think it is a very important topic, especially to disburden the nursing because a lot of colleagues suffer from back pain and stop working because of that, therefore I really like [NurseCare], it is a good approach."* (p_{03})

The overall response to the question of how the nursing students perceive the idea of the system was very positive. All participants considered the idea of NurseCare as meaningful. The partic-

ipants liked the approach of NurseCare to supply direct feedback on risky movements. The lack of awareness of ergonomic work routines can be addressed with the help of direct feedback.

> *"[...] so for us in nursing it is really great because it just reminds you that you are currently not working ergonomically."* (p_{09})

Seven participants further appreciated that NurseCare increases the awareness for health risks and ergonomic work in general (p_{01}, p_{03} – p_{06}, p_{08}, p_{09}). Particularly, NurseCare could help to point to Kinaesthetics as care concept among the colleagues.

> *"I think [NurseCare] would win recognition and help to refresh the knowledge also among colleagues who solely heard Kinaesthetics once."* (p_{05})

Finding 1.2: Bluetooth connection problematic

Six out of nine participants stated problems to establish a Bluetooth connection with the sensor occasionally. Some of them also noted the connection issues in the e-diary (p_{01} – p_{03}, p_{05} – p_{07}):

> *"Connection issues. Temporarily, I was not able to connect despite multiple restarts."* (p_{03})

Due to this technical problem, four participants were only able to use the sensor at work for two shifts instead of three (p_{02}, p_{03}, p_{05}, p_{07}). The logging data did not uncover reasons why the connection failed for the specific devices. Except for the cases with the described Bluetooth issues, the logfiles showed a daily usage of the sensor. On average, the participants connected the sensor for 05:38:44 hrs (SD = 02:02:54 hrs) per day. Days on which the sensor could not be connected were not included during this calculation to avoid a distortion of the results. The logging data show that the participants used the wearable part of NurseCare and real-time feedback.

The participants also stated that they needed to reconnect the sensor from time to time. One participant commented:

> *"Sometimes the connection did not work, so I had to try it several times...and I sometimes had to check whether the sensor was still connected. Strange to say, but at some days it was more reliable and on other days I had to check more often [...] but despite that, I could use everything within the app well."* (p_{06})

Although the participants were asked to contact the researcher in case of any problems, solely participants 07 and 02 took this opportunity. They called and reported that they were not able to connect to the sensor. In both cases, a restart of the application solved the problem.

Three participants did not state any connection problems at all. One of them was provided with a loaner (p_{04}) and the other two used their own devices (p_{08}, p_{09}).

Finding 1.3: High usability of NurseCare

> *"[NurseCare] is really easy to integrate into the everyday life."* (p_{06})

Despite the connection problems, the participants were overall satisfied using NurseCare in their everyday life. Although they were only briefly introduced in the functionality of the application, all nursing students considered NurseCare as easy to use during the interview.

> *"The application is just easy comprehensible and it offers a lot of features!"* (p_{09})

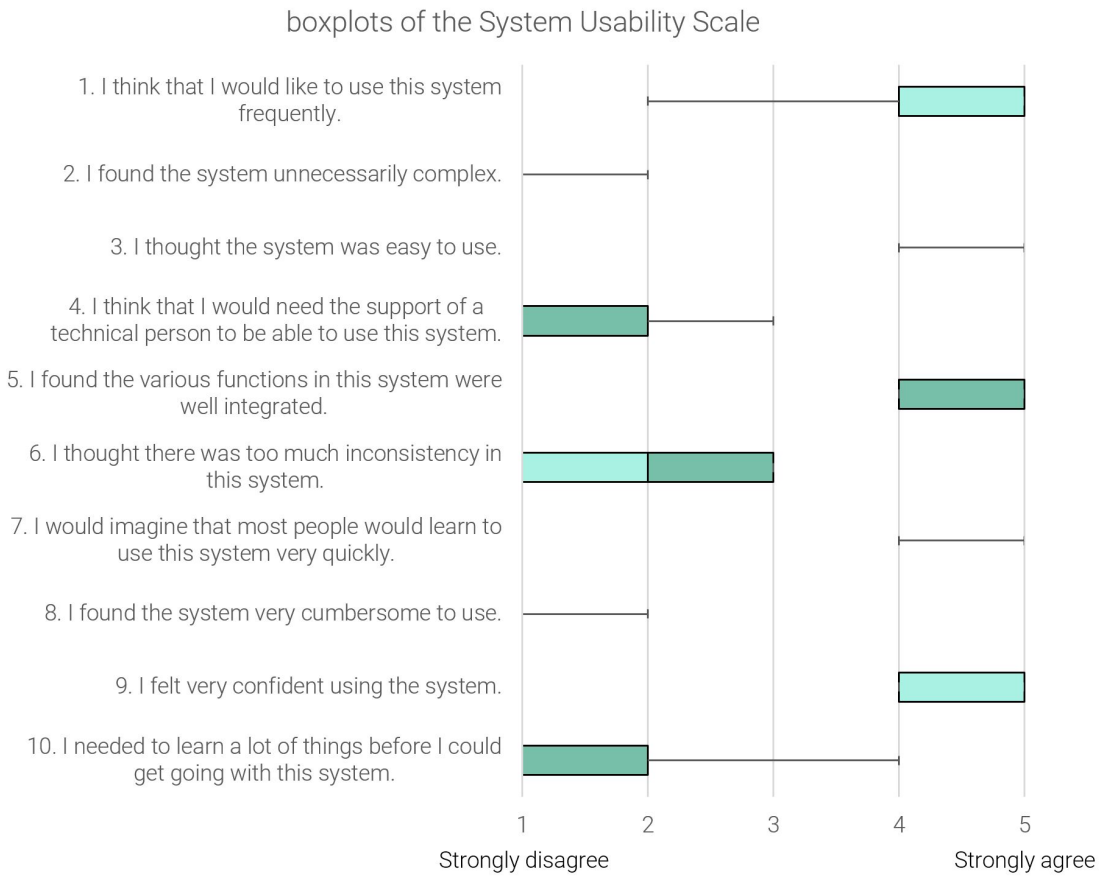


Figure 37 Boxplots of the SUS items

All participants felt that NurseCare was easy to embed in the work context and did not state any major disruptions during their workflow.

Turning to the quantitative results, the analysis of the SUS confirms these findings. Sauro [91] proposes the interpretation of the mean score on a grading curve from A (best grade) to F (worst grade). Our calculated value of 88.6 can be interpreted as the grading A. Figure 37 visualises the boxplots of the SUS items in English. The participants were provided with the German version during the study.

In addition to that, one item in the system-evaluation-questionnaire measured to what extent the participants would recommend NurseCare to a colleague (1 = not at all, 5 = very much). The participants responded with a mean score of 4.56 (SD = .73).

Finding 1.4: The chest strap - easy usable in the clinic

> *"The chest strap was comfortable to wear, it did not bother me at all. Sometimes I even forgot it, unless it started vibrating."* (p_{09})

Regarding the usability of the wearable, the participants did not state any major problems. All of them were able to use the chest strap during work. Six out of the nine participants perceived it as really convenient (p_{01}, p_{02}, p_{06} – p_{09}). One participant for instance commented that he "almost forgot that he wore the sensor during work" (p_{01}). Two participants just noted that it started to become slippery in warm conditions (p_{03}, p_{06}). Other two participants indicated that it felt inconvenient to lean back in a chair as one leans against the case of the sensor (p_{04}, p_{05}).

"[. . .] I think it must be lighter...if you wash the patients, for instance, it gets warmer and being disturbing because it created a certain friction." (p_{03})

The participants likewise discussed alternatives for the future design of the wearable. One participant proposed the integration of the sensor directly into the work-wear (p_{04}). Likewise, participant 02 did so, yet considered this approach as hard to realise because the work-wear is washed every day. Another idea was the integration of the sensor in a T-shirt, for instance, as electronic-textile (e-textile), also known as smart clothing or smart garments. This possible improvement was welcomed by the majority of the students (p_{02} – p_{05}, p_{07}, p_{08}).

Finding 1.5: Feedback serves its purpose but is expandable

As outlined in section 6.3.1, all participants appreciated the idea to get real-time feedback. Regarding the feedback threshold of 50 degrees, the majority of the participants considered the feedback in general as suitable for the state of a prototype (p_{01}, p_{02}, p_{04} – p_{09}). As participant 04 stated:

"Often the feedback was correct, often it vibrated when I was at the same time realising: 'Now I am moving in an unhealthy way!'." (p_{04})

Solely one participant felt that the threshold was too low. He often thought that his phone started vibrating even though he did not consider his movement as harmful (p_{03}). For future systems, the participants expressed the wish to extend the sensory features and, thereby, improve the feedback accuracy (p_{02}, p_{04} – p_{06}, p_{08}, p_{09}). Some even came up with own ideas. They proposed more sensors regarding the back (p_{02}, p_{08}) but also sensors to measure the force of the arms (p_{04} – p_{06}), sensors for the legs (p_{05}) and the neck (p_{04}).

"Sure, the sensor was good, but maybe three sensors would have been even better, you know? One on the top, one in the middle and one on the bottom of the back, so that the whole back is recorded. And maybe that it vibrates on the back." (p_{08})

In addition to that, four participants reported that they occasionally perceived the vibrotatcile feedback as annoying in situations when it was unavoidable to bend down (p_{01}, p_{04}, p_{05}, p_{09}). One participant told of an emergency where she was not able to correct her movements and her phone was consistently vibrating (p_{09}).

Another recurrent theme among five participants was the wish for on-body feedback. Two participants (p_{08}, p_{09}) stated that they sometimes did not realise the vibration of the smartphone. Therefore, they expect on-body feedback to be more efficient. The other three participants (p_{02}, p_{03}, p_{07}) mainly argued that they would prefer vibrotactile feedback independently from the smartphone.

Finding 1.6: The smartphone - in general practical as an output device

The smartphone as an output device was in general perceived as valuable to make use of the features of the application. Four participants explicitly mentioned the smartphone as handy to watch instruction-videos (p_{02}, p_{06}, p_{08}, p_{09}). They liked that it is mobile and always available. In the previous section, the wish for smartphone independent feedback was mentioned. This idea was not related to the usage in the clinic in general, but in the patients' room for hygienic reasons. The neck punch which was provided on request by the workers' council as a hygienic solution, was explicitly perceived as inconvenient by three participants (p_{01} – p_{03}). One participant stated, that she finally put the smartphone in the pocket of her trousers as otherwise, she did not notice the vibration (p_{08}).

Interestingly, four participants reported that they felt insecure using the smartphone in the clinic, even though the study was officially approved (p_{01}, p_{03}, p_{05}, p_{06}).

Concerning potential device alternatives, participant 02 proposed smart watches, which are still forbidden to use though:

> *"Smart watches are forbidden, but some are wearing them anyway. As long as you just wear it to work, it is no problem. You could also wear it on the upper arm."* (p_{02})

In response to the question, whether she would like to replace the smartphone completely, she points out:

> *"No. It [the smartphone] is still useful to watch instruction-videos in a break or at the end of a shift, just not in the patients' room"* (p_{02})

Moreover, the majority of the participants liked the idea to use smart glasses in the clinical setting (p_{02}, p_{05} – p_{09}). Yet, one participant expressed doubts regarding the usage directly in the patients' room (p_{08}). Likewise, participant 07 liked the idea, but admitted that this future scenario is hard to imagine for him.

Finding 1.7: Interest in NurseCare from colleagues

As the nursing students are usually not allowed to use the smartphone in the patients' room, some of the participants informed their colleagues on the study design and the purpose of NurseCare. Six participants told that even registered nurses were interested in the system and liked the idea of it (p_{01}, p_{02}, p_{05}, p_{06}, p_{08}, p_{09}). The comments below illustrate the positive feedback of the students' colleagues:

> *"The coworkers would like to try [NurseCare] as well one day, also the registered nurses, they who finished their education years ago. Actually, all just said: 'Cool'."* (p_{08})

> *"[...] the others, the registered nurses as well, they who have worked already for 30 years, they found [NurseCare] exciting. They told, that they like to wear such a chest strap themselves one day, to see what it is like for them."* (p_{09})

Finding 1.8: Good reminder in stressful situations

The stress during work differs from day to day, but also from ward to ward. As outlined earlier, the participants considered NurseCare as easy to use. Likewise, those participants who reported that they worked on wards with a higher stress level, did not state any usability issues. To give an example, participant 09 ranked the level of stress with a mean score of 4.33. She also described her ward as follows:

> *"I have 10 different specialisations there, the doctors always come at different times and you have to be always present, that's why it is so stressful."* (p_{09})

However, she did not state any major problems. In contrast, she indicated that she "would use [NurseCare] any time again". Participant 01 reported that he worked on a less stressful ward. When he was asked whether he thinks he could likewise use NurseCare in stressful situations he answered:

> *"I think there would definitively be good results, especially in those situations, where you forget to adjust the bed height [...]., it can sensitise you that you think: 'Oh I*

forgot something, something is vibrating...I will just increase the bed's height'." (p_{01})

6.3.2 SG2: Application of Kinaesthetics

Regarding the continuous learning and application of Kinaesthetics the following findings were revealed.

Finding 2.1: Lack of knowledge after the Kinaesthetics course

> *"Sure we had this basic course, but it was not that good so you only apply Kinaesthetics rarely afterwards and therefore you are not aware of situations where those Kinaesthetics movements can be applied."* (p_{01})

Five participants explicitly reported that they can hardly remember movements or theoretical information from the Kinaesthetics course. They mentioned various reasons such as the course quality itself (p_{01}, p_{02}, p_{05}, p_{07}) or no possibilities to apply the gathered knowledge (p_{03}). This verifies the issues regarding Kinaesthetics, pointed out in the introductory chapter 1 and during the first workshop.

> *"...but if you have like me this basic course and afterwards work on the children's medical unit where you do not carry anyone and then you work in the psychiatric ward where you do not practise anything like caring someone as well you forget most of the things from the basic course again really fast [...]."* (p_{03})

Two participants additionally commented on the need for knowledge to apply Kinaesthetics (p_{02}, p_{05}). In response to the question, whether he could have applied Kinaesthetics similarly without the instruction-videos participant 05 pointed out:

> *"In certain areas yes, but not to this extent how it was possible with the videos now. You need knowledge that you can access."* (p_{05})

Finding 2.2: NurseCare as good refresher

In response to the question whether the participants were able to enlarge their knowledge in Kinaesthetics three participants agreed (p_{02}, p_{05}, p_{06}):

> *"The videos were nice. They helped to understand more aspects which have not been clear so far."* (p_{05})

Three others stated, that they did not enlarge their knowledge with NurseCare. Two of them felt that they already know the content (p_{08}, p_{09}) and one participant expressed that she is just not interested in Kinaesthetics (p_{04}). The last three participants also stated that they did not increase their knowledge about Kinaesthetics, but appreciated the possibility to refresh the information (p_{01}, p_{03}, p_{07}). Yet, participant 01 refers to the insufficient transfer of theoretical Kinaesthetics knowledge as a general issue:

> *"[...] but in general, the problem is about the Kinaesthetics education that it was not good and the theoretical background was not taught sufficiently and it is difficult to*

compensate for this gap with an application." (p_{01})

Finding 2.3: Which support in current practice?

Similar to the lack of theoretical knowledge in Kinaesthetics, the analysis of the interview verified the investigated issues regarding a lack of current support in practice. During the interviews, the majority of the participants reported that the support is limited to electric assisting tools such as lifters (p_{01} – p_{03}, p_{05}, p_{07}, p_{09}). In case of questions regarding Kinaesthetics itself, even the clinical facilitator often cannot help or do not focus on ergonomic movements. Clinical facilitators are trained nurses who assist the trainees in their practice phase. They are also responsible for training registered nurses on a new ward.

> *"Compared to current practice as support? To be honest...which current practice? Unfortunately, a lot of colleagues in our hospital do not even know Kinaesthetics because most of them are older or they had it - just like us - at the beginning of their education [...] and afterwards it has never been mentioned again. So I think [NurseCare] would win recognition and help to refresh the knowledge also among them who solely heard Kinaesthetics once."* (p_{05})

The results of the demographic questionnaire assure these results. In response to the open-ended question about available support in practice, four nursing students did not write down any kind of support (p_{01}, p_{02}, p_{04}, p_{08}). Four other participants reported electric assisting tools (p_{03}, p_{05}, p_{06}, p_{09}) and one participant wrote down: "maybe the help of colleagues" (p_{07}).

Finding 2.4: NurseCare as a good starting point to support the appliance of Kinaesthetics

> *"At some point I became kind of ambitious about it: 'No, in the next room it cannot start vibrating!'."* (p_{09})

When the participants were asked whether they perceived NurseCare as providing to apply Kinaesthetics during work, seven nursing students reacted positively (p_{02}, p_{03}, p_{05} – p_{07}, p_{09}). The comments below demonstrate in how far some participants perceived NurseCare as an assisting tool:

> *"I really think [NurseCare] helped me to better apply Kinaesthetics because I then correct myself - automatically"* (p_{06})

> *"It actively helped me - especially moving the patient up - to once really work it out in a different manner than just pulling the patient up."* (p_{03})

However, solely two participants reported a concrete example of a patient transfer (p_{02}, p_{03}). They told that they tried to move the patient up in the bed according to the recommendations in the application. Turning to the quantitative results of the system-evaluation questionnaire, the results show a difference in the perceived support in applying Kinaesthetics and the perceived support in applying ergonomic work. In response to the question about to what extent NurseCare was perceived as helpful to apply Kinaesthetics, the nursing students answered with a mean score of 3.44 ($SD = 1.42$). A broad range of answers was elicited as illustrated in the left diagram of figure 38. For instance, participant 05 rated that NurseCare did not help him at all to apply Kinaesthetics. In the open-ended question regarding an explanation for the ranking, he wrote down that on his ward there were not many possibilities to apply Kinaesthetics. Participants

03 and 07 indicated that NurseCare helped solely to some extent. As mentioned above, during the interview participant 03 reported, that NurseCare supported him and even gave a concrete example for a transfer. In the questionnaire, he reasoned his ranking with a lack of time (p_{03}). He also refers to this issue during the interview:

> *"[...] but this [Kinaesthetics] can quickly get lost in everyday work life. Or you have to hurry up and of course in those situations you neither want to ask the coworker: 'Should we do it according to a specific technique?'."* (p_{03})

Participant 07 reasoned his ranking in the questionnaire with the fact that more practise is needed to realise the Kinaesthetics transfers (p_{07}). Likewise, participant 01 referred to external obstacles during the interview:

> *"It inspired me to behave in a Kinaesthetics manner as good as I could, but if I really worked according to Kinaesthetics I don't know because it needs more...so I think it is also a structural problem of the healthcare system, which can be decentralised with sensitisation for the topic but finally the lack of knowledge is quite a problem and also the clinical facilitators do not keep an eye on Kinaesthetics."* (p_{01})

These cautious results were likewise confirmed by the paired sample T-Test of the self-evaluation questionnaire before and after the usage of NurseCare. Although the arithmetic means were higher after the usage of NurseCare than before, the paired sample T-Test did not show any significant difference in the means of the items regarding the appliance of Kinaesthetics ($p > 0.05$).

In contrast, there was a consistent view of the perceived support regarding the appliance of ergonomic work routines in general. Ergonomic work routines mean for instance adjusting the bed height or bending the knees. Those hints were also part of NurseCare within the coach section. Yet in this case, they do not include the Kinaesthetics transfers provided by the instruction-videos. The participants answered with a mean score of 4.11 ($SD = .60$). The right diagram in figure 38 illustrates the responses to the item that measured to what extent NurseCare was perceived as helpful to apply ergonomic work (1 = not at all, 5 = very much). Two participants noted that NurseCare helped them very much (p_{02}, p_{08}), six participants rather much (p_{01}, p_{04} – p_{07}, p_{09}) and one participant was undecided (p_{03}).

When participant 09 was asked during the interview whether she felt supported in applying Kinaesthetics, she pointed out:

> *"I would say yes and no. I rather focused on ergonomic work, so not how to perform it in a Kinaesthetics manner with the patient, but rather like: 'Oh gosh now I am bending forward to the patient, it is better to stay straight in the back.' So rather these ergonomic work routines, but that is not wrong. (laughs)"* (p_{09})

Likewise, the results of the e-diary which included the same two questions reflect these findings. The results indicate a higher mean score for the item concerning ergonomic work in general ($M = 3.61$, $SD = .88$, 1 = not at all, 5 = very much) than for the item regarding Kinaesthetics in particular ($M = 3.15$, $SD = .74$, 1 = not at all, 5 = very much).

> *"My first impression was, that I was really annoyed by this vibration, so I really tried to avoid that and that's why I think it made me work more ergonomically"* (p_{04})

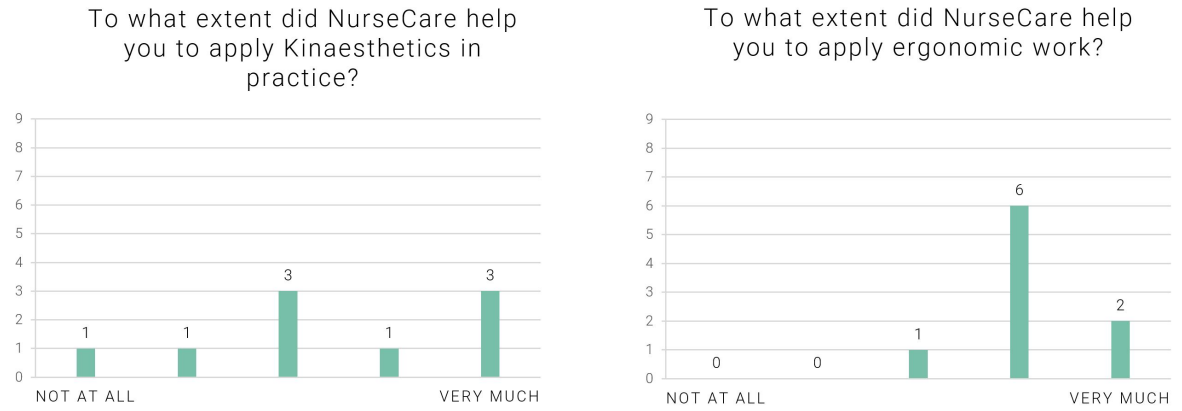


Figure 38 Results from the system-evaluation questionnaire regarding the perceived support of NurseCare to apply Kinaesthetics (left) and ergonomic work (right)

Finding 2.5: The participants changed their view on ergonomic work

A common view amongst the nursing students was a perceived change of the view on ergonomic work and Kinaesthetics. This indicated the results of the system-evaluation questionnaire. In response to the question of whether the view on ergonomic work and Kinaesthetics changed due to NurseCare, eight out of the nine participants responded positively. Solely participant 04 responded negatively, yet made a contrary statement in the interview:

> *"I think the idea is really beneficial because usually, I do not pay attention to ergonomic work [...]. I rather do not adjust the bed height because I am too lazy. So I considered [NurseCare] as cool because with NurseCare I prevented my back from damage."* (p_{04})

This reinforces the expressed belief regarding the perceived increased awareness on health risks described in section 6.3.1. Moreover, the questionnaire included an open-ended question to reason the given answer regarding the change of view. Participant 03 for instance wrote down:

> *"Now, I focus more on my back or rather my position during work."* (p_{03})

The conducted T-Test of the self-evaluation questionnaire confirmed this finding. It showed a significant difference in the mean scores before (M = 3.33, SD = .71) and after the usage (M = 4.11, SD = .78) regarding the item "As how implementable do you consider Kinaesthetics?" (conditions t(8) = -2.4, p = 0.043). One could assume that the usage of NurseCare and the appliance in practice supported the understanding of Kinaesthetics as actually applicable in practice.

Finding 2.6: Real-time feedback in combination with instructions and summative feedback perceived as most supportive

During the interview it should be investigated how the participants perceived the implementation of the requirements as features in NurseCare. Figure 39 illustrates an overview of the investigated benefits and shortcomings.

Overall the vibration of the smartphone as real-time feedback was perceived as a good approach and most supportive among all participants. The vibration was a good opportunity to give feedback without disrupting the users' workflow. Although the participants had the possibility to switch off the vibration in case of problems, none of them did so. In contrast, they especially appreciated the increase of awareness and sensitisation for the own health. As one

participant commented:

> *"[NurseCare] is really something that supports you in your everyday life because it reminds you of that [Kinaesthetics] because often you are so stressed and just forget it...and then, when it vibrates, you know: 'Okay, maybe in the next room - because I have time - I can try to realise it and otherwise you just often do not think about it."* (p_{09})

When the participants were asked how they reacted to the real-time feedback, 100% reported that they tried to adapt their movements to make the smartphone stop vibrating if possible. Moreover, four participants explicitly reported a perceived positive effect of NurseCare regarding ergonomic movements (p_{05}, p_{07} – p_{09}).

> *"Actually after the first day I realised that every time when the sensor reminded me "do not do that", actually the next day some movements were, funnily enough, improved automatically, so for instance that I knee down instead of bend forward."* (Pp_{05})

> *"Then I said to myself: 'Okay that was wrong'. And then I often tried performing a movement again in a right way to check whether it starts vibrating...and exactly, it did not vibrate and I think it is a huge learning effect if you at some point always perform the movement in a correct way then you also perform it in a correct way automatically."* (p_{06})

Besides the real-time feedback, almost all participants expressed that they perceived the video instructions as helpful (p_{01} – p_{03}, p_{05} – p_{09}). Solely participant 04 stated, that she did not watch any instruction-videos as she is neither interested in the concept of Kinaesthetics nor a media-oriented person. Concerning improvements about the coach section, participant 06 expressed the wish for video instructions with real actors instead of animated videos. Moreover, participant 08 proposed to extend the variety of videos. In response to the question, whether NurseCare was supportive to apply Kinaesthetics, participant 05 especially referred to the video instructions:

> *"Yes [it supported me], however, I would not say because of the sensor, but really because of the instruction-videos because they were designed really well."* (p_{05})

Regarding the summative feedback integrated into the movementprofile, the majority of the participants indicated that they used the feature and perceived it as helpful (p_{03} – p_{09}). Solely participants 01 and 02 did not perceive the feature as particularly interesting. However, they stated that in general they like the idea of the movementprofile and consider it as useful on other wards. Participant 02, for instance, worked at the intensive care unit. She explained that the patients are transferred every two hours and, therefore, she was able to connect time and risky situations by herself.

Among the other participants, two benefits emerged during the interview. At first, five participants appreciated that the statistical overview communicates the relevance of the topic (p_{04} – p_{07}, p_{09}) . They felt "amazed" seeing how long they stay in a crooked position. Amongst others participant 04 explained that she considered the movementprofile a thought-provoking feature:

> *"That was fascinating...I really considered that as fascinating, that I thought: 'Oh gosh, today I was for one hour or something in a crooked position'. That encouraged me to reflect because I asked myself how would that be without the chest strap as I already thought with the chest strap I bend down a lot less."* (p_{04})

Secondly, four participants reported that they used the statistical overview to reflect on specific situations (p_{05}, p_{07} – p_{09}).

	benefits	n	shortcomings	n
R1: Real-time feedback	+ makes aware of risky situations + persistent feedback	9 8	- annoying when bending of the back cannot be avoided - occasionally irritating due to inaccuracy	4 2
R2: Reflection in everyday life	+ amazement of statistics + thought-provoking + supports reflection on specific situations	5 4 4	- not possible to link times to situations	2
R3: Instruction / demonstration	+ beneficial to understand Kinaesthetis + good refresher	8 3	- videos not with real actors - limited amount of videos	1 1
R4: Rewards	+ good as motivation	5	- not directly perceived as motivational	4
R5: Reminder	+ increases awareness	4	- superfloous due to individual working hours - sensor is enough as daily reminder	3 2

Figure 39 Benefits and shortcomings of the interactive features

> *"Yes, you look at [the movementprofile] because it is interesting and you ask yourself: 'Okay, what was the problem at 12 o'clock?'"* (p_{08})

When participant 09 was asked if she used the statistics to focus on a specific situation for the succeeding day, she considered the combination of direct and summative feedback as beneficial:

> *"Yes, I sometimes tried to say, okay tomorrow in this room I will keep an eye on that, but you forget it anyway. That's why the vibration is good because then you think: 'Oh yes, now I remember!"* (p_{09})

The logfiles were also used to analyse how much the participants used the coach and the movementprofile feature of NurseCare. The summative feedback in the movementprofile was used by all participants. On average, they spent 02:07 minutes (SD = 02:44 min) on this screen during the study. Furthermore, the participants opened the movementprofile on average 10.9 times (SD = 11.4). The majority of the participants also selected different days and hours to get details-on-demand about their movements (p_{01}, p_{03}, p_{04}, p_{06} – p_{09}).

In contrast, the coach section was not used by all participants. The logging data uncovered, that participants 01, 04 and 07 did not watch any instruction-videos at all. Participant 04 also stated during the interview that she did not watch any videos. Reasons for participant 01 and 07 might have been, that there was no concrete situation where a patient handling technique was needed due to their working situation. Participant 01 worked on the children's medical unit and participant 07 on the maternity ward. Participant 07 also reported during the interview that he "did not face the specific cases" from the instruction videos during the study. The mean usage time among the other participants was 01:59 minutes (SD = 01:26 min) during the whole study.

Although the Standard Derivation indicates that the usage times differ among the participants, one should bear in mind, that the participants worked on different wards and with different working conditions. Moreover, they also reported different interaction patterns during the interviews. For instance, participant 01 stated that he solely used the movementprofile rarely, even though he considered the feature as meaningful. In contrast, participant 08 stated that she showed the movementprofile also to her colleagues. Those varieties are also reflected in the usage times of the features and therefore in the logging data.

Finding 2.6: Patients feature not used but wished as integration in electronic medical records

The patient feature was not used during the study. The participants stated that due to the high number of changes among the patients and the short usage time, there was no need to save notes for a patient. Nevertheless, all participants considered the idea in general as meaningful and can imagine an integration of the feature in potential electronic medical records.

> *"That would be really sensible, for instance for the surgical ward because there the patients stay longer...then you could add notes and I know I performed this transfer with this patient and that worked out well."* (p_{06})

Especially the fact that knowledge could be exchanged seemed beneficial to the nursing students. Caregivers who are new to a ward could directly see which kind of transfer is feasible and which electric assisting tool required. The comment below illustrates the idea:

> *"It would be good when all use it and they can see: 'Ah, she transferred him like that and that worked out'. But then [NurseCare] should be cross-linked, so that everyone can access the information."* (p_{02})

Finding 2.7: Reminder and rewards - nice add on

Two divergent views on the usefulness of the reminder and rewards emerged. Five participants felt that the reminder was rather superfluous (p_{04} – p_{08}). On the one hand, the time of the reminder did not fit the beginning of the shifts due to shift changes. Even though the time is individually adjustable in the settings of the application, the participants did not take this opportunity. On the other hand, putting on the sensor itself was perceived as reminding enough. In contrast, three participants liked the push-notification as an additional reminder (p_{01} – p_{03}). However, participant 03 expressed the idea to exchange the content of the reminder over time or refer to the performance of the previous days. Likewise, the participants expressed two diverse beliefs about the rewards which were integrated as badges. Four participants did not directly perceive the rewards as motivational (p_{01}, p_{03}, p_{04}, p_{07}). As participant 03 put it:

> *"Sure, you always have the feeling that you need some kind of reward, but that is hard to realise in the application."* (p_{03})

When the participants were asked whether they could imagine real rewards as motivational, the majority expressed doubts on the realisation. Participants 03 and 07 argue that the own health should in an ideal case be motivational enough:

> *"I could not think of an example...just because it is mainly for yourself...so the main idea is good to give extra motivation but I consider that as difficult."* (p_{07})

In contrast, more than 50% perceived digital rewards as motivational (p_{02}, p_{05}, p_{06}, p_{08}, p_{09}) . However, one participant also admits that this view depends on personality:

> *"I also think its a personal thing, but I always considered that as really motivational."* (p_{02})

Finding 2.8: Daily hints and direct address - nice add-on

All nursing students liked the direct address of the user. They reported that this way of communication in the application established a personal character. Participant 04 assumed that the direct address could increase the motivation primarily subconsciously:

> *"Consciously I did not notice that as helpful but subconsciously I did. if someone says 'Hey XXX' it has a different character as if it would be anonymous. Then you would not take it that serious."* (p_{04})

Likewise, six participants stated that they sometimes read the daily hints and considered them as a nice add-on (p_{02}, p_{03}, p_{05} – p_{07}, p_{09}). In contrast, two other participants found the daily hints to be superfluous (p_{04}, p_{08}).

Finding 2.9: NurseCare not only used in the clinic

During the interviews, participants also reported in which context they used NurseCare. Some participants commented that they watched the instruction-videos at home (p_{02}, p_{05}, p_{06}). As explained by participant 06:

> *"I watched the videos at home. I thought about a situation in the past, where I had problems and then re-watched a video for that."* (p_{06})

Others reported that they also watched the videos in the hospital (p_{08}, p_{09}). This also applies to the movementprofile, which was used at home, but also alone or with colleagues in a break at work.

> *"I watched the videos and checked the movementprofile as well on the ward, we looked at it together with the colleagues."* (p_{08})

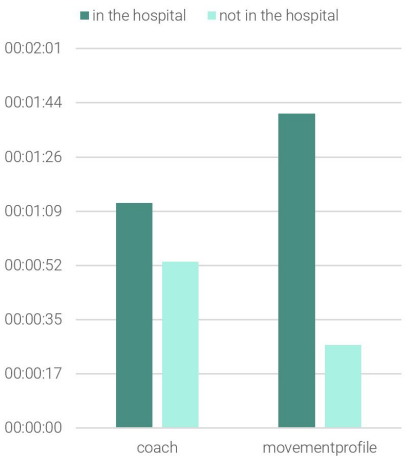


Figure 40 Average usage time of the coach and movementprofile section in the hospital and outside the hospital

The logging data confirmed the assumption, that the coach and movementprofile section were not only used in the hospital context. Figure 40 demonstrates the usage time of the features on average split into the usage of the coach section in the hospital (M = 01:12 min, SD = 01:10 min) and not in the hospital (M = 00:53 min, SD = 01:31 min) as well as the movementprofile section in the hospital (M = 01:40 min, SD = 02:22 min) and not in the hospital (M = 00:27 min, SD = 00:30 min). These values allude to the time, that the participants actively interacted with these features.

As mentioned in section 6.3.1, four participants reported that the usage of the smartphone in the clinic still felt wrong, despite the approval (p_{01}, p_{03}, p_{05}, p_{06}). This aspect might have influenced the interaction with the application in the clinical context for those participants.

6.3.3 SG3: Preference

This section summarises the findings concerning the user preference for NurseCare.

Finding 3.1: A long-term usage of a system like NurseCare is imaginable

A recurrent theme in the interviews was a potential long-term usage of NurseCare. During the interviews, 100% of the participants indicated that they can imagine a long-term usage of a system like NurseCare. Turning to the quantitative results of the system-evaluation questionnaire, the results can be confirmed. Eight out of nine participants stated that they can imagine further using a system like NurseCare. Solely participant 08 noted a negative answer in the questionnaire. However, she made a contrary statement during the interview.

Finding 3.2: Consistent real-time feedback as benefit

In the course of long-term usage of NurseCare, the participants were asked which benefits or shortcomings they see for this kind of system in contrast to current practice. The nursing students did not see any shortcomings. In contrast, a common view amongst all participants was the benefit of the continuous real-time feedback. The nursing students regarded this advantage of mobile technology as superior to other approaches. As participant 04 commented:

> *"The system is the whole time present, it reminds you to work ergonomically and this cannot be provided by any clinical facilitator."* (p_{04})

Finding 3.3: Participants can imagine NurseCare as support in practice

When the participants were asked whether they wish an integration of a system like NurseCare in current practice, 100% reacted positively. Various ideas were elicited, how this integration could look like.

Six participants explicitly expressed the wish for an early introduction in the system directly after the Kinaesthetics course (p_{02}, p_{04}, p_{06} – p_{09}). Moreover, three participants emphasized, that NurseCare should be provided by the head nurses themselves as a assisting tool (p_{02}, p_{06}, p_{07}). Participant 02 liked the idea, that the system is briefly introduced during the Kinaesthetics course and then an external coach introduces everyone into the system. Furthermore, participant 01 proposed an integration with the help of the clinical facilitators:

> *"[...] and now also one as the 'Gesundheitsverbund' should take this opportunity - if you now have the possibility - and say: 'Okay one could also send a clinical facilitator to the station who is well versed with [NurseCare], that one can have a conversation or something."* (p_{01})

Participant 04 expressed the belief that it would be beneficial if everyone uses NurseCare:

> *"I think the whole thing would have success if everyone wears this sensor on the ward, if you just naturally get it when you start to work there, or if it is sewed in your work-wear. Because when it's just me who has the sensor, then [...] I am the one who is vibrating all the time and I have to explain to everyone why. If it starts vibrating for two persons, one would certainly also adjust the bed's height."* (p_{04})

Participant 06 also factored additional education into Kinaesthetics pointing out how he imagines the integration:

> *"It would be smart if there was someone who is well versed in the system and also uses it and if there was also a room where Kinaesthetics is also explained to beginners again."* (p_{06})

Likewise, participant 03 expressed the desire for a place to repeat Kinaesthetics transfers after the course. He told, that he attended a talk where the idea of a virtual ergonomic trainer of the ERTRAG project was presented. To his mind, such a system would be helpful to practice. It should be combined with a system like NurseCare for the support during work.

Finding 3.4: Idea - an integration in electronic medical records could benefit working conditions

As described in section 6.3.2, there was a positive attitude towards the idea of the integration of the patients feature. Caregivers could take notes for specific patients regarding transferring techniques or add appropriate assisting tools. Three participants additionally expressed the wish for the integration of the whole system in the electronic medical records (p_{03}, p_{05}, p_{07}). Participant 03 proposes a connection between the electronic medical records and the data of the sensor:

> *"I have those visions, that when you do the shift changes then you see directly [in the electronic medical record]: Caring for this patient my colleague only bends down in a risky manner, maybe this patient is tiring. And then I enter the room with specific awareness or just with the idea, that I will solely work ergonomically or pay additional attention to that. But I think those are also ideas for the future, and it depends on the hospital..."* (p_{03})

Moreover, according to the participants, it could be advantageous if the people in charge use the gathered data to improve the working conditions of the nurses. In response to the question whether he can imagine an integration in electronic medical records, participant 05 explained:

> *"If those in charge really look at the data and see: 'Okay, today we had this patient. He was really immobile. He had to be supported all the time'. And you see that the carer had to apply a lot of pressure and if then you want to improve the situation for the carer and say: 'This patient can only be transferred in two'. I that worked out, then definitely. But if one part works out, it does not mean the other part works out as well."* (p_{05})

6.4 Discussion

Overall, the findings in the previous section helped to clarify how the participants perceived the usage of NurseCare "in-the-wild". This section will now discuss the results, again structured along the subgoals of the study.

6.4.1 SG1: User Experience

The central research question related to the first subgoal of the study was the following:

> RQ1: Does a system like NurseCare provide a high perceived User Experience, that is adequate for the nurses complex work domain?

Overall, the findings described in section 6.3.1 revealed predominantly positive views on the system usage regarding various aspects.

The investigation of related work in section 3.1 disclosed a gap in the design space regarding a mobile system that supports nurses in applying ergonomic patient transfers in practice.

NurseCare introduced the idea to provide real-time feedback combined with other supportive features such as instruction-videos. Both were realised through a sensor integrated into a chest strap as wearable and a corresponding smartphone application. The results of the qualitative analysis indicate that this solution approach was overall perceived as useful. It can thus be suggested that a mobile system that follows the lead is a good approach to support nurses in applying Kinaesthetics with mobile technology. Future studies in this direction are therefore recommended.

Despite the connection issues, the positive results of the SUS and the interview suggest that NurseCare was perceived as easy to use and understand. Likewise, the short introduction time did not lead to any usability problems. One should bear in mind that it was not possible to evaluate the vibrotactile feedback in a real-world scenario beforehand. Thus, it was not clear whether the threshold of the bending angle would lead to feedback perceived as valuable for the students. However, during the study, the participants found NurseCare to be suitable during their work in the clinic. It was fundamental, that its use would not interrupt the workflow of the nurses. Neither it should irritate the patients, for instance, with audio feedback. This aspect was steadily considered during the design process.

A possible explanation for the positive results in terms of the User Experience might be the involvement of the caregivers in the design process. The methods based on Participatory Design helped to match the users' needs and understand the system context. Especially the second workshop revealed important insights about how users wish to make use of NurseCare during their workday. One could speculate that the guidance of the design process by the workshop results had a positive impact on the User Experience of the system. Future work that deals with systems in the context of caregivers should build on these results. The caregivers should be involved in the design process as early as possible. Furthermore, one could speculate whether this approach can also be advantageous for mobile technology that aims to prevent WRMD in other domains of work.

Concerning the wearable, the results suggest that the design in the form of the chest strap was overall perceived as a good approach. Nevertheless, some nursing students expressed the wish for a lighter design and on-body feedback in the future. Moreover, the current version of NurseCare solely measures risky movements based on the bending angle. This serves its purpose as a prototype for now. Yet, the results show that the participants prefer an extension of sensors to increase the feedback accuracy. The idea of a smart garment was appreciated. While this work sought to examine an overall interaction concept, future research could concentrate on the investigation of the technical part. The work of Muckell, Young, and Leventhal [50] already suggests how different risky movements during patient transfers can be detected with the help of multiple IMU sensors. Future research is required to refine the design of the wearable and the sensory features based on the identified weaknesses.

Another important aspect concerns the chosen output device. The current study found that the smartphone was in general perceived as convenient. The participants appreciated that it is always at hand and, therefore, information is always accessible. However, some participants desired smartphone independent feedback, for instance, for hygienic reasons in the patient's room. The neck punch provided was accepted as an initial solution but perceived as inconvenient. One could argue that the wearable itself could work independently and no output device is needed. Yet, the participants perceived especially the combination of real-time feedback and features such as instruction-videos as beneficial. The withdrawal of the smartphone application would, therefore, be no option. In addition, one could think about replacing the application for the smartphone completely with an application for smart glasses, for instance. However, caregivers usually do not own smart glasses. If the smart glasses were provided by the clinic, the interaction with NurseCare would be limited to the clinical context. Reflecting on the movements or watching instruction-videos at home, how the participants did, would not be possible and the benefit of a mobile system be restricted. Consequently, this idea would limit the revealed benefits of NurseCare. Future research in this field would be of great help to examine how

various output devices could supplement each other in the various contexts to support nurses.

Implication $_1$: Combine domain-specific and technical knowledge

The findings suggest that support designed as wearable in combination with a smartphone application is perceived as a useful approach to make aware of risky situations. Furthermore, this approach matched the conditions of the clinical context. Future research of mobile systems in nursing should aim at taking advantage of methods in Participatory Design to understand the potential interaction flow of a novel system in its natural setting. Domain-specific knowledge by caregivers should be combined with technical knowledge to derive a suitable interaction concept.

6.4.2 SG2: Application of Kinaesthetics

Related to the second subgoal, two key questions should be examined. The first of those questions focused on Kinaesthetics:

> RQ2: Do the nurses consider a system like NurseCare as supportive to continuously learn and apply Kinaesthetics transfers into practice?

The results indicate a lack of follow-up support after the Kinaesthetics basic course. These findings are consistent with the results of prior studies presented in the introductory chapter 1 and, therefore, reinforce the motivation for this work.

In terms of learning Kinaesthetics, NurseCare was not designed to replace the basic course, but to provide a way to access learning content also after the course. The quantitative analysis of the logging data revealed a non-usage of the coach section among three participants. As already discussed, a possible explanation for the non-usage might be the working conditions during the study. Depending on the daily tasks, the participants may not have felt the need to look at instructions regarding specific transfers. However, eight out of nine participants appreciated the opportunity to have access to the instruction-videos. Consequently, the findings suggest that the design of NurseCare with step-by-step video instructions was perceived as helpful either to refresh or enlarge Kinaesthetics knowledge. Future systems could increase the learning content, for instance with more kind of movement transfers.

Related to the appliance of Kinaesthetics, it is expedient to distinguish between ergonomic work in general and Kinaesthetics in particular. Even if both aspects have a positive effect on the relief of the back, NurseCare explicitly focused on the practical support of Kinaesthetics. The findings indicate, that the participants perceived NurseCare as supportive to apply simple ergonomic work routines more often. This also applies to the use of Kinaesthetics. Yet, the perceived support regarding Kinaesthetics transfers was lower. Furthermore, only two participants reported a concrete example of an applied Kinaesthetics patient transfer. This result can have multiple explanations.

At first, the appliance of Kinaesthetics transfers is more complex and needs more practise. It also asks for concrete situations where patient handling techniques can be realised. Some participants worked on wards, where they solely needed to transfer a few patients, for instance, the maternity ward. Similar to the lack of need for specific instructions during the study, this aspect in combination with the short usage time might have led only to few opportunities to apply Kinaesthetics.

Secondly, obstacles independent from NurseCare should not be disregarded. The results show that the lack of time is often an issue to apply Kinaesthetics. This obstacle cannot be smoothed out by the mobile system. Even though NurseCare could address a lack of knowledge and awareness, the lack of time was still present for some participants.

Thirdly, one could speculate whether the lower perceived support for Kinaesthetics is re-

lated to a lower acceptance for Kinaesthetics among the colleagues in general. The findings revealed that due to the lack of follow-up support, most of the coworkers do not know much about Kinaesthetics. One could assume, that this lack of knowledge comes along with a lack of acceptance which might likewise hamper the appliance of Kinaesthetics. Especially nursing students might be influenced who are new in their profession. As the results further revealed a positive effect on the view of Kinaesthetics among the participants, using NurseCare might also increase the acceptance among senior nurses. Interestingly, the social aspect was an initial requirement based on a pre-selected BCT. During the interaction concept, an online forum was the idea to facilitate the exchange of knowledge regarding Kinaesthetics. In the study, only a few participants would use the system simultaneously and knowledge exchange in a forum would be limited. Therefore, this feature was shifted to future work. A further study should take the social aspect into account. It could investigate whether a usage in the group could increase the acceptance of Kinaesthetics and, therefore, facilitate its appliance.

Even though NurseCare was found to be less helpful for the application of Kinaesthetics than ergonomic work in general, the results were nevertheless positive with regard to both aspects. Therefore, future work in this field can build on the design of NurseCare. Yet, a further investigation over a longer period of time is needed to gain more insights into the actual appliance of Kinaesthetics transfers with the help of a system like NurseCare.

As the investigation revealed obstacles regarding the working conditions, it might be worth referring back to Participatory Design. In section 2.4, it was pointed out that Participatory Design originally aroused to empower workers. A recent special issue of the ACM ToCHI journal called "Reimagining Participatory Design" was published dedicated to concerns and discussions about the question where PD stands today. In the introduction, the authors state that among others one theme of recent discussions was that PD "lost some of its clarity and lacks political teeth" [92]. Moreover, it seems that the term PD is often used as a synonym for User Centered Design. In their paper "Participatory Design that Matters — Facing the Big Issues" Bødker and Kyng [93] discuss problems in current PD work and propose new directions presenting examples of current projects that overcome those challenges. Discussed topics are for instance short-sightedness or convenient collaborations instead of collaborations that might lead to political conflicts. It is beyond the scope of this master thesis to overcome the discussed issues particularly the "lack of political teeth". Still, the results of this study in combination with those of prior studies presented in the introductory chapter 1 show that caregivers in Germany could require some form of empowerment, maybe facilitated by Participatory Design.

Implication $_2$: Consider sociocultural aspects

Although the findings indicate a positive view on NurseCare as assisting tool to apply Kinaesthetics, the actual appliance of Kinaesthetics transfers depends on various factors. Obstacles related to the working conditions have been identified in the workshops and were likewise present during the evaluation. Future research should not neglect those impacts. On the one hand, future systems might be designed extending the design process with the involvement of people in charge such as head nurses. On the other hand, the evaluation of future systems might likewise be extended from individual nurses on different wards to the evaluation of all nurses within one ward.

The second research question related to this subgoal deals with the interactive features of NurseCare:

> RQ3: To what extent are the different interactive features (e.g. real-time feedback or video instructions) instrumental for the continuous learning and application of Kinaesthetics transfers?

The results suggest that especially the combination of real-time feedback, instruction-videos of the coach section and a statistical overview in the movementprofile section of the application

was perceived as helpful. Real-time feedback alone would not suffer as support to apply Kinaesthetics. These results match with the claims of Du, Wang, Baets, *et al.* [44] introduced in section 3.1. They argued that in the field of wearables previous research often did not go beyond simple real-time feedback. In addition to that, the participants did not express the wish for other features. In contrast, they only proposed improvements for the existing features. For instance, the patients feature was not used but considered a supportive idea. Its integration in the electronic medical records in a future scenario was desired. A possible explanation for the positive response about the features might be the requirements gathering process. The requirements for the interactive features were based on the BCT-Wheel framework in combination with a workshop with the end-user. It might be that this approach was beneficial to derive suitable requirements according to the users' needs. Assuming a positive effect of this approach, one can speculate how far the study results can be extended to other fields where a behaviour change is pursued in a complex work-field.

Another aspect that emerged from the workshops was the idea to consider to "care for the carer". Caregivers tend to consistently neglect their own health while focusing on the patient's health. NurseCare, therefore, was designed, to call the user's attention to the own health. To give an example, the user is addressed directly by his name and reminded to keep track of his back. The participants liked this approach and perceived that as motivational. Future research might extend these results by investigating to what extent virtual representations can increase the motivation of systems in this field.

One advantage of a mobile system is its usability in various contexts. In chapter 2, the consideration of Distributed Cognition led to the conclusion that the learning process of Kinaesthetics unfolds in different contexts. Thereafter, the results of the workshops reinforced the idea that the caregivers like to be supported not only in the hospital but also, for instance, at home to reflect on their movements. The study results indicated that the participants used NurseCare beyond their working hours also at home. Consequently, NurseCare was used as expected in the various contexts and the participants made use of the advantages of a mobile system. Future research that deals with mobile systems to support continuous learning could likewise make use of Distributed Cognition to understand how the learning process unfolds and can thus be supported.

Implication $_3$: Combine domain-specific knowledge and theoretical frameworks

The findings show that the interactive features (e.g. instruction videos or summative feedback) were perceived as helpful to apply Kinaesthetics transfers. Those features were realised based on the system's requirements. Future work should consider both theoretical backgrounds and the users' needs when deriving requirements. The appliance of different Participatory Design techniques combined with theoretical frameworks might be beneficial for that purpose.

6.4.3 SG3: Preference

Out of the third subgoal the following research question emerged and will be central within this section:

> RQ4: Do nurses prefer an integration of a system like NurseCare compared to the existing support?

As outlined in the previous section, there is a lack of support in applying Kinaesthetics in the clinic. The findings listed in section 6.3.3 illustrate a wish for the supply of a system like NurseCare as support and, therefore, emphasise the potential of such a system. In a future scenario, a system like NurseCare should be introduced during or directly after the Kinaesthetics

basic course. It should also be integrated into electronic medical records and be assistant in two ways. On the one hand, the caregivers could directly watch instruction-videos or add notes regarding transfers in the electronic medical records. On the other hand, the sensor data could be connected with specific patients. Thus, people in charge could keep an eye on the exposure of their workers' back and, at best, draw conclusions to improve the working conditions.

Nevertheless, the results must be interpreted with caution as so far there is no similar system like NurseCare. One should consistently improve the weaknesses revealed for the current version in an iterative process and build on the study results.

Implication $_4$: Integrate as early as possible

The findings imply that an integration of a system like NurseCare into current practices is wished. In addition to that, one might speculate that it is even necessary to increase the awareness for the topic. Future research should aim for an early and continuous integration of a system like NurseCare. It should support caregivers to improve their movements and motivate people in charge to improve the conditions to do so.

6.5 Limitations

The findings indicate, that a system like NurseCare could support caregivers in applying Kinaesthetics. However, a number of limitations need to be considered.

First, multiple participants faced Bluetooth connection issues which partly impaired the usage time. One might argue, that this interfered with the comparison of the sensor data or the user's experience with the system. However, this issue had only a low impact on the overall positive qualitative results of the study which were the focus of interest. The important insights in the interaction with NurseCare in its natural setting compensate for the loss of some hours of quantitative sensor data.

Secondly, a potential limitation of the study is the relatively small number of participants, all nursing students from the same nursing school, working in the same clinic. This implies several arguable weaknesses. Probably related to their young age, the nursing students were all quite familiar with new technology. This might have facilitated positive results regarding usability. Moreover, the working conditions for nursing students might be different from those of registered nurses. Likewise, the attitude towards Kinaesthetics and ergonomic work in general. Hence, future research is needed to examine to what extent the study results also apply for senior, registered nurses. The findings can only provide an initial idea that there is also an interest in a system like NurseCare among the senior colleagues of the participants. Despite the weaknesses, one must bear in mind, that a required approval limited the possibility to recruit any participants from any clinic. Therefore, the recruitment of nursing students with the help of the local nursing school was a pleasing opportunity to conduct the study "in-the-wild". Even though the number of participants was rather small, the results still go beyond those of a possible lab study as an alternative. Furthermore, the participants worked on various wards during the study. Consequently, even though all worked in the same clinic, a broad range of experiences within this clinic could be gathered.

Thirdly, the study explored the interaction with NurseCare within five days solely. As NurseCare is a newly introduced system, one must consider the novelty effect. Further research regarding the long-term usage of the system is needed. Additionally, ensuring for an exact equal usage time of NurseCare for each participant was not possible. The shift changes of the nurses complicated the scheduling of the study. To give an example, it was not possible to schedule the introductory and the closing session at the same hour of the day. It might be that the participants work in an early shift on the first day and have a late shift on the last day. However, it was defined, that the nurses need to work at least three shifts between the introductory and

the closing session. Differences in the usage time can be seen as a trade-off of an "in-the-wild" study, where control is limited.

Finally, the current study is limited to the specific use case of Kinaesthetics in Germany. However, it also exist other care concepts besides Kinaesthetics. Future research could investigate how NurseCare could integrate the support of patient transfers based on different care concepts that can be combined. Moreover, working conditions, structural issues in the healthcare system and the education of care concepts might be different for other countries. This would also influence the system context of NurseCare. To give an example, in other countries such as Sweden, electronic medical records are already more common [94]. Future research would be needed, to explore the requirements and the context for a system like NurseCare in other countries.

CHAPTER 7

Implications for Future Work

This chapter is dedicated to the implications for future work based on the findings presented in the previous chapter. After positive results regarding NurseCare as an assisting system, the first section 7.1 presents a possible integration in current practice. Thereafter, it is outlined how NurseCare could be extended in the future. Section 7.2 deals with ideas regarding the redesign of the wearable followed by redesign ideas for the smartphone application in section 7.3. The concluding section 7.4 proposes ideas for future study designs.

7.1 Integration in current practice

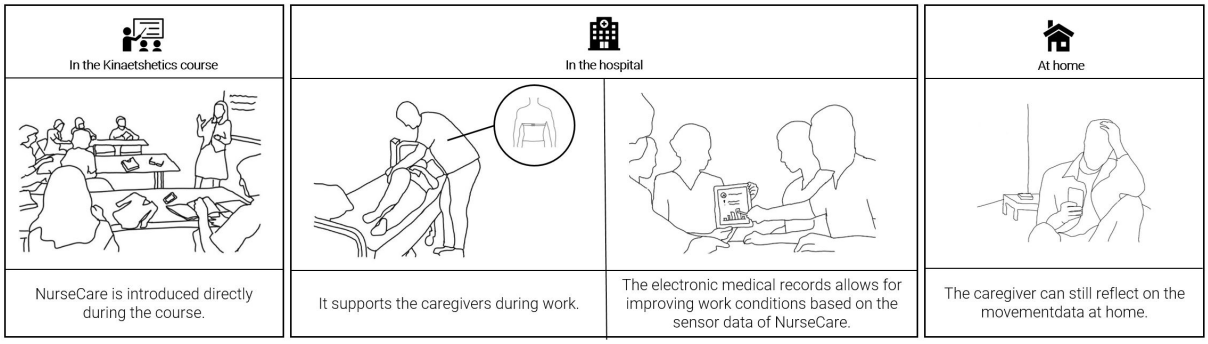


Figure 41 Potential integration of NurseCare into current practices

As depicted in section 6.3.3 all participants can imagine the provision of a system like NurseCare as support in practice. The participants further expressed various ideas about how the integration in current practice could look like. Based on those ideas, the sketches in figure 41 demonstrate a possible realisation.

The system should particularly be introduced during or directly after the basic course to avoid the acquirement of hazardous movement patterns. Furthermore, this could help to increase awareness of the topic just from the beginning of the education.

After the course, the participants use NurseCare during their work. The study results indicate that the participants favor the integration of a system like NurseCare also into electronic medical records. Although this concept is still not the rule in German hospitals, some hospitals already implemented electronic medical records and more will follow. At first, it would be beneficial to save the electric assisting tools, that were needed for a specific patient. Moreover, it should be saved, which transfer alternatives worked out well and which did not. Thus the caregivers could make use of the each other's knowledge. One could also think of integrating the instruction-videos. Secondly, the sensor data could be connected to specific patients, as proposed by some participants. This could help to identify patients where caregivers perform more hazardous movements based on quantitative values. The ward managers could make use of this knowledge. The electric assisting tool could be, for instance, placed directly in the specific patient rooms to increase the accessibility. Another idea would be, that those patients could then only be

transferred with multiple caregivers. Of course, this idea might not be relevant for all wards, but for those where patients stay multiple days. At home, the users can still access their data and reflect on it or watch instruction-videos.

7.2 Design of the wearable

This section comprises visions about how the current design of the wearable in the form of the chest strap with one mbientlab sensor might be improved in the future.

7.2.1 Extension of motion tracking

Being a research prototype, the real-time feedback implemented in NurseCare is solely based on the accelerometer data from one IMU sensor. However, risky movements depend on multiple other factors as well. To give an example, the force that the carer must apply similarly influences in how far a movement can be categorised as hazardous. If the carer applies much force to carry the patient although the bending angle is low, the position might be risky to him anyway. If one considers the initiation of a system like NurseCare in the clinic, the feedback accuracy must be increased with the extension of motion tracking. Muckell, Young, and Leventhal [50] for instance, pursue an interesting approach, on that future work could be based. They use 17 sensors in total and data from a 3D video to define thresholds with a physiotherapist concerning four metrics: Detecting Wide Support Base, Squat, Good Posture (Upright Stance) and Good Posture (Avoid Spine Twist). Figure 42 visualises the motion tracking data represented in an avatar comparing low and high-risk movements according to the four categories. Likewise, NurseCare could be extended considering those movement patterns with a combination of different sensory features. Furthermore, thresholds could be defined by experts such as physiotherapists.

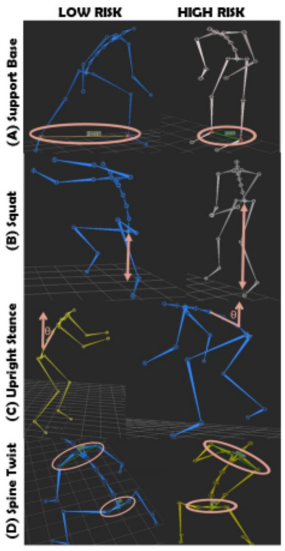


Figure 42 Comparison of low and high-risk movements defined in the work of Muckell, Young, and Leventhal [50]

7.2.2 E-textile as lighter alternative

Some participants expressed the wish for the lighter design of the sensor. One also proposed the integration directly into the workwear. Yet another participant reported that due to the daily change of the workwear, this might be no option. Another alternative would be a T-shirt, or other clothing, where the specific sensors are directly embedded in. The nursing students reacted positively to the idea of an e-textile.

Gonçalves, Silva, Gomes, *et al.* [95] recently published a review on sensors, actuators and control elements in wearable e-textiles. Although e-textiles are still in an early phase, they consider e-textiles as "opportunities for new markets". In addition to that, Fleury, Sugar, and Chau [96] conducted a scoping review on e-textiles in the field of rehabilitation. They conclude that textile sensors are already able to measure certain values important for rehabilitation.

During the ERTRAG project, eight different error categories were examined [97]. To give an example, one category is called "The arms are bent". If the caregiver pulls the patient with bent arms, the whole pressure weighs on the upper body. Stretching the arm and performing a

step backward can distribute the pressure and disburden the upper body. A further study could investigate which sensors should be embedded in the e-textile to detect the error categories. Moreover, it might be of interest what kind of sensors are suitable for the clinical context.

Figure 43 Zishi: A smart garment to correct posture [98]

To give an example, Salvado and Arsenio [99] developed a wearable sleeve with flex sensors that measure the bending angle of the arm. It targets supporting the correct execution of sport or rehabilitation exercises. It might likewise be useful in our use case to detect the described error category. To give another example, Haladjian, Scheuermann, Bredies, *et al.* [100] developed KneeHapp, a smart bandage to support knee rehabilitation. A future system can build on this work to measure the knee bending of nurses while transferring patients. Turning back to the measurement of the back angle, an e-textile that could be a potential basis for future work is Zishi. Wang, Toeters, Chen, *et al.* [98] developed this system as a vest with integrated Arduino based wearable electronics. So far Zishi solely supports shoulder training, yet the work could be extended to low back posture monitoring. Figure 43 visualises the latest version of Zishi.

7.2.3 On-body feedback

The wish for on-body feedback was reported for two reasons. On the one hand, this allows for smartphone independent feedback. On the other hand, some participants expected a clearer sense of vibration.

Previous studies already investigated vibrotactile on-body feedback to support motion learning [101]–[103]. Lieberman and Breazeal [101] for instance developed a suit which embeds eight actuators at the right arm. With the help of optical motion tracking the users' performance on motion tasks can be accessed and tactile on-body feedback can be provided. The authors conducted a comparative study with 40 participants. The participants were split into two equal groups and asked to imitate certain target motion videos while wearing the suit. One group was provided with visual feedback and the other group additionally with tactile feedback. The study results indicate a statistically significant gain in subjects' performance for the last group.

Considering e-textiles as presented in the previous section, actuators could be directly embedded into NurseCare to provide sufficient feedback to the caregiver. This poses the question where the actuators should be placed since the skin sensitivity differs among different body parts [104]. Future research could examine suitable body-parts for vibrotactile feedback in the context of patient transfers. Additionally, it could be investigated whether the combination of different vibration patterns can communicate different hints to improve the movements. Naturally speaking the work context must still be considered. Hence, the question arises which level of feedback is helpful during work and at which point it overstrains the user.

Still considering the clinical context, one must keep in mind that the actuators cannot make the wearable cumbersome. For instance, wires should be avoided and the wearable still needs to be convenient to wear. Thus future research can focus on the technical question about how on-body feedback could be realised matching the requirements of the clinical context.

In the course of rethinking the real-time feedback, one could also address the issue of emergencies. Some participants reported, that they were annoyed by the vibration in situations where they were not able to adjust their posture. The future system should use a threshold to stop providing real-time feedback at some point.

7.3 Design of the application

In this section, implications for future work concerning the smartphone application are presented.

7.3.1 Increase the individuality

Some nursing students came up with the idea to increase the individuality of the content. This might affect the individuality of feedback, but also reminder or daily hints that could include the previous performance of the user. If we refer back to the idea presented in section 7.2.2 and think about the detection of multiple error categories, this information could be used to provide more individual content. The real-time feedback could, for instance, directly include the detected error category and provide a related idea for improvement.

Another idea is to extend the summative feedback in the movementprofile section. This could improve the support to reflect on the daily performance. For instance, one could integrate the error categories also here. Different symbols could visualise the different error categories and help the caregiver to improve specific movement patterns. At the same time, one must still ensure, that the movementprofile is not overloaded with information. One could think about providing two different views: One view could still present the content similar to the current version. This view can be helpful when the user does not have much time and solely wants to get a quick overview. The second view could be a more detailed version including the error categories. This version could be beneficial when the user has more time to reflect on his movements, for instance at home.

7.3.2 Additional output device - Smart glasses / Smart watch

As outlined in section 6.3.1, one could think about a different or an additional output device besides the smartphone. Smart glasses or smart watches appeared as ideas. By overlaying the real world, smart glasses would have the advantage that the user could watch instructions about patient transfers, for instance, directly while working with the patient. The study results showed a positive attitude among the participants towards this vision. An example in research, where smart glasses should support nurses during outpatient intensive care, is the project "Pflegebrille" [105]. This project focuses on pain treatment, but likewise, an application for NurseCare could be implemented for smart glasses. The sketch in figure 44 visualises an initial idea.

Figure 44 Sketch of an idea for NurseCare with smart glasses as the output device

The Vuzix Blade, for instance, could be an option [106]. Waveguide based see-through optics is used to augment the reality with content. Furthermore, it is possible to develop own Android applications in Android studio and test them just directly on the smart glasses. As NurseCare is also based on Android, a transfer of the application for the smart glasses was tested in the form of an initial prototype for the Vuzix Blade.

As argued in section 6.4, a combination of different output devices can be fruitful for different contexts: In the clinic, the caregivers use smart glasses that stay in the clinic and are therefore no hygienic risk. At the same time, the head nurses can access the sensor data in the electronic medical records, probably provided on a tablet or a computer in the nurse's room. At home or in a break, the caregivers can likewise use NurseCare on their smartphone, for instance, to check their movementprofile. They can access their profile from all devices. Combining different devices asks for different interaction techniques.

How can the interfaces look like on the various devices and how can the interaction concepts be combined? Especially the interaction with smart glasses is different from the interaction with a smartphone. Furthermore, the information displayed is subject to different requirements.

7.4 Study Design

The previously described implications already included questions that further studies could concentrate on related to the extension of NurseCare. Likewise, the study limitations described in section 6.5 imply some unanswered questions that ask for further investigation.

At first, a follow-up study could explore the usage of NurseCare for all caregivers within one ward. This approach would be profitable regarding multiple aspects. The interaction of NurseCare could not only be investigated for young nursing students but at the same time for senior, registered nurses. This could provide new insights regarding the usability of NurseCare. In addition to that, it could show differences in the motivation to use a system like NurseCare. In contrast to the participants, registered nurses might already have experiences with work-related back injuries. Moreover, the usage in a team would help to explore the influence of the social aspect. In how far does the usage of a system like NurseCare in a group influence the appliance of Kinaesthetics?

Secondly, a further study investigating the long-term effects of NurseCare would be interesting. It might be surveyed whether a long-term usage of NurseCare can lead to a better appliance of Kinaesthetics in comparison to the current support. One approach could be a comparative longitudinal study design as already discussed in section 6.1.1. Although the resources to recruit a suitable number of participants exceeded the frame of a master project, a follow-up study with more resources at disposal could realise this idea. One could also think about a further cooperation with the local nursing school. For instance, NurseCare could be introduced to only half of the students after the next Kinaesthetics basic course. After a few months, the participants could be asked to perform patient transfers in a lab setting while wearing the wearable. The results of the sensor data could then be compared regarding the number of hazardous movements between both groups.

Besides the advantage of analysing the movement data quantitatively, this study design would also permit the investigation of the interaction with NurseCare in the long-term. A question that might be explored is whether NurseCare is used in the long-term at all and whether it overcomes the novelty effect. If it is abandoned at some point, which improvement of the features could address this problem. Additionally, a further study could concentrate on the examination of a behaviour change among caregivers who already inherited "wrong" movement patterns. The movements of the participants could be initially tracked for a certain amount of time without using the NurseCare features. Next, they would use NurseCare regularly for a longer period. The movement data from the end of the usage time could then be compared to the data from the beginning. However, to gain reliable results, this study design would ask for a lot of time and participants.

CHAPTER 8

Conclusion

This thesis introduced NurseCare to investigate how a mobile system can support nurses in applying Kinaesthetics during work. An interaction concept was developed involving nurses and HCI students during two workshops. To gather requirements, it was depicted how the BCT Wheel framework can be applied to ensure theory-based requirements verified by end-users in a future workshop with caregivers. Furthermore, Distributed Cognition helped to understand the learning process of Kinaesthetics and form the guiding topics during this workshop. In a second step, it was outlined how a workshop can be organised and structured to integrate the derived requirements in the nurses' complex workflow. It showed how to make use of domain-specific knowledge by nurses in combination with technical knowledge by HCI students. Finally, the implemented prototype was evaluated "in-the-wild" with nine nursing students, each of them within a five-day schedule.

The results of the study highlight a need for support that extends current practices and therefore reinforce the results of previous studies outlined in the introductory chapter 1. Furthermore, it was shown that support with a system like NurseCare is desired by the participants. The design of NurseCare as a combination of wearable and a smartphone application can be considered as a favorable approach. Integration into current practices should unfold directly after the basic course. Ideas for the improvement of NurseCare in the future are, for instance, the extension of sensory features and the implementation of on-body feedback.

This work contributes in various ways. First, NurseCare as a prototype is, to our knowledge, the only system so far that combines mobile and sensory technology to support the transfer of patient-transfer skills directly during work. Although technical weak points must be addressed in future systems, the concept of NurseCare can be taken as grounding. Furthermore, this work focuses on the application of Kinaesthetics but can be enlarged with other care concepts.

Secondly, the "in-the-wild" study clarified to what extent a system like NurseCare can withstand the requirements of its natural field of application. The results go beyond the examination of usability issues in a lab setting. The study has demonstrated, that vibrotactile feedback on risky movements can support caregivers in the clinical setting without disrupting the workflow. Moreover, it was shown that an "in-the-wild" evaluation is also possible when the regulatory framework must be considered and clarified beforehand.

Thirdly, this thesis contributes from a methodological point of view. It demonstrates how the BCT Wheel framework and Participatory Design methods can be combined to gather theory-based requirements that are also geared to the users' needs. Moreover, it showed how Distributed Cognition can be used as the basis for guiding topics during a future workshop. As the study results indicate high values regarding the Usability of the system in its natural setting, other researchers might take the presented approach into account for their design process.

While WRMD is still a big problem for caregivers who consistently care for others, NurseCare might be an initial idea of how a mobile system can care for carers. This thesis emphasises a need for systems that support caregivers in applying Kinaesthetics. A system like NurseCare cannot be seen as one solution but could be integrated into a holistic supply of technological and educational support.

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Appendix

A BCT Wheel analysis

Table 1 Mapping of the issues on the Behavior Change Wheel

COM-B	**Addressed problem**	**Intervention function**	**BCT**
physical capability	a lack of time no practice of Kinaesthetics	Training, Enablement	12.1 Restructuring the physical environment
psychological capability	a lack of knowledge regarding the correct appliance of principles a lack of awareness that Kinaesthetics could be applied a lack of feeling of one owns body	Education, Training, Environmental Restructuring	1.1 Goal setting (behaviour) 1.2 barrier identification / problem solving 1.4 Action planing 2.3. Self-monitoring of behaviour 2.2. Feedback on behaviour 4.1 Instruction about how to perform the behavior 6.1 Demonstration of the behavior 7.1 Prompts/Cues 8.2 Behavioral substitution 8.4. Habit rehearsal 12.5. Adding objects to the environment

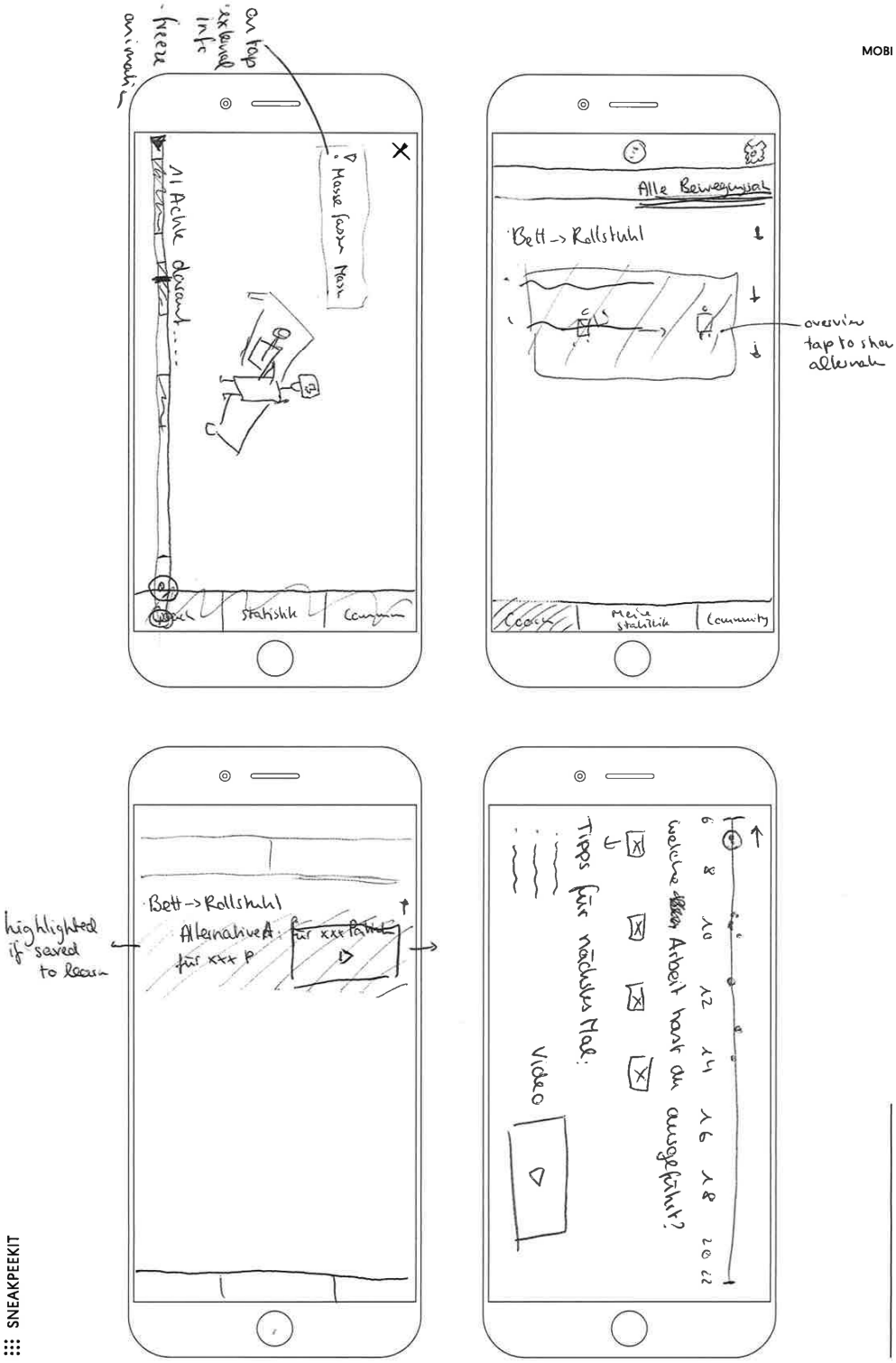
social opportunity	a lack of acceptance of Kinaesthetics of team members hierarchy: more experienced nurses do not want to try new approaches	Education, Persuasion, Environmental Restructuring	3.1. Social support (unspecified) 5.1. Information about health consequences 9.1 credible source 12.2. Restructuring the social environment 13.5. Identity associated with changed behavior
physical opportunity	perception that appliance of Kinaesthetics takes too much time a lack of a colleague to help a lack of the proper equipment (lifting equipment) a lack of "expert" to contact	Education, Environmantal Restructuring	4.1 Instruction on how to perform the behavior 8.2 Behavioral substitution 8.3. Habit rehearsal 12.1 Restructuring the physical environment 12.2 Restructuring the social environment
reflective motivation	a lack of knowledge about the benefits of applying the principles a lack of knowledge about the consequences of risky movements	Education, Persuasion, Incentivisation	1.1. Goal setting (behaviour) 1.2 barrier identification / problem solving 1.4. Action planning 2.2. Feedback on behavior 7.1. Prompts/cues 5.1. Information about health consequences 9.1 credible source 10.3. Non-specific reward
automatic motivation	lack of awareness of the health risks fear of failing fear of being too slow	Incentivisation, Persuasion, Modelling	2.2. Feedback on behavior 5.1. Information about health consequences

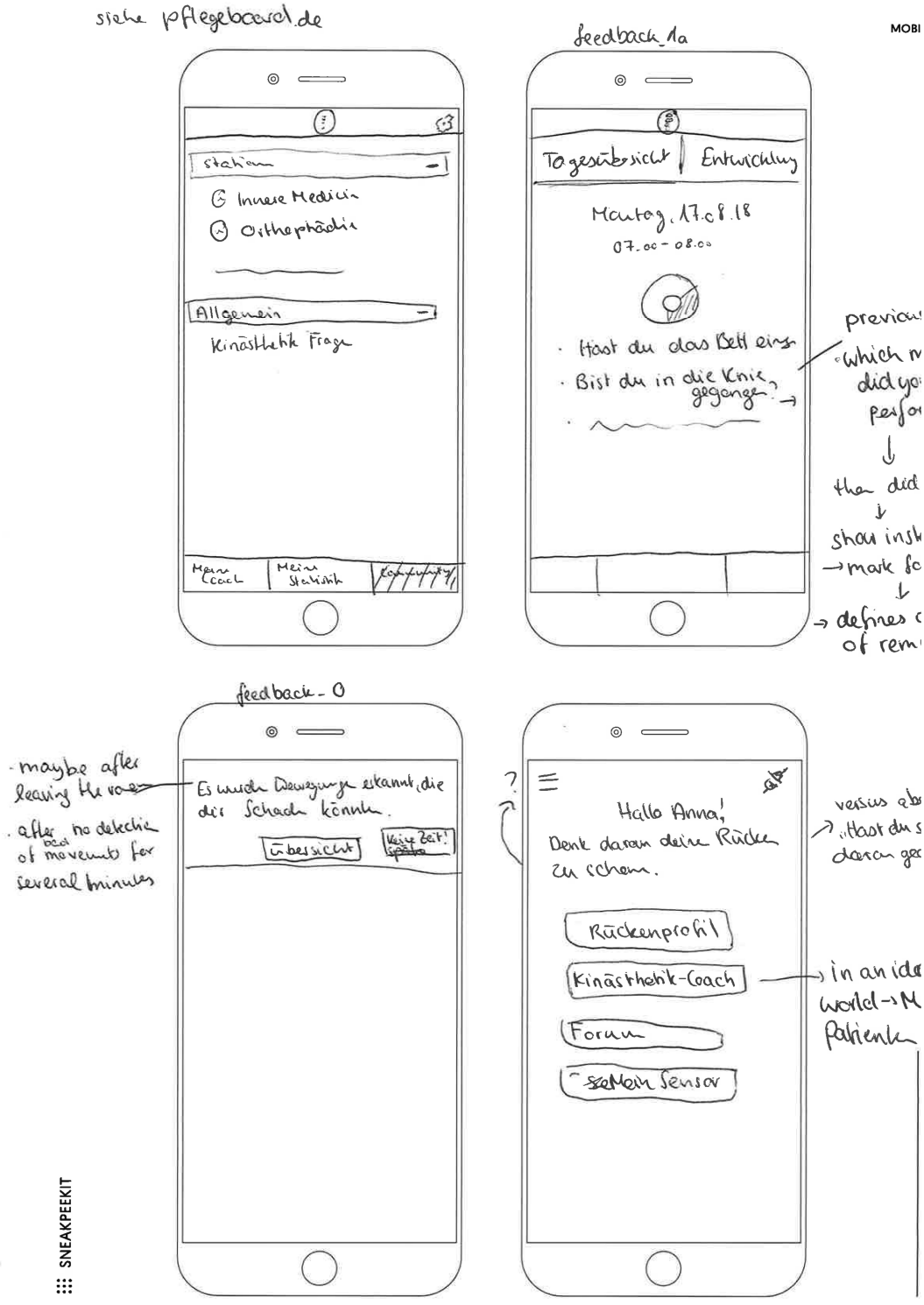
B Workshop 1.0: results of the structured brainstorming

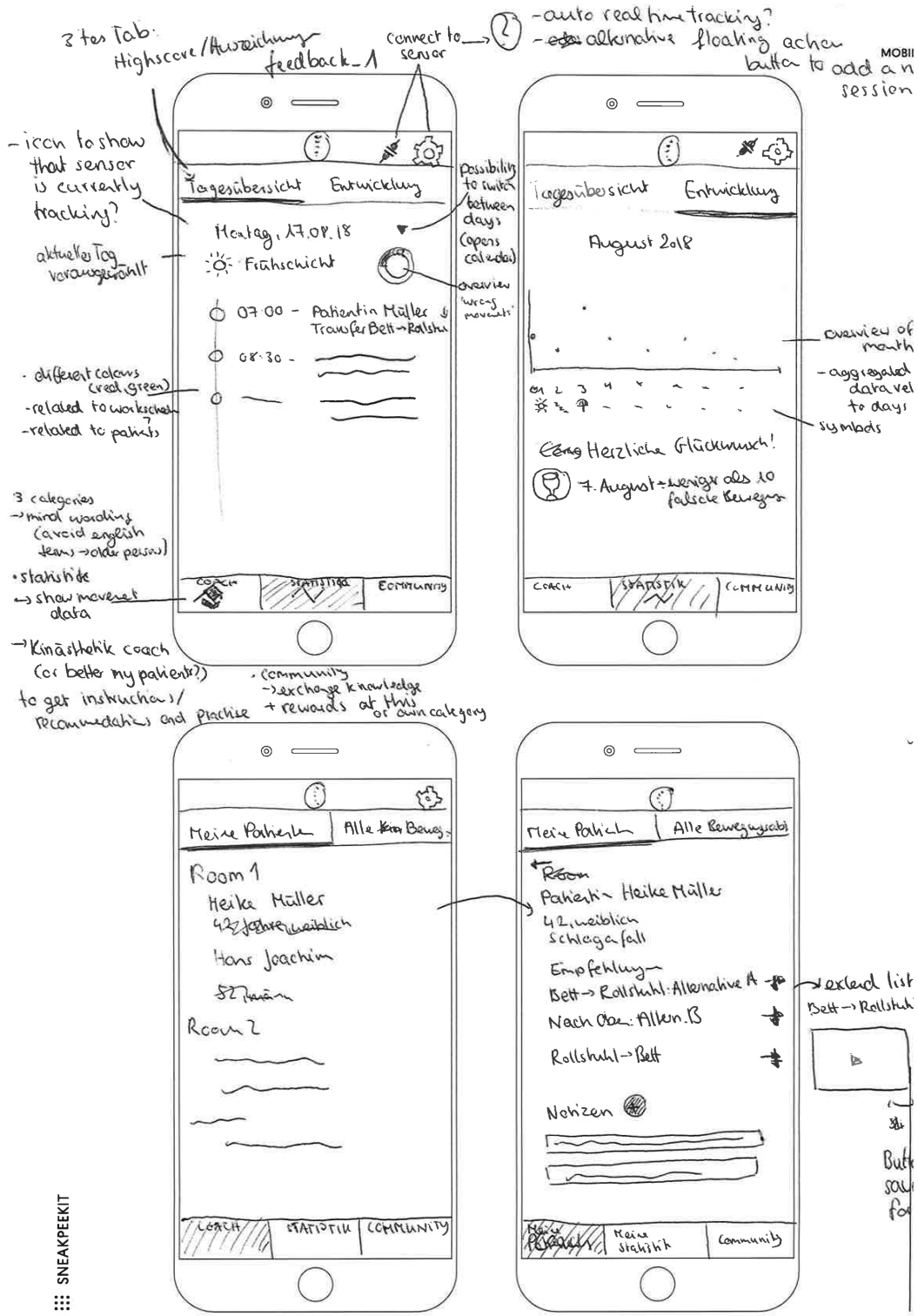
Table 2 Outcome of the structured brainstorming

context	**problem - green (frequency)**	**solution - yellow (frequency)**	**BCT - blue**
The school context	lack of practice and repetition during the workroutine (3) too late during the education (1) lack of further education in Kinaesthetics (1)	constant practice of Kinaesthetics movement patterns directly with patients (5) more possibilities for further education (1)	-
The clinical context	lack of practice and therefore experience (3) lack of social support / experts (4) habit of wrong movement patterns (1) lack of connection between work and spare time (1) no awareness for health risks (1)	direct positive/negative feedback (vibration) (5) instruction (3) reward (2) social interaction (3) reminder (2) education of more experts (1)	feedback on behaviour social support (unspecified) instruction on how to perform the behaviour information about health consequences demonstration of the behaviour prompts cues habit rehearsal non-specific reward
The home context	lack of time for reflection (1)	reflection in everyday life (2)	self-monitoring behaviour

C Sketches


MOBI
Alle Bewegungen
Bett -> Rollstuhl
Bett -> Rollstuhl
Alternative A:
Tipps für nächstes Mal:
Video
highlighted if saved to Room
SNEAKPEEKIT


siehe pflegeboard.de
feedback_1a
MOBI
Station
Innere Medizin
Orthopädie
Allgemein
Kinästhetik Frage
Mein Coach
Mein Statistik
Tagesübersicht
Entwicklung
Montag, 17.08.18
07.00 - 08.00
Hast du das Bett eing
Bist du in die Knie gegangen?
feedback - 0
Es wurde Bewegung erkannt, die dir Schaden könnte.
Übersicht
Hallo Anna!
Denk daran deine Rücken zu schonen.
Rückenprofil
Kinästhetik-Coach
Forum
Mein Sensor
SNEAKPEEKIT


3 tes Tab:
Highscore/Auszeichnung
feedback_1
connect to sensor
- auto real time tracking?
- alternative floating action button to add an session
- icon to show that sensor is currently tracking?
Tagesübersicht
Entwicklung
Montag, 17.09.18
aktueller Tag voreingestellt
Frühschicht
possibility to switch between days (opens calendar)
overview (wrong movements)
07.00 - Patientin Müller Transfer Bett→Rollstuhl
08.30 -
- different colours (red, green)
- related to workschedule
- related to patients
3 categories
→ mind wording (avoid english terms → older person)
• statistics
→ show meaningful data
→ Kinästhetik coach (or better my patients?)
to get instructions/ recommendations and practice
COACH
STATISTIK
COMMUNITY
- community
→ exchange knowledge + rewards at this or own category
August 2018
overview of month
- aggregated data related to days
symbols
Herzliche Glückwunsch!
7. August - weniger als 10 falsche Bewegungen
Meine Patienten
Alle Bewegungsdaten
Room 1
Heike Müller
42 Jahre, weiblich
Hans Joachim
52 Jahre
Room 2
Patientin Heike Müller
42, weiblich
Schlaganfall
Empfehlung
Bett → Rollstuhl: Alternative A
Nach oben: Alternative B
Rollstuhl → Bett
Notizen
extend list
Bett → Rollstuhl
Meine Statistik
Community
SNEAKPEEKIT


MOBIL
Mein Shirt
Kinästethik Coach
Community
Profil
Coach
Alle Abläufe
Spezifische
Theorie
Wie schätzt du dein Patient ein?
mobil
immobil
Was willst du machen?
Bett
Rollstuhl
nach
Coach
Alle Abläufe
Spezifisch
Achte auf folgendes:
Bewegungsprofil
Montag, 17.08.18
Ablaufe nochmal ansehen
Hilfe im Forum suchen
SNEAKPEEKIT

D Cognitive Walkthrough - Instructions

NurseCare - Cognitive Walkthrough

Vielen Dank für deine Teilnahme! Bei dieser Evaluation geht es darum zu ermitteln, ob die Applikation - so wie sie geplant ist - bedienbar und verständlich ist.
Ich bitte dich im folgenden die untenstehenden Aufgaben nacheinander zu bearbeiten. Wenn du denkst du hast die Aufgabe erledigt, gib einfach Bescheid. Ich richte dann alles für die nächste Aufgabe. Bitte versuche deine Gedanken im Bezug auf die Applikation die ganze Zeit laut auszusprechen, sowohl wenn du etwas nicht verstehst, dir etwas unnatürlich vorkommt oder auch wenn du etwas hilfreich findest!
Wenn du bereit bist, sag kurz Bescheid ;)

Aufgabe 1: Verbinde deinen Sensor mit der App am morgen!

Aufgabe 2: Am Abend öffnest du die App wieder. Schaue dir Tipps zu deiner gebeugten Haltung am heutigen Tag zwischen 14.00 Uhr und 16.00 Uhr an!

Aufgabe 3: Du musst gleich zu der immobilen Patientin Heike Müller und sollst sie in den Rollstuhl transferieren. Schaue dir noch einmal den Bewegungsablauf an!

Aufgabe 4: Antworte auf Klaus Beitrag im Kinästhetik Fachforum.

E Study documents

E.1 Introductory session

Willkommen

Ich freue mich, dich bei meiner Studie begrüßen zu dürfen!

Im Folgenden werden noch einmal grundsätzliche Informationen bezüglich der Studie und ihrem Ablauf zusammengefasst. Ich bitte dich, während des Studienverlaufs nicht mit anderen Teilnehmern über die Inhalte der Studie sowie die zu Verfügung gestellte Applikation zu sprechen, da dies die Studienergebnisse verfälschen könnte.

Ziel meiner Masterarbeit ist es ein mobiles System zu entwickeln, welches KrankenpflegerInnen dabei unterstützt Kinästhetik im Alltag anzuwenden, um langfristig Rückenschmerzen zu reduzieren.

Um herauszufinden, ob das entwickelte System seinem Ziel gerecht wird, brauche ich euch als TeilnehmerInnen.

Im Rahmen der Studie wirst du am ersten Studientag kurz in das neue System eingeführt, welches aus einer Smartphone-App, einem Gurt, inklusive eines Sensors besteht. Anschließend werden einige Fragebögen ausgefüllt.

In den folgenden 5 Tagen bitte ich dich, das System täglich, sowohl auf der Arbeit, als auch zu Hause zu nutzen, um möglichst viele Patiententransfers kinästhetisch umzusetzen. Zu deinen Erfahrungen, positiv wie auch negativ, sollst du täglich in der App einige Fragen beantworten.

Am letzten Studientag wirst du, nach Rückgabe des Systems, erneut einige Fragebögen ausfüllen. Abschließend werde ich dir in einem Interview einige Fragen bezüglich deiner Erfahrungen mit dem System stellen.

Du hast jederzeit das Recht die Studie ohne Angaben von Gründen abzubrechen. Bitte gib mir dazu einfach Bescheid.

Falls du Fragen zum Ablauf der Studie hast, scheue dich nicht diese zu stellen ☺

T01_01 ID: ___

Einverständniserklärung

Über das Ziel, den Inhalt und die Dauer der Studie wurde ich informiert. Im Rahmen dieser Studie werden durch Audioaufnahmen, Fragebögen, Speicherung der Interaktionen mit der an mir herausgegebenen Applikation (Logging), Notizen, Videos und Fotos Daten erhoben. Hiermit bin ich darüber aufgeklärt, dass diese Daten pseudonomisiert analysiert und vertraulich behandelt werden. Die Daten werden ausschließlich für die Auswertung verwendet und für die Analyse, Dokumentation, Präsentation und Publikation von wissenschaftlicher Arbeit genutzt. Abseits der genannten Zwecke werden die Daten nicht an Dritte weitergegeben.

Im Rahmen der Studie wird eine Android-Applikation auf meinem Mobiltelefon installiert. Hierfür wird der Entwicklungsmodus aktiviert. Die Speicherung der Interaktionen (Logging) erfordert die Berechtigung zur Speicherung von Daten auf meinem Mobiltelefon. Des Weiteren benötigt die Applikation die Berechtigung Bluetooth zu nutzen, um mit dem zu Verfügung gestellten Sensor zu kommunizieren. Darüber wurde ich aufgeklärt und erkläre mich damit einverstanden. Ich erkläre mich ebenfalls dazu einverstanden, dass die Studienleitung mein Mobiltelefon nach Durchführung der Studie an einen Laptop anschließt, um die oben beschriebenen Daten zu Auswertungszwecken zu speichern.

Im Hinblick auf eine anstehende digitale Kurve, ermöglicht es die Applikation Patientenspezifische Informationen, welche relevant für rückenschonendes Arbeiten sein könnten, zu speichern. Ich verpflichte mich hiermit, keinerlei Daten zu speichern, welche nach Ablauf der Studie das Zurückführen auf einzelne Patienten ermöglicht.

Für die Dauer der Studie wird mir ein MetaMotion R 0.1 Sensor, ein Google Pixel Smartphone, ein USB-Ladekabel, ein Brustgurt, sowie eine Aufbewahrungstasche für das Smartphone geliehen. Ich erkläre hiermit, dass ich die mir verliehenen Materialien sorgfältig behandeln und nach Abschluss der Studienteilnahme wieder vollständig zurückgeben werde.

Ich wurde ebenso darauf aufmerksam gemacht, dass ich meine Einwilligung jederzeit widerrufen kann. Weiterhin wurde mir mitgeteilt, dass ein Widerruf nicht mehr möglich ist, falls bereits mit der Auswertung der erhobenen Daten begonnen wurde. Pseudonomisierte Daten welche in wissenschaftliche Arbeiten eingeflossen sind, können nicht mehr gelöscht werden.

Sollten du noch Fragen haben, zögere bitte nicht mich anzusprechen! :-)

Hiermit erkläre ich mich mit den oben genannten Punkten einverstanden:

_____	_____	_____
(Name, Druckbuchstaben)	(Ort, Datum)	(Unterschrift)

Hiermit verpflichtet sich die Studienleitung, sämtliche der gewonnenen Daten lediglich wie oben beschrieben zu verwenden:

_____	_____	_____
(Name, Druckbuchstaben)	(Ort, Datum)	(Unterschrift)

Demographischer Fragebogen

Demographie

Alter: _____

Geschlecht: _____

Falls vorhanden, Sehstöhrungen (z.B. Farbenblindheit): _____ _____

Falls vorhanden, Erkrankungen im Rückenbereich aufgrund der Arbeit im Krankenhaus: _____ _____ _____

Wie gut schätzt du deine Kenntnisse in der deutschen Sprache ein?

☐ ☐ ☐ ☐ ☐

sehr schlecht sehr gut

Ausbildung

Aktuelle Ausbildung (z.B. Schüler Pflege): _____

Aktuelles Semester / Lehrjahr: _____

Vorausbildung: _____ _____

Welche Kinästhetik Kurse hast du bereits besucht? _____ _____ _____

Arbeitszeiten

Während der Studienteilnahme (vom _____ bis zum _____) arbeite ich wie folgt auf folgender Station: _____

Montag: ☐ Frühschicht (___ - ___ Uhr) ☐ Spätschicht (___ bis ___ Uhr)
☐ Nachtschicht (___ - ___ Uhr) ☐ frei

Dienstag: ☐ Frühschicht (___ - ___ Uhr) ☐ Spätschicht (___ bis ___ Uhr)
☐ Nachtschicht (___ - ___ Uhr) ☐ frei

Mittwoch: ☐ Frühschicht (___ - ___ Uhr) ☐ Spätschicht (___ bis ___ Uhr)
☐ Nachtschicht (___ - ___ Uhr) ☐ frei

Donnerstag: ☐ Frühschicht (___ - ___ Uhr) ☐ Spätschicht (___ - ___ Uhr)
☐ Nachtschicht (___ - ___ Uhr) ☐ frei

Freitag: ☐ Frühschicht (___ - ___ Uhr) ☐ Spätschicht (___ - ___ Uhr)
☐ Nachtschicht (___ - ___ Uhr) ☐ frei

Samstag: ☐ Frühschicht (___ - ___ Uhr) ☐ Spätschicht (___ - ___ Uhr)
☐ Nachtschicht (___ - ___ Uhr) ☐ frei

Sonntag: ☐ Frühschicht (___ - ___ Uhr) ☐ Spätschicht (___ - ___ Uhr)
☐ Nachtschicht (___ - ___ Uhr) ☐ frei

Umgang mit technischen Geräten

Wie hoch/gering schätzt du deine Kenntnisse im Umgang mit Computern und verwandten Systemen (z.B. Smartphones) ein?

sehr gering sehr hoch

☐ ☐ ☐ ☐ ☐

Hast du schon mal digitale Medien genutzt, um dir rückenschonende Arbeitsweisen anzueignen / zu wiederholen?

Ja Nein

☐ ☐

Falls ja, welche Quellen hast du genutzt?

_____
_____

Praxisunterstützung

Welche Mittel stehen dir zu Verfügung, um den Transfer von Kinästhetik in die Praxis zu unterstützen?

_____
_____

Als wie hilfreich würdest du die dir zu Verfügung stehenden Mittel bewerten?

Gar nicht hilfreich Sehr hilfreich

☐ ☐ ☐ ☐ ☐

T01_03 ID: ___

Selbsteinschätzung

Allgemein

Als wie praktisch anwendbar stufst du Kinästhetik ein?

gar nicht sehr

☐ ☐ ☐ ☐ ☐

Wie sicher fühlst du dich im Umgang mit Kinästhetik?

gar nicht sehr

☐ ☐ ☐ ☐ ☐

Wie häufig setzt du in deinem Arbeitsalltag Kinästhetik ein?

gar nicht sehr

☐ ☐ ☐ ☐ ☐

Wie präsent ist das Thema „Rückenschonendes Arbeiten“ in deinem Arbeitsalltag?

gar nicht sehr

☐ ☐ ☐ ☐ ☐

Falls du Kinästhetik gar nicht oder eher selten anwendest: Was hindert dich daran, Kinästhetik in deinem Arbeitsalltag anzuwenden?

_____
_____
_____
_____
_____

T01_03 ID: ___

FRAGEBOGEN ZUR KINÄSTHETIK KOMPETENZ VON PFLEGENDEN (H. Gattinger, 2017)

Dieser Fragebogen wurde entwickelt um die Kompetenz von Pflegen den in der Bewegungsunterstützung einer pflegebedürftigen Personen basierend auf Kinästhetik zu evaluieren. Kompetenz in Kinästhetik ist ein sich ständig weiter entwickelnder Prozess. Diese Selbsteinschätzung soll Hinweise geben, welche Haltung, welches Wissen und welche Fertigkeiten vorhanden sind und welche Praktiken angewendet werden.

Anhand der Ergebnisse kann der allfällige Weiterentwicklungs- bzw. Trainingsbedarf des Pflegepersonals bei der Bewegungsunterstützung von pflegebedürftigen Menschen abgeschätzt werden. Ihre Angaben werden vertraulich behandelt.

Instruktion: Bitte kreuzen Sie jeweils eine der vorgegebenen Antworten die Ihrer Einschätzung entspricht an. Wenn eine Antwortvorgabe nicht 100 % ihre Meinung trifft, dann wählen Sie bitte diejenige aus, die Ihrer Einschätzung am Nächsten kommt. Bitte beachten Sie, dass es bei diesem Fragebogen keine „richtigen" oder „falschen" Antworten und kein „schlechtes Abschneiden" gibt.

Wie gut können Sie in der Praxis folgende Aspekte von Kinästhetik anwenden? (Nr. 22 – 28)

Ich kann in einer Unterstützungssituation meine Aufmerksamkeit bewusst auf meine eigene Bewegung lenken.

Überhaupt nicht	Teilweise	Gut	Sehr gut
☐	☐	☐	☐

Ich merke, wann ich in einer Unterstützungssituation beginne, Gewicht der pflegebedürftigen Person zu heben.

Überhaupt nicht	Teilweise	Gut	Sehr gut
☐	☐	☐	☐

Ich kann in Bewegungsunterstützungen mein Bewegungsmuster wahrnehmen und gezielt veränd

Überhaupt nicht	Teilweise	Gut	Sehr gut
☐	☐	☐	☐

T01_03 ID: ___

Ich bemerke, wann ich in einer Bewegungsinteraktion „die Führung“ übernehme.

Überhaupt nicht	Teilweise	Gut	Sehr gut
☐	☐	☐	☐

Ich kann eine pflegebedürftige Person in ihren Aktivitäten so unterstützen, dass sie mit ihren Armen und Beinen wirkungsvoll ziehen und drücken kann.

Überhaupt nicht	Teilweise	Gut	Sehr gut
☐	☐	☐	☐

Ich kann einer pflegebedürftigen Person helfen, eine Position zu finden, in der sie ihre Spannung regulieren kann.

Überhaupt nicht	Teilweise	Gut	Sehr gut
☐	☐	☐	☐

Ich kann eine pflegebedürftige Person in einer gehenden Fortbewegung (z.B. im Bett hinaufrutschen) unterstützen.

Überhaupt nicht	Teilweise	Gut	Sehr gut
☐	☐	☐	☐

NurseCare

Ich freue mich, dich bei rückenschonendem Arbeiten unterstützen zu dürfen. Über den beiliegenden Sensor versuche ich, dir Feedback zu deiner Rückenbeugung zu geben.
Du kannst dich beliebig mit dem Sensor verbinden / die Verbindung trennen.
Manchmal kann es sein, dass sich der Sensor nicht sofort verbindet. Ist dies der Fall, überprüfe folgendes:

1. Stelle sicher, dass Bluetooth eingeschaltet ist.
2. Starte die App neu und versuche die Verbindung erneut aufzubauen / zu trennen.
3. Lade den Sensor und versuche dich erneut zu verbinden.

Bei Fragen oder Problemen, kannst du dich jederzeit unter folgender Nummer melden:
0176/XXXXXXXX

Aufgabe:

Im Kinästhetik Kurs hast du einige Möglichkeiten kennengelernt, um rückenschonend zu arbeiten. Während der Studie sollst du nun **möglichst viele Patiententransfers auf Basis von Kinästhetik** durchführen, um deinen Rücken zu schonen.

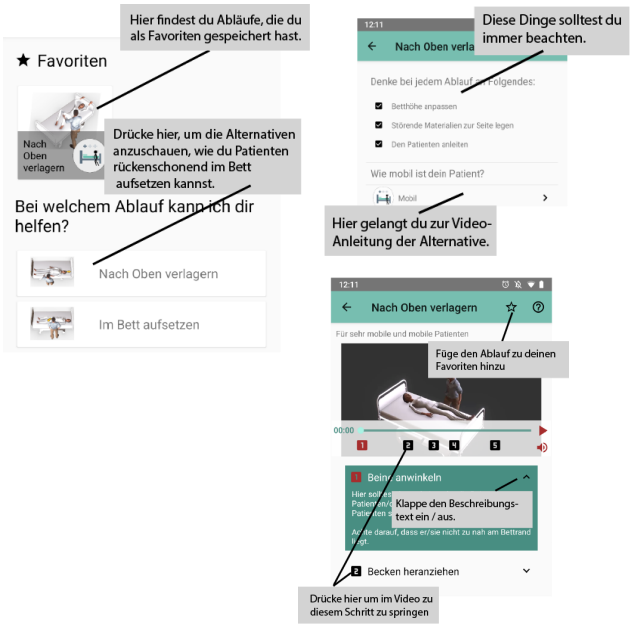
Nutze *NurseCare* dazu als Hilfe. Versuche alle Bereiche der App (Patienten, Coach, Bewegungsprofil und Verbindung mit dem Sensor) ausführlich zu nutzen. Natürlich kannst du NurseCare auch außerhalb der Klinik nutzen. Versuche den **Sensor beim Arbeiten zu tragen und zu verbinden.**

Fülle nach Nutzung am Tagesende das **„Tagebuch" aus.**

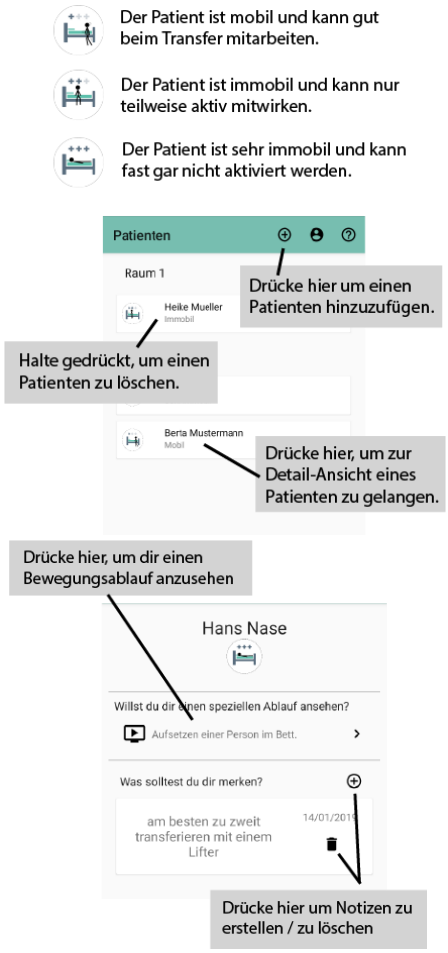
Anleitung

1. **Start**

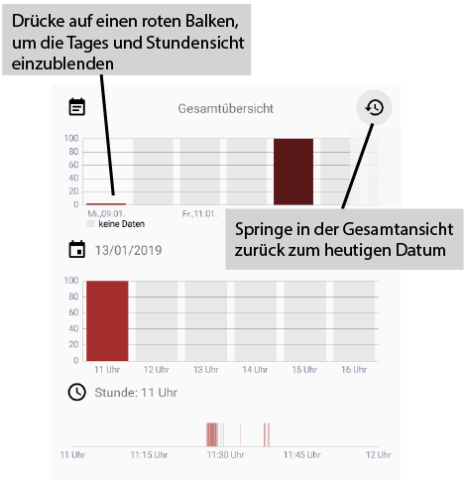
2. **Coach**



3. Patienten



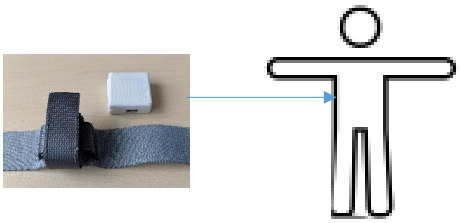
4. Bewegungsprofil



➔Der USB Slot soll nach unten gerichtet sein

➔Das Fixierband des Sensors soll nach oben hin enden

➔Der Brustgurt soll direkt unter der Brust mit dem Sensor am Rücken angelegt sein



Tagebuch (als E-diary implementiert)

Als wie stressig würdest du deinen heutigen Tag einschätzen?

gar nicht Sehr

☐ ☐ ☐ ☐ ☐

Inwiefern hat dir NurseCare geholfen Kinästhetik in der Praxis anzuwenden?

gar nicht sehr

☐ ☐ ☐ ☐ ☐

Inwiefern hat dir NurseCare geholfen bewusster auf rückenschonendes Arbeiten zu achten?

gar nicht sehr

☐ ☐ ☐ ☐ ☐

Hast du eine der oben genannten Funktionen als besonders unterstützend empfunden? Wenn ja, warum? Wie, wofür und in welchem Kontext hast du Sie verwendet?

_____
_____
_____

Notizen (positive wie negative Anmerkungen, Erweiterungsideen etc.):

_____
_____
_____

E.3 Closing session

T02_01 ID: ___

Selbsteinschätzung

Allgemein

Als wie praktisch anwendbar stufst du Kinästhetik ein?

gar nicht sehr

☐ ☐ ☐ ☐ ☐

Wie sicher fühlst du dich im Umgang mit Kinästhetik?

gar nicht sehr

☐ ☐ ☐ ☐ ☐

Wie häufig setzt du in deinem Arbeitsalltag Kinästhetik ein?

gar nicht sehr

☐ ☐ ☐ ☐ ☐

Wie präsent ist das Thema „Rückenschonendes Arbeiten“ in deinem Arbeitsalltag?

gar nicht sehr

☐ ☐ ☐ ☐ ☐

T02_01 ID: ___

FRAGEBOGEN ZUR KINÄSTHETIK KOMPETENZ VON PFLEGENDEN (H. Gattinger, 2017)

Dieser Fragebogen wurde entwickelt um die Kompetenz von Pflegen den in der Bewegungsunterstützung einer pflegebedürftigen Personen basierend auf Kinästhetik zu evaluieren. Kompetenz in Kinästhetik ist ein sich ständig weiter entwickelnder Prozess. Diese Selbsteinschätzung soll Hinweise geben, welche Haltung, welches Wissen und welche Fertigkeiten vorhanden sind und welche Praktiken angewendet werden.

Anhand der Ergebnisse kann der allfällige Weiterentwicklungs- bzw. Trainingsbedarf des Pflegepersonals bei der Bewegungsunterstützung von pflegebedürftigen Menschen abgeschätzt werden. Ihre Angaben werden vertraulich behandelt.

Instruktion: Bitte kreuzen Sie jeweils eine der vorgegebenen Antworten die Ihrer Einschätzung entspricht an. Wenn eine Antwortvorgabe nicht 100 % ihre Meinung trifft, dann wählen Sie bitte diejenige aus, die Ihrer Einschätzung am Nächsten kommt. Bitte beachten Sie, dass es bei diesem Fragebogen keine „richtigen" oder „falschen" Antworten und kein „schlechtes Abschneiden" gibt.

Wie gut können Sie in der Praxis folgende Aspekte von Kinästhetik anwenden? (Nr. 22 – 28)

Ich kann in einer Unterstützungssituation meine Aufmerksamkeit bewusst auf meine eigene Bewegung lenken.

Überhaupt nicht	Teilweise	Gut	Sehr gut
☐	☐	☐	☐

Ich merke, wann ich in einer Unterstützungssituation beginne, Gewicht der pflegebedürftigen Person zu heben.

Überhaupt nicht	Teilweise	Gut	Sehr gut
☐	☐	☐	☐

Ich kann in Bewegungsunterstützungen mein Bewegungsmuster wahrnehmen und gezielt veränd

Überhaupt nicht	Teilweise	Gut	Sehr gut
☐	☐	☐	☐

Ich bemerke, wann ich in einer Bewegungsinteraktion „die Führung" übernehme.

T02_01 ID: ___

Überhaupt nicht ☐ Teilweise ☐ Gut ☐ Sehr gut ☐

Ich kann eine pflegebedürftige Person in ihren Aktivitäten so unterstützen, dass sie mit ihren Armen und Beinen wirkungsvoll ziehen und drücken kann.

Überhaupt nicht ☐ Teilweise ☐ Gut ☐ Sehr gut ☐

Ich kann einer pflegebedürftigen Person helfen, eine Position zu finden, in der sie ihre Spannung regulieren kann.

Überhaupt nicht ☐ Teilweise ☐ Gut ☐ Sehr gut ☐

Ich kann eine pflegebedürftige Person in einer gehenden Fortbewegung (z.B. im Bett hinaufrutschen) unterstützen.

Überhaupt nicht ☐ Teilweise ☐ Gut ☐ Sehr gut ☐

T02_02 ID: ___

Systemeinschätzung

Als wie hilfreich hast du die Nutzung von NurseCare insgesamt empfunden, um rückenschonendes Arbeiten anzuwenden?

Gar nicht hilfreich				Sehr hilfreich
☐	☐	☐	☐	☐

Kannst du dir vorstellen NurseCare in deinem Alltag zu nutzen?

Ja	Nein
☐	☐

Würdest du NurseCare einem Kollegen/einer Kollegin empfehlen?

Auf keinen Fall				Auf jeden Fall
☐	☐	☐	☐	☐

Inwiefern fändest du eine Integration von NurseCare in traditionelle Lehrmethoden zur Unterstützung wünschenswert?

Gar nicht wünschenswert				Sehr wünschenswert
☐	☐	☐	☐	☐

Inwiefern hat dir NurseCare geholfen bewusster auf rückenschonendes Arbeiten zu achten?

Gar nicht geholfen				Sehr geholfen
☐	☐	☐	☐	☐

Konnte dir NurseCare helfen Kinästhetik in der Praxis anzuwenden?

Auf gar keinen Fall				Auf jeden Fall

☐ ☐ ☐ ☐ ☐

Warum (nicht)?

_____
_____
_____
_____

Hat sich deine Einstellung in Bezug auf Kinästhetik und rückenschonendem Arbeiten durch die Nutzung von NurseCare verändert?

Ja Nein

☐ ☐

Falls ja, inwiefern?

_____
_____
_____
_____

Hättest du Kinästhetik auch ohne Teilnahme an der Studie im Alltag versucht anzuwenden?

Ja Nein

☐ ☐

Falls nein, warum nicht?

_____
_____
_____
_____

Fragebogen zur System-Gebrauchstauglichkeit

1. Ich denke, dass ich das System gerne häufig benutzen würde.

Stimme überhaupt nicht zu 1	2	3	4	Stimme voll zu 5
○	○	○	○	○

2. Ich fand das System unnötig komplex.

Stimme überhaupt nicht zu 1	2	3	4	Stimme voll zu 5
○	○	○	○	○

3. Ich fand das System einfach zu benutzen.

Stimme überhaupt nicht zu 1	2	3	4	Stimme voll zu 5
○	○	○	○	○

4. Ich glaube, ich würde die Hilfe einer technisch versierten Person benötigen, um das System benutzen zu können.

Stimme überhaupt nicht zu 1	2	3	4	Stimme voll zu 5
○	○	○	○	○

5. Ich fand, die verschiedenen Funktionen in diesem System waren gut integriert.

Stimme überhaupt nicht zu 1	2	3	4	Stimme voll zu 5
○	○	○	○	○

6. Ich denke, das System enthielt zu viele Inkonsistenzen.

Stimme überhaupt nicht zu 1	2	3	4	Stimme voll zu 5
○	○	○	○	○

7. Ich kann mir vorstellen, dass die meisten Menschen den Umgang mit diesem System sehr schnell lernen.

Stimme überhaupt nicht zu 1	2	3	4	Stimme voll zu 5
○	○	○	○	○

8. Ich fand das System sehr umständlich zu nutzen.

Stimme überhaupt nicht zu 1	2	3	4	Stimme voll zu 5
○	○	○	○	○

9. Ich fühlte mich bei der Benutzung des Systems sehr sicher.

Stimme überhaupt nicht zu 1	2	3	4	Stimme voll zu 5
○	○	○	○	○

10. Ich musste eine Menge lernen, bevor ich anfangen konnte das System zu verwenden.

Stimme überhaupt nicht zu 1	2	3	4	Stimme voll zu 5
○	○	○	○	○

T02_03 ID: ___

Interview

Alltagstauglichkeit & Usability (auf App verweisen!!)

1. Beschreibe deinen Ersteindruck der Nutzung von NurseCare mit 3 Worten! → Erklärung
2. Inwiefern hast du die Idee (Unterstützung von rückenschonendem Arbeiten) allgemein als (nicht) sinnvoll empfunden?
3. Beschreibe deine Nutzung von NurseCare anhand eines Tagesablauf der letzten Woche! (Pilottest: Sind Fehler aufgetreten?) (Wann hast du NurseCare wo genutzt? Welche Ziele wolltest du damit erreichen?)
4. Wie hast du die Handhabung von NurseCare empfunden?
    a. Wie hast du die Handhabung des Sensors empfunden?
    b. Konntest du in der App immer das umsetzen, was du wolltest?
    c. Hast du bei der Nutzung der App an manchen Stellen gezögert, oder warst dir nicht sicher wie du ans Ziel gelangen konntest?
5. Inwiefern konntest du die Nutzung von NurseCare (nicht) gut in deinen Arbeitskontext einbinden?
    a. Hast du hier Verbesserungsvorschläge?
6. Inwiefern hat sich deine Nutzung von NurseCare zwischen stressigen und nicht-stressigen Tagen unterschieden? War die Nutzung in beiden Situation für dich hilfreich?

Lernen und Anwenden von Kinästhetik

1. Denkst du, NurseCare hat dir geholfen Kinaesthetics besser im Alltag anwenden zu können?
2. Denkst du NurseCare hat dir geholfen dein Wissen im bezug auf Kinästhetik zu erweitern / zu halten?
3. Httest du auch ohen das System auf rückenschonendes Arbeiten geachtet?
    a. Was hindert dich daran?

Real-Time Feedback

1. Hast du Vibration als Benachrichtigung genutzt?
2. Hast du die Benachrichtigung und / oder Vibration als hilfreich empfunden? Warum?
3. Verbesserungsvorschläge?

Reflexion

1. Hast du dir dein Bewegungsprofil angeschaut? Wenn ja, wo, wann und wie oft?
2. Wie bist du dabei vorgegangen?
3. Hast du das Bewegungsprofil als (nicht) hilfreich empfunden? Was fandest du positiv / negativ?
4. Konntest du die Visualisierungen intuitiv bedienen und verstehen?
5. Verbesserungsvorschläge?

Anleitung

1. Hast du den Bereich Coach genutzt? Wenn ja, wo, wann und wie oft? Denkst du er hat dir geholfen Kinästhetik besser nachvollziehen zu können?
2. Wie bist du dabei vorgegangen?
3. Hast du die Einbindung der Theorie genutzt? Warum (nicht)?
4. Inwiefern hast du die Einbindung der Theorie als hilfreich empfunden?
5. Inwiefern hast du die Schrittunterteilung als (nicht) hilfreich empfunden?
6. Inwiefern hast du die Aufteilung in Patiententypen als (nicht) hilfreich empfunden?
7. Verbesserungsvorschläge? (Schritte optional etc..)

T02_03 ID: ___

Auszeichnungen

1. Als wie motivierend hast du die Auszeichungen empfunden?
2. Verbesserungsvorschläge?

Erinnerung

1. Hast du die Erinnerungsfunktion genutzt?
2. Inwiefern hast du die Erinnerungsfunktion als hilfreich empfunden?
3. Verbesserungsvorschläge?

Sonstiges

1. Welche der besprochenen Funktionen hast du als am hilfreichsten / wenig hilfreichsten empfunden? / Fandest du Funktionen überflüssig?
2. Hast du die direkte Anrede der App als (nicht) unterstützend empfunden? Wenn ja, warum?
3. Als wie hilfreich hast du die Tagestipps empfunden?

NurseCare versus traditionelle Lehrmethoden

1. Was sind Vorteile/Nachteile von NurseCare im Gegensatz zu den aktuellen Lehrmaterialien in Bezug auf Kinästhetik?
2. Welche Verbesserungen von NurseCare wären für dich wichtig?
3. Welche Erweiterungsideen hättest du im Bezug auf ein System ähnlich zu NurseCare?
    a. Sozialer Austausch
    b. Erweiterung von Smart Glasses als Ausgabemedium?
    c. Weitere Funktionen?
    d. Einbindung in digitale Kurve
4. Könntest du dir eine langfristige Nutzung von NurseCare vorstellen?
5. Falls ja, würdest du dir eine Einführung eines solchen Systems als Ergänzung wünschen? Wie sollte diese Integration aussehen? (Einführung im Kurs, Unterstützung vom Arbeitgeber? Krankenkasse?)

T02_04 ID: ___

Auszahlungsbestätigung

Hiermit bestätige ich den Erhalt von 30 Euro in Bar als Kompensation für die Teilnahme an der Studie *In-the-wild Evaluation eines mobilen Systems zur Unterstützung von Pflegenden bei der Anwendung von Kinästhetik* im Kontext der Masterarbiet von Carla Gröschel, Studentin an der Universität Konstanz.

_____ _____ _____

(Name, Druckbuchstaben) (Ort, Datum) (Unterschrift)

F Study permission

Benutzerstudie der Smartphone Applikation „NurseCare“ zur Unterstützung von rückenschonendem Arbeiten und der Anwendung von Kinästhetik im Klinikalltag

Im Rahmen meiner Masterarbeit im Informatik-Studium mit dem Schwerpunkt „Mensch-Computer-Interaktion“ an der Universität Konstanz habe ich eine Smartphone-Applikation entwickelt, welche Pflegende bei rückenschonendem Arbeiten unterstützen soll. Die Masterarbeit ist eingebettet in das ERTRAG Projekt, in dem die Gesundheitsakademie Konstanz und die Universität Konstanz, sowie weitere Projektpartner erforschen, wie Technologie die Lehre kinästhetischer Bewegungsabläufe unterstützen kann.

Meine Masterarbeit fokussiert sich hier speziell auf die mobile Unterstützung direkt während der Arbeit. Ein Transfer von kinästhetischen Bewegungsabläufen soll unter anderem mit direkter Rückmeldung über „rückenschädigende“ Bewegungen erleichtert werden. „Rückenschädigende“ Bewegungen werden vorerst zu Forschungszwecken mit Hilfe eines Sensors, befestigt an einem Brustgurt, identifiziert. Der Sensor ist per Bluetooth mit dem Smartphone verbunden. In der entwickelten Applikation kann sich der / die Pflegende unter anderem eine tägliche Übersicht anzeigen lassen, zu welchem Zeitpunkt oben beschriebene Bewegungen identifiziert wurden. Desweiteren können Anleitungsvideos zu ausgewählten kinästhetischen Bewegungsabläufen als Hilfestellung angesehen werden.

Ob und inwiefern, das System seinem Ziel gerecht wird und welche Erweiterungsmöglichkeiten denkbar wären, soll in einer Benutzerstudie vom 23.04.2019 bis zum 23.06.2019 untersucht werden. Um möglichst aussagekräftige Ergebnisse zu erhalten, würde ich die erstellte App und den Sensor gerne ca. 15 Auszubildenden aus der Pflege für ca. 5 Tage zur Nutzung im Alltag (Arbeit im Klinikum und Freizeit zu Hause) mitgeben. Um zu untersuchen, ob das System im Klinikalltag als unterstützend empfunden wird und wie es verbessert werden kann, ist es notwendig, dass die Auszubildenden Ihr Smartphone, sowie den Brustgurt inklusive Sensor, auch während der Arbeitszeit bei sich tragen dürfen. Ich werde die Teilnehmer als Teil einer Einverständniserklärung um Ihr schriftliches Einverständnis ersuchen, dass Smartphone im Klinikum nur als Teil der Studie und nicht zu anderen Zwecken einzusetzen. Die App nimmt während der Nutzung keine Daten durch die Smartphone-Kamera oder das Mikrofon auf, um die Privatsphäre der PatientInnen zu gewährleisten.

Soweit es für die Teilnehmer in Ordnung ist, würde ich Sie darum bitten die App für die Dauer der Studie auf Ihrem eigenen Smartphone zu installieren. Alternativ wird den Teilnehmern ein Leihgerät zur Verfügung gestellt.

Die Studie soll im Zeitraum vom 23.04.2019 bis zum 23.06.2019 stattfinden. Dies bedeutet nicht, dass die Studie sich über den gesamten angegebenen Zeitraum erstreckt. Es soll lediglich eine möglichst flexible Terminwahl für die Auszubildenden ermöglicht werden.

Vor und nach der Nutzung soll durch Fragebögen und ein abschließendes Interview die Erfahrungen der Pflegenden ermittelt werden. Das Interview wird zu Auswertungszwecken aufgezeichnet. Dabei werden ebenfalls in Form von Notizen, Fotos oder Videoaufnahmen Daten erhoben. Um die Nutzung der Applikation im Alltag besser nachvollziehen zu können, werden während der Nutzung die Interaktionen der Auszubildenden mit dem System durch Logging aufgezeichnet. Desweiteren werden durch ein Tagebuch, welches die Auszubildenden selbst ausfüllen sollen, Daten erhoben.

Ich verpflichte mich als Studienleitung, dass diese Daten pseudonomisiert gespeichert und vertraulich behandelt werden. Die Daten werden ausschließlich für die Auswertung zu genanntem Zweck verwendet und für die Analyse, Dokumentation, Präsentation und Publikation von wissenschaftlicher Arbeit genutzt. Abseits der genannten Zwecke werden die Daten nicht an Dritte weitergegeben. Die Auszubildenden werden ausführlich über die Erhebung und Verwendung der Daten aufgeklärt und in Form einer Einverständniserklärung um ihr Einverständnis ersucht.

Genehmigung zur Smartphone-Nutzung im Klinikum im Rahmen einer Benutzerstudie

Hiermit wird die Durchführung einer Benutzerstudie zur Smartphone-Applikation „NurseCare“ vom 23.04.2019 bis 23.06.2019, mit ca. 15 Auszubildenden aus der Pflege mit einer Dauer von ca. 5 Tagen pro Auszubildenden genehmigt. *„NurseCare“* wurde im Rahmen eines Masterprojekts an der Universität Konstanz entwickelt, um PflegerInnen beim Anwenden von Kinästhetik zu stützen. Langfristig sollen so Rückenschmerzen reduziert werden.

Um zu evaluieren, ob das mobile System auch tatsächlich im Arbeitsalltag unterstützend einsetzbar ist, ist es notwendig, dass die Teilnehmer die Smartphone App und den an einem Brustgurt befestigten Sensor während der Arbeit verwenden. Aus diesem Grund wird den teilnehmenden Auszubildenden das Mitführen des Smartphones sowie das Tragen des Brustgurts inklusive Sensor während der Studiendauer im Klinikum genehmigt.

_____	_____	_____
Name (Druckbuchstaben)	Datum	Unterschrift

Hiermit verpflichtet sich die Studienleitung, dass durch „NurseCare“ während der Nutzung keine Daten durch die Smartphone-Kamera oder das Mikrofon aufgenommen werden, um die Privatsphäre der PatientInnen zu gewährleisten. Sämtliche der gewonnenen Daten werden lediglich wie oben beschrieben verwendet. Weiterhin werden teilnehmende Auszubildende über die Erhebung und die Verwendung der erhobenen Daten aufgeklärt und ihr Einverständnis wird in Form einer Einverständniserklärung eingeholt.

_____	_____	_____
Name (Druckbuchstaben)	Datum	Unterschrift

G Log file example

The listing below illustrates an extract from a log file of participant 06 during the study. It serves providing an idea of the logging structure.

```
2019-06-04T08:13:14#Sensor#Service##ServiceCreated
2019-06-04T08:13:14#Sensor#Service##ServiceStartForegroundIntent
2019-06-04T08:13:14#Sensor#SensorInteractor##BluetoothConnectionEstablished
2019-06-04T08:13:20#Sensor#Connections##ConnectionEstablished
2019-06-04T08:13:20#Sensor#Connections##AccelerometerStarted
2019-06-04T08:13:38#Interactions#Home#onCreateView#SwitchedToStart
2019-06-04T08:13:50#Interactions#Home#onCreateView#SwitchedToStart
2019-06-04T08:13:54#Interactions#Patients#onCreateView#SwitchedToPatients
2019-06-04T08:13:55#Interactions#Patients#onDestroyView#ClosedPatients
2019-06-04T08:13:55#Interactions#Coach#onCreateView#SwitchedToCoach
2019-06-04T08:14:02#Interactions#Coach#exercise_card#TappedOnExerciseCard_chair
2019-06-04T08:14:02#Interactions#Coach#onDestroyView#ClosedCoach
2019-06-04T08:14:02#Interactions#CoachDetails#onCreateView#SwitchedToCoachDetails_chair
2019-06-04T08:14:11#Interactions#CoachDetails#coach_exercises_video_list#TappedOnRecording_chair_a
2019-06-04T08:14:11#Interactions#CoachDetails#onDestroyView#ClosedCoachDetails
2019-06-04T08:14:11#Interactions#CoachVideoFragment#onCreateView#SwitchedToCoachVideo_chair_a
2019-06-04T08:14:12#Interactions#CoachVideoFragment#player#VideoIsPaused
2019-06-04T08:14:22#Interactions#CoachVideoFragment#onDestroyView#ClosedCoachVideo
2019-06-04T08:14:22#Interactions#CoachDetails#onCreateView#SwitchedToCoachDetails_chair
2019-06-04T08:15:17#Interactions#CoachDetails#onDestroyView#ClosedCoachDetails
2019-06-04T08:15:17#Interactions#Coach#onCreateView#SwitchedToCoach
2019-06-04T08:15:23#Sensor#Feedback##AngleBiggerThan50
2019-06-04T08:15:23#Sensor#Feedback##NegativeFeedback
```

H Content flash drive

The attached flash drive contains:

- Digital version of the thesis
- Digital version of the project paper
- Documents of the user study