Learning Patient Transfers with Technology: A Qualitative Investigation of the Design Space

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ABSTRACT
Nurses who care about patients with functional disabilities are frequently required to transfer a patient from one place to another. To prevent nurses from injuring themselves during patient transfers, many government-supported schools in Germany provide programs which teach how to conduct transfers based on the kinaesthetics care conception. However, the program is typically limited to merely three lectures. With the goal of promoting nurses’ health behavior, we analyzed current practices in kinaesthetics education and explored how interactive technology can extend those practices. We interviewed nursing-care teachers (N = 5) and students (N = 27), and conducted four contextual inquiries during kinaesthetics course sessions. A qualitative analysis of the data revealed three themes. Based on these, we describe a set of implications to support the learning of kinaesthetics-based transfers by means of technology. We propose the use of the implications as initial design goals for user-centered design processes and exemplify their application by illustrating a concept for a tablet-based learning system.

CCS CONCEPTS
• Human-centered computing → Human computer interaction (HCI); User centered design.

KEYWORDS
patient transfer, movement learning systems, nursing-care education, kinaesthetics

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1 INTRODUCTION
Demographic developments in Western societies imply a growing portion of elderly society members. Accordingly, this trend entails an increasing need for nursing-care personnel. Yet, nursing-care personnel frequently injure themselves while conducting their duties. Especially patient-transfer tasks are perceived as stressful to the lower back [8] and can lead to musculoskeletal disorders [28, 35]. In order to reduce these physical impairments, multiple government-supported schools in Germany provide courses teaching patient-transfer movements based on the kinaesthetics care conception. We henceforth refer to these movements as kinaesthetics transfers. Presently, nursing-care students typically only take part in one kinaesthetics course over three nonconsecutive days. As part of the course, usually practical exercises are conducted (see Figure 1). Aside from the course, typically no further support for learning kinaesthetics transfers is provided by educational institutions. Furthermore, most existing materials for self-directed learning lack an interactive support for the practical training of the movements.

Previous research shows that interactive technology, including interactive mirrors [1], virtual reality technology [46], and haptics [24] can be effective in supporting learning movements. In this paper, we explore the current practices for learning kinaesthetics transfers and identify limitations and
opportunities. Interviews with nursing-care teachers and students, and contextual inquiries serve as the basis for our work. Overall, we present a qualitative study into the learning of kinaesthetics transfers as part of nursing-care students’ education. Our findings confirm that there are several limitations related to the current support of learning. Future technology may help to address these. Based on our findings, we describe a set of implications to support the learning of kinaesthetics transfers with technology. We propose to use the implications as initial design goals for user-centered design processes. In line, we provide an example of their application by illustrating a concept for a tablet-based learning system.

2 RELATED WORK

In this section, we give an overview of (1) previous research that investigated computer-supported movement learning and (2) systems for the learning of nursing-care activities.

Computer-supported Movement Learning

Various researchers explored and designed computer systems that support learning movements. Portillo-Rodriguez et al. [32] presented a system which enables learning of Tai Chi movements by imitation. Aside from sports, researchers also investigated technology for movement learning related to rehabilitation. Tang et al. [39, 40] explored the design of movement guidance and feedback for rehabilitation exercises at home. SleeveAR [37] uses projections onto the floor and onto a user’s arm to provide egocentric hints.

The use of a first-person visual perspective was also investigated by other researchers. Yang and Kim [46] employed a ghost metaphor, which allowed the viewer to experience and imitate a virtual trainer performing the movements to be learned from a first-person perspective. LightGuide projects hints onto a user’s body to guide hand movements [36]. Chua et al. [4] used virtual reality technology to create a system for Tai Chi training. The system allows for rendering one or multiple teachers surrounding the student and superimposing a teacher’s movements over a student’s virtual body.

Previous research has also yielded systems that support movement learning from a third-person visual perspective. YouMove, a system based on an interactive mirror, allows for the recording and learning of arbitrary movement sequences [1]. Velloso et al. [42] presented MotionMA which enables experts to demonstrate arbitrary movements, automatically extract a movement model, and provide novices with visual feedback while they perform a movement. Relatedly, Kyan et al. [22] introduced a system which allows the recording, assessment and visual representation of ballet dance-movements in a CAVE virtual environment.

Aside from systems that make use of the visual sense, multiple researchers explored the use of haptics to support the learning of movements. Lieberman and Breazeal [24] investigated TIKL, a system which employs a wearable suit to enable simultaneous tactile feedback on different joints for motor learning. In relation, MusicJacket [18, 41] employs motion capture and small vibrators that are attached to a user’s body, to aid the learning of violin bowing. Furthermore, Spelmezan et al. [38] explored the design and perception of full-body vibrotactile patterns that users can wear on their body to get assistive instructions during physical activities.

Most of the presented research investigated how technology can guide learners, how to provide them with feedback during learning, or both. Sigrist et al. [34] reviewed research on the potential of visual, auditory, haptic, and multimodal feedback. As part of their findings, the authors stated that previous research mainly explored simple, rather artificial labor tasks, whereas, in reality, the majority of motor tasks are complex. This goes in line with our observation of past research related to computer-supported movement learning. The transfer of patients in nursing care often requires a close physical, and social interaction between nurse and patient consists of multiple steps and can be influenced by the behavior and needs of both, nurse and patient. Only few of the reviewed works investigated technology which aids the learning of such rather complex movements. Most previous research focused on movements that do not involve bodily and social interactions between humans.

Learning Systems in Nursing Care

Various researchers explored technical systems that aid the learning of surgical skills [19, 23]. Considering nursing-care education, the majority of researched systems employs common computer screens [5] which are sometimes combined with a physical manikin, parts of a manikin, or haptic output (e.g., [33]). Few systems make use of virtual reality technology [43], augmented reality technology [3], wearable sensors [10], or support mobile learning [31]. Furthermore, most systems focus on the conduct of an activity related to a patient, while neglecting potential health implications for nursing care workers. Thus, several authors (e.g., [7, 45]) conclude that previous research explored only part of the potential provided by current technology.

Technology that supports the learning of patient-transfer movements is no exception in regard to this. Related research was mostly published during the past five years. Huang et al. [14, 15, 17] implemented a system for the training of patient-transfer skills which allows learners to view movements as videos and receive feedback on a computer screen. In an evaluation, the authors found improvements when
learning with the system compared to the use of textbooks and a demonstration video [17]. Nakagawa et al. [30] presented a system for the training of patient transfers with a slide sheet. Furthermore, Dürre et al. [6] suggested application possibilities for mixed reality technology to support motor learning. They used data related to the learning of patient transfers as a basis. Kopetz et al. [21] investigated the potential of augmented reality smart glasses in nursing-care education. The authors suggested that nursing-care students are in demand for additional support during their practical education. In a subsequent effort, they implemented an app for use with smart glasses to support the training of patient transfers [20]. Huang et al. [12, 13, 16] researched the design and implementation of a robot patient for training patient-transfer skills. They found that the transfer of the robot patient was more challenging than the transfer of a human simulating a patient [13]. The authors suggested that a higher difficulty level when transferring the robot patient might motivate learners to practice more. Others investigated the detection [29] and evaluation [25] of patient-transfer movements through technology. Based on their results, Muckell et al. [29] suggested that a wearable motion tracking system might be efficient for preventing health impairments.

In summary, much existing work studied the development, the design, and the evaluation of systems for the learning of physical movements. However, research on how to support learning rather complex patient-transfer scenarios—which afford bodily and social interactions between nursing-care workers and patients—is limited. To our knowledge, at present, the design space for related systems has not been widely analyzed. We address this gap by reporting and discussing the results of a qualitative investigation. Furthermore, we provide a set of implications to support the learning of kinaesthetics transfers by means of technology.

3 STUDY METHODS & PROCEDURE

Nursing-care schools aim at providing their students with theoretical and practical knowledge applicable to their daily work. As part of this, various institutions in Germany offer courses in regard to the conduct of kinaesthetics transfers. The research presented in this paper was conducted collaboratively with four of these institutions. The research activities were approved by the collaborating institutions. Furthermore, all participants were informed about the use of their data and their written consent was obtained.

Educational Concept: Kinaesthetics

Kinaesthetics is a concept for the provision of care interventions which is primarily taught in Central Europe [2]. It is supposed to allow for patient-transfer movements, during which the health development of both, nursing-care workers and patients is supported and injuries are avoided. Kinaesthetics is typically taught in the form of a basic course over three nonconsecutive days. Training rooms at nursing-care schools are used for the practical training which is usually part of the course. Depending on the resources available at an institution, the training rooms provide equipment of differing quality. Typically multiple electrically or mechanically adjustable beds are available. Some rooms also supply learners with one or multiple wheelchairs.

In Germany, the education of nursing-care students is conducted in the form of classroom and on-site work blocks. This implies that nursing-care students spend a few weeks at a school, followed by a few weeks at a health-care institution. Kinaesthetics course sessions are usually embedded in classroom blocks.

Data Collection

We conducted semi-structured interviews with nursing-care teachers and students at four different institutions in Germany. We supplemented our data with four contextual inquiries of kinaesthetics basic course sessions.

Interviews. We interviewed five nursing-care teachers (three female) and 27 students (21 female). The interviews were organized together with the collaborating institutions and most were conducted in a room of the corresponding institution. Due to a larger geographical distance to one teacher, we conducted one interview over the phone. The approximate duration of each interview was 90 min per teacher and 45 min per student. Each student was compensated with 8 €. Teachers were not compensated. The interviewed teachers were aged between 33 and 63 years (M = 51, SD = 11.9). They had between four and 25 years (M = 15.2, SD = 8.3) of experience in teaching kinaesthetics. Three students gave no information about their age. The other 24 were aged between 18 and 47 years (M = 25, SD = 7.6). At the time of the interview 13 students were enrolled in the third, 11 in the fourth and three in the seventh semester of their studies (M = 3.9, SD = 1.2). Each of the interviewed students had already participated in a kinaesthetics course.

All interviews were audio recorded. We asked participants about their subjective experiences with and their opinions about the application of ergonomic patient-transfer movements. Furthermore, we inquired into current opportunities for learning. As part of this teachers were asked in regard to the ways in which they support learning at present, as well as what benefits and limitations they see in the state-of-the-art. In turn, nursing-care students were asked about their past experiences with and the advantages and disadvantages of the educational support they were provided.
Contextual Inquiries. We attended four kinaesthetics course sessions. Three sessions for nursing-care students and one refresher course for nursing-care workers. Each session was held by one teacher, attended by 9–16 nursing-care students (M = 13.5, SD = 3.1) and took approximately four hours. To gain a deeper insight, we participated during some of the exercises and occasionally asked questions. However, at all times we were careful to minimize disturbances of the lectures. When participating, we temporarily integrated into a group of learners as if we were regular group members. Inquiries in the form of questions were usually delayed to a natural break in the lecture flow. For example, when a teacher switched between groups.

We documented the contextual inquiries with video recordings when allowed by the teachers and students and created handwritten notes when time permitted and while we were not participating. We aimed at getting an insight into the overall structure of the methods used during kinaesthetics course sessions. We observed students actions as well as the ways in which the teachers supported the learning of kinaesthetics transfers. As part of this, we noted how the teachers instructed the students and in which ways they provided them with feedback.

Data Analysis

After finishing the data collection, we transcribed the audio recordings of the conducted interviews and digitized all handwritten notes. Subsequently, we conducted a qualitative analysis of the acquired data. Our aim was to better understand current practices, limitations and potential opportunities related to the learning of ergonomic patient-transfer movements in nursing-care education. We employed an affinity diagramming approach [11]. In a first step, we clustered similar statements in our data. The resulting clusters were labeled. Second, we formed groups of clusters, also labeling these. Groups were again grouped, thereby creating a hierarchical structure. This process was not entirely linear but of dynamic nature. As part of the process, initial groupings were resolved, labels were changed, and parts of groups were regrouped. As a result, we identified three main themes in the collected data: (T1) “Learning and Application,” (T2) “Experience,” and (T3) “Body and Movement.”

4 THEMES & IMPLICATIONS FOR SUPPORT

In the following, we present three themes that we identified from our analysis. For each theme, we describe our findings by reporting the present situation inline with opportunities and limitations. Based on the findings, we identified a set of implications that should be addressed by interactive technology that supports the learning of kinaesthetics transfers. Table 1 provides a summary of the relationship between the three themes (T1–T3) and the identified implications (I1–I6).

Table 1: Themes (T1–T3) and related Implications (I1–I6)

<table>
<thead>
<tr>
<th>Themes (T1–T3)</th>
<th>Related Implications (I1–I6)</th>
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<tr>
<td>T1: Learning and Application</td>
<td>I1: Support Self-directed Learning and Application</td>
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Our findings are reported including quotes and identifiers for the statements of teachers and students. All quotes in this paper were translated from German to English. The identifiers for the teachers’ statements are prefixed with the letter t and the ones for the students with the letter s.

T1: Learning and Application

The main support for the learning of kinaesthetics transfers is presently provided in the form of the kinaesthetics course which nursing-care students usually visit as part of their education. Typically a large part of the course consists of the demonstration and subsequent practice of kinaesthetics transfers. During practice, the students are usually split into small groups. The groups get feedback from the teacher who is supervising the practical exercises.

Multiple students but only one teacher: While kinaesthetics courses are visited by multiple students, these are typically mentored by only one teacher. We observed that students sometimes felt unclear about how to conduct a movement during the practical training or to what extent they performed it correctly. The teacher usually demonstrated the movement before the students started to practice. They could not review the demonstration without the teacher. Nor could they get professional help during practice as long as the teacher was occupied with another group.

“I found there were too many people. In this case, a teacher cannot observe exactly what the individual groups do.” (s15)

Forgetfulness and an insecure feeling: Multiple students mentioned that they quickly forgot what they learned after the course (s05, s07, s08, s09, s12, s15, s19, s25) and that they or their colleagues felt insecure about applying the movements during their practical work (s07, s08, s10, s16, s18, s24, s25).
“And then [what was learned during the course] is quickly forgotten, I might say, somehow. And then, because it falls into oblivion and no one can explain it again, one just puts it out of his mind.” (s08)

I would like to practice by myself, but how?: The students expressed an interest in self-directed education (s01–s03, s05, s07, s08–s11, s14, s15, s18, s20, s21, s23). Multiple students stated that further practice is necessary besides the course, to allow the application of the movements as part of their work.

“But there are many areas where in my opinion [the application of the learned patient-transfer movements] takes too long and one is not sufficiently trained. I think if one does [the movements] more often and gains confidence, then one is also faster.” (s16)

The students remarked that they lacked the support to practice by themselves (s08, s16, s19, s23), to refresh their knowledge (s04, s24), and to take what they had learned with them (s04, s08). Existing learning materials like books and notes are insufficient to effectively support students practice.

“You could not practice [the learned patient transfer movements] again at home or anywhere else.” (s08)

I would like to apply kinaesthetics transfers, but how?: Aside from the course students often lack the support of a person they can ask for help during their practical work. There are usually few teachers or trainers at health-care institutions who can support the students in learning and applying kinaesthetics transfers. Colleagues who have been employed as professional nursing-care workers for multiple years often cannot support the students, because they did not learn kinaesthetics as part of their education.

“I would not know who had kinaesthetics at the ward.” (s24)

Multiple students expressed their wish for better support to continue learning and to apply the movements from the course during their practical work (s02, s05, s08, s10, s11, s13, s16–s18, s21–s28). For example, one wished:

“That someone is there who always improves it when something is wrong.” (s11)

1. Support Self-directed Learning and Application

Our findings suggest that there is a lack of support in regard to the self-directed learning and application of kinaesthetics transfers. One teacher cannot continuously support all participants of a kinaesthetics course during practice. Furthermore, students lacked the support to practice by themselves as existing resources for learning are insufficient. Future technology should assist teachers during course sessions by supporting students while the teacher is occupied, help students to continue their learning after the course, and support students in applying the kinaesthetics transfers into practice.

An interactive procedure to teach kinaesthetics transfers: During the course sessions, we observed that teachers sometimes conducted sensory exercises with the students. Besides this, the teachers taught different kinaesthetics transfers. When teaching a transfer, the teachers usually followed an interactive procedure that can be separated in the three essential components: instruction, practice, and feedback.

Instruction: Typically a teacher first showed a kinaesthetics transfer by demonstration. During or after the demonstration, the teacher explained related theoretical concepts and informed students about potential pitfalls.

Practice: After the demonstration, the students typically came together in small groups of two to five persons to practice the kinaesthetics transfer. The students usually practiced the transfer multiple times.

Feedback: During practice, the teacher walked from group to group and provided individual feedback to the groups and participants. After the practical training, the teacher typically discussed the experience with the participants and provided further feedback.

Let’s do it again, or proceed: Sometimes the teacher repeated the exercise equally or with modifications.

In-course demonstrations are limited: The teachers typically selected one student from the participants to demonstrate a kinaesthetics transfer. This student acted as the patient and was transferred by the teacher while the remaining course participants observed and asked questions. We observed that the students were limited by their perspective of these demonstrations. All course participants were usually standing around the demonstration, each trying to see what was happening from their own point of view. Furthermore, demonstrations are usually only provided before practice or when the teacher visits a group during practice.

Interactive learning can facilitate understanding: We observed that teachers supported the practical training of kinaesthetics transfers in an interactive manner. One way in which they supported students was by demonstrating them a kinaesthetics transfer again (s06, s08, s15, s18, s19, s21, s25). Sometimes they also corrected students by showing problems and improvements (s04, s05, s07, s11, s14, s19, s20, s24, s25) or by physically moving parts of their body to guide their movements (s01–s04, s06–s08, s11, s14, s17–s21, s23, s25–s27). Such interactive support can facilitate students’ understanding.

“And then I pull them sometimes, for example at the pelvis or at the upper body, when I notice that they are standing
Teachers saw practical exercises as very important. Thus students’ self-experience and empathy towards patients (triadic process. Especially the role of the patient can increase students’ awareness regarding the patient, and all remaining group members surveyed the patient’s perspective. During training, one group member acted as the nurse who conducted the transfer, one acted as the patient, and the remaining group members surveyed the patient’s perspective of the movement. Eventually, our findings suggest that interactive support during practice can facilitate students’ understanding of the movements. Relatedly, previous research already found benefits from investigating interactive technological support for the learning of movements (e.g., [46], [38]). However, presently available materials for the self-directed learning of transfers (e.g., books) mostly lack any interactivity. The teachers saw it as important to foster students’ capacity and movement possibilities.

The experience to act as the patient during practice also helped students to better understand patients’ movement capabilities and movement possibilities.

"By then it was often clearer to me how the patient sometimes feels when one expects something from him. One cannot implement [a kinaesthetics transfer] if one cannot do the movement himself. If, for example, one is now the nurse and tells the patient 'Bend your leg here.' And then one pulls it, but it does not work in itself because one simply cannot do the movement. And that only became conscious the moment one acted as the patient." (s19)

You should “activate” the patient! Teachers also emphasized that it is important to foster in patients the desire to regain movement capability; this can help the patient to regain independence and at the same time reduce the load on the body of the nursing-care worker. Students were encouraged to “activate” patients, i.e., to motivate patients to actively participate during transfer movements.

“So when one turns on his side to stand up, one has an arm. The patient can use [his arm] to support himself. Then he can press up, and then he practically helps to sit himself up.” (t01)

Reflecting experiences can help to understand and improve: The teachers saw it as important to motivate students to reflect as this can help students to realize what happened and to improve their behavior in the future. For example, one teacher who encouraged students to reflect by writing their experiences down stated:

“If I can write it down, I can analyze it. And if I can analyze it, I can change it.” (t02)

Teachers frequently encouraged reflection: We observed, that after either a student or the teacher identified a problem, the
teacher often stimulated the student’s self-reflection by asking him or her about what he or she had just done. Sometimes this was connected with a request for self-assessment.

"Well then [the teacher] said first of all 'Yes, what do you have now... think about what you just did and whether that was properly applied.'" (s09)

We also observed, that teachers encouraged all participants of a course session to discuss a learned kinaesthetics transfer and their individual experiences after practicing it.

"So in the group, everyone just told what his experience was and the lecturer gave feedback." (s22)

In addition, we observed that the students reflected upon experiences by themselves, by discussing during or after the practice of a movement with their fellow group members.

I1: Support Reflection

During our inquiries, we identified the importance of reflection. Teachers frequently motivated students to reflect upon their experiences by individual talks, by asking students to write down experiences, as well as in the form of group discussions. Future systems should aid the learning of kinaesthetics transfers by encouraging students to reflect on their learning experiences. While traditional learning materials like books can provide general questions related to a kinaesthetics transfer, technology can go beyond this. For example, a future system could identify problems related to how two students conducted a practical exercise, by use of a tracking system and a classification algorithm. Such a system could provide students with support for reflection that is directly associated with the identified problems. However, when applying reflection, it is important to assure that there is appropriate guidance for the reflection process [27].

I2: Support Diversity and Realism

Our findings show that there are different ways to transfer a patient with kinaesthetics dependent on the patient’s condition and movement capabilities; e.g., transferring an immobile or mobile patient from a bed into a chair. Future technology that supports the learning of patient transfer movements should aim to provide support for a diverse range of patients and movements. Furthermore, our results suggest that the practice of transfers as part of kinaesthetics courses lacks in terms of realism. Students can only simulate diverse patient conditions in a limited fashion and typically have no stress or time-pressure when they conduct a practical exercise as part of a kinaesthetics course. As these differences can hamper the transfer of the learned movements into application, future technology should strive to help close this gap by providing more realistic support, thus facilitating an easier application into practice.

T3: Body and Movement

During the observed courses, teachers taught movements for different situations; e.g., these included movements to transfer a patient upwards in bed, or from a bed into a chair.

Real patients are diverse: Real patients are usually sick or impaired and often have a lower movement capability than nursing-care students. As the students in the course usually practiced kinaesthetics transfers with one student acting as the patient, the practice experiences were limited in terms of realism. This limitation can hamper the application of learned movements in the practical work.

"And [the application of kinaesthetics transfers] is really difficult to implement in everyday life, because one does not only have the patient one has in the training, but one has an overweight stroke patient. Thus it is difficult to individually care for the patient." (s27)

In relation, we observed that teachers sometimes showed different movements that might be used for patients with a higher or lower movement capability or a certain disease. For example, a different movement might be applied to transfer a patient form a bed into a chair if the patient cannot move by himself, than if the patient has dementia but is partly mobile.

Stress and time pressure: Multiple students mentioned that stress and time pressure are also an influence during their practical work which was not given during the course (s01, s02, s05, s07, s08, s12, s14−s18, s20, s22, s25, s27).

"During the course, one simply has a lot of time, and that is the main difference. That you just do not have that time when you are at the ward. Not always, but often you just have your head full with things you still have to do, and then you have this time pressure." (s12)

Theory can help to understand body and movement: We observed that teachers tried to communicate a theoretical substructure while teaching the movements. They saw it as important to go beyond just providing step-by-step instructions of how to pursue a kinaesthetics transfer. They extended their teaching with insights into the theory of kinaesthetics which helps to better understand the human body’s capabilities and provides a set of principles for the conduct of ergonomic patient-transfer movements.

"And for that I need the theoretical substructure, because in advance I have to understand: how does my own movement actually work. And if I have understood that, then I can help someone else, too." (t02)
The results of our qualitative investigation confirmed that to a technology like smart glasses [21]). To our knowledge, only considered part of the overall design space (e.g., specific transfer movements. Most previous research in this direction has several limitations. For example, students avoid the application of kinaesthetics transfers as they feel insecure and forget the movements due to a lack of practice and learning support. Interactive technology may help to address existing limitations and aid students learning. However, only few past research investigated technology for the learning of patient transfer movements. Most previous research in this direction only considered part of the overall design space (e.g., specific to a technology like smart glasses [21]). To our knowledge, a broad analysis of the design space for technology that supports the learning of kinaesthetics transfers is amiss.

Based on our findings we identified six implications to support the learning of kinaesthetics transfers by technology. Our analysis was rather broad, as it considered different situations like learning as part of a kinaesthetics course and aside from a course, and the opinion of teachers and students from different institutions. The implications can provide an overview of aspects that are important for technology to support the learning of kinaesthetics transfers. However, they do not provide detailed information about how each implication should be addressed for different situations and technologies. Instead, we propose to use them as initial design goals that provide a framing for iterative, user-centered design processes which lead to novel learning systems.

**A Concept to support Learning with Tablets**

In the following, we exemplify the use of the identified implications (I1–I6) by presenting mockups that depict a concept for a tablet-computer-based mobile learning system (see figure 2a–f). The concept was created by using the identified implications as initial goals for a user-centered design process. We focus on tablets as these are widely available, cheap and familiar to most nursing-care students. Tablets allow for interactive learning content and individual feedback that can adapt depending on students learning. They also facilitate mobile use, which provides students the flexibility to easily take materials with them. The resulting concept is reported along the mockups in figure 2a–f and related to the implications (I1–I6). The application of each implication is mainly described in relation to one of the mockups.

**Support Self-directed Learning and Application (I1).** The concept addresses a system for the self-directed learning and practice of kinaesthetics transfers by one or two students who already participated in a kinaesthetics course. Students can use the system at different places (e.g., at home or at school) to view kinaesthetics transfers and related information for different transfer purposes (see figure 2a). The system also supports the co-located collaborative practice of the transfers in the training room of an institution by two students. To do so the students can connect their tablets.

**Support Diversity and Realism (I5).** Students can freely select a kinaesthetics transfer they want to learn. The system not only supports the learning of patient transfer movements for different purposes (e.g., transferring a patient from a bed into a wheelchair), but also allows the learning of diverse ways to conduct a transfer for a selected purpose for patients with different movement capabilities (see figure 2b). The system supports the practice of two students together, one in the role of the **nurse** and one acting as the **patient**. Thus, the

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Sharpen your senses: To deepen the understanding of the human body in line with the theoretical principles, we observed teachers occasionally conducting sensory experiences.

“Then she always initially explained to us ‘Feel yourselves for once. Where are your masses? Where are the bones? Where are the soft parts?’” (s25)

**I5: Foster the Link of Theory, Body and Movement**

Our findings revealed the importance of encouraging students’ awareness regarding the human body and its movement capabilities. Interactive technology should foster students in developing the necessary understanding. To facilitate nurse-patient experiences (see I5) and to support reflection (see I4) can already help students to understand their own and patients movement capabilities better. However, to provide a complete picture, future technology should also incorporate the theoretical substructure that is used by the teachers in the kinaesthetics courses and create a strong link between this substructure and practical movement experiences. For example, technology could automatically provide information about theoretical principles as part of instructions, highlight important theoretical principles during practice and also relate to relevant theory when providing students with feedback. To deepen students’ understanding further, future technology may also provide support for the conduct of sensory exercises. However, especially when the aim is to foster the understanding of body and movement, future systems should also aim to avoid distractions on the body and eventually disappear by “weaving themselves into the fabric of everyday life” [44].

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**5 USING THE IMPLICATIONS FOR DESIGN**

In this section, we discuss how the identified implications might be used to support the learning of kinaesthetics transfers by technology. As part of this, we provide an example of how we applied the implications as initial goals to develop a concept for a tablet-computer-based mobile learning system.

The results of our qualitative investigation confirmed that the current support for the learning of kinaesthetics transfers has several limitations. For example, students avoid the application of kinaesthetics transfers as they feel insecure and forget the movements due to a lack of practice and learning support. Interactive technology may help to address existing limitations and aid students learning. However, only few past research investigated technology for the learning of patient transfer movements. Most previous research in this direction only considered part of the overall design space (e.g., specific to a technology like smart glasses [21]). To our knowledge,
practice is similar to the practice as part of a kinaesthetics course and also has the same limitations in terms of realism.

**Support Interactive Learning by Instruction, Practice, and Feedback (I₂).** Inspired by our observations during the kinaesthetics courses, when learning together, the students are guided along three phases: instruction, practice, and feedback (see figure 2c). As part of the phase instruction, students can interactively explore recordings of transfers, e.g., by viewing different movement steps, rotating transfers to change their visual perspective, or zooming closer to view parts in detail. The students can also view the visual recordings during the practice phase, while key information is represented in the form of short audio instructions. If two students practice together at the training room of an institution the system can be connected to a camera-based tracking system. Based on the tracking data, the learning system provides feedback.

**Foster the Link of Theory, Body and Movement (I₃).** The relation to the kinaesthetics theory is highlighted throughout all of the three phases instruction, practice, and feedback. The instructions on how to conduct the kinaesthetics transfers are split and represented in steps. For each step, theoretical information is provided to explain how specific parts of a movement should be carried out and which parts of a patients body should be handled in what way (see figure 2d). During practice, important theoretical information is provided as part of short audio tracks. The feedback information is also coupled with theory to clarify why identified problems are problematic and how they might be avoided in the future.

**Facilitate Nurse-Patient Experiences (I₄).** To increase the self-experience of students and their empathy towards patients, the system supports the practice of nurse-patient experiences. When students decide to learn and practice a kinaesthetics transfer together, they are asked by the system to occupy the roles nurse and patient. The user interface continuously reflects the role a student occupies (see top right in figure 2d–f) and the system adapts dependant on the occupied role. For example, the students receive different instructions and feedback. During practice, the students can place their tablets at a for them suitable position (e.g., on a night stand) and review visual recordings (see figure 2e). Furthermore, the system encourages students in the role nurse to “activate” the patient and provides audio examples for a correct nurse-patient communication as part of the instruction phase.
We focused our qualitative investigation on the learning of ways to support the learning of ergonomic patient-transfers without the risk to injure real patients. Additionally to their related to the movement capabilities of patients and nurses.

**Support Reflection (I₄).** To increase students’ understanding, the system encourages students to reflect upon their learning experiences as part of the phase feedback (see figure 2f). If the students learn in the training room of an institution, the posture of the student in the role nurse can be tracked by a previously installed camera-based tracking system. After practice, the system provides students with a video of their practice which is enhanced with an overview of detected problems in regard to the posture and behavior of the student who enacted the role nurse. Visual marks on a timeline allow the students to easily identify at what times the system detected a problem. For each identified problem, the students can rewatch their own performance. Additionally, the system provides the students with reflective questions they can ask to themselves or to their learning partner, as well as with the information why the problem is a problem and how it might be avoided in the future.

**Further Use as initial Design Goals & Subgoals**
Aside from the described concept, the identified implications might also facilitate the design of systems that make use of different technology. For instance, mixed reality technology could be used to create novel systems that allow for the “safe” learning and training of patient transfers. Students could learn in an immersive virtual world, with a realistic virtual nurse or patient in the future. This would open up the possibility to learn and, as part of this, practice realistic situations without the risk to injure real patients. Additionally to their potential use as initial design goals, the identified implications may help to reveal important subgoals that should be investigated. For example, in regard to a mixed reality system for the “safe” learning and training of patient transfers, I₄ implicates the need for realistic interactions between humans and virtual patients, as well as the related subgoals to (i) create virtual patients that allow the simulation of different degrees of movement capability and different symptoms, and to (ii) make such virtual patients tangible and behave naturally. Past research already took first steps in this direction (e.g., by providing haptics to walls and objects in virtual reality [26]) but still leaves ample room and need for further investigation of the exemplary subgoals.

**6 LIMITATIONS & FUTURE WORK**
We focused our qualitative investigation on the learning of patient-transfer movements based on kinaesthetics. However, we believe that our findings can also prove valuable for technology that aims at the support of ergonomic patient-transfer movements independent of kinaesthetics. Future research may extend our findings by investigating other ways to support the learning of ergonomic patient-transfers. Furthermore, current curricula also teach other concepts, related to the movement capabilities of patients and nurses.

For example, the bobath concept is frequently applied to facilitate the neurological rehabilitation of patients [9]. The nursing-care teachers we interviewed mentioned the concept as complementary to kinaesthetics. Future research may investigate to what extent different concepts should be combined and how technology can support their symbiosis.

Another limitation to our inquiries is that our data collection was conducted with a focus on Central European standards of education. Kinaesthetics is widely used in this context. All of the four participating institutions are located in Germany. However, the education related to ergonomic patient-transfer movements could be different at other locations. This aspect might be investigated by future research.

Although, we focused on the education of kinaesthetics transfers in Germany, for this domain our investigation was holistic. We included data from four institutions and participants with a wide range of age. Future research may extend our currently rather broad understanding of the design space by conducting further, more focused investigations of important subareas. The described themes and implications may serve as a starting point for such investigations.

We described a concept for a system which supports the learning of kinaesthetics transfers with tablet computers. As part of this work, we illustrated the concept in the form of mockups. We plan to report on the implementation and evaluation of such a system as part of our future work.

**7 CONCLUSION**
In this paper, we presented a qualitative investigation of current practices in the education of patient-transfer movements based on the kinaesthetics care conception. We conducted five interviews with nursing-care teachers, 27 interviews with nursing-care students and four contextual inquiries during kinaesthetics course sessions. By a qualitative analysis of the collected data we derived three relevant themes: “Learning and Application,” “Experience,” and “Body and Movement.” Based on these, we describe a set of implications that may be used as initial goals for user-centered design processes, in order to support the learning of kinaesthetics-based patient transfers by means of technology (see Table 1). Furthermore, we present a concept for a tablet-based learning system to illustrate the exemplary use of the described implications.

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REFERENCES


