

VITT — VIRTUAL TRANSFER TRAINER:
DESIGN AND EVALUATION OF A
VIRTUAL REALITY SYSTEM TO
SUPPORT THE SELF-DIRECTED
TRAINING OF ERGONOMIC PATIENT
TRANSFERS

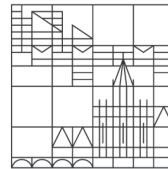
Master's Thesis

submitted by

Daniel Schweitzer

at the

Universität
Konstanz



Department of Computer and Information Science
Human-Computer Interaction Group

1. Reviewer: Prof. Dr. Harald Reiterer
2. Reviewer: Prof. Dr. Michael Grossniklaus

Konstanz, 2021

Copyright © 2021, Daniel Schweitzer: *ViTT — Virtual Transfer Trainer: Design and Evaluation of a Virtual Reality System to Support the Self-directed Training of Ergonomic Patient Transfers*

Department of Computer and Information Science,
Universität Konstanz

ABSTRACT

There is a high prevalence of musculoskeletal disorders among medical care professionals, in parts resulting from frequent patient transfers. The so called kinaesthetics care conception is a movement system to promote ergonomic patient-transfers, that both support the caregiver as well as the patient. The educational support structure for kinaesthetics is very limited in Germany, as only limited resources are allocated. This issue extends into, and is afflicted by, a general shortage of medical care professionals in Germany: there are not enough nurses, which affects the quality of work and their own health. This also impacts usage of kinaesthetics during every-day work. There are not enough instructors, which affects the education of students and potential re-education. The last part of this vicious cycle is a high number of students, who abandon this education as a result.

A virtual reality learning application may help nursing students to partially overcome these difficulties by providing a readily available and immersive training environment, without the need for instructors or training partners. Research into existing work regarding virtual reality, immersion and learning effects has been done, which led into the creation of a concept for such an application. It has been iteratively created, making use of information gathered via concept walkthroughs from a kinaesthetics instructor as well as three experienced nurses of varying ages. Finally the concept has been iteratively implemented and partially evaluated. A pilot study has been executed, revealing well-functioning as well as critical areas of the application. Within the limits of a pilot, results were mostly encouraging for a theoretical full-fledged usability study, though one important area has shown lacking robustness. Based on this, sensible changes and additions have been made to the implementation.

KURZFASSUNG

Unter Krankenpflegern und Krankenpflegerinnen sind Beschwerden des Bewegungsapparates verbreitet. Diese resultieren teils aus häufigen Patiententransfers. Die sogenannte Kinästhetik ist ein Bewegungssystem, das ergonomische Patiententransfers ermöglichen soll, und das sowohl den Pflegenden als auch den Patienten unterstützt. Die Lehrstrukturen sind für die Kinästhetik in Deutschland begrenzt, da nur wenige Ressourcen bereitgestellt werden. Das Problem der Ressourcenknappheit spannt sich über den ganzen Sektor, denn es gibt zu wenige Pfleger und Pflegerinnen, was letztlich Rückwirkungen auf die Lehre hat. Die Auswirkungen sind unter anderem gesundheitliche Beschwerden bei Pflegenden, Pflegende, die die Kinästhetik nicht gewinnbringend einsetzen können, und Auszubildende, die ihre Lehre wegen zu geringem Rückhalt abbrechen; es ist ein Teufelskreis.

Eine Lehranwendung in Virtual Reality könnte Pflegende dabei unterstützen diese Schwierigkeiten teilweise zu bewältigen, indem eine ständig verfügbare immersive Übungsumgebung bereitgestellt wird, ohne dass ein Lehrer oder Übungspartner benötigt würde. Forschungsarbeiten zu Virtual Reality, Immersion und Lerneffekten wurden als Basis für die Erstellung eines Konzeptes, für solch eine Lehranwendung, herangezogen. Das Konzept entstand auf iterativem Weg, unter anderem unter Nutzung von Design-Walkthroughs, mit einem Kinästhetiklehrer und drei Pflegenden. Auch die darauf folgende Implementierung verlief iterativ. Sie wurde teilweise evaluiert. Eine Pilotstudie wurde durchgeführt, die gut funktionierende, aber auch kritische Teile der Anwendung, offenbarte. Innerhalb der Grenzen eines Piloten, waren die Ergebnisse, im Hinblick auf eine vollständige Usability-Studie, größtenteils positiv, wobei ein bestimmter Bereich fehlende Stabilität zeigte. Als Folge wurden sinnvolle Änderungen und Erweiterungen implementiert.

PREVIOUS WORK

Previous work was done in the master's seminar *Investigating Immersion for the Self-Directed Learning of Patient-Transfer Movements in Virtual Reality* and subsequent master's project *ViTT (Virtual Transfer Trainer): A Virtual Reality System to Support the Self-Directed Learning of Ergonomic Patient-Transfer Movements*. The literary research during the master's seminar resulted in a set of requirements, which informed the design and implementation of a VR prototype application later during the master's project. The design and implementation cycle was strongly iterative. Those works, the seminar and project, will be referenced in this master's thesis.

CONTENTS

LIST OF FIGURES [vii](#)

LIST OF TABLES [viii](#)

1	INTRODUCTION	1
	1.0.1	Proposal & Related Work 3
	1.0.2	Research Contribution 6
	1.0.3	Research Questions & Outline 7
2	CREATION OF VITT	8
	2.1	Requirements 8
	2.1.1	Scenarios 8
	2.1.2	Requirements Drawn From Context 11
	2.1.3	Requirements Drawn From Related Work 12
	2.1.4	Requirement Summary 15
	2.2	Concept & First Prototype 15
	2.2.1	Ideation, Sketching & Iterative Design 16
	2.2.2	Design Walkthroughs 21
	2.2.3	Hardware Analysis 24
	2.2.4	Final Concept Design & First Prototype 28
	2.3	Second Prototype 33
	2.3.1	Features & Workflow 33
	2.3.2	Provided Code and Resources 46
3	STUDY DESIGN	47
	3.1	Evaluating ViTT 47
	3.1.1	Determine the Overall Goals 48
	3.1.2	Explore the Specific Questions 48
	3.1.3	Choose the Evaluation Approach and Techniques 49
	3.1.4	Identify the Practical Issues 53
	3.1.5	Decide How to Deal With Ethical Issues 54
	3.1.6	Evaluate, Analyze, Interpret, Present 54
	3.1.7	Variation Using Computer Science Students and PhDs 55
	3.2	Pilot Study 55
	3.2.1	Results, Discussion & Consequences 55
4	FUTURE WORK & CONCLUSION	57
	4.0.1	Future Work 57
	4.0.2	Conclusion 61
	BIBLIOGRAPHY	63
	APPENDIX	69

LIST OF FIGURES

Figure 1	Kinaesthetics care conception	1
Figure 2	Example kinaesthetics patient transfer	2
Figure 3	ViTT: overview both modes (crop)	3
Figure 4	Martial arts VR practise	5
Figure 5	KiTT: overview workflow	6
Figure 6	Lea, nurse	9
Figure 7	Joachim, a nurse in training	10
Figure 8	Aspects related to immersion	14
Figure 9	Final refined requirements	15
Figure 10	Getting the right design and getting the design right	16
Figure 11	Sketch: transfer guide	17
Figure 12	UI development history	17
Figure 13	Sketch: interaction	18
Figure 14	Concept state diagram	19
Figure 15	Sketch: wireflow prototype	20
Figure 16	Sketch: walkthrough interaction	21
Figure 17	Hardware: Valve Index	26
Figure 18	Hardware: ManusVR	27
Figure 19	Lipsync	29
Figure 20	Setup: overview	30
Figure 21	Setup: menu	31
Figure 22	Control center UI first prototype	32
Figure 23	Final patient rendering	33
Figure 24	UI: information board	35
Figure 25	UI: control center	35
Figure 26	UI: button press feedback	36
Figure 27	UI: repeat button	37
Figure 28	UI: information board position	38
Figure 29	UI: control center UI rotation	38
Figure 30	ViTT: mode 2 overview	39
Figure 31	ViTT: mode 2 video	40
Figure 32	ViTT: mode 2 transfer step X to step X+1	41
Figure 33	ViTT: patient highlights	42
Figure 34	ViTT: tutorial overview	44
Figure 35	ViTT: tutorial steps	45
Figure 36	ViTT: mode 1 and 2 overview	51
Figure 37	Evaluating UX	53
Figure 38	CaregiVR	61

LIST OF TABLES

Table 1	Hardware analysis overview: VR HMDs.	24
Table 2	Hardware analysis overview: hand-tracking technologies.	26

1

INTRODUCTION

German medical care staff suffer from notorious mental and physical stress.[35, 4] In general, there is a high prevalence of musculoskeletal disorders among nursing staff.[62, 7] They frequently need to physically help patients who are not able to move freely on their own anymore. This entails for instance transferring them from a wheelchair into a bed. One can imagine, that in many instances, this is hard work for the nurse. Such physical stress, when afflicted by on a regular basis, may lead to lower back pain.[58, 56] These difficulties might increasingly occur when they are in a hurry or when there are not enough colleagues available to help because of the general shortage of nurses.

Kinaesthetics[2] is supposed to reduce physical stress for both the nurse and the patient by enabling more ergonomic transfers. In the therapeutic sense, it is a system comprised of nurse and patient, communicating and working together with the goal of a transfer, that is as safe as possible for both parties. At its core, it is about awareness of ones abilities. See figure 1 for the general idea.



Figure 1: A diagram showing the vision behind kinaesthetics (cropped). It is a system designed to facilitate safe ergonomic transfers between a patient and caretaker. The paradigm is to make use of the patient's current capabilities and the immediate surroundings.[2] (Maietta-Hatch-Kinaesthetics: <https://kinaesthetics.com>, <<https://www.bewegungskompetent.com/>>).

For instance, transferring a paraplegic patient from a wheelchair onto a bed could look like shown in figure 2. The patient is still able to move his upper body, thus he is also able to support his own body weight to a degree, helping the nurse in the process. Both are part of the transfer, needing to communicate with each other and being aware of each other's abilities.



Figure 2: Kinaesthetics-based transfer of a patient from wheelchair to bed (cropped). Sequence of actions from top left to bottom right in reading direction. The nurse firstly is transferring the weight of the patient onto her steady knee and then secondly rotating the patient on this knee onto the bed. The nurse did not need to lift the patient. She shifted the patient with his help. The patient's weight rested on the nurse's knee during the transfer (Schweizer Paraplegiker Vereinigung, <https://www.spv.ch/__/frontend/handler/document/42/2772/Transfer_von_Personen_im_Rollstuhl_d.pdf>).

This concept is taught only once as a workshop usually in Germany, which is split into three non-consecutive days. Seasoned nurses may never have received training in kinaesthetics¹, as its popularity only grew stronger over the last 10–20 years.[3, 1] Educational support for learning ergonomic patient-transfer movements is very limited.[14] Additionally, there is a general lack of employees [35], which results in more mental and physical strain, as the patient-per-nurse-ratio has become increasingly large. This leads to a vicious cycle, where not enough empty job positions are filled with new nurses and where many existing nurses do not want to continue working in this field. The issue is underlined by current reports during the SARS-

¹ Two seasoned nurses working at Klinikum Konstanz explained to the author during an interview, that they originally did not receive training in kinaesthetics. One of them took part in a course once after the fact by his own accord. See the design walkthrough later in 2.2.2.

CoV-2-pandemic.[17] This shortage extends into education, where students may not receive the support they might need. As a result, students may feel ill-prepared or abandon their nursing education.[66, 43] One German hospital created a position in late 2019 solely for supporting students for that reason.[15]

To combat a portion of the aforementioned limiting situation, the prototype application *Virtual Transfer Trainer (ViTT)* (see figure 3) has been created as part of the foregoing master's project, while research into related and relevant concepts has been done in the master's seminar before that. This master's thesis has been used to further implement multiple features, fine-tune various facets of the experience, design a usability study, and conduct a pilot.

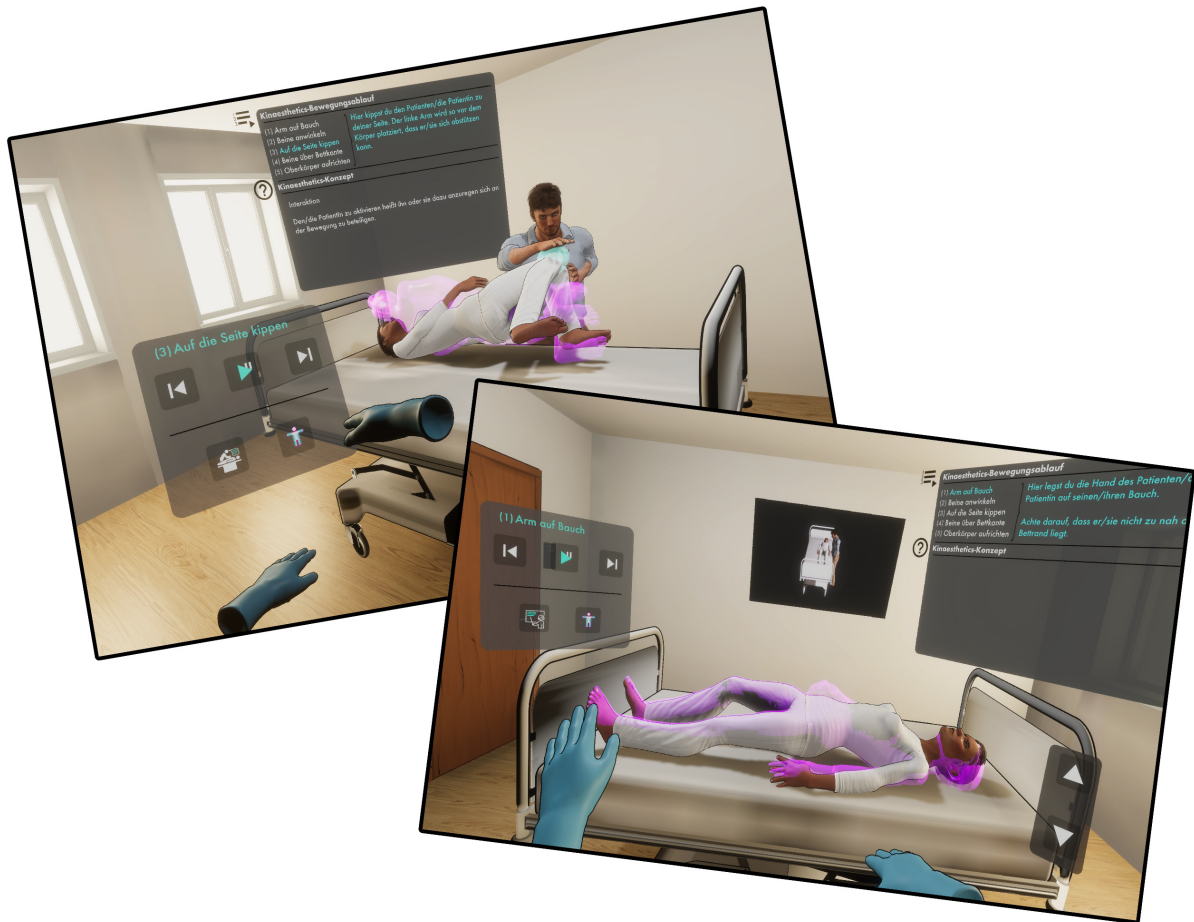


Figure 3: A quick look at ViTT, a VR application prototype designed to support the self-directed learning of patient-transfer movements.

1.0.1 Proposal & Related Work

Broadly speaking, ViTT is a prototype application in the space of learning movements and underlying concepts in VR. It leverages state-of-the-art consumer VR technology to deliver an immersive two-phase training environment. ViTT consists mainly of two modes or phases: (i) a mode where the user can observe a virtual patient transfer and (ii) a mode where the user can train a patient transfer in VR by him- or herself, all while making use of several virtual enhancement features, that help and guide the user (specifics

are shown in the next chapter). It has been, however, motivated by, and thus is purpose-built for, the training of ergonomic patient-transfer movements on basis of kinaesthetics. This puts ViTT into the more specific space of VR training in nursing education.

An immersive educational platform for the self-directed learning of patient-transfer movements could potentially provide support for students as well as already educated caregivers who are in need of additional guidance in the kinaesthetics care conception. Using an immersive virtual reality (VR) system as a learning platform could be beneficial for nursing students, as previous work has shown promising improvements in learning performance. For instance, Gutiérrez et al. have shown an enhanced effect of knowledge structure improvements in VR versus on a desktop monitor: medical students profited more from a virtual first responder training exercise when being immersed in VR.[26] Sweeney states a need to embrace simulations of any kind, including virtual technologies, for teaching medical students in *“Teaching Surgery to Medical Students”*. [59] Cummings and Bailenson write in their meta-analysis, that *“greater levels of immersive quality [...] [enhance] the effectiveness of a mediated experience.”* [12]

Very recently, Woon et al. found in their meta-analysis, regarding the effectiveness of VR training in nursing education, that *“[VR] may be a viable teaching strategy to improve knowledge acquisition, but it is presently suitable for supplementing convention teaching methods.”* [73] They found it most efficient when teaching procedural knowledge to nursing students when conducted in multiple, self-guided, and short sessions of up to 30 minutes, while being little to moderately immersed. Similarly timely, Cheng et al. conducted a related meta-analysis.[11] They found, that *“VR education methods can improve nursing students’ knowledge.”* The other investigated areas skills, satisfaction, confidence, and performance time, did not show differences to traditional teaching methods. They also suggest using VR to supplement other teaching methods.

However, Weiß et al. found in their respective meta-analysis, that many previous works use VR as a somewhat unspecific term pertaining simply to *“anything computer based.”* [69] They then differentiate between *immersive* and *non-immersive* VR as it is used by some authors, regarding whether a head-mounted display (HMD) is used or not, and they argue that *“a convergence in terminology is required,”*² following Milgram’s *virtuality continuum*. [41] Consequently, they only included VR applications using an HMD in their analysis, and only found ten, that fit their criteria. Only one of those ten focused on *psychomotor skills*. The paper stems from Butt et al. [8] They developed a VR application, using unspecified hardware other than an HMD and *“interactive gloves,”* to exercise urinary catheterization. While usage and participant ratings showed great promise, follow-up skill demonstrations did not show a difference to the control. Lastly, Fealy et al. looked for (immersive) VR systems as well. [18] They, however, looked specifically in the fields of tertiary nursing and midwifery education. After two rounds of screening, two articles were the result of their search. One is the aforementioned paper by Butt et al. [8], while the second one comes from Kilmon et al. [34], which explores VR with an *“application targeting speed and accuracy of nurse response in emergency situations requiring cardiopulmonary resuscitation.”* Kilmon et al. concluded VR to be fitting for simulation-based nursing education. Fealy et al. finally conclude, that the topic of VR in tertiary nursing and mid-

² In this thesis, VR means immersive VR using an HMD. Yet, *immersive* VR is mentioned in places. This phrasing is meant purely as an emphasis on immersion.

wifery education is in need of more high-quality published literature, and that there is high potential in this field.[18]

What about less specifically related work? For instance, Takala et al. created a martial arts training system with full-body interaction in VR (see figure 4).[60] The user seems to be completely tracked, aside from the fingers, as the prototype seems to use normal VR controllers.



Figure 4: An immersive VR martial arts training application.[60]

Other recent work comes from Senecal et al., where they implemented and evaluated a VR salsa dance practise simulator.[55] A virtual dancing partner was present in VR with the participants, who they lead through the dance steps by using timed gestures, that triggered the dancing partner. In Senecal et al.'s evaluation they found non-dancers improved in their performances, converging to a more uniform profile, more similar to more experienced dancers.

The other way around, not directly related in its technological execution, but highly related in its topic, Dürr et al. created *KiTT*³, a tablet-based AR application to promote the learning of ergonomic patient transfers based on kinaesthetics (see figure 5).[13] It supports the self-directed learning in three phases: (i) *interactive instructions* provide step-by-step information and a 3D-animated view in AR of pre-recorded kinaesthetics transfers, (ii) *training of transfer conduct* guides two nurses (acting nurse and training partner) through a transfer step by step, and (iii) *feedback and reflection* provides feedback for the just executed transfer. Dürr et al. conclude, based on their evaluation with nursing-care students, that their system provides a good user experience, good subjective learning support, that it can promote ergonomically correct patient transfers, and that it would be desirable to integrate *KiTT* into existing nursing education.

³ It comes at no surprise, that *KiTT* and *ViTT* are somewhat related. Although they have not been developed together, *ViTT* was influenced by *KiTT* and was allowed to use some of the same assets from project ERTRAG[16] as the virtual models, their animations and the transfer instructions.



Figure 5: An overview of KiTT's workflow, a tablet-based AR application to support the learning of ergonomic patient transfers based on kinaesthetics. The application is divided into three phases: (i) *interactive instructions*, (ii) *training of transfer conduct*, and (iii) *feedback and reflection*.^[13]

Of course, related work, pertaining to specific design directions and decisions therein, has been explored during the master's seminar and project. A summarized version is shown later in the next chapter, when covering ViTT's requirements.

1.0.2 Research Contribution

The goal of this thesis is determined as the proposal of an immersive VR application, ViTT, tailored for self-directed studying of patient-transfer movements on basis of the kinaesthetics care conception. The proposal is presented by means of summarizing efforts, which led to the status quo of the application, as well as a study design for its evaluation. ViTT is a prototype application and is based on a design-driven conceptualisation. It includes the basic techniques or tools to manifest a snippet of the vision, that started this project.

As has been explored above, there is a distinct lack of VR applications in the space of nursing-care. It could be concluded as well, that well-designed applications using the virtual space in general can be a helpful teaching tool in medical care. The constantly improving, and still emerging, sector of VR poses as a great opportunity to tackle issues in current nursing-care education and play a supporting role.

Trying to categorize ViTT's contribution, it seems to most closely fit the definition of an *artifact* according to Wobbrock and Kientz.^[72] ViTT does not

solve the crisis in nursing-care. Instead, it acts as a prototype display of possibilities for further research in the field. KiTT already has shown concrete promise for integration into nursing-care education.[13] ViTT tackles related problems in a different manner, trying to facilitate self-directed patient-transfer training without a real-life exercise partner. Additionally, the base for a potential future empirical contribution has been laid by means of the study design (see later in chapter 3 *Study Design*).

1.0.3 Research Questions & Outline

The following research questions have been posed, to be studied within the context of ViTT:

- R1 Does a system like ViTT provide a high user experience?
- R2 To what extent can a system like ViTT promote the learning of Kinaesthetics for the ergonomic transfer of patients?
- R3 How can a system like ViTT integrate into and extend conventional practices to support the learning of Kinaesthetics?
- R4 To what extent is the virtual patient used in ViTT a good surrogate for real patients and for human-simulated patients that are used in partner exercises?

This thesis summarizes previous efforts of the foregoing master's seminar and master's project, and partly evaluates the prototype application, which has been created as a result of both, within a constrained envelope. This envelope was given by the on-going prevalence of SARS-CoV-2 and its effects on interhuman contacts, thus not allowing for the originally planned study. Nonetheless, a usability study has been devised, planned, and executed by means of a pilot in a save manner. Its results have been used to further fine-tune the study design and prototype application. Time, that would have otherwise been used for executing the study, has been used to expand the implementation, as will be detailed later in chapter 2 *Creation of ViTT*.

The outline is as follows: chapter 2 *Creation of ViTT* encapsules everything, in a highly summarized and organized fashion, that has been done in the master's seminar and project, in mainly chronological order. Thus, it will show the refined set of requirements generated in the master's seminar, the path to the final concept from the master's project together with parts of the implementation from the project, and then introduce the status quo of the application, after additional work during the thesis. Moving on, the following chapter 3 *Study Design* is concerned with designing a study around the posed research questions, using the prototype application, and discussing the pilot study, that has been conducted. Lastly, chapter 4 *Future Work & Outlook* serves as a hypothetical look at future work in relation to enhancements for ViTT, and a very concise look back over the complete development timeline of ViTT.

2

CREATION OF ViTT

The master's seminar's goal was to create requirements, that guide the development of a concept for ViTT. Afterwards, in the master's project, those requirements were presented in a refined compact manner, in order to show the reader the foundation for creating the concept, which led into the prototype's implementation.

This chapter aims to do both. It portrays a summarized version of the requirement-finding process, the concept creation, and subsequent implementation of ViTT, to *paint the full picture*. It aims to show a concise, yet coherent, path, that led to ViTT, from beginning to end of development.

2.1 REQUIREMENTS

Starting from the beginning, in the early stages of development during the master's seminar, a general use case had been envisioned by becoming familiar with the topic. Originating from it, two personas had been created. The first one, Lea, is modelled after a nurse, who is acquainted with the author, and shared her experiences. The second one, Joachim, is based on the difficult situation nursing students are faced with.

2.1.1 Scenarios

General high-level context-based requirements have been extracted from the following scenarios.

Lea the Nurse

Lea (see figure 6) is a 33 years old nurse working at a German hospital. She is a bit shorter than the average German woman at roughly 1.62 m. She has an average build, has two children and is married. Her day-job at the hospital is taxing both mentally and physically. Always on her feet, she has to care for at least 20 patients by herself. For her the most intense part is helping older mostly immobile patients out of bed into their wheelchair within certain time constraints. She usually needs to hurry immediately to her next patient. Patients come in all sizes, so Lea does need to lift and transfer heavy patients. There are certain natural weight limits up to which she can handle the transfer, even when making use of kinaesthetics. "Around 70 kg," she says, is the heaviest she could handle alone, if patients cannot move by themselves or just to such a small extend, that it would not be of any help. If they are heavier than that, she would ask colleagues for help or the patients would need to stay in bed or their wheelchair for the time being.



Figure 6: Nurse Lea, helping an elderly woman to stand up. She laments lower back pain, working in the hospital (rawpixel.com, freepik, <https://www.freepik.com/free-photo/nurse-helping-senior-woman-stand_2997326.htm#page=2&query=caregiver&position=15>).

Once her shift is over she goes shopping, picks her children up from kindergarten and drives home. At home, she cares for her children, cooks, plays with them and cleans the apartment. Time for personal activities like reading or sports and exercise is very rare, as other daily tasks creep up on her.

From time to time she laments lower back and knee pain — something her older colleagues suffer from a lot. If a patient is particularly difficult to transfer and she is under pressure, she tends to hurry and does not take the necessary precautions anymore the correct application of kinaesthetics would need. Workshops to refresh these techniques are offered externally though medical care staff would need to attend on their own time and pay by themselves. She does not attend those workshops and knows no colleagues who ever did.

The concept of kinaesthetics needs to be second nature. It might be helpful to have a way to review and train them more spontaneously and more often. It might also be of value if her older colleagues, who never received dedicated training in kinaesthetics in the first place, could receive support for ergonomic patient-transfer movements.

Joachim the Trainee

Joachim (see figure 7) is 19 years old, obtained his general qualification for university entrance in Germany (*Abitur*) and travelled around parts of eastern and western Asia for a few weeks with some of his friends. He was taken by the scenery but mostly impressed by the different cultures and social structures. Families of multiple generations living together, everybody caring for each other and immense poverty. Those are impressions, that Joachim did not get in Germany. He knew his elderly grandfather needed additional health care but it was difficult to come by. From German news he

knew, that the situation for both the needy and the nurses was precarious. Back home, inspired from his trip, he decided to become a nurse himself.



Figure 7: Nurse in training Joachim, being stressed by the structures of the health-care education system (katemangostar, freepik, <https://www.freepik.com/free-photo/stressed-young-man-suffering-from-headache_3629826.htm>).

Months later, Joachim is in the midst of his education. He still aspires to be a caretaker for the elderly. His conviction is to help in this sector as much as he can. There are not enough nurses, for those nurses there is too much work, the pay is not adequate and there are not enough trainees graduating. Joachim wants to help out because he sees the impact first hand on his grandfather who would need more professional help.

Unfortunately, the effects of missing funds are obvious as well in the educational process. There are not enough qualified teachers and the support structure for trainees is lacking greatly, according to Joachim.[66, 14, 43] He needs more guidance especially in exercising kinaesthetics.

He took part in a three-day kinaesthetics course, but it was lacking in realism. It was always clear, that it was training and not “real” with his fellow trainees. They never even pretended to be in a real situation, lacking simulations of different narratives.

In the hospital, instructors do not have enough time for repetitions, while most older experienced nurses did not have dedicated kinaesthetics training at all. As a result, Joachim feels very insecure when it comes to the application of kinaesthetics on real patients.

It could be helpful for Joachim and his fellow trainees, if they had means to repeat especially the practical parts of the training. During routine check-ups the educator shows Joachim what he has to do in certain cases hands-on, but there is no time to do it slowly or to answer many questions, as the educator is on duty him or herself and needs to rush to the next patient. Reiterating for example on kinaesthetics could make sense, as we know from persona Lea, that an incorrect application can lead to health issues for the practitioner and might also potentially unsafe for the patient. Like Lea,

they would need the possibility to train and reiterate on these techniques spontaneously.

2.1.2 Requirements Drawn From Context

From the foregoing scenarios, or rather the context they represent, the following high-level requirements have been extracted. RQ2 and RQ3 have been supplemented with some relevant related work during the master's project.

RQ1 FLEXIBILITY Flexibility is a mostly hardware-based requirement owing to current constraints of VR hardware. Consumer hardware is still constrained by compulsive trade-offs as mobility versus tracking capabilities or mobility versus rendering power. Stand-alone self-contained VR devices, which could be used virtually anywhere, like the Oculus Quest [46] or similar devices, have to house their processing hardware inside the device itself, hence having big constraints in processing capabilities. Devices which make use of external processing, like the Valve Index [65], need to be connected with this external processor. With the help of the low latency of the starting 5G mobile standard, untethered distances between VR device and processor potentially may be virtually endless, although the technology has not reached its potential yet.[70] While *traditional* tethered VR devices still deliver, generally speaking, the best experiences, more and more mobile devices launch. For instance, the new Oculus Quest 2 [47] (not yet available world-wide), just got an update that enables wireless connection to an external processor. That means, although the Oculus Quest devices have everything built-in, you may not only connect a cable to a much more powerful PC to use as the processor, you now may also connect said PC wirelessly. There is then only one more, albeit large, step missing: wireless connections to external processors over a network, for instance through the aforementioned 5G technology.

RQ2 COMMUNICATION Communication¹ between the virtual patient and real user should be facilitated for greater realism, which in turn may increase learning benefits through heightened immersion. This may include aspects important to the kinaesthetics care conception, as for instance information about the patient's restricted range of movement, due to injury. In kinaesthetics, communication between all persons involved in a transfer is rather important. Not only may the patient communicate his or her current state of well-being, but the medical care professional may also communicate the current step of the transfer. Additionally, missing communication may result in an uncanny feeling, depending on the overall implementation of the virtual human.[22]

RQ3 NARRATIVE AND BEHAVIOUR Narratives may support the story-telling of the virtual scene and be used to induce feelings of empathy in the user, in turn again improving on the immersive experience. Patient behaviour must not be omitted either in this context. This may include reactions, through facial expressions or words, in response to user actions. Behaviour is part of the portrayed narrative. Behaviour implicitly tells a story about the acting (virtual) person, part of the narrative.

¹ Communication here means verbal communication. Non-verbal communication by other means is covered in RQ3 as *behaviour*

Designing the virtual scene as realistically as possible can establish cognitive empathy (“Almost Real Live Technique,” as per Fisher [20]). Fisher states, “*within these role plays, connecting decisions to embodied movement and actions has helped participants conceptualize perspectives and develop unique, synthesized value systems.*” VR experiences in general may enhance active listening, social problem solving and emotional empathy.[20]

Milk made use of VR as a medium for story-telling and produced a VR-showcase located in a refugee camp, that aimed for the viewer’s empathy. [42] He calls VR “*a machine[,] that makes us more human.*”

RQ4 USABILITY Usability [27], as an integral part of user experience, should be high for an application that is designed to be used in real-life scenarios by real-life medical care students and professionals:

- Ease of use, learnability and error avoidance are important, otherwise the system would not be used and is useless. If the learning curve is too steep the risk is high, that many users would not try using the application.
- Efficiency, productivity and retainability are important, otherwise there is perhaps too little training progress and the system would not be used anymore. The target audience are people with a notoriously low amount of time, so there needs to be an obvious benefit for the the users.

Of course, stating that usability should be high is not necessary. It is however important to also keep it in mind during development. Certain design decisions and feature creep may have an unexpected impact. In the end, usability can not be completely separated from the other requirements. Although obvious, usability has to be at the forefront of concept and development. As seen later in the last phases of development, the final prototype of ViTT has been simplified a bit during the thesis. This was done as a measure to better ensure that study participants would be able to quickly learn the ins and outs of ViTT. For more details see 2.3 *Second Prototype* as the last part of this chapter.

These context-based requirements get detailed and constrained by the following aspects of *VR learning environment propositions, Aspects related to immersion* and *Motor learning in 3D environments*.

2.1.3 Requirements Drawn From Related Work

In chapter 1 *Introduction* some related work has been presented. Those were related applications or analyses of the space. Following, related work is mentioned, that has been used, during the master’s seminar, to directly inform the high-level context-based requirements RQ1–RQ4 from the previous section. It was a top-down process, firstly looking at broadly defined abstract needs, which then became refined by specific related work. The aim was to get a foundation on which to build the concept design and implementation.

RW1 VR LEARNING ENVIRONMENT PROPOSITIONS Schwarze et al. [52] set out to create a rough guideline for creating learning experiences in VR. More than just the visual sense should be stimulated, for instance aural and haptic.

Distractions from the current task should be kept to a minimum. Immersion, or rather measures to increase immersion, should be used mindfully, as there might be situations of too much immersion. For instance, a user might want to sit on a virtual chair, while in real-life there is none, and consequently might get hurt. Additionally, the application should focus on conveying implicit outcomes and knowledge, for example knowledge about procedures. Research from Nazir et al. [44] somewhat implied a similar result, when they looked at different approaches to teach participants a set of steps to repair a power plant, although it was not in VR but traditional 3D as known from the cinema. Participants, which saw the process done by a professional beforehand, including explanations about the importance of certain steps, fared much better in learning it than participants, which got a theory lesson and a “guided tour.” A guided tour was a run through the steps with helping highlights through the system. No additional teacher was present.

These aspects are generally important for usability (RQ4) but also for communication (RQ2) as well as patient behaviour (RQ3).

RW2 ASPECTS RELATED TO IMMERSION Immersion in itself and its manipulation was the core of the analyses of the master’s seminar. As such, it receives special attention in the following. The understanding about immersion comes mostly from Slater’s work.[57] Other central parts played Cummings’ and Bailenson’s meta-analysis of the interaction between presence and immersion [12], as well as Calleja’s description of *immersion as absorption* [10], which was called psychological immersion in the master’s seminar.

Immersion can be divided into the sub-parts *technological immersion* and *psychological immersion* (for a diagram of the following summary see figure 8). While the former is a description of purely objective hardware and software attributes, as for instance display resolution and lighting model, the latter is the subjective side. It is the psychological engrossment someone may feel when using any kind of medium (a video game, a book, a movie et cetera). *Presence*, the feeling of *being there* in a specific place, may be in interplay. It stands as a separate entity, though it both is affected and does affect immersion. As per Slater: “[*technological immersion*] provides the boundaries within which [*presence*] can occur.”[57] The greater the technological immersion, the greater the possibility that the user is able to feel a sense of presence. The better the technology (hard- and software), the higher is the chance for a user to be so immersed that a feeling of presence occurs.

As an extension, *plausibility illusion* may result in a sense of believability of what is portrayed within the application, helping overall immersion.[57]

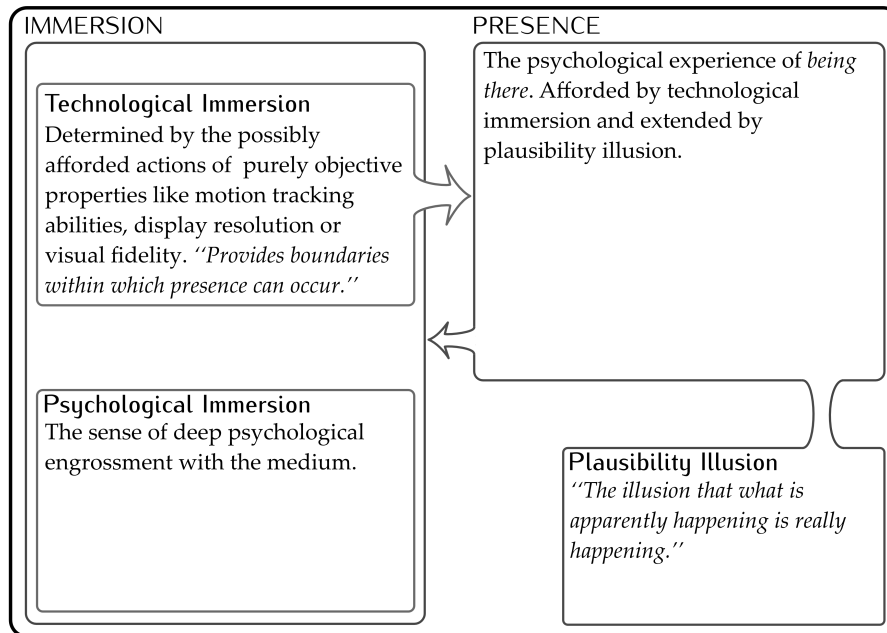


Figure 8: Immersion, presence, and plausibility illusion. Immersion may be broken down into technological and psychological immersion. Technological immersion, the objective fidelity, provides boundaries within which presence can occur. As long as presence exists, plausibility illusion may act as an extension of it. Presence feeds back into the structure of immersion.

Of utmost importance is a consistent level of fidelity, mainly concerning visual and behavioural attributes. The uncanny valley is an effect of sudden discomfort when confronted with usually a realistic computer generated or modified display of a human. Just one minor inconsistency in a seemingly realistic portrayal may be enough to cause discomfort.[53] The defect could be so small, that it does not jump out immediately as evident but rather a subconscious feeling, that something is *wrong*. As Brenton et al. write, human eyes have been identified as a major contributor. Even subtle imperfections within a realistic rendering may quickly cause an uncanny feeling.[5]

The same principle also applies to the behaviour. It comes down to anticipations, that different people have about certain attributes and features and how these anticipations are met by the rendering. Those anticipations become more intricate the more realistic the display aims to be. A toon-style cel-shaded rendering does not evoke the same anticipations and dangers of the uncanny valley as a photo-realistic rendering might. For instance, participants had uncanny sensations in a condition of Garau et al.'s study [22] where they expected a different behaviour from NPCs. Consistently low quality attributes end in a more positively received display than a mixture of high and low quality.[6] Consistently high quality is preferable but only if consistency could be guaranteed. This is an important conclusion drawn in the master's seminar.

As such, consistency is critical for the implementation of context-based requirements RQ2 to RQ4. It is critical for all requirements, that are software-based.

RW3 MOTOR LEARNING IN 3D ENVIRONMENTS Previous research from Pomplun and Mataric has shown interference effects. They discovered, that for an imitation of arm movements, participants performed substantially better, if they firstly concentrated on observing the movement and only then tried to imitate it.[38] Research from Nazir et al. adds, that each important step should be meaningfully explained.[44] Only after the user internalized the displayed movement, including knowledge about the importance of certain parts, repetition should be attempted for better learning effects.

This should be done to increase the usability (RQ4) of the system.

2.1.4 Requirement Summary

Firstly, context-based requirements had been extracted from example scenarios (RQ1–RQ4) and secondly requirements from related work (RW1–RW3) had been used to refine, expand and constraint those first high-level context-based requirements (see figure 9).

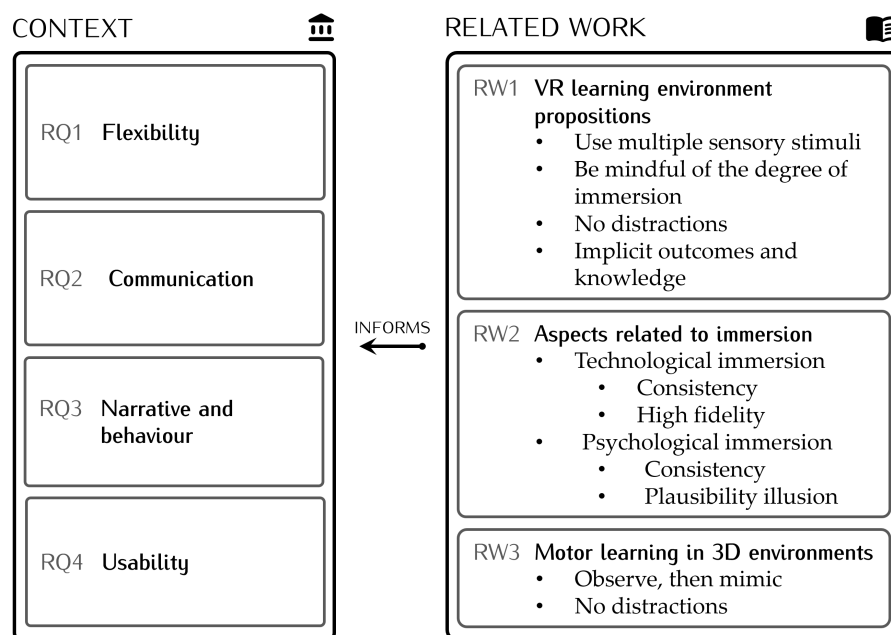


Figure 9: Requirements for a VR prototype for supporting the study of ergonomic patient-transfer movements. The implementation of broadly defined context-based requirements (RQ1–RQ4) get informed by separate more specific requirements from related work (RW1–RW3).

This was the foundation on which the concept had been constructed as the first major part of the master’s project. That concept and the subsequent first prototype implementation is presented in the following.

2.2 CONCEPT & FIRST PROTOTYPE

This section shows the process of creating the concept for ViTT in a condensed form. The more elaborated version has been shown as part of the master’s project. The following, however, does display essential components more carefully and detailed as before.

As is stated in *The UX Book 2*[30], design begins with a system concept statement. So firstly, a system concept statement will inform about the vision of the finished application.[29]

SYSTEM CONCEPT STATEMENT ViTT is a virtual reality application for the self-directed learning of patient-transfer movements (kinaesthetics) for medical care students as well as professionals. This application provides access to a virtual kinaesthetics training simulation with a virtual instructor and a virtual patient. It delivers an immersive multi-sensory (visual, aural, haptic) training experience for effective learning and recapitulation of patient-transfer movements.

Musculoskeletal disorders are a prevalent issue in medical care. This results from patient transfers amongst other straining physical activities. The correct application of the kinaesthetics care conception is supposed to enable save patient transfers but currently medical care students do not receive enough support during their education. Those students, as well as professionals, should benefit from the possibility of the spontaneous repetition and training of kinaesthetics in virtual reality, as it enables a safe and more readily available training environment.

2.2.1 Ideation, Sketching & Iterative Design

Following Buxton[9], early sketching and ideation has been performed to *get the right design* (see figure 10 top) and build a solid basic fundament on which to create later iterations by *getting the design right* (see figure 10 bottom).

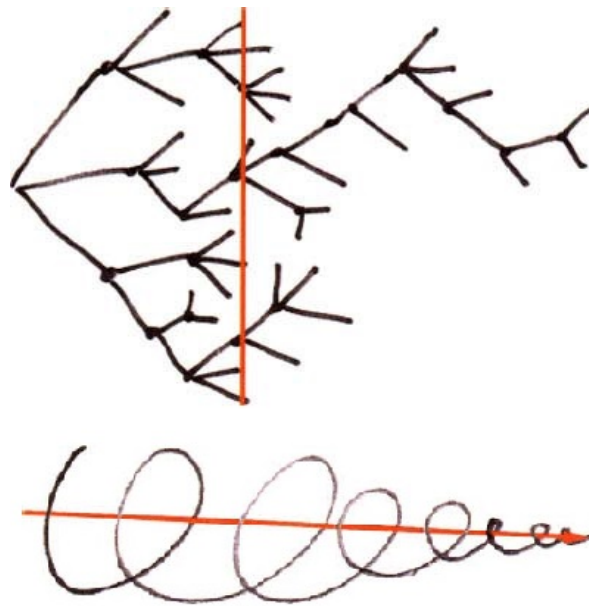


Figure 10: Considering many different possible ideas and directions by branching out in the beginning design phases (top), to then iteratively refine a design until a satisfactory state is reached (bottom). [9]

There have been various brainstorming sessions. Initially, they were a search for different design and implementation paths (see for instance figure 11), as well as interaction paradigms (see for example figure 13). Later

on, they were for instance used to create and iteratively detail a general workflow (see figure 14).

This was not only done during the concept phase but naturally also during the implementation, seeing as for instance even very particular elements as the specific design and feedback mechanisms of UI elements have gone through multiple major revisions (see figure 12).

Jumping ahead in time to the planning of the study, an informal precursor to the pilot study has been conducted with an HCI student (27 years old, male), which provided hints for the study design and another opinion for the, at the time, current prototype. Resulting, the information was taken into consideration for the next iterations of study design and prototype implementation.

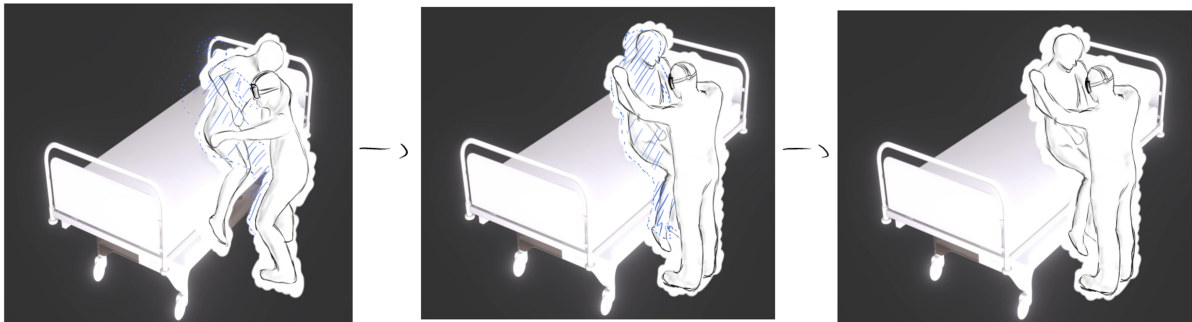


Figure 11: A sketch of a virtual helper feature: when performing a transfer, the goal end position of the patient for the current step of the transfer is displayed as a translucent outline of the patient model (shown here in blue). When the user (displayed with HMD) moves the patient to the correct position the system marks the step as solved and starts the next one. When the patient is moved to nearly the correct position, the model snaps into place.

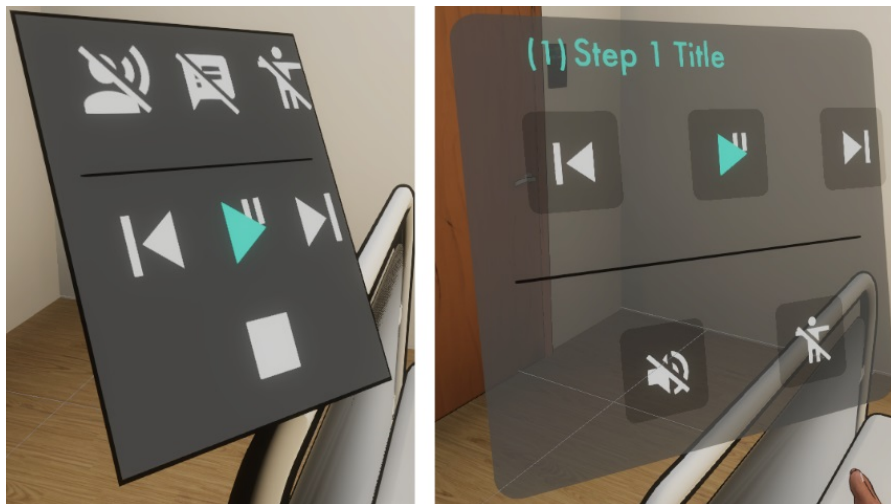


Figure 12: The state of the UI at the end of the master's project (left) and the status quo after another extensive iteration (right). Ease of use and robustness has been enhanced greatly, the overall aesthetic is more akin to modern mobile interfaces, more icons have been created, and the feedback mechanism has been modified (not visualized here, but seen later in 2.3 *Second Prototype* figure 26).

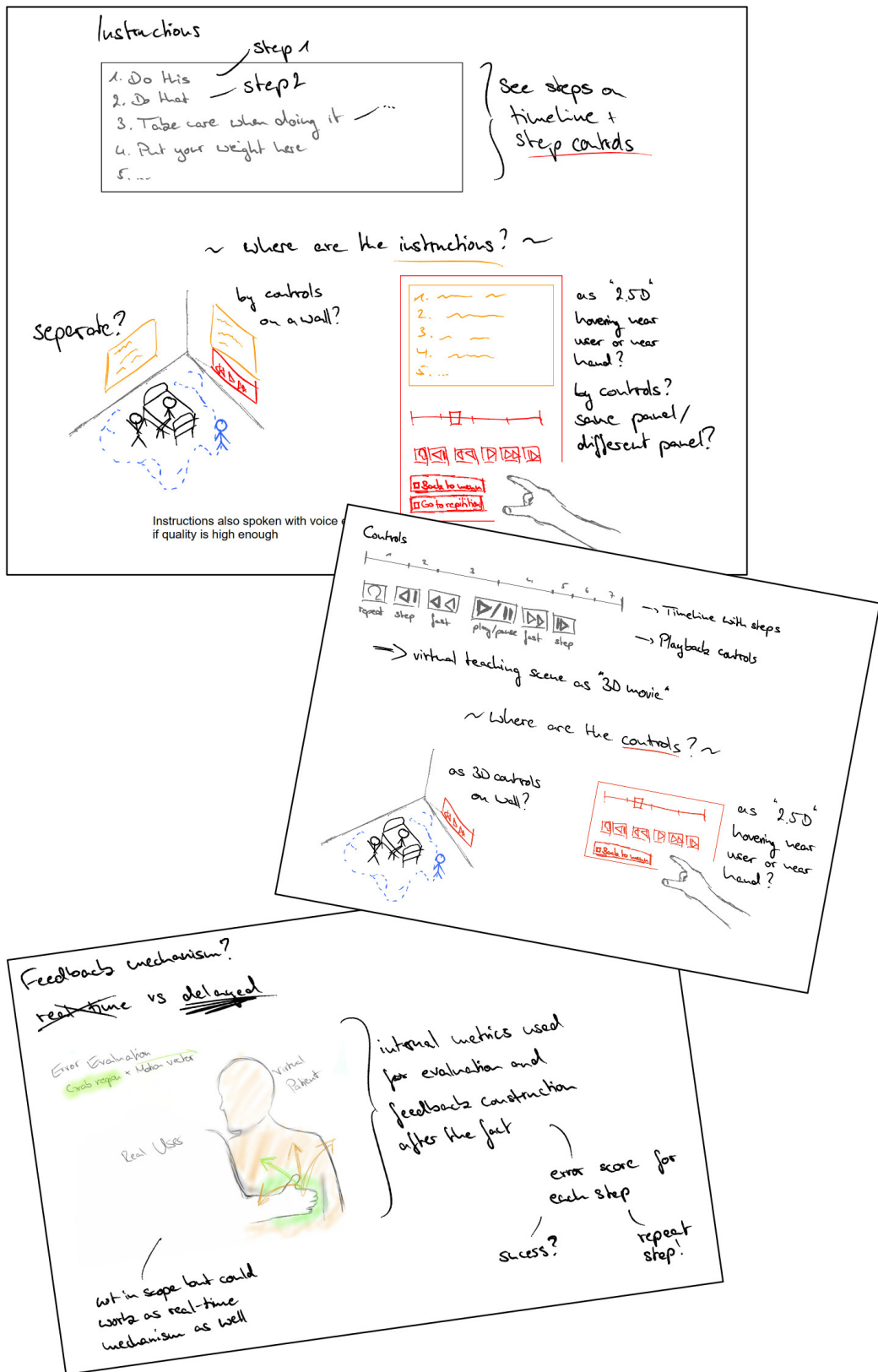


Figure 13: Some sketches while and after brainstorming interaction ideas for room design, static and interactive UI, and potential feedback mechanisms.

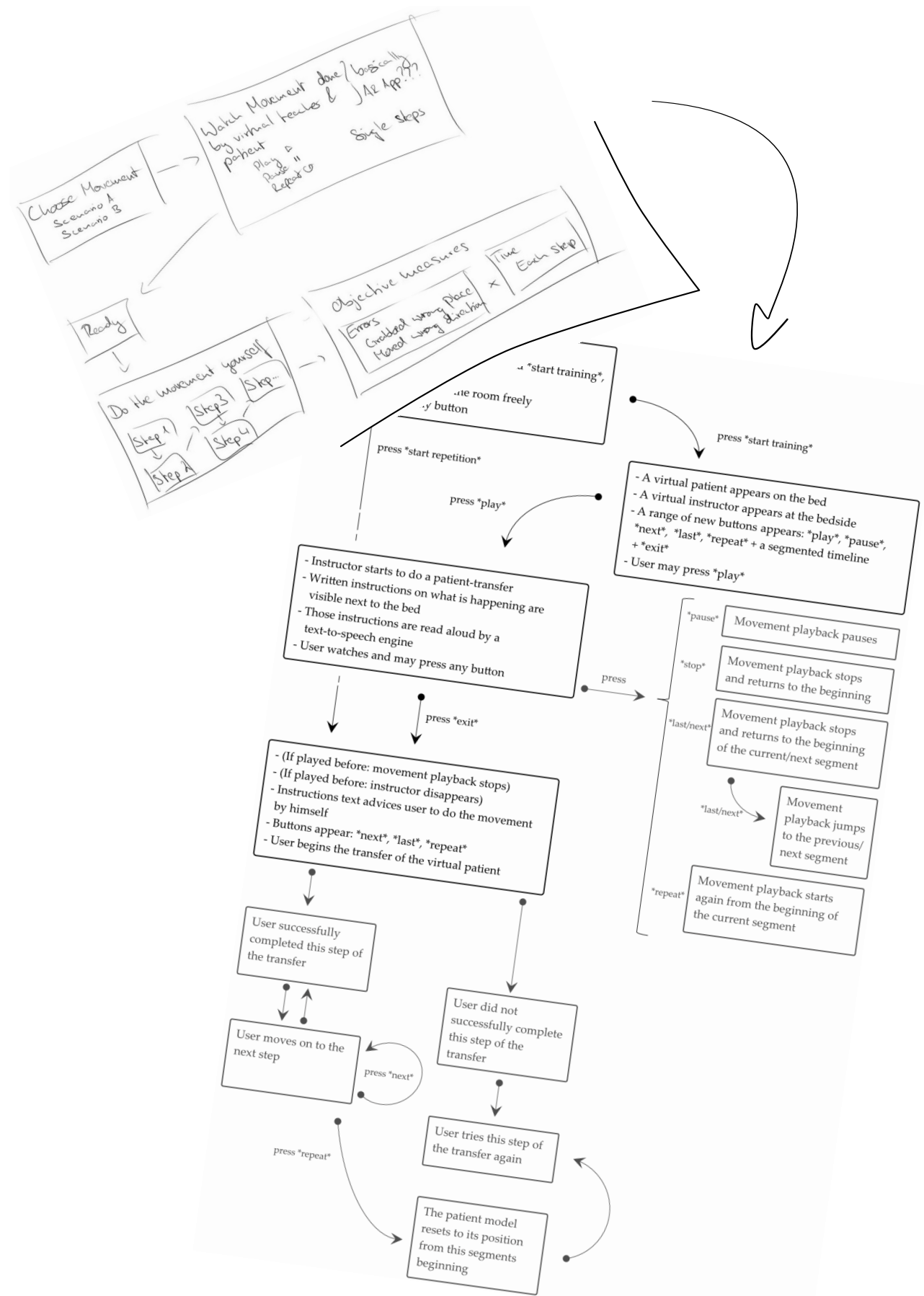


Figure 14: A sketched abstract state diagram of the application to display its different steps and functions (top), and a concept state diagram after a few iterations where the complete core workflow is facilitated (bottom).

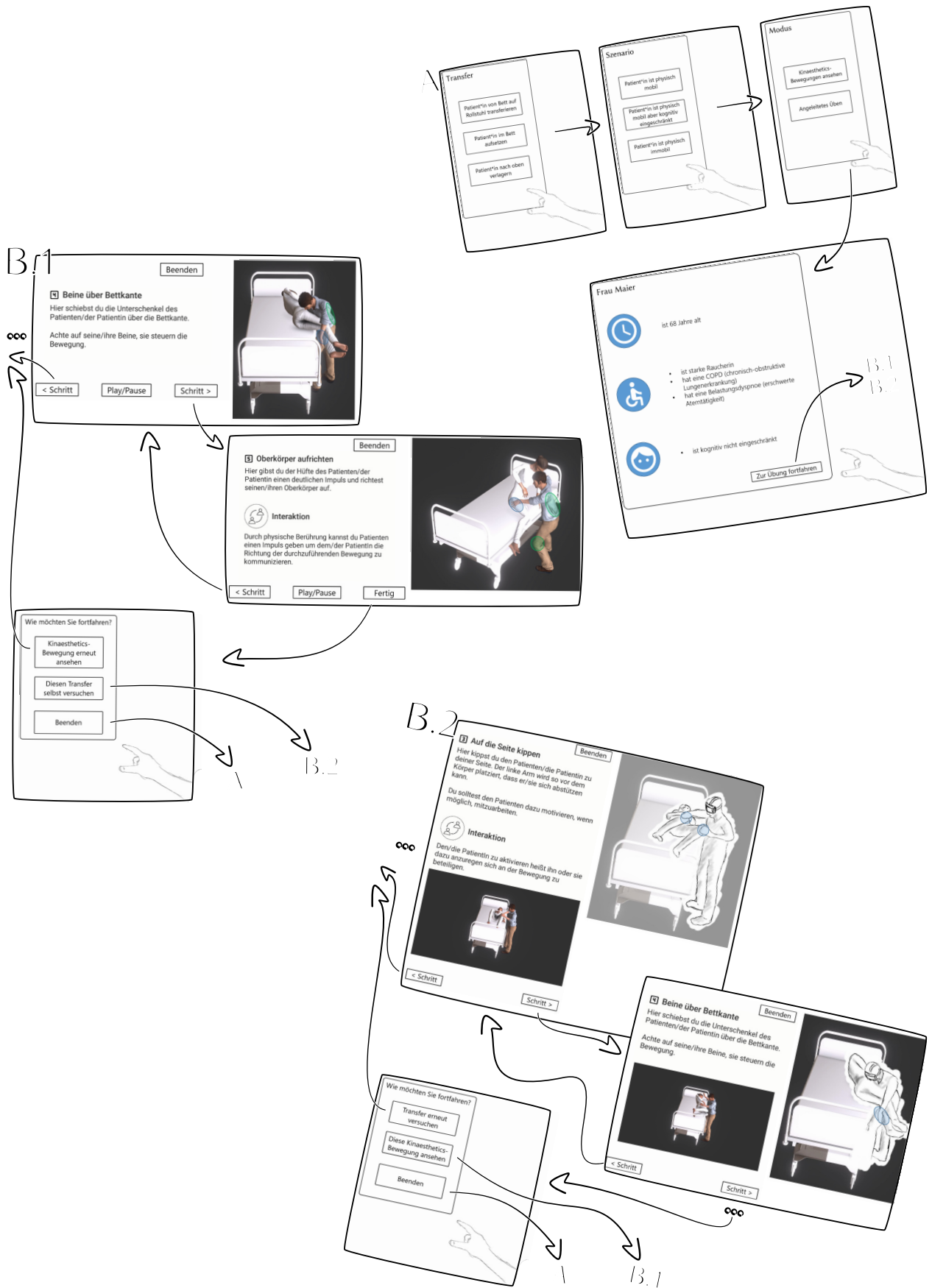


Figure 15: This is a sketched wireflow. It was used for the design walkthroughs (without the arrows, they are just present for the sake of illustration).

Towards the end of the concept phase, wireflow prototypes had been sketched (see figure 15). These were then also used for two design walkthroughs, to further refine the concept. One set of walkthroughs was conducted as a first iteration (a walkthrough with multiple experts). Some improvements had been made to the design and questions, leading into a second iteration later on (a walkthrough with another expert). Those walkthroughs are described in detail in the following section.

2.2.2 Design Walkthroughs

As part of the master's project, design walkthroughs had been conducted. Design walkthroughs (or cognitive walkthroughs) are a useful tool to gather potentially crucial information for the development process. A concept or prototype is presented to an expert or target audience, step by step thinking through the workflow and its functions. As the walkthrough consists of sketches, wireframes and similar approximations, the UX designer/walkthrough conductor has to be active during the walkthrough and simulate the back-end.[28] This simulation was actually done with a PowerPoint presentation and various hyperlinks, which were operated by the author.

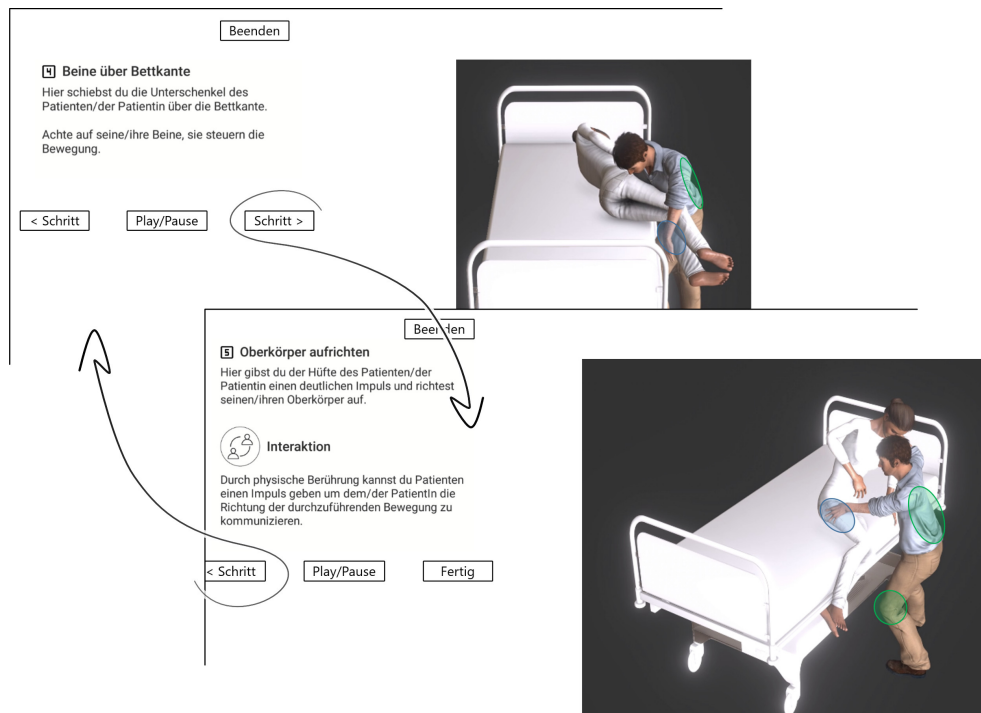


Figure 16: Two different slides from a design walkthrough (upper slide shows step 4, lower one step 5). On the left hand sides is the transfer step number, some instructions and buttons. These elements would be displayed in another fashion in VR, though they had to be displayed in planar view for the walkthroughs. On the right hand sides there is an approximation of the 3D scene with additional elements to show functionality.

Slides were filled with a depiction of the virtual scene and UI elements. Those UI elements were hyperlinks to different specific slides of the presentation, showing the corresponding result from clicking the specific UI element beforehand. In this manner, a click-through prototype was created, as seen in figure 16, which shows two different slides from the PowerPoint

prototype. When pressing for example the *Schritt* > or < *Schritt* buttons it would alternate between two steps of the simulated system and thus those two displayed slides. Pressing *Beenden* brought you back to the initial menu simulating a system restart.

Planning and Execution

The author is acquainted with three medical care professionals, working at Klinikum Konstanz. One young but already experienced female nurse (31 years old, working in nursing-care for 12 years and knows kinaesthetics also for 12 years), one female seasoned nurse (57 years old, working for 25 years in the current nursing-care position, does not have knowledge in kinaesthetics) and one seasoned male nurse (61, working for 38 years in nursing-care, took an optional kinaesthetics course 12 years ago). The opportunity presented itself to perform a first walkthrough, using an intermediate concept, with those acquaintances. Later on, there was another opportunity to perform a second walkthrough with a seasoned kinaesthetics instructor (63 years old, 40 years experience with kinaesthetics and teaching it for 35) working, but also teaching, at Klinikum Konstanz (Gesundheitsakademie). This allowed for unique insights to inform the refinement of the concept and laid bare areas of high importance but also a lot of opportunity for future work.

The walkthrough with the acquaintances was easily planned and executed. All three of them participated one after another and gave very valuable input, especially during the semi-structured interview. However, the second walkthrough with the kinaesthetics instructor took a bit of effort from both sides, as the pandemic was already present by then and permission was needed to enter the Gesundheitsakademie. Nonetheless, it was possible to meet the instructor at the Gesundheitsakademie and conduct the walkthrough.

The walkthroughs were constructed like a small-scale study with all the usual documents like an introductory briefing, a questionnaire, a consent form and a semi-structured interview (see the documents in the appendix [A.1–A.5](#)). Participants did not receive any compensation but were happy to help. The sessions were recorded in audio. All-in-all, there are roughly 4.5 hours of audio files. Significant information has been transcribed.

Findings

Resulting from these walkthroughs important insights were gained. Following, findings are ordered by topic.

BED HEIGHT The initial aspect that was mentioned by the first participant was already a feature that directly influenced the concept and subsequent implementation: the very first step in a transfer is, that the nurse adjusts the height of the bed, according to her or his own height as well as the type of transfer. The guideline is to adjust the height of the bed or other working area to hip level. This was incorporated into the prototype and even the tutorial as an important first step.

As Dürr et al. also revealed very recently in their evaluation of KiTT, many nursing students forgot to properly adjust bed height and did so even though KiTT provided feedback for the issue.^[13] They suggest the implementation of a more dominant warning system for future systems.

GUIDING MECHANISMS The general idea of immediate feedback was deemed to be important by most participants, as to not learn and train something that is wrong.

The visual guiding features ideas were generally very well received. The feature where the respective end position per step is visualized was especially praised by two of the three working nurses and even more so by the kinaesthetics instructor (see figure 11 before). It might portrait something very important in kinaesthetics, according to the instructor, and that is a physical direction for this step of the transfer. One of the nurses highlighted, that the patient snapping into place is a good idea, as each patient is different, meaning the transfers progress differently each time either way.

GENERAL REMARKS The general idea of the application was deemed to be good and useful by all participants. This includes the core features like the movie-like controls, feedback, and guiding mechanisms. The audio feature was also rated positively. The instructor particularly liked the possibility of “*ultimate liberty*” regarding training the already studied transfers. It was added, that having gathered experience with ViTT, before working with real patients, could lead to “*exorbitantly high learning effects and feelings of validation.*” First contact with patients, after kinaesthetics training, seems to be always “*very disillusioning*” according to the instructor.

Such an application like ViTT could not replace *real* training on patients though, most participants remarked. In addition, the example transfer in ViTT was rated as an unrealistic case simply for the purpose of training. For most patients, the transfer is hard due to added difficulty through illness or other aspects. All participants mentioned patients, who do not want to be transferred, which also can result in very difficult transfers. This underscores general limitations of the current technology and especially ViTT. Yet, it seems like a good first step or auxiliary training method to the participants, maybe even substituting traditional unrealistic parts of the kinaesthetics course. Limitations are obvious, especially regarding an actual realistic depiction of a patient transfer. These and other limitations are further explored in the *Future Work* sections below and at the end of this master’s thesis.

FUTURE WORK The following is put under the umbrella of *future work*, as none of it is realistically solvable within the scope of ViTT. However, this information seems to be extremely valuable for actual future work, as a project with a development team and resources behind it. It will also be explored in a bit more detail in the last chapter of this thesis in 4 *Future Work & Conclusion*.

A lot of information was given concerning the every day working situation and general hardships with respect to patient transfers and kinaesthetics. These interviews highlighted again some of the difficulties medical care professionals face each day, which was outlined in the introduction, and thus the necessity for creative solutions in this space.

Crucially though, they also pointed out difficulties of every day work, which either do not translate into a virtual simulator, like weight or secretions of patients, or are out of scope for this project but offer extension possibilities for future work, like simulating surgical drains as movement is

then vastly restricted and transfers would have to be adapted². One participant had the idea of a difficulty setting.

Influence on this Concept

After those walkthroughs, how did they influence further concept design and subsequent implementation? Generally, it showed what the experts saw as important, speaking from experience, and what new ideas they were fond of. From this, it became clear, that the concept was generally in a good place, within the envelope of the scope. A lot of ideas and crucial features for future work also is not bad in any way. It shows a lot of potential for this space.

Further work then, directly resulting from this, was put in the implementation of a feature to set the bed's height. This includes a separate transfer step and intuitive controls, as seen later in this chapter. Additionally, focus was set on an easy-to-use prototype. As mentioned, ViTT cannot be a system right now, where a hyper-realistic patient transfer could be trained. It is a system to increase the general knowledge and become more confident in kinaesthetics skills. Thus, it was seen to be best to focus on fewer features (the features they liked the most) and to make those robust.

2.2.3 Hardware Analysis

Moving on, the following presents the summary of the hardware analysis from the master's project.

HARDWARE Concerning hardware choices, there have been a few between various VR HMDs and ways of tracking the users' hands. The intricacies of that comparison are not relevant anymore within the scope of this thesis.³ However in the following, the overview tables, created as part of the master's project, containing the different hardware choices, and very concise argumentation, are shown.

Table 1: This table shows various VR HMDs, that have been considered for development and respective criteria.

VR HMD	Display	Tracking	Additional Thoughts
HTC Vive Pro	1440 x 1600 pixels per eye (2880 x 1600 combined, Pentile) @ 90 Hz / AMOLED / 110°	Outside-in	A very good HMD similar to the Valve Index with a far higher contrast ratio and better reaction times. Everything else is a step back. A wireless adapter is available.

² It has been explained by all participating professionals, that many patients do have some drains or other hindrances attached to them where then a normal transfer is simply not possible anymore.

³ If desired, please see the hardware analysis in the master's project report in chapter 4 *Implementation*, page 24 and following.

Valve Index	1440 x 1600 pixels per eye (2880 x 1600 combined, RGB) @ 144 Hz / LCD / 130 °	Outside-in	An excellent HMD similar to the Vive Pro with less screen-door ⁴ effect (RGB matrix), thus an effective higher resolution, a higher refresh rate and wider field of view. Contrast is worse as it is an LCD screen. No wireless adapter available yet.
Pimax 8k X	3840 x 2160 pixels per eye (7680 x 2160 combined, RGB) @ 75–90 Hz resolution dependent / LCD / 200 °	Outside-in	Can be used as a SteamVR HMD and is compatible with Vive Pro and Valve Index controllers. According to early reviewers there is no screen-door effect present anymore and the field of view is very wide, albeit with significant distortions. The low refresh rate is very bad for immersion, and display contrast is low. No wireless adapter available.
Oculus Quest	1440 x 1600 pixels per eye (2880 x 1600 combined, Pentile) @ 72 Hz / OLED / 100 °	Inside-out	Very present screen-door effect, very high contrast but rather low refresh rate display. Inside-out tracking works very well. A good HMD but low processing speed. Inherently wireless. For development, a wired mode to an external workstation is available.

For this prototype at least, a stationary VR device of universally good qualities seemed to be the best choice, although a wireless devices with inside-out tracking would be desirable as a future development platform.⁵ The Valve Index was chosen as primary hardware target platform (see figure 17). Although, as many other HMDs work with SteamVR and the same tracking technology as well, it could theoretically just be switched out later.

⁴ The so called screen-door effect describes a result of the display's pixel matrix. Pixels consist of sub-pixels. In VR HMDs manufacturers use normal RGB or also pentile matrices, as was popular in smartphone displays. Pentile matrices use some sub-pixels for multiple adjacent pixels, thus lowering the effective resolution and fill-rate. The screen-door is a description of the pixel pitch pattern you see (German: "Fliegengittereffekt"). [71]

⁵ In the beginning of development, a very basic implementation of the application has been tested on the Oculus Quest HMD. The performance was not at all sufficient. By now the more powerful Oculus Quest 2 was released, which is a potential candidate for future work.



Figure 17: The Valve Index is a versatile advanced HMD for VR applications (Valve, <<https://www.valvesoftware.com/de/index>>).

Table 2: This table shows different hand tracking technologies, that have been considered for development and respective criteria.

Technology	Tracking	Feedback	Additional Thoughts
ManusVR data gloves	Glove with inertia and finger bending sensors / SteamVR Vive tracker	Vibration motors on top of each finger and on the back of the hand	Good tracking and relatively accurate translation of finger bending, but fingers are not actually tracked, only their bending angle is recognized (i.e. no spreading). The vibration motors do a good job of simulating virtual touch, it does add to immersion.
Dexmo exoskeleton gloves	Glove-like exoskeleton for your hands with inertia and bending sensors / SteamVR Vive tracker	Each "exofinger" is attached to a servo motor, which can lock and pull, thus providing resistance	Looks very promising, although additional vibration motors might be helpful for certain cases. This device could not be tested, though early reviewers do find positives and negatives about interacting with it. [45]
Oculus Quest hand tracking	No additional physical device needed / HMD front-facing cameras	/	Hand recognition works well and quite consistent, although it was a bit jittery at the times of testing. The lack of any physical feedback, as you also would have with a simple controller, is negative.

Leap Motion hand tracking	Small mobile leap motion device needed, hands are recognized in small area in front of it	/	Leap Motion tracking does usually also work well, although as is the case with the Oculus Quest, there is no physical feedback mechanism at all.
---------------------------	---	---	--

It was clear, that there is a need for haptic feedback for the user's hands to provide a maximum of amount of (technological) immersion in this area. Only few products are on the market and the author was lucky, as he got access to the ManusVR gloves, by courtesy of the HCI department (see figure 18). What ManusVR delivers with their gloves is, when well enough implemented, subjectively a good experience that does indeed immediately add to the immersion. One does feel more grounded and *present* in the virtual world. Virtual objects get a certain *physicality, a tangibility*, through per-finger haptic feedback when touching them.



Figure 18: The ManusVR Prime Haptic gloves offer hand tracking and per-finger haptic feedback primarily for VR applications (ManusVR, <<https://manus-vr.com/>>).

SOFTWARE Concerning software choices, Unity was a rather obvious choice. The development environment for VR and small-scale games or gamified applications often is Unity[63]. Unity has come a long way over the years and can be considered, even in the high-end segment, as a nearly fully-fledged alternative to other well-established game development engines like the very popular Unreal Engine[21].

The used IDE was Rider by JetBrains[33], which is a C# editor with excellent Unity integration.

The character models and their animations were created with iClone and Character Creator by Reallusion[49]. These were created beforehand as part of another project at the same HCI department within *Projekt ERTRAG*[16],

KiTT[13]. Usage of those models and pre-recorded transfer animations was granted for the development of ViTT.

2.2.4 Final Concept Design & First Prototype

At the beginning of this chapter, two layers of requirements have been presented. Four context-based and more abstract requirements (RQ) and subsequently three further detailed requirements, stemming from related work (RW). The latter informed the former, filling the more abstract RQs with design directions. Now this section looks back at the requirements and shows some corresponding parts from the implementation of the first prototype. It has been sorted and grouped by context-based requirements, while inside the specific description of RQ1–RQ4 the detail-providing RW1–RW3 are set into context.

The following shows a marriage of select parts of the final concept, its relation to the requirements and the parts of the implementation of the first prototype of ViTT, as was the status quo at the end of the master’s project.⁶ To stay in scope and in order to not repeat too much information unnecessarily, a complete description of ViTT will only be given in the next and final section of this chapter (2.3 *Second Prototype*).

The purpose is to conclude this first part of the chapter, the concept and subsequent implementation of ViTT’s first version, to then lead over to the enhanced implementation and overhauled features of ViTT’s current state. The additional implementation phase was part of the master’s thesis. At the end of this chapter, one should have a complete picture of ViTT and its rationale from ideation to concept, and to its final iteration.⁷

RQ1 Flexibility

Flexibility is a hardware-bound requirement. It extends into three attributes: the system should be flexible with regard to the deployment in various real-life spaces, for instance a living room at someones home or a training room in a facility. As long as there is no dedicated training room for this exact purpose, the system should be able to be set up in various locations with little effort. Lastly, the system should be flexible while using it. It should make sure that the user does not get hindered by certain idiosyncrasies it might have, for instance the rather thick cord many systems use for the connection to the external processor.

For these reasons a self-contained VR system would be a good choice. A device like the Oculus Quest would fulfil all mentioned attributes. The reason why a self-contained device is still not an ideal choice is the processing power of the integrated chips. These chips have essentially the processing power of mobile phones. Even though they have made leaps forward during the last few years, it would still be a big constraint, seeing as good looking VR games do need powerful and current PC hardware to run properly. Additionally, as has been ascertained in the master’s seminar, *technological immersion* should be kept as high as possible (RW2 Immersion).

⁶ If desired, kindly see the complete description of the concept in the master’s project report in chapter 3.4 *Creating a Concept*, page 20 and following. Subsequently, for a detailed look at prototype 1, please have a look at the master’s project report in chapter 4.2 *The Prototype*, page 28 and following.

⁷ The final iteration is the final iteration only in name within this thesis. As implicitly seen in the future work sections, there is a large amount of potential features to be implemented given the time, resources and technology.

The trade-off then is to give up some flexibility for the prototype, but deliver more potential technological immersion.

RQ2 Communication

RQ2 on the other hand is a mostly software-based requirement. True communication between a real user and a virtual character is not possible to implement within this project's scope or rather with today's readily available technologies.

The question during the concept creation was then mainly how much communication could be achieved within the scope of the master's project. At its end, the communication implementation sadly was rather limited. Only very basic one-sided communication from virtual instructor to patient is present, by means of the written and spoken instructions. The development of other features was simply deemed to be more important and thus prioritized. Additionally, one of the biggest takeaways from the master's seminar was the need for consistency, to not break immersion (RW1 VR learning environments, RW2 Immersion). Thus, the communication has to be consistent within itself. If a highly advanced natural language processing (*NLP*) AI would be used, the baseline is a lot higher, than just playing pre-recorded speech audio clips. Although the hypothetical AI version is far more advanced and theoretically more immersive, possible inconsistencies, for example simple errors, might have a lot more impact than otherwise with a lower baseline. If the 90 % solution produces an error it is seen as worse as when the 10 % solution makes one. In terms of consistency, this would imply for instance that the speaking characters need appropriate facial expressions and mouth movements. Such features, ready for general implementation do exist, but it could not be implemented with the available character model (see figure 19).



Figure 19: *A:* working Oculus lipsync at runtime with a provided demo model. *B:* without a correctly set up face with each required facial feature, facial expressions are not correct, as for instance here the mouth does not move at all, just the eye brows in unusual ways.

RQ3 Narrative and Behaviour

RQ3 is software-based as well. The narrative may be used to make the training exercise more realistic. It sets a point of origin for patient behaviour, a baseline for a character. Short and concise narratives can be tailored to specific patients and their injuries. One might imagine a virtual patient in bed with a cast around the arm. The system mentioned beforehand, that the patient was in a car crash and broke the arm in multiple spots. As part of the concept, but ultimately also future work, there is a multitude of possibilities for the patient to exhibit different behaviours and convey his state of being to the user.

A baseline-setting narrative has been implemented as part of the initial setup/main menu (see figure 20). The initial menu system has not been further developed after the master's project though, as it was deemed unnecessary for the study (see the study design in chapter 3 *Study Design*).

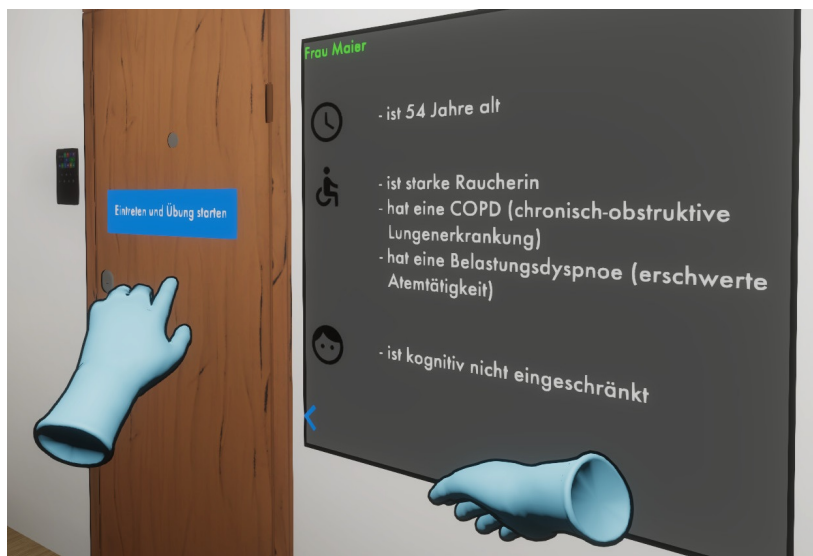


Figure 20: This is the last-panel-overview of the setup menu. It shows a personalization of the transfer that follows, to give a bit of background and narrative to the patient. The button at the left hand side on the door teleports you into the room where the transfer will happen (you enter the room of the patient by doing so). For the study, the initial menu system has been removed.

RQ4 Usability

This spans over both hard- and software. Making sure, that the system can be used well by various groups of people within the target range is important (medical care professionals and students, mostly young but also potentially seasoned nurses).

There should only be a necessary amount of UI. Some easy-to-use settings, for example to choose a narrative and a specific transfer type, may be needed. The application may start in front of a room with a closed door. On the door, these settings could be displayed as drop-down menus, checkboxes or in other simplistic ways (see figure 21). After the appropriate settings have been chosen, the user may open the door and walk into the room, which was set up according to those options.

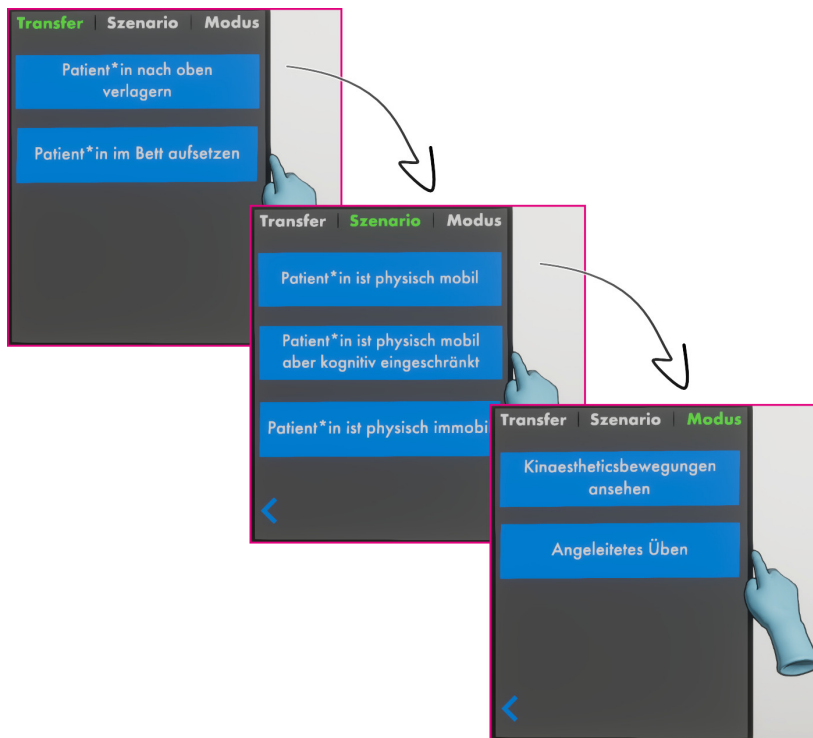


Figure 21: The initial setup menu in front of the hospital room with options to setup the transfer. For the study, this menu system has been removed.

Other settings, which concern application usage during runtime, should be quick to access and understand. In general, the amount of settings should be kept low and as distraction-free as possible (RW1 VR learning environments, RW3 Motor learning in 3D, see figure 22). This menu specifically has been overhauled during this master's thesis and will be explained later in this chapter.

The workflow should be obvious and clear for the user, capitalising on the step-by-step transfer approach, with clear goals (RW1 VR learning environments). The workflow consists of two modes or phases: (i) a mode where a virtual teacher performs a transfer on a virtual patient, so that the user can turn her or his complete focus on observing and understanding the transfer, (ii) and a mode where the user has to perform the virtual transfer on the virtual patient by her- or himself (but still with virtual tools to assist the user). This clear division between modes might be useful to satisfy different user needs, as some might want just a quick look, others might want to train. Importantly though, this division caters to RW3 Motor learning in 3D (firstly focused observation, secondly replication). In either of those modes, the transfer is user controllable with a small simple menu (see figure 22). The transfer in mode 1 is an animation, that can be controlled at will. It is essentially a 3D movie, with corresponding playback controls.

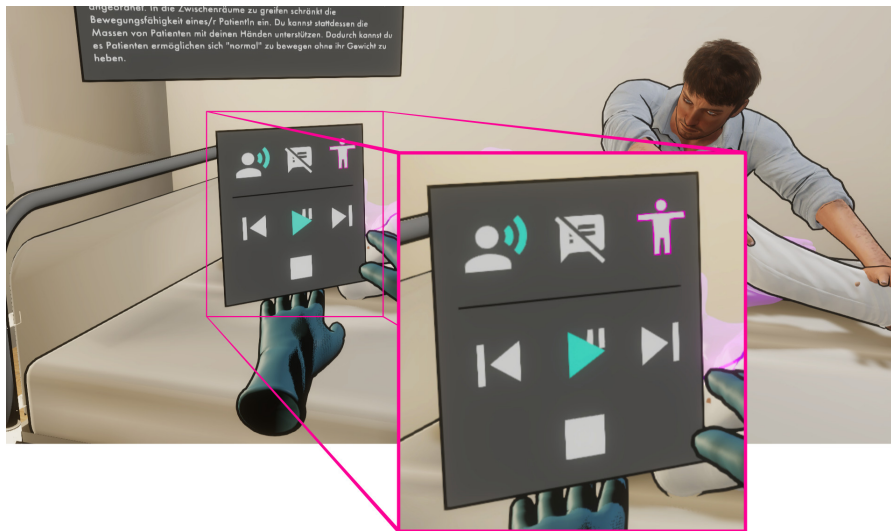


Figure 22: This small menu is the control center for the user in its iteration for the first prototype. The functionality will be detailed by means of the current version in the second prototype. Noteworthy, as those features have been removed from the current version of ViTT: top-center shows a subtitle button, which could toggle subtitles if an audio track was playing. Bottom: the stop button could instantly reset the transfer.

What has not been talked about yet explicitly is the software side of technological immersion (RW2 Immersion). It is to be treated discretely from the hardware side but similar constraints apply: graphical fidelity should be high, although simply *better graphics* does not equal higher immersion or better user experience. First and foremost the quality needs to stay consistent in order to avoid breaks in immersion and/or presence. This constant state of qualities is difficult to ensure, especially within the scope of a project like ViTT. One important hint is delivered by McDonnell et al. [39] where not necessarily the objectively most advanced rendering resulted in the single best experience. A rendering technique, which is very familiar to people and is seen generally as positive and familiar, gained very favourable reactions from participants, likewise to high-quality rendering: toon shading. Thus, a form of toon rendering/cel-shading seemed to be a good fit for this prototype, as it does not need the highest quality techniques and assets to function properly.

In practise, it came with some hurdles, that could not be overcome: toon shading could not be implemented in unison with global illumination, that was in place (a static form of ray tracing, bounce lighting is baked into lightmaps). Dynamic objects receive bounce light by use of light probes, delivering an approximate result. The main issue was, that this did not function correctly with the toon shading.⁸

The solution was to not use toon shading, but just make it seem like it. By just using an outline shader, a familiar “toony” look could be achieved. Additionally, this left open all possibilities for further measures for realistic high quality rendering, such as sub-surface scattering. In the end then, a generally high quality rendering was supplemented by a bit of toon rendering (see figure 23)

⁸ More in-depth information can be found in the master’s project report page 41 and following, 4.2 *The Prototype*.



Figure 23: The patient model's head. By use of Unity's HDRP rendering pipeline, several high quality rendering techniques are employed: multiple light sources as a mix of point and area lights. Light sources are differently coloured, the sun as a warm area light through the windows and a cooler-toned point light as a lamp on the ceiling. All light sources contribute to global illumination, resulting in a realistic lighting model. The skin material uses sub-surface scattering, simulating light piercing through the first layers of skin and bouncing out again, resulting in a typically warm, soft, and realistic rendering of skin. This is off-set by the toon outline, creating a high quality look, which is still forgiving to rendering errors.

2.3 SECOND PROTOTYPE

The second prototype is an enhanced version of the first one. As part of the thesis, instead of conducting a full study, that time instead was used to enhance the prototype by reiterating development of multiple features.⁹ Following, the current version of ViTT is shown comprehensively. Overhauled features are explained in relation to the previous prototype from the master's project.

Hardware and software have not changed from the master's project.

2.3.1 Features & Workflow

Moving on, the current version ViTT is shown on a feature-by-feature basis in the order of the envisioned workflow. This version was edited for a study setting (see later in chapter 3 *Study Design*). Aside from much effort in refine-

⁹ More information concerning the study situation, please see chapter 3 *Study Design*.

ment, the following explicit changes have been made, in favour of a more focused version, that is faster to understand by participants within a very limited time-frame: the initial setup menu in front of the hospital room has been removed, a tutorial mode was added (see at the end of this chapter), the subtitles have been removed and the stop button was essentially substituted with a repeat button (see later).

ViTT consists of two modes. Those modes differ in their purpose but there are, however, many similarities. These similarities are presented first, then follows a detailed look at the different modes. The modes are unchanged from the first prototype: (i) a mode where the user observes a patient transfer between a virtual patient and virtual instructor and (ii) a mode where the user may execute the same transfer by him- or herself. The user has control over the transfer with several features.

The transfer is divided into steps, which essentially can be played/paused like a movie. Skipping to different steps is possible as well. Additionally, the transfer features two audio tracks, which contain instructions. As an additional virtual helper, a highlighting feature shows relevant information for each transfer step. All those features are detailed below.

General Elements

The user is displayed egocentrically by means of the VR headset and his or her own tracked hands. The ManusVR gloves transport the user's hands and fingers into the virtual world, including haptic feedback per finger, when specific elements are touched. It is possible to walk around freely within the virtual space. Virtually, they have the appearance of blue silicone hospital gloves.

USER INTERFACE The UI is divided into elements, that provide information, and elements, that are used to control the virtual transfer. The latter have been substantially overhauled.

In figure 24 you see the information board, a large panel, that displays various bits of information for the current patient transfer. It displays all the steps of the current transfer with a short descriptive name, for instance "*Beine anwinkeln*". The current step is highlighted. At the right hand side, instructions for this step are visible. The lower half of the whole panel is reserved for additional information, that is currently applicable. Meaning, for example, knowledge, hints, and rules for "*Funktionale Anatomie*" concerning kinaesthetics for this particular step.

The controlling element of the UI is placed in direct physical reach of the user. It is a small control center, a UI panel with buttons, that provide control over the transfer (see figure 25):

Play/pause, repeat lets you play/pause the transfer

Step back/forward lets you change the current step of the transfer

Audio track toggle lets you turn the audio on/off or change the audio track

Highlight toggle lets you turn the patient highlighting on/off or change the highlighting mode

As can be seen, there are elements that resemble typical video player controls, and they function as expected, based on this resemblance. More details on those controls are mentioned in the specific mode sections below.



Figure 24: The information board shows two main sections, *Kinaesthetics-Bewegungsablauf* and *Kinaesthetics-Konzept*. The former displays all transfer steps with corresponding instructions for the currently active step. The latter displays additional reading material regarding kinaesthetics, if there is something available for the current step.

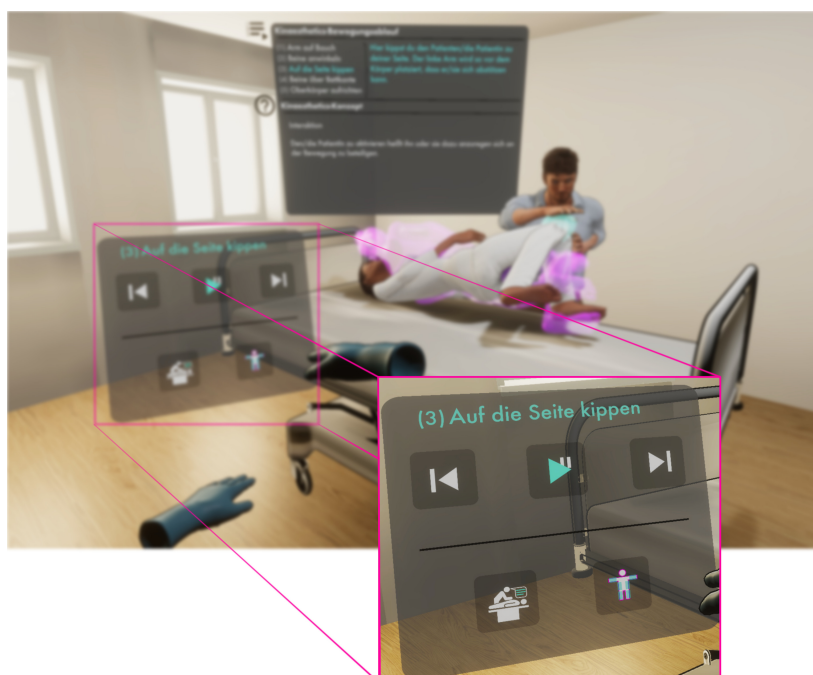


Figure 25: This small menu is attached to the left hand during mode 1, and to the left side of the bed during mode 2. From left to right upper row: (i) step back in the transfer, (ii) play/pause the transfer, (iii) step forward in the transfer. From left to right lower row: (iv) audio track toggle, (v) highlight toggle for highlights on the patient. All buttons show clear states. Most buttons have been heavily customized from their original source.

Pressing UI buttons is done completely physically-based, in contrast to prototype 1. The virtual finger touches the virtual button and depresses it, as if it was a physical tangible object, reacting continuously to the force of the touch. Internally, Unity's physics engine is used. The fingers touching the button vibrate on contact, providing haptic feedback. The button is highlighted additionally, for visual affirmation, when it is completely pushed in and the function behind it is activated (see figure 26). A timeout ensures the button stays depressed for a quick moment, providing additional confirmation, that a seemingly solid element has been pressed and clicked into place.

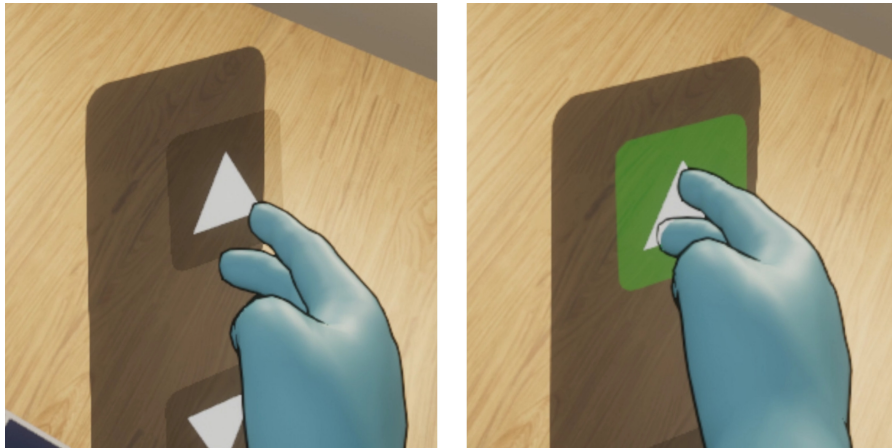


Figure 26: UI buttons are physical objects, that can be pressed in using either hand or even single fingers. When a button is touched, the corresponding part of the hand vibrates in real-life by means of the ManusVR gloves' haptic feedback. Buttons have a small but discernible travelling distance until the *pressed* state is triggered. Buttons light up green and are locked in place for a quick but again discernible moment, to provide additional affirming visual feedback.

Design-wise, an even more minimalist style than before has been adopted. Rounded corners, a semi-translucent background, and bigger clearer buttons with more space between them provide a cleaner presentation. Aside from a subjective visual improvement, the changes were also made, so that interaction with the control center is easier, with less unintended button presses and more consistent feedback. The current step is displayed above the buttons. It shows the user the active step without him or her needing to look at the information panel. It is implicitly linked to the playback controls, that are directly under it (Gestalt principles: law of proximity [68]). Lastly, when the final step is finished, play/pause is substituted by *repeat* (see figure 27), which restarts the transfer from step 1.



Figure 27: When the transfer is finished, the play/pause button is substituted with the repeat button (upper row, middle). This button resets the transfer, letting it start from step 1 again. The repeat button is substituted then for the play/pause button, if pressed.

AUDIO There are two audio tracks — the virtual instructor directs the user or instructs the virtual patient — that have been re-recorded with Google’s text-to-speech service [24], as the previous ones sounded somewhat artificial. Play/pause, or rather the video controls in general, control the audio track as well of course.

HIGHLIGHTING There are different ways of highlighting the virtual patient, one is in *magenta* and one is in *cyan*. The magenta highlight is a translucent version of the patient, in magenta, in the end position of the currently active transfer step. The cyan highlight is visual feedback. When the patient is touched, the area where the touch occurred is highlighted in cyan. There is a combined mode, where both mentioned ways of highlighting are active. For those highlighting modes, see figure 33 a bit further down.

Mode 1 – Observation of a Patient Transfer

In mode 1 the user takes the role of a student, who observes a virtual patient transfer being performed by a virtual instructor. As this is an immersive VR application, the user may walk around the scene and observe the transfer from various angles. By means of the UI, control over the transfer is provided. There are multiple virtual elements to discuss, which are designed to help the user to better understand and learn this transfer.

USER INTERFACE This information panel is always situated in the opposite corner of the room in regard to the user’s current position. When the user walks around the bed for instance, the panel will move to the currently opposite side (see figure 28).



Figure 28: In mode 1, the information board switches between four different room positions, depending on the current user position. The information board always tries to be in the opposite room corner, respective to the user. There are buffer zones, so that erratic and confusing behaviour is mitigated. Additionally, the information board always directly faces the user through rotation. Those measures should ensure constant easy visibility.

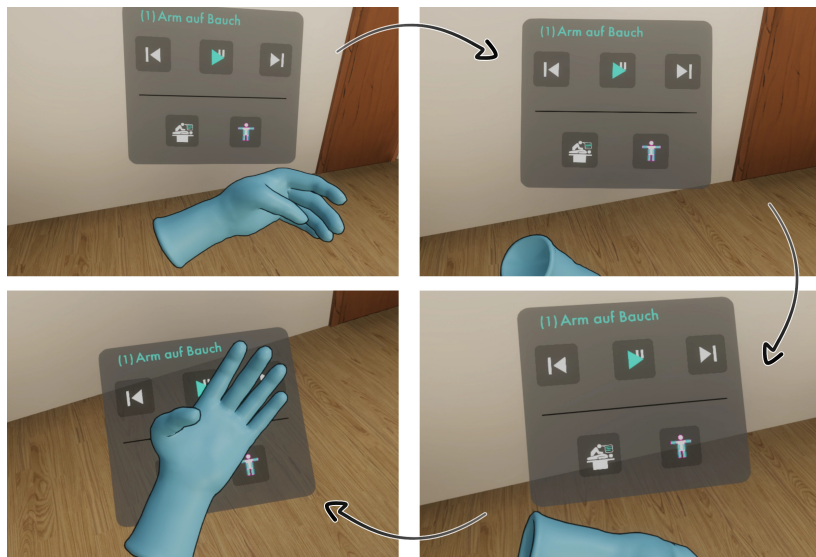


Figure 29: In mode 1, the control center UI is attached to the user's hand in a constant short distance. Additionally, it always directly faces the user by rotation. The sequence shows the user rotating his or her hand downwards. This implementation ensures that the control center UI is (i) easy to hide, (ii) easy to show, (iii) easy to adjust in distance and position.

The control center is attached, floating and rotating, to the user's hand (see figure 29). Through this, the panel always faces the user when looking at it and can easily be moved out of the way when it is not needed, and that just by the looking direction and rotation of the hand it is attached to.

Play/pause plays or pauses the transfer animation. The transfer in mode 1 is like a 3D movie, where you can walk around the scene and control the movie the way you like. *Step forward/backward* behaves in the same fashion, recognizable as movie controls. *audio toggle* lets the user toggle through two audio tracks or mute it entirely while *highlight toggle* then toggles through four different modes: off, magenta highlight, cyan highlight, everything on. Explanations for those modes follow below shortly.

HIGHLIGHTING The magenta highlights works in mode 1 as described above, the patient's end position per step is visible as a magenta highlight. In mode 1, only the virtual instructor can interact directly with the patient. When the instructor touches the patient, and the cyan highlighting is active, the respective areas on the patient are highlighted.

Mode 2 – Training of a Patient Transfer

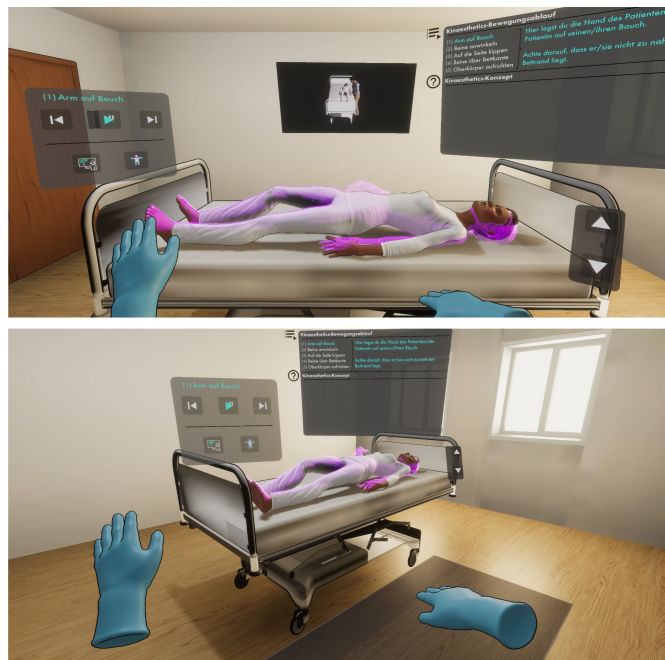


Figure 30: This is a simple visual overview of ViTT's second mode, where the transfer has to be performed by the user. Up: the user stands in front of the bed with the patient. A training video for additional help is displayed behind the bed. All UI elements are in clear view: information board in the far right corner, control center UI attached to the bed's left side, and UI to elevate or lower the bed is attached to its right side. Down: The scene from a slightly different position, showing the UI rotation to the user for optimal visibility. The training video is disabled, as the user does not stand in front of the bed on floor panel. Standing on it, the panel would turn green and the video is activated again, showing the user that he or she stands at the correct position.

In mode 2 then the user tries to perform this patient transfer on the virtual patient by him- or herself. The user may still walk around freely but is implicitly discouraged to do so. Firstly, the information panel does not change its position anymore based on the user's position. It can be seen head-on from right before the bed, where the transfer should take place. Secondly then, right before the bed is a grey area on the floor, which turns green once the user stepped into it, affirming correct positioning. This also activates a video panel behind the bed, which can be viewed head-on from the current position before the bed. Lastly, and rather obviously, the transfer cannot really be done from any other position. An overview of this virtual space in mode 2 can be seen in figure 30.

USER INTERFACE The information panel stays the same from mode 1, barring its positioning as mentioned. Mostly the same is true for the control center UI. It is fixated on the left hand side of the bed, as it would be in the way when attached to the user's hand. With a side step at most the panel can be reached, depending on where the user stands alongside the bed.

The control center does function the same way as before, on a fundamental base, although there are significant differences when glancing at it quickly: play/pause does not control the patient directly anymore. Instead, a video recording of mode 1 is displayed behind the bed, timestamped at the current transfer step. This video is set to loop within the current step. For instance, pressing play in the beginning of the transfer, the video would show the instructor from mode 1 performing step 1 in a loop (see figure 31).

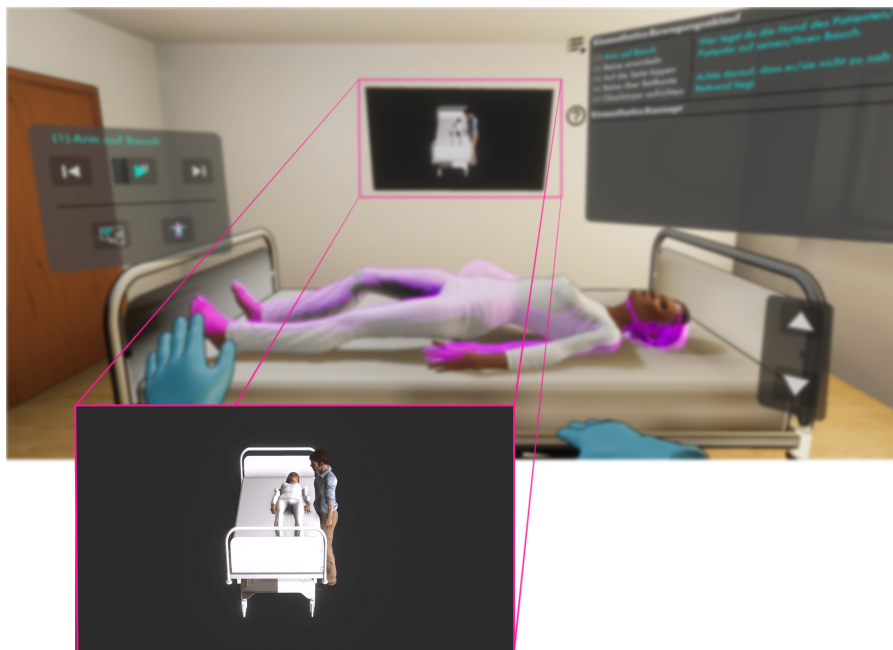


Figure 31: In mode 2, a virtual video recording of the currently active step is displayed in the user's view, as if it was shown on a television. This video is additional optional help for the user, if a part of the transfer is not clear yet. The video only plays when the play button is pressed on the control center UI to the left-hand side. It pauses on pause and skips to the currently active step. When played, it loops through the relevant portion (for instance, in step 2, on play it would loop through the portion that shows step 2).

Toggling through the steps does always set the video to the respective step but also sets the *the actual* patient on the bed to the starting point of the respective step. So for instance, toggling to step 3 would also set the patient to the beginning position of step 3, which naturally coincides with the end position of the previous step 2 (see figure 32).

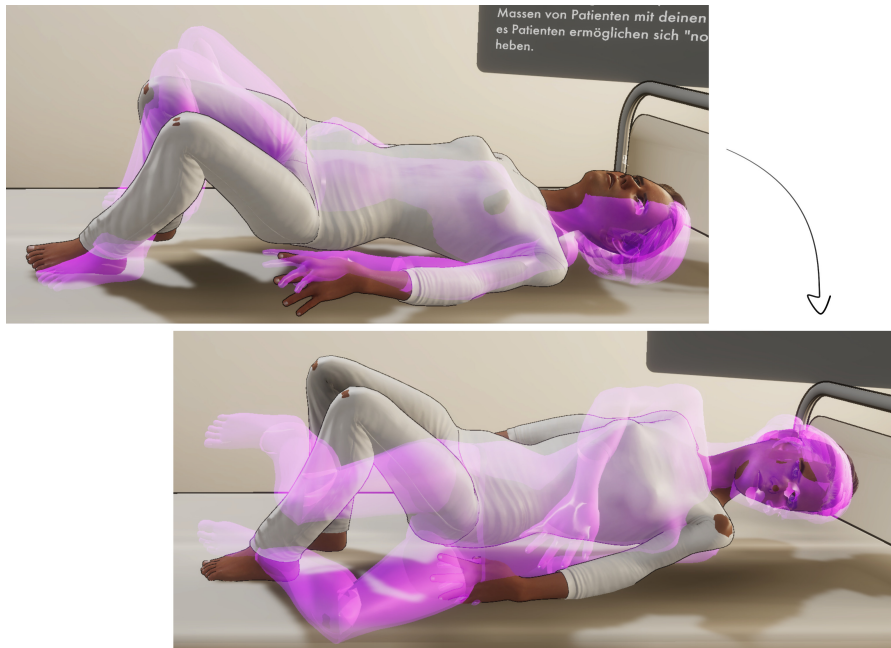


Figure 32: Mode 2: the upper image shows the patient in transfer step 2, the lower image in transfer step 3. The magenta highlight always depicts the goal end position of the current step. The end position of a step X is the starting position of step $X + 1$, for instance as is shown here from step 2 to 3. When the patient is moved into the correct end position in step 2, the magenta highlight switches to the next step, showing the next goal to the user. Likewise, when the user toggles the next step through the control center UI, instead of moving the patient by him- or herself, the magenta highlight switches as before, but the patient is also set automatically. While in step 2, toggling step 3 would set the patient to the end position of step 2, coinciding with the starting position of step 3 (lower image).

Additionally in mode 2, there are buttons on the right hand side of the bed to move the bed up or down. This is necessary, as mentioned in the concept, to facilitate the correct bed elevation for each user.

HIGHLIGHTING The patient highlighting works the same as in mode 1. Just now obviously, the patient has to be touched and moved by the user. When active, body areas are highlighted in cyan when touched, as before with the instructor (see figure 33). The magenta highlight now acts as successive milestones for the transfer, intermediate goals the user has to achieve.



Figure 33: The left image shows mode 1, where the user observes a patient transfer, with all patient highlights active. The instructor touches the patient, the respective body parts light up in cyan on the patient. The magenta highlight shows the goal end position of the current step. The right image shows the same scenario, but in mode 2, where the user performs the patient transfer. Touched body parts on the patient light up in cyan, while the current goal end position is shown as a magenta highlight. Highlights may be toggled in any combination: cyan on and magenta on / cyan off and magenta on / cyan on and magenta off / cyan off and magenta off.

TRANSFERRING THE PATIENT This is the actual task of mode 2, performing a patient transfer with a completely virtual patient in VR.

As is the case with the UI buttons, the transfer is physically-based. On top however, is a lot of extra effort to make it work and *behave properly*. The base is Unity's physics engine. In itself, just using physics including gravity, the patient can be moved, but it does not feel or look realistic. It is a lifeless puppet, behaving strangely, without a tangible sense of weight or heft. Additionally, this would allow a movement without restrictions, which could lower the complete user experience because users quickly might maneuver the patient into *unsolvable* and unrealistic, immersion-breaking positions. Within the envelope of ViTT, an app for training patient transfer movements using kinaesthetics, it cannot be left like this. The transfer needs obligatory structure. That structure had been tried to be provided by means of virtual guiding and an active transfer help. ViTT is not trying to portrair a perfectly realistic scenario, where the user can not differentiate anymore between what is real and what is not, but it rather tries to facilitate a training use case enhanced with *digital power*, on the found fundamentals of immersive egocentric application design.

One could ask, if it would be possible to make use of the animation from mode 1. The answer is: not directly. In Unity, when an animation plays on a model, the model is locked in place. The user could not move the patient at all. A solution in-between those extremes, movement without restriction at all and no movement possible, would be favourable. Luckily, a library has been found, that does exactly this: *PuppetMaster* [50]. Simplified, it essentially creates a second patient model, which has been attached to the transfer animation by a pinning force. This force is highly customizable and it is customizable at runtime as well. Meaning, that when the pinning

force is at 100 % the patient follows the animation exactly, while when it is at 0 % the patient is again the lifeless puppet. Finding a fitting set of parameters somewhere in-between, had proven to be extremely challenging. 15 different parts of the model are configurable separately with mainly 4 parameters per body part, aside from over 12 global parameters, that affect each other. In addition, there are parameters from the underlying physics engine for every body part (mostly mass, drag, and angular drag), as well as gravity, and naturally, also joint forces, which connect the body parts to each other. Then, after this is all set, the user exerts force by means of the hands to one or multiple body parts, again affecting all those parameters interacting with each other.

To round this confusion off, lastly, there is also collision. Moving body parts will inadvertently cause collisions between at least some of them. This is also a force. This force pushes the colliding parts away from each other until their colliders don't intersect anymore. This can cause severe issues during the transfer. Turning collisions off can alleviate some issues but is inherently unrealistic of course, when several body parts just clip into each other. Collisions have been kept active, as the gain in transfer stability has not been found to be large enough to justify the immense reduction in subjectively perceived realism.

In short: finding a balance, which still is not optimal, was a difficult and long-lasting iterative process throughout the master's project and even this master's thesis.

Two ideas in particular have been very helpful for making the transfer more robust: setting a custom gravity and drag. Gravity was even disabled but then substituted with a custom force per body part, that is exerted perpendicular to the ground, just like gravity. But this force can be varied in strength per body part, making it highly flexible. This was already done during the master's project. The new trick for more stability was looking at mass and drag parameters. An object with high drag for instance takes longer to react to external forces, as the naming would suggest. This was then used to set drag parameters, again per body part, at runtime to inhibit strange and sudden "mishaps" with the underlying physics. In essence, the patient's physics "react" slower to external input, dynamically set per body part and step, than before. This does subtract realism but adds more robustness. This was implemented after the pilot study, as can be read later in section 3.2 *Pilot Study*.

Exemplary Usage

ViTT is in mode 1. The user presses play on the controls and the transfer is starting. The teacher is talking to the patient, providing some information about the current transfer. More educational information is displayed on the information board. The user pauses the transfer in order to slowly read the information on the board. He or she walks around the room, looking at the current (paused) state of the transfer from various angles. Because this would be a cumbersome modus operandi for this particular user, always having to pause in order to get all relevant information, the user just swaps the audio tracks in the control center, attached to his or her hand, and presses play again. Now the teacher says, in a shortened version, what is displayed on the information board so the user can concentrate on watching the transfer, while listening to the auxiliary information. What attracts his or her attention in particular are the highlights. They show crucial information, as to where to touch the patient and where to move him or her, visually

encoded. The transfer is finished and the user wants to have a second look at certain steps so he or she just skips a few steps back via the video controls and watches that part again until he or she feels content. The user then switches to ViTT's mode 2.

The user now has taken the place of the virtual instructor from mode 1. The patient lies on the bed. The control center UI is attached to the left hand side of the bed, at the right hand side are controls to move the bed up or down. That is what the user has to do firstly as well. Pushing buttons with his or her *own* hands provides haptic feedback through the worn gloves. It provides a certain degree of illusion and ownership of these virtual hands. The user pushes the patient's arms and legs to the in magenta highlighted goal position. The step is complete, the system switches to the next step. The user forgot a detail of this step and presses play on the control UI. The video panel behind the bed plays a recording of the step and the user remembers. He or she completes the step but skips back and completes it again to make sure the movement sticks in their memory.

The Tutorial

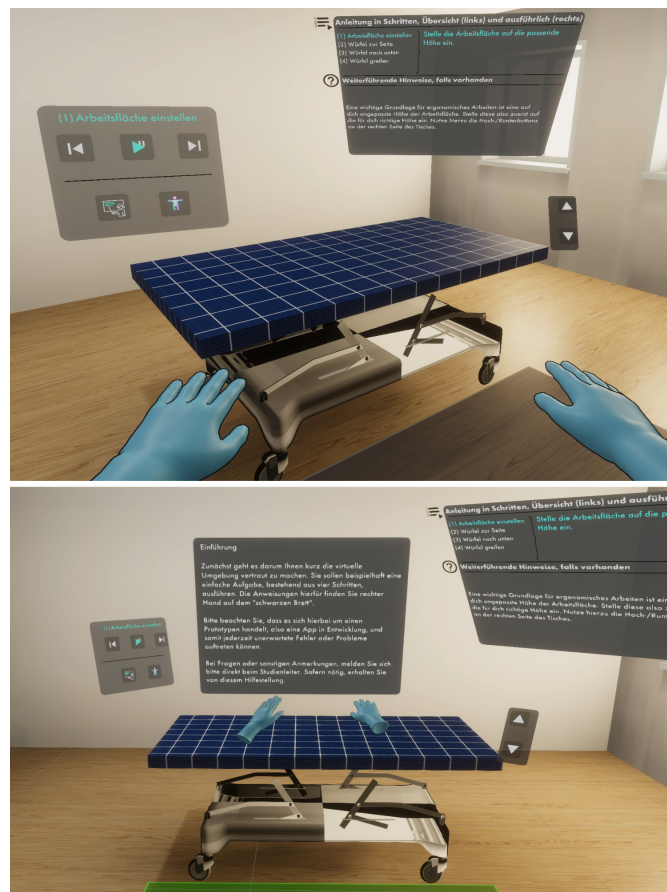


Figure 34: A visual overview of the tutorial scene. It is very reminiscent of mode 2. The bed is substituted for an abstract working surface.

As will be detailed later on in chapter 3 *Study Design*, a tutorial has been created specifically for the study, to acclimatise participants to ViTT. It has been created as part of the master's thesis. Here, the tutorial itself is shown. It is structured like a mixture of mode 1 and 2, abstractly showing participants

how the different functions work. The tutorial steps have been designed to show participants how the underlying systems of ViTT work.

The participant is located in the same room as later on in modes 1 and 2 (see figure 34). The bed in the middle of the room has been substituted by a generic working surface of the same dimensions and also with the ability to move up and down. On the ground next to it is the same grey area, that turns green, when stepping inside. When this area is green, a panel with tutorial text appears, where the video panel in mode 2 would be.

The arrangement of information panel and control center UI are the same as in mode 2. The information panel shows four steps:

1. Arbeitsfläche einstellen
2. Würfel zur Seite
3. Würfel nach unten
4. Würfel heben

Per step, a cube needs to be moved from position *A* to position *B*. On success, the next step starts with a cube on a new position *A* ready to be moved to a new position *B*. See in figure 35 what these steps look like.

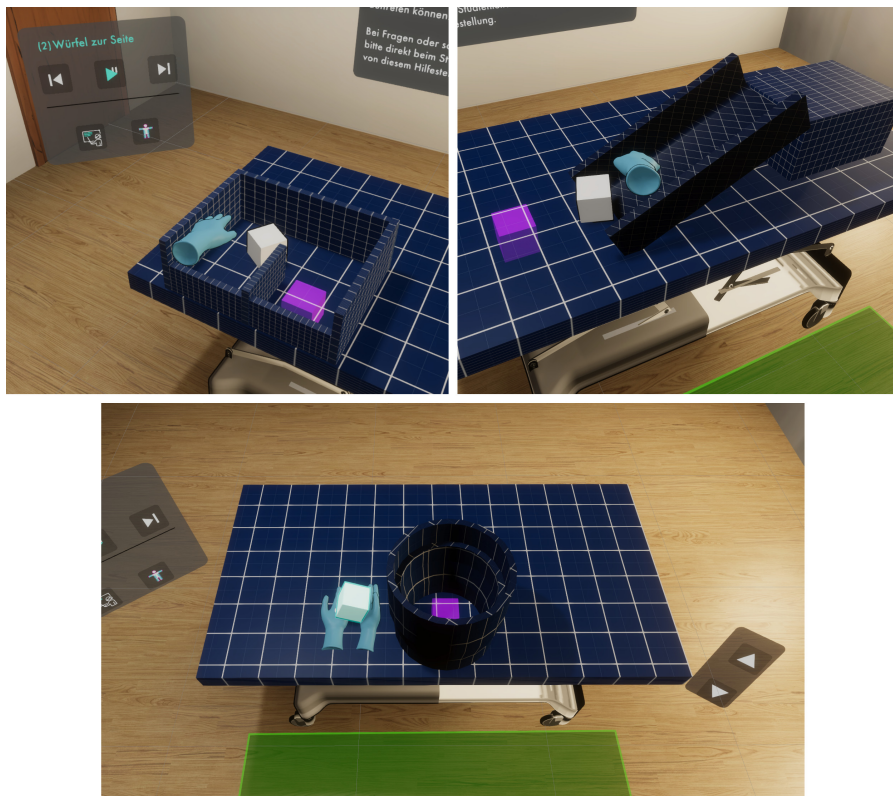


Figure 35: Top left, top right, bottom: (i) participants need to push a cube through a “labyrinth” to the goal position. (ii) They need to push a cube down a ramp to the goal position, and (iii) lastly they need to lift a cube in order to put it into the position inside a tube. Not shown is the very first step of the tutorial (*Arbeitsfläche einstellen*), where participants just see the empty working surface and they are asked to adjust its height to the correct elevation.

The general functionality of the UI stays the same. The video controls change through the steps or make the cube move on its own to the goal position *B* (play/pause). When the respective highlighting modes are active, the magenta highlight shows the goal position and the cyan highlight shows as visual feedback, when the cube is touched. A new audio track has been recorded as well by means of the mentioned Google service [24]. As in modes 1 and 2, the voice describes what should be done in the current step.

Now, one might ask why step 4 is “Würfel heben” instead of “Würfel greifen” for instance. Step 4 actually was the latter but, as explained later in chapter 3 *Study Design*, issues arose during the pilot study. The grabbing feature was subsequently disabled for added robustness. To solve this step of the tutorial “transfer,” instead of grabbing the cube and dropping it into the tube, one has to take it with both hands or put it onto a palm of either hand (see figure 35).

2.3.2 Provided Code and Resources

The author has been supplied with some resources from a different but related project out of project ERTRAG.[14] This includes the bed asset, the character models for patient and teacher, the original audio tracks from prototype 1, written instructions, timings and all of their transfer animations. The managing raw data has been saved as a JSON file. The library SimpleJSON [23] was used to read this file at runtime; integration code from the other project has also been supplied. It has been adjusted and expanded to fit the particular needs of this project.

For managing the transition between animation and real-time physics, the PuppetMaster library has been used.[50] It has been supplied to the author by the HCI department.

For managing some basic VR interaction, the VRTK library has been used as part of the resources provided by ManusVR.[67]

Learning resources for the outline shader were provided via an online tutorial. It has been followed along and re-created by the author.[19]

UI icons have been sourced from Google [25] and the Noun Project [61], and have been vastly modified to create a coherent design language.

The re-recording of the audio tracks has been done with Google’s text-to-speech service.[24]

For code samples and further information on the implementation itself (prototype 1), please see chapter 4 *Implementation* in the master’s project. Moving on, the following chapter shows the construction of a study and subsequent evaluation of its pilot for ViTT.

3 | STUDY DESIGN

This chapter requires a short preamble, as it would usually not only report about the study design but also its execution as well as analysis of its gathered data.

As previously mentioned in chapter 1, the situation during the given time-frame was rather special due to SARS-CoV-2. Since the beginning of the master's project, there was great willingness by the *Gesundheitsakademie*, a site where lessons for medical care students take place within the complex of Klinikum Konstanz, to be a part of the project's concept phase as well as the evaluation phase later on during the thesis. During the creation of the concept it was possible to visit the *Gesundheitsakademie* after some correspondence. Visiting and talking to a single person naturally means less risk and far less bureaucratic complexity compared to a usability study, involving over 20 or so people. Further efforts then to make the usability study work where partly responded to but ultimately it became clear, that this thesis would have to be completed without executing the planned study. Correspondence efforts were led by Maximilian Dürr, who has my sincere gratitude.

What then is reported in this chapter? As mentioned, a usability study had been planned, making use of the friendly and helpful connections to the *Gesundheitsakademie*. The design of that study is the core of this chapter. Moving on, a further usability study has been devised, as a slight iteration of the "proper" study. Lastly, a pilot study has been conducted in a safe environment to evaluate the viability of the design. Limited findings will be covered.

It might be of importance to note, that the following has been designed as if the study would have taken place without issue.

3.1 EVALUATING VITT

The study design has been created by means of Roger's, Sharp's, and Preece's DECIDE framework [48], while for approaching the underlying questions of the framework, Chapter 21[28] *UX Evaluation Methods and Techniques* from *The UX Book (Second Edition)*[30] has been used as a guideline. DECIDE is a framework to guide evaluation. Its parts are the following:

- (i) Determine the overall goals
- (ii) Explore the specific questions
- (iii) Choose the evaluation approach and techniques
- (iv) Identify the practical issues
- (v) Decide how to deal with ethical issues
- (vi) Evaluate, analyze, interpret, present

Hereinafter, those parts are explored and mapped to create an evaluation plan for ViTT.

3.1.1 Determine the Overall Goals

The goal of this thesis is determined as the evaluated proposal of ViTT, an immersive VR application tailored for the self-directed studying of patient-transfer movements, on basis of the kinaesthetics care conception. Its evaluation should provide a clear picture of ViTT's general acceptance within a professional medical care setting. It should become clear, whether the general idea of ViTT is worth further exploration. Thus, the overarching goal coincides with R1, the amount of user experience, as it encapsulates, in addition to the actual usability of the system, the users' feelings before and after using the system. This is important because in contrast to "just" good or bad usability, there might be reasons why users still like or dislike the application. An application with good usability might still not be used when the rest of the user experience is bad and likewise when usability is rather bad, but users in general like using the system, they might still run it. In either case appropriate evaluation may show weaknesses in the application design, that are the respective causes for bad experiences or performances of users. This abstract understanding is crucial to deliver a system, that functions as intended.

3.1.2 Explore the Specific Questions

As lastly mentioned in chapter 1 *Introduction*, these are the chosen research questions. There is a hierarchical tendency, as each question R1 to R4 can be viewed as a super set of the following one, though not in the strictest sense. R1 is about the user experience as a whole, which incorporates usability. R2 to R4 are about usability or certain areas of usability. While R2 is more abstract about its general usability in the study of kinaesthetics, R3 is already rather specific. It questions the app's integration into existing workflows when teaching and learning kinaesthetics. R4 then explores a very specific part of kinaesthetics education.

R1: Does a System Like ViTT Provide a High User Experience?

As explained above, it is critical, that ViTT does provide a high user experience. Loosely speaking, it is a construct of the user's feelings before and after using the system, in addition to the system's usability. R2 to R4 are rather concerned with different facets of usability, mainly regarding nursing students' education in kinaesthetics. They are concerned with a part of the complete user experience. Thus, only R1 questions explicitly beyond usability, yet also implying R2 to R4 as subsets.

R2: To What Extent Can a System Like ViTT Promote the Learning of Kinaesthetics for the Ergonomic Transfer of Patients?

R2 begins to specifically question usability. It is still a rather broad question though, it questions general usability within the space of kinaesthetics education. It questions in what way ViTT can be of use when learning or teaching kinaesthetics.

R3: How Can a System Like ViTT Integrate Into and Extend Conventional Practices to Support the Learning of Kinaesthetics?

Getting much more specific, R3 asks about ViTT's integration into existing teaching workflows. Could ViTT be added into the workflow as an integral

part, could it be added as an optional extension or could it substitute an already existing part?

R4: To What Extent Is the Virtual Patient Used in ViTT a Good Surrogate for Real Patients and for Human-simulated Patients That Are Used in Partner Exercises?

Patient transfers are partly taught and trained in pairs — one student transfers the other training partner and vice versa. This means, that for training kinaesthetics, one would need another training partner at hand. That is one issue that ViTT tries to tackle. Does it succeed? Does it fail? What could be done better about this specific feature?

3.1.3 Choose the Evaluation Approach and Techniques

Evaluation should be a triangulation, aiming to analyse the data from different angles. For instance, using multiple questionnaires with different purposes, a semi-structured interview as well as observations.

Participants

The study is designed to evaluate user experience from the viewpoint of three different participant pools. In one pool are nursing students, who are already taught in kinaesthetics. Another pool consists of professionals, who teach kinaesthetics to those students, and in the last pool of participants are experienced nurses, who do not teach kinaesthetics. By testing these three somewhat different user pools, the degree of ViTT's success in user experience could be thoroughly evaluated. A big question in terms of data gathering and validity of results is the number of participants as a whole as well as per pool. Limitations for this study become quickly apparent here, not only because of the demanding situation called forth by the pandemic, but also because naturally it is much easier to enlist more students into a study than working professionals with a notoriously small amount of time. Judging from the contact with the Gesundheitsakademie, an evaluation with very few instructors and ten to twenty students would have been possible under normal circumstances. Additionally, the author is acquainted with three experienced nurses, who would have participated as well. This would have produced participant pools of roughly 2 + 3 + 15. As a whole, participant numbers should be fine for a usability evaluation. An issue arises though, when evaluating the individual pools, as the numbers of the "professional pools" are much too small for running statistical analysis on quantitative data. Only qualitative findings could be analysed.

Study Design

Following, the study design will be specified.

COURSE OF ACTION These are the study parts and their respective order. Some parts need an explanation and will be detailed further on.

1. Welcoming the participant
 - 1.1 Greetings, quick oral explanation, hygiene instructions ("Hygienebelehrung")
 - 1.2 Provide disposable gloves
 - 1.3 Welcome form & consent form

2. Demographic questionnaire
3. Preparations
 - 3.1 Show how to use the hardware
 - 3.2 Participant puts on/adjusts hardware
4. Tasks
 - 4.1 Provide task description tutorial
 - 4.2 Run tutorial
 - 4.3 Provide task description mode 1
 - 4.4 Run mode 1
 - 4.5 Provide task description mode 2
 - 4.6 Run mode 2
 - 4.7 Remove hardware
5. Questionnaires & interview
 - 5.1 User Experience Questionnaire (UEQ)
 - 5.2 Igroup Presence Questionnaire (IPQ)
 - 5.3 Custom questionnaire
 - 5.4 Semi-structured interview
6. Debriefing, monetary compensation, send-off

A hygiene instruction (“Hygienebelehrung”) has been created as part of the consent form (see appendix B.2), which informs the participants of the taken precautions. The steps taken reach significantly beyond what would be necessary according to law or internal regulations, in order to keep everyone involved as safe as possible. This is of extraordinary importance, especially considering that hospitals are becoming more saturated by the day and there is a lack of personnel. Anything less than the best possible precautions would be irresponsible.

As an unusual hurdle, participants need to be instructed on how to “wear” the hardware, not only how to use it. They need to be shown how to put on the ManusVR gloves and the VR HMD and set everything correctly without the study conductor being able to physically help.

TASKS Before the actual study starts, participants are presented with a tutorial task. They are asked to move three small cubes from locations *A* to locations *B*. Each “cube transfer” has its own step assigned. Virtual helping features, such as highlighting or an audio track, are present similarly. This task is designed to provide fundamental skills for the actual tasks. By means of this tutorial, participants become accustomed to the virtual world, participants get to know interaction paradigms of UI as well as physical tasks, and participants learn how virtual elements behave in response to their actions (see the tutorial description with figures from before in 2.3 *Second Prototype, Feature & Workflow Presentation, The Tutorial*). Either after around 7 minutes or when they feel ready, whatever comes first, the tutorial is finished.

Moving on to the actual study tasks, there are two of them. Both represent one of two parts of the application, which in turn represent parts of the kinaesthetics course. Task 1 is an observation. Participants have up to

10 minutes to watch a patient transfer and get even more familiar with the interaction paradigm. This is a test of how well this form of teaching transposes into the virtual world, where a teacher is demonstrating a transfer for the students. It is a question of subjective acceptance by participants but also a question of the objective ability to learn and remember information by means of ViTT.

Lastly, during the second task participants are asked to execute the transfer, which they just observed and controlled during task 1, by themselves. The feature-set, concerning UI and general interaction, is largely the same between the two tasks (see figure 36). For detailed differences, please refer back to 2.3 *Second Prototype*.



Figure 36: A visual overview of both modes, 1 (top) and 2 (bottom). In mode 1 participants observe and control a patient transfer with the help of various virtual features. In mode 2 participants need to perform the observed patient transfer by themselves, while again having control over the transfer with several optional features.

QUESTIONNAIRES & INTERVIEW As mentioned, there are three different participant pools: kinaesthetics instructors, nursing students, and experienced working nurses. As such, the study documents need to be adjusted for each group. Documents, that differ from each other, are the demographic questionnaires in the beginning (see B.3, B.4, and B.5 in the appendix). The semi-structured interview can be adapted on-the-fly to the respective participant (see B.9). However, these documents, amongst others, did actually go through an additional revision for an alternative version of this study (see a passage later on in this chapter: 3.1.7).

What questionnaires are used and how have they been created? In the beginning, before the tasks, there is a demographic questionnaire. Aside from the standard demographic questions, it consists of questions regarding kinaesthetics education and using kinaesthetics during every-day work. Answers are either in free-form or on a five-point Likert scale. After the tasks are finished, there are three further questionnaires. Firstly, the well-known UEQ with KPI addition is used, as is recommended if you want to calculate a meaningful KPI, by the UEQ creators [51] (see B.6 in the appendix). Secondly, the IPQ is used, which measures the sense of presence (see B.7 in the appendix). Immersion and presence were a large part of the master's seminar and consequently also the master's project. The last questionnaire is bespoke with questions pertaining to this thesis' research questions (see B.8 in the appendix).

At the very end, there is an interview. Its questions are somewhat of a summary of the foregoing questionnaires. By its semi-structured nature however, participants get the chance to talk freely about their education or work experiences. As was the case during the concept walkthroughs in the application design phase during the master's project, there might be critical information, that otherwise could not have been gotten.

Data

What data is collected and for what purpose? The following listing quickly summarizes it:

- Quantitative
 - *Questionnaires (objective)*
Quantitative objective data as simple demographics (age, gender...).
 - *Questionnaires (subjective)*
Subjective participant assessments on Likert scales.
 - *Logging (objective)*
Basic logging of time taken and user movement.
- Qualitative
 - *Questionnaires (objective)*
Participants for instance listing digital teaching methods they know.
 - *Questionnaires (subjective)*
Qualitative subjective data as open-ended questions.
 - *Semi-structured interview (subjective/objective)*
An interview with some basic questions, which evolves with the answers of the participant and further explores interesting directions per participant.
 - *General observations (objective)*
General observations of the study conductor or participant.

This data is used for a user experience evaluation, consisting of a formative and an informal summative evaluation, as explained in *The UX Book 2* (see figure 37) [28].

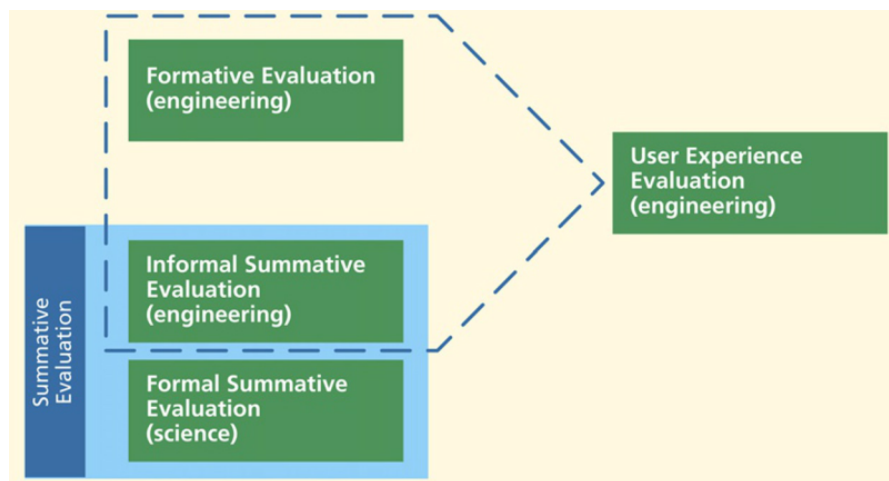


Figure 37: “Engineering UX evaluation is a combination of formative evaluation and informal summative evaluation.”[28]

Hartson and Pyla state, that a formative UX evaluation is used to diagnose the UX with qualitative data to form, fix and refine designs. Summative UX evaluation is an evaluation to “*assess the success of a UX design*”.[28] Above it is written, that the summative evaluation here is informal. *Informal* may be understood as a weaker version of *formal*. Informal uses a smaller number of participants, fewer variables and no experimental controls. Informal summative evaluation is used to support formative evaluation in the evaluation process.[28]

In this iterative development cycle, there have been multiple stages of (formative) evaluation of certain parts and aspects of the system, which led to the current design. The data, that is gathered by means of this study then, is (informal) summative, as a score of the status quo, but of course also formative, as the system is by no means a finished product.

3.1.4 Identify the Practical Issues

Organisation is difficult, especially during these times with SARS-CoV-2. There might be the possibility of executing the study at the Gesundheitsakademie or at the university. In the first case planning is also highly dependent on the Gesundheitsakademie, even more so than when doing it at the university. Both options need a lot of preparation though as Covid-related guidelines and laws are strict. Additionally, obviously all participants need to be fully aware of potential risks and agree to the terms of the study. Participants, of course, may opt-out at any time. To not have multiple participants opt-out after the study is fully planned, an information event, held beforehand, could be highly beneficial. It would be held during participant acquisition, informing possible participants beforehand about the risks involved. There was correspondence with the Gesundheitsakademie about visiting a class and presenting the study proposition in person.

Keeping those situational issues aside, in general there is the difficulty of managing three different participant pools. Although it could be a blessing in disguise, as it breaks down a larger number into smaller, perhaps easier to manage, chunks. Most definitely rather complex is finding and allocating time slots for the student pool. They are hard at work in their education after all. Their time table also is cyclical, switching between different modules involving more theory or more hands-on education in the hospital. It has been proposed as beneficial to execute the study directly at the Gesundheitsakademie. The study could be set up in a dedicated room and students could come over in their breaks. Although still restrictive, it opens up the possibility of more students willing to participate, as there is no need to come to university after a long day for instance.

3.1.5 Decide How to Deal With Ethical Issues

Most involved ethical issues seem also to be practical issues related to Covid and are covered above as practical issues as well as issues regarding the safety of everyone involved (see hygiene instructions). To re-iterate one important point: opt-out is possible at any time. More abstractly, there is the looming question of whether such a study is ethically sound, regardless of safety precautions. It could be argued, that only because something is not outright prohibited by law or guidelines, it does not make it a good course of action. In this case though, as already mentioned, precautions are on a very high level and the recommendation is to conduct the study, if facilitated by the Gesundheitsakademie.

3.1.6 Evaluate, Analyze, Interpret, Present

Under normal circumstances, this part would show the specific analysis and interpretation of the gathered data. Instead, the following mentions what might have been done or what would have been the plan to do. Seeing as this was planned as a usability or rather UX study, grand statistical analysis would not make any sense. It would not make much sense in terms of statistics but also would not answer any of the research questions. Those mostly can only be answered by interaction with the participants, using their experience from everyday life and then ViTT. Only R1 (*Does a System Like ViTT Provide a High User Experience?*) could potentially be answered directly by measured and computed results from the UEQ.

The UEQ is very helpful for UX evaluation not only because that is what it specializes in, but also because it delivers the tools for analysis as well. The questionnaire data is put into an excel file, which computes a multitude of results, that only need to be put into context of what has been tested. It tests pragmatic quality aspects, hedonic quality aspects and an overarching “*valence dimension*,” called attractiveness, as they say. For computing a KPI, they have added an optional attachment with additional items. Those results also only need to be put into the provided excel file.

R2–R4 then may be answered by the semi-structured interview, on basis of the other questionnaires. R2–R4 ask specifically about the practices of kinaesthetics and how ViTT may be integrated in those. Those questions cannot be answered by means of a UX or presence questionnaire, but rather only by directly questioning a range of participants. Their answers in the questionnaires may then serve as hints for other directions in the interview and as supplementing information for R1 — especially the custom question-

naire may build a solid base for the interview, as it essentially asks the research questions. It may help to better understand certain aspects within R1. The other way around may also be true: R2–R4 may be better understood when looking at R1 because in the end a good UX is the base of a successful system.

In addition, analysing the IPQ might give insight about the rate of success regarding the implementation of an immersive experience and if that was an important factor for participants in one way or another. In that sense, the IPQ is not only supplementary material but an evaluation of a specific design-aspect of ViTT, pertaining to R1.

3.1.7 Variation Using Computer Science Students and PhDs

As mentioned beforehand, a slight variation of this study has been devised later on as well. This was to plan for the eventuality of conducting a smaller study with people from the HCI department at University of Konstanz, as a substitute for an impossible study at the Gesundheitsakademie.¹

What has been adjusted? The study is the same but documents have been adjusted to facilitate users outside of medical care. It neither makes sense to explain VR to a PhD student in the welcoming letter, nor does it make sense to ask them in questionnaires about their kinaesthetics usage in their everyday working life in the hospital. One important additional aspect is to ask about patient transfers in private care situations. As mentioned beforehand during the concept finding phase, apparently there is an issue of transfers in private care as well, as mentioned by an experienced nurse. Caring family members are prone to musculoskeletal disorders as well, more so than professionals, due to a lack of education in that space. That is an angle, which is explored a bit in this adjusted version.² The adjusted documents can be found in the appendix as well (C.1, C.2, C.3, C.4).

3.2 PILOT STUDY

As mentioned in the beginning of this chapter, the study could not be conducted. Instead, only a pilot study took place. The reason for a pilot study is to find out, if the study design works as intended. Are time allocations well-put? Are there errors or unnecessary difficulties in the documents? Is the order of all the study parts thought through? Pilot studies are extremely important. Starting the trial period without testing it beforehand might result in having to conduct another study because results are invalid because of bad design, that was overlooked in the design process.[32]

3.2.1 Results, Discussion & Consequences

The pilot study is analysed in this section. Results are reported and resultant consequences regarding the study design are discussed.

TIME ALLOCATION Beforehand, an educated guess was used to project the time needed for the study and its parts, which came in at 76.5 minutes. The

¹ The author is writing this master's thesis at the same HCI department.

² No scientific data on this issue could be found, but it seems plausible. This information then is at least anecdotal evidence, that such an issue exists.

pilot study took 72.5 minutes. The sub parts mostly felt well-paced with only few exceptions. Notably, there should be a bit more time allocated to the tutorial phase. The participant (31 years old, female) was not very proficient with modern digital technology in general and had no experience with VR at all, more time was needed to feel confident in the virtual space. Considering that participants need to put the hardware on by themselves in this study, it provided an additional hurdle especially with the participant's glasses, as outlined below. What usually takes only very little time, might now be rather complicated and time intensive, due to the special precautions (see hygiene instructions), as experienced with the pilot participant.

TECHNICAL ISSUES The participant was wearing large glasses. The used HMD was the Valve Index. When putting on the headset, there was a fear, that the glasses were too large. Participants with even larger frames may have a problem. Especially as there is a trend for a few years now to rather large glasses, it might be necessary to tell potential participants during recruitment, that they wear contact lenses if possible. Additional difficulties occurred, that may have been caused by the glasses, regarding overall sharpness of the image. The participant needed to greatly re-adjust the HMD's headband and the distance of the HMD's lenses, but there was a feeling, that it could not be setup to be sharp. Resulting were some difficulties to read certain text panels in VR. The feeling was, that the HMD was simply too large for the participant's head (including the distance of the lenses). This is a reminder, that VR tech is still somewhat in its infancy, compared to many other modern tech sectors. For the prototype this means, that text and icons should be made as large as possible, as long as it still "fits" within given boundaries. The transfer probably should not be impaired by a slightly blurry presentation.

THE TASKS All in all, task 1 went smoothly. Task 2 however, did not. From observation and subsequent questioning during the interview, it became clear, that some parts of the UI were not completely understood. The participant was under the impression, that in order to move the patient, the play button had to be pressed prior. This issue could have been amended by prolonging the tutorial section a bit and making certain, that the participant does understand everything.

Furthermore, the participant struggled with task 2 in general. Task 2 was still a bit "finicky" to use. Following the movement steps carefully did result in a successful transfer, but being rather "careless" can produce erroneous outcomes. The larger culprit though was the grab mechanic. Intended to give a more natural and intuitive interaction, the participant often grabbed the patient unintentionally and sometimes the system did not register the "letting-go gesture" properly. This resulted in multiple occurrences of dragging the patient around and provoking faulty behaviour of the underlying physics. This led to two changes in the implementation. Firstly, grabbing was simply disabled. From the pilot, it was clear, that this mechanic cannot be used in the intended way with real participants. It works, when one is careful about using it, but it is not robust by any means. Secondly, the patient was slowed down, so to say. Softening effects from gravity and PuppetMaster forces lead to significantly better usability in first tests. The trade-off is less realism. This applies to the disabled grab mechanic as well. For more implementation details see the section before in chapter 2 *Creation of ViTT, 2.3.1, Mode 2, Transferring the Patient*.

4

FUTURE WORK & CONCLUSION

This last chapter serves mostly as an outlook to potential sensible enhancements for ViTT, which are numerous. The original vision for ViTT was somewhat grand, so several conceptualized features could not be implemented. Instead, ViTT may have become a proof of concept—or it could have become that, if the evaluation could have been done properly. In the end, *would have*, *could have* and *should have* are of no consequence. Before some final concluding thoughts on what has been achieved, future work follows with features, that did not become implemented in ViTT, and features, that could not have possibly been implemented within this scope or possibly with today's means at all.

Additionally, ViTT is not strictly limited to the training of kinaesthetic patient transfers. Kinaesthetics is “just” on top of ViTT's base layer, which is a VR system to train movements through two separate modes, instruction and practise.

4.0.1 Future Work

As can be seen throughout the requirements and concept, there are proposed features missing from this current prototype of ViTT. Those and additional ideas are proposed as future work in the following. It may be important to note, that some parts could not be implemented right now, even if an experienced team of developers would take it on. Thus, some parts may seem somewhat *out there*.

MORE NATURAL PHYSICAL INTERACTION The interaction could definitely be more natural during mode 2, when transferring the patient. Firstly, the existing work could still be made more robust, of course. If that would entail implementing or integrating a different underlying physics engine, can not be answered right now, but it is a possibility. Yet, judging from state-of-the-art VR games, where natural interaction is enforced, it is not obvious, that a vastly more natural implementation would be possible in general today (see for instance Half-Life: Alyx [64]). These games do implement grabbing well, but it still adheres to the same principles, as the discarded version of this prototype: on recognition of a grabbing gesture near an object, the system “glues” the object to the player hand, until it is let go. Also, mostly only small simple static objects are interacted with. This worked in ViTT as well (with less robustness). Interacting with a “living” ragdoll is, as was found out however, a lot more complex.¹

Suddenly, multiple systems compete against each other, resulting more often than it should in seemingly breaking physics. This breaks immersion and the interaction flow. As was posed by means of the Master's seminar, the more realistic a depicted situation or interaction is in VR, the easier it

¹ Note: this does not mean, that a professional solution from a state-of-the-art video game would not possibly be considerably better than ViTT's solution. It was merely a remark regarding small static objects versus something like a virtual patient within ViTT's solution.

is to break immersion by introducing errors. During the pilot finally, it was found, that grabbing a patient was not robust enough.

Now, talking about the aspect of natural interaction, it can be seen in a different light. For instance, playing modern VR games mostly does feel natural, but the ceiling still is far from being reached. It mostly feels natural *enough* in context, but that is dependent on the context. Creating a natural feeling, during a virtual patient transfer, seems to be very difficult because of its context. When talking about specifics like grabbing a patient's arm, other ways may be in need of being found, that adhere to real-world physics like grabbing force and friction. Sophisticated mechanics like those would be clearly future work, but VR is an emergent technology still. Looking at the market, one might get the impression, that VR and associated technologies are still somewhat in their infancy. Mainstream VR will still take some time, as it often is the case with emerging and initially expensive technologies.

Natural interaction is a very generalized blanket term though. It may, *naturally*, also include other things like embodiment; how is the user represented? The inclusion of at least forearms for the user seems plausible. Increased embodiment has been shown in recent work by Seinfeld and Müller, however the differences have been found to be small in tasks involving both hands.[54] Nevertheless, a host of difficult design decisions may arise, so implementation should be careful and sensible. The uncanny valley needs to be circumvented. Anecdotally, state-of-the-art VR video games as Half-Life: Alyx [64] usually only show the hands, without forearms, as well.

Tracking for at least the forearms could be employed in ViTT, searching for differences in user experience and transfer skill in contrast to only using hands, as is the case right now.

Natural interaction also may include the following paragraphs, depending on one's viewpoint concerning "natural." For clarity reasons at least, these talking points have been divided, although they overlap somewhat.

LESS NATURAL PHYSICAL INTERACTION It might be sensible to not only look at more natural physical interaction, but also at implementing a patient transfer with less natural interaction. Such an implementation might for example not have physical interaction at all, but just a simulation of it: when touching the patient and trying to move him or her into the correct position, the underlying system could potentially move the patient by itself, according to the transfer animation. The patient would move into the correct position as if on rails (see current implementation mode 1, an animation is playing), but the animation is only playing when the user tries to move the patient into the correct position. *Uncanny* immersion-breaking scenarios are imaginable, but it would be a trade-off for robustness. An evaluation between such an implementation and the current version of ViTT might be interesting.

COMMUNICATION & BEHAVIOUR As seen before within the context-based requirements and later during the concept, a communication and reaction-based behavioural framework was at least thought about. The patient would enforce the surrounding narrative by having certain injuries, which cause him or her to react in different ways to *physical* inputs from the user. This might entail audio and facial expressions according to the specific situation. It could be used as an instant feedback mechanism, telling the user that he or she made an error in the transfer, for instance.

During the design walkthrough experts remarked, that real patients often are in a state of fear during the transfer. Pain is often involved, so they do not want to be transferred, although they have to. Oftentimes, they inadvertently stiffen up for example, making the transfer harder. This could be seen as non-verbal communication. Of course, this would be a sophisticated feature and difficult to implement.

From another point of view, this feature-set may be especially important when looking at how it may induce empathy in the user (see “Almost Real Live Technique” [20]), which in turn may improve immersion.

SCENARIOS FOR DIFFERENT TRANSFER SITUATIONS In ViTT, one patient transfer has been implemented. This was mostly done to be able to concentrate the resources and make better use of the available time. As has been mentioned, the implementation needed a lot of fine-tuning and debugging. However, there are more available materials from project ERTRAG[16], such as different patient transfers regarding various patient capabilities.

Much more difficult to implement in this context would be an actually realistic depiction of the patient and transfer. This does incorporate aspects previously mentioned just above. A realistic scenario, going by the information and feedback gathered during the design walkthroughs, would be a patient with injuries. He or she is in pain, has multiple drainages on his or her body, which greatly limits the movement possibilities, and absolutely does not want to be transferred. Even turning the patient onto the other side is a rather difficult task sometimes. When the carer tries, the patient stiffens up. Often, the carer has to come in close for a successful transfer, which might be a rather repugnant situation regarding bodily fluids. These are every-day situations. A believably realistic virtual simulation could be prohibitively hard to implement.

Apropos difficulty, an expert also mentioned, that a choice of difficulty settings might be a good idea. It certainly seems sensible— various scenarios in different difficulties for training variable transfers. To put this firmly into the future work territory, an automated system could perhaps be used to create those different scenarios. There would need to be access to a database containing relevant patient data. Looking at it from a data privacy viewpoint, there might need to be an opt-in/opt-out for patients and use could only be internal. The system would then be used to access certain attributes like illnesses, injuries, sex, weight, and others, which sets the pertaining parameters for the virtual patient. A virtual patient has been created, on the basis of a real patient. Ad-hoc training scenarios may be used to prepare for specific, “hard to transfer,” patients.

SIMULATION OF MASS One issue, that might only be solved far into the future, is the simulation of mass in VR. There does exist a prototype however by Lopes et al., which creates resistance in users’ arms, stimulating muscles with electrodes, simulating resistance and mass.[36] A solution via an exoskeleton could be thinkable as well, but seems to be more or less in the same realm of future work (see for instance work by Holotron [31]).

The more sensible question then maybe is, how necessary the simulation of virtual mass is for the intended learning effects. This could probably be researched within controlled conditions in a laboratory with highly specialized prototype hardware.

AUGMENTED REALITY WITH A PUPPET On the other hand, there is at least one instance where the simulation of mass is unnecessary, as mass is already present. This could be the case, when ViTT would be re-implemented as an augmented reality application, for instance. Instead of a purely virtual patient, a real puppet for medical training may be used, overlaid with virtual information. This would also take care of haptic feedback, which in the current version of ViTT is handled by ManusVR gloves. A sophisticated AR device, that could possibly facilitate this task, would be the relatively new HoloLens 2 [40].

A large drawback however, could be that overall flexibility is vastly restricted. Where VR ViTT could depict and create virtually any scenario, AR ViTT is bound to the real world. Flexibility would also be restricted in the sense of RQ1 Flexibility: such a puppet would require a dedicated training room or area with a bed or table, that could be adjusted in its height. AR, naturally, has wildly different requirements from the real world, compared to VR.

SWITCHING THE ROLES, BECOMING THE PATIENT Dürr et al. interviewed kinaesthetics instructors and students.[14] An interesting piece of information was given by some students: being in the role of the patient, in an exercise of a patient transfer, reveals another level of understanding of how the patient may feel in a *real* situation. “By then it was often clearer to me how the patient sometimes feels when one expects something from him [...],” one student remarked.

This begs the question however, could this reverse in student-patient relationship be implemented in a VR application, without actually having a second person as an exercise partner? Would there be alternative ways of exploring this space?

FOCUS AND FEEDBACK ON POSTURE ViTT itself and the previous future work propositions in this chapter have focused on the patient transfer. By means of kinaesthetics, awareness for ergonomics is implied. However, a *complete* system could put special focus on the nurse and his or her posture by monitoring it and actively providing feedback. This functionality was part of ViTT’s early concept, its vision, but was not further pursued, as it became clear it was out of scope. Feedback in general is an integral part of the kinaesthetics education, as noted by Dürr et al. The training loop consists of *instruction, practise* and then *feedback*.[14] While instruction and practise are arguably covered by ViTT’s current state, feedback is limited to the magenta highlighting, which only provides affirmation for the patient’s correct end position. Feedback for the him- or herself is currently completely missing.

Such systems, which do monitor the user’s posture in real-time and provide feedback, do exist. For instance, Mahendra recently created such a prototype system, called *CaregiVR*, as part of his master’s project and thesis (see figure 38).[37] CaregiVR functions in the same realm of ergonomic patient transfers as ViTT. A marriage between ViTT and such a system may elevate ViTT’s real-world usefulness to a higher level. Of course, this may increase system complexity considerably. An integration concept would need to be carefully created and evaluated, so that the system integrity would not be compromised.



Figure 38: CaregiVR, a VR application focused on providing feedback on user's posture during a patient transfer.[37]

4.0.2 Conclusion

This thesis set out to portray a complete picture of ViTT's development. Usually, more focus would lie on the conducted study, than on the development. Seeing as a traditional study situation did not happen, additional effort was put into the implementation, which is reflected in a more detailed general description of the development as a whole.

MASTER'S SEMINAR Initial research into the topic of medical care education, with a focus on kinaesthetics, in Germany was used to create a set of four context-based requirements. They described rather high-level needs for ViTT. Subsequently, three requirements, with several sub-points, were created from a related work analysis, which focused on virtual reality, immersion, and learning effects in virtual worlds. Those requirements were more detailed and low-level, and they were used to inform and refine the first four requirements.

MASTER'S PROJECT Using the the master's seminar as a base, during the master's project firstly a detailed concept was created and iteratively evaluated, by conducting two design walkthroughs with experts from the target user-base. That concept was subsequently implemented, with some features missing. However, a working prototype had been created.

MASTER'S THESIS Part of this thesis' scope was to create a study design, as if the study could be conducted normally. Of course, it was not clear for quite a while whether a study could go forward or not. As the prognosis for a successful study became more negative, more and more remaining time was allocated for additional implementations. Issues with the prototype have been addressed, the UI was overhauled, and the study design was carefully completed. An additional tutorial mode was implemented as well, as part of the study design. That design was tested with a pilot. Results were finally used to tweak the design and implementation further.

In the beginning, four research questions were posed. Sadly, none of those can be answered from results of this thesis, as the full evaluation could not be conducted. There are only sentiments from the design walkthroughs

during the concept creation, where questioned experts expressed, that they see potential in the idea of an application like ViTT. As such, these research questions still remain. Nonetheless, through an iterative design cycle, ViTT could be finished as a prototype, showing theoretical potential, ready to be evaluated.

BIBLIOGRAPHY

- [1] Berufsfachschule für Altenpflege und -hilfe Erlenbach. *1. Preis im Ideenwettbewerb 'Gesunde Schule'*. URL: <https://web.archive.org/web/20140110211121/http://www.altenpflegeschule-erlenbach.de/aktuelles/1.-preis-im-ideenwettbewerb-gesunde-schule> (visited on 17/05/2021).
- [2] European Kinaesthetics Association. *Kinaesthetics*. URL: https://www.kinaesthetics.net/download/eka/infoblaetter/deutsch/Infoblatt_1_Was_ist_Kinaesthetics.pdf (visited on 16/05/2021).
- [3] European Kinaesthetics Association. *Kinaesthetics history*. URL: https://www.kinaesthetics.net/download/eka/infoblaetter/deutsch/Infoblatt_4_Die_Geschichte_von_Kinaesthetics.pdf (visited on 17/05/2021).
- [4] Kai Biermann, Manuela Dursun and Karsten Polke-Majewski. "Wo bleibt der Aufstand?" In: *ZEIT ONLINE* (2018). URL: <https://www.zeit.de/arbeit/2018-02/krankenhaus-pflege-fachkraeftemangel-bezahlung-mangel> (visited on 16/05/2021).
- [5] Harry Brenton et al. "The uncanny valley: does it exist". In: *19th British HCI Group Annual Conference: workshop on human-animated character interaction*. 2005, pp. 2–5. URL: <http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.160.6952>.
- [6] Andrea Brogni et al. "Variations in physiological responses of participants during different stages of an immersive virtual environment experiment". In: *Proceedings of the ACM symposium on Virtual reality software and technology - VRST '06* (2006), pp. 376–382. DOI: [10.1145/1180495.1180572](https://doi.org/10.1145/1180495.1180572). URL: <http://portal.acm.org/citation.cfm?doid=1180495.1180572>.
- [7] Pinky Budhrani-Shani et al. "Mind-Body Exercises for Nurses with Chronic Low Back Pain: An Evidence-Based Review". In: *Nursing Research and Practice* 2016 (2016), pp. 1–10. ISSN: 2090-1429. DOI: [10.1155/2016/9018036](https://doi.org/10.1155/2016/9018036).
- [8] Ann L. Butt, Suzan Kardong-Edgren and Anthony Ellertson. "Using Game-Based Virtual Reality with Haptics for Skill Acquisition". In: *Clinical Simulation in Nursing* 16 (2018), pp. 25–32. ISSN: 1876-1399. DOI: <https://doi.org/10.1016/j.ecns.2017.09.010>. URL: <https://www.sciencedirect.com/science/article/pii/S1876139917301986>.
- [9] Bill Buxton. *Sketching User Experiences: Getting the Design Right and the Right Design*. Morgan Kaufmann, 2007. ISBN: 9780080552903. DOI: <https://www.doi.org/10.1016/B978-0-12-374037-3.X5043-3>. URL: <https://www.sciencedirect.com/book/9780123740373/sketching-user-experiences?via=ihub=>.
- [10] Gordon Calleja. *In-Game: From Immersion to Incorporation*. The MIT Press, 2011, p. 234. ISBN: 9780262295451. DOI: [10.7551/mitpress/8429.001.0001](https://doi.org/10.7551/mitpress/8429.001.0001). URL: <https://direct.mit.edu/books/book/2889/in-gamefrom-immersion-to-incorporation>.

- [11] Feng-Qin Chen et al. "Effectiveness of Virtual Reality in Nursing Education: Meta-Analysis". In: *Journal of Medical Internet Research* 22 (2020). DOI: [10.2196/18290](https://doi.org/10.2196/18290). URL: <https://www.jmir.org/2020/9/e18290>.
- [12] James J. Cummings and Jeremy N. Bailenson. "How Immersive Is Enough? A Meta-Analysis of the Effect of Immersive Technology on User Presence". In: *Media Psychology* 19.2 (2016), pp. 272–309. ISSN: 15213269. DOI: [10.1080/15213269.2015.1015740](https://doi.org/10.1080/15213269.2015.1015740). URL: <https://www.tandfonline.com/doi/full/10.1080/15213269.2015.1015740>.
- [13] Maximilian Dürr et al. "KiTT - The Kinaesthetics Transfer Teacher : Design and Evaluation of a Tablet-based System to Promote the Learning of Ergonomic Patient Transfers". In: *Proceedings of the ACM Conference on Human Factors in Computing Systems (CHI 2021)*. New York: ACM, 2021. ISBN: 978-1-4503-8096-6. DOI: [10.1145/3411764.3445496](https://doi.org/10.1145/3411764.3445496). URL: <https://dl.acm.org/doi/10.1145/3411764.3445496>.
- [14] Maximilian Dürr et al. "Learning Patient Transfers with Technology: A Qualitative Investigation of the Design Space". In: *Proceedings of Mensch Und Computer 2019. MuC'19*. Hamburg, Germany: Association for Computing Machinery, 2019, pp. 79–90. ISBN: 9781450371988. DOI: [10.1145/3340764.3340784](https://doi.org/10.1145/3340764.3340784). URL: <https://doi.org/10.1145/3340764.3340784>.
- [15] Julian Erbersdobler. " 'Für einige sind gerade die ersten beiden Wochen schlimm' ". In: *Süddeutsche Zeitung* (2021). URL: <https://www.sueddeutsche.de/karriere/corona-ausbildung-pflege-krankenhaus-1.5251117> (visited on 29/04/2021).
- [16] Projekt ERTRAG. *Projekt ERTRAG*. URL: <https://www.technik-zum-menschen-bringen.de/projekte/ertrag> (visited on 11/09/2020).
- [17] Alexander Eydlin. "Pflegebeauftragter warnt vor Massenflucht aus Pflegeberufen". In: *ZEIT ONLINE* (2021). URL: <https://www.zeit.de/politik/deutschland/2021-04/corona-krise-pflegeberuf-massenflucht-pandemie-arbeitsbedingungen-stress> (visited on 29/04/2021).
- [18] Shanna Fealy et al. "The integration of immersive virtual reality in tertiary nursing and midwifery education: A scoping review". In: *Nurse Education Today* 79 (2019), pp. 14–19. ISSN: 0260-6917. DOI: <https://doi.org/10.1016/j.nedt.2019.05.002>. URL: <https://www.sciencedirect.com/science/article/pii/S0260691719300711>.
- [19] FeitizoGames. *Outline shader*. URL: https://www.youtube.com/watch?v=XPGpaA-JExA&ab_channel=FeitizoGames (visited on 16/09/2020).
- [20] Joshua A Fisher. "Empathic Actualities: Toward a Taxonomy of Empathy in Virtual Reality". In: *International Conference on Interactive Digital Storytelling*. Ed. by David Oyarzun et al. Vol. 7648. Lecture Notes in Computer Science. Berlin, Heidelberg: Springer Berlin Heidelberg, 2017, pp. 233–244. ISBN: 978-3-642-34850-1. DOI: [10.1007/978-3-319-71027-3_19](https://doi.org/10.1007/978-3-319-71027-3_19). URL: https://link.springer.com/chapter/10.1007%2F978-3-319-71027-3_19.
- [21] Epic Games. *Unreal Engine*. URL: <https://www.unrealengine.com/en-US/> (visited on 11/09/2020).

- [22] Maia Garau et al. "The responses of people to virtual humans in an immersive virtual environment". In: *Presence: Teleoperators and Virtual Environments* 14.1 (2005), pp. 104–116. ISSN: 10547460. DOI: [10.1162/1054746053890242](https://doi.org/10.1162/1054746053890242). URL: <https://direct.mit.edu/pvar/article/14/1/104/18559/The-Responses-of-People-to-Virtual-Humans-in-an>.
- [23] Markus Göbel. *SimpleJSON*. URL: <https://github.com/Bunny83/SimpleJSON> (visited on 20/09/2020).
- [24] Google. *Google Text-to-Speech*. URL: <https://cloud.google.com/text-to-speech?hl=de> (visited on 22/04/2021).
- [25] Google. *Material design icons and guidelines*. URL: <https://material.io/> (visited on 23/04/2021).
- [26] F. Gutiérrez et al. "The Effect of the Degree of Immersion upon Learning Performance in Virtual Reality Simulations for Medical Education." In: *Journal of Investigative Medicine* 55.1 (2007), pp. 155–160. ISSN: 1081-5589. DOI: [10.1097/00042871-200701010-00099](https://doi.org/10.1097/00042871-200701010-00099). URL: <https://pubmed.ncbi.nlm.nih.gov/17377256/>.
- [27] Rex Hartson and Pardha Pyla. "Chapter 1 - What Are UX and UX Design?" In: *The UX Book (Second Edition)*. Ed. by Rex Hartson and Pardha Pyla. Second Edition. Boston: Morgan Kaufmann, 2019, pp. 3–25. ISBN: 978-0-12-805342-3. DOI: <https://doi.org/10.1016/B978-0-12-805342-3.00001-1>. URL: <http://www.sciencedirect.com/science/article/pii/B9780128053423000011>.
- [28] Rex Hartson and Pardha Pyla. "Chapter 21 - UX Evaluation Methods and Techniques". In: *The UX Book (Second Edition)*. Ed. by Rex Hartson and Pardha Pyla. Second Edition. Boston: Morgan Kaufmann, 2019, pp. 435–451. ISBN: 978-0-12-805342-3. DOI: <https://doi.org/10.1016/B978-0-12-805342-3.00021-7>. URL: <http://www.sciencedirect.com/science/article/pii/B9780128053423000217>.
- [29] Rex Hartson and Pardha Pyla. "Chapter 5 - Prelude to the Process Chapters". In: *The UX Book (Second Edition)*. Ed. by Rex Hartson and Pardha Pyla. Second Edition. Boston: Morgan Kaufmann, 2019, pp. 81–93. ISBN: 978-0-12-805342-3. DOI: <https://doi.org/10.1016/B978-0-12-805342-3.00005-9>. URL: <http://www.sciencedirect.com/science/article/pii/B9780128053423000059>.
- [30] Rex Hartson and Pardha Pyla. *The UX Book (Second Edition)*. Ed. by Rex Hartson and Pardha Pyla. Second Edition. Boston: Morgan Kaufmann, 2019. ISBN: 978-0-12-805342-3. DOI: <https://doi.org/10.1016/C2013-0-19285-9>. URL: <https://www.sciencedirect.com/book/9780128053423/the-ux-book?via=ihub=>.
- [31] Holotron. *Holotron Exoskeleton*. URL: <https://www.holotron.com/> (visited on 17/05/2021).
- [32] Kasper Hornbæk. "Some Whys and Hows of Experiments in Human–Computer Interaction". In: *Foundations and Trends® in Human–Computer Interaction* 5.4 (2013), pp. 299–373. ISSN: 1551-3955. DOI: [10.1561/1100000043](https://doi.org/10.1561/1100000043). URL: <https://www.nowpublishers.com/article/Details/HCI-043>.
- [33] JetBrains. *JetBrains Rider*. URL: <https://www.jetbrains.com/de-de/rider/> (visited on 11/09/2020).

- [34] C. Kilmon et al. "Immersive Virtual Reality Simulations in Nursing Education". In: *Nursing Education Perspectives* 31 (2010), pp. 314–317. ISSN: 1536-5026. URL: <https://pubmed.ncbi.nlm.nih.gov/21086871/>.
- [35] Franz Knieps and Holger Pfaff. *BKK Gesundheitsreport 2020: Mobilität - Arbeit - Gesundheit. Zahlen, Daten, Fakten*. MWV Medizinisch Wissenschaftliche Verlagsgesellschaft, Dec. 2020. ISBN: 978-3-95466-559-4. URL: https://www.bkk-dachverband.de/fileadmin/Artikelsystem/Publikationen/2020/Gesundheitsreport_2020/BKK_Gesundheitsreport_2020_web.pdf.
- [36] Pedro Lopes et al. "Providing Haptics to Walls & Heavy Objects in Virtual Reality by Means of Electrical Muscle Stimulation". In: *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*. CHI '17. Denver, Colorado, USA: Association for Computing Machinery, 2017, pp. 1471–1482. ISBN: 9781450346559. DOI: 10.1145/3025453.3025600. URL: <https://dl.acm.org/doi/10.1145/3025453.3025600>.
- [37] Tanveer Singh Mahendra. "CaregiVR: A Virtual Reality System that Provides Concurrent and Terminal Feedback for the Self-Directed Training of Ergonomic Patient Transfers". Under review. MA thesis. University of Konstanz, 2021.
- [38] Marc Pomplun and Maja Matarić. "Evaluation metrics and results of human arm movement imitation". In: *First IEEE-RAS International Conference on Humanoid Robotics* (2000). URL: <http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.146.2967>.
- [39] Rachel McDonnell, Martin Breidt and Heinrich H. Bühlhoff. "Render me real?" In: *ACM Transactions on Graphics* 31.4 (2012), pp. 1–11. ISSN: 07300301. DOI: 10.1145/2185520.2185587. URL: <http://dl.acm.org/citation.cfm?doid=2185520.2185587>.
- [40] Microsoft. *HoloLens 2*. URL: <https://www.microsoft.com/de-de/hololens/> (visited on 08/05/2021).
- [41] Paul Milgram and Fumio Kishino. "Taxonomy of mixed reality visual displays". In: *IEICE Transactions on Information and Systems* E77-D.12 (1994), pp. 1321–1329. ISSN: 09168532. DOI: 10.1.1.102.4646. URL: http://web.cs.wpi.edu/~gogo/courses/cs525H_2010f/papers/Milgram_IEICE_1994.pdf.
- [42] Chris Milk. *How virtual reality can create the ultimate empathy machine*. 2015. URL: https://www.ted.com/talks/chris_milk_how_virtual_reality_can_create_the_ultimate_empathy_machine (visited on 08/05/2021).
- [43] Ministerium für Arbeit, Gesundheit und Soziales des Landes Nordrhein-Westfalen. *Landesberichterstattung Gesundheitsberufe Nordrhein-Westfalen 2017. Situation der Ausbildung und Beschäftigung*. URL: https://broschuerenservice.nrw.de/files/download/pdf/lb-gesundheitsberufe-web-pdf_von_landesberichterstattung-gesundheitsberufe-nordrhein-westfalen-2017-vom_mags_3008.pdf (visited on 18/05/2021).
- [44] Salman Nazir, Annette Kluge and Davide Manca. "Can Immersive Virtual Environments make the difference in training industrial operators?" In: *Proceedings of the Human Factors and Ergonomics Society Europe* 4959.2003 (2014), pp. 251–265. ISSN: 0008-8846. URL: <https://www.hfes-europe.org/wp-content/uploads/2014/06/Nazir.pdf>.
- [45] Virtual Reality Oasis. *Dexmo Review*. URL: <https://youtu.be/IYf-QAW27ao?t=217> (visited on 24/09/2020).

- [46] Oculus. *Oculus Quest*. URL: <https://www.oculus.com/quest/> (visited on 23/09/2020).
- [47] Oculus. *Oculus Quest 2*. URL: <https://www.oculus.com/quest-2/> (visited on 08/05/2021).
- [48] Jennifer Preece, Helen Sharp and Yvonne Rogers. *Interaction Design: Beyond Human-Computer Interaction*. 4th. Wiley Publishing, 2015. ISBN: 978-1-119-08879-0. URL: <https://www.wiley.com/en-us/Interaction+Design%3A+Beyond+Human+Computer+Interaction%2C+4th+Edition-p-9781119088790>.
- [49] Reallusion. *Reallusion iClone and Character Creator*. URL: <https://www.reallusion.com/> (visited on 11/09/2020).
- [50] RootMotion. *PuppetMaster*. URL: <https://assetstore.unity.com/packages/tools/physics/puppetmaster-48977> (visited on 11/09/2020).
- [51] Dr. Martin Schrepp. *User Experience Questionnaire Handbook*. URL: <https://www.ueq-online.org/Material/Handbook.pdf> (visited on 30/04/2021).
- [52] Anna Schwarze et al. "Is Virtual Reality the Future of Learning? A Critical Reflection". In: *Proceedings of the 52nd Hawaii International Conference on System Sciences*. 2019, pp. 1759–1768. ISBN: 9780998133126. DOI: 10.24251/HICSS.2019.214. URL: <https://hdl.handle.net/10125/59616>.
- [53] Valentin Schwind, Katrin Wolf and Niels Henze. "Avoiding the Uncanny Valley in Virtual Character Design". In: *Interactions* 25.5 (Aug. 2018), pp. 45–49. ISSN: 10725520. DOI: 10.1145/3236673. URL: <http://dl.acm.org/citation.cfm?doid=3271652.3236673>.
- [54] Sofia Seinfeld and Jörg Müller. "Impact of visuomotor feedback on the embodiment of virtual hands detached from the body". In: *Scientific Reports* 10 (2020). ISSN: 2045-2322. DOI: 10.1038/s41598-020-79255-5. URL: <https://www.nature.com/articles/s41598-020-79255-5>.
- [55] Simon Senecal et al. "Salsa dance learning evaluation and motion analysis in gamified virtual reality environment". In: *Multimedia Tools and Applications* 79.33 (2020), pp. 24621–24643. ISSN: 1573-7721. DOI: 10.1007/s11042-020-09192-y. URL: <https://link.springer.com/article/10.1007%2Fs11042-020-09192-y>.
- [56] Shwn Huey Shieh et al. "Increased low back pain risk in nurses with high workload for patient care: A questionnaire survey". In: *Taiwanese Journal of Obstetrics and Gynecology* 55.4 (2016), pp. 525–529. ISSN: 18756263. DOI: 10.1016/j.tjog.2016.06.013. URL: <https://www.sciencedirect.com/science/article/pii/S1028455916300894?via%3Dihub3>.
- [57] Mel Slater. "Place illusion and plausibility can lead to realistic behaviour in immersive virtual environments". In: *Philosophical Transactions of the Royal Society B: Biological Sciences* 364.1535 (2009), pp. 3549–3557. ISSN: 14712970. DOI: 10.1098/rstb.2009.0138. URL: <https://royalsocietypublishing.org/doi/10.1098/rstb.2009.0138>.
- [58] J. Smedley et al. "Manual handling activities and risk of low back pain in nurses". In: *Occupational and Environmental Medicine* 52.3 (1995), pp. 160–163. ISSN: 13510711. DOI: 10.1136/oem.52.3.160. URL: <https://oem.bmj.com/content/52/3/160>.

- [59] W. Brian Sweeney. "Teaching Surgery to Medical Students". In: *Clin Colon Rectal Surg* 25.3 (2012), pp. 127–133. ISSN: 1531-0043. DOI: [10.1055/s-0032-1322525](https://doi.org/10.1055/s-0032-1322525). URL: <https://www.thieme-connect.de/products/ejournals/abstract/10.1055/s-0032-1322525>.
- [60] Tuukka M. Takala et al. "Martial Arts Training in Virtual Reality with Full-body Tracking and Physically Simulated Opponents". In: *2020 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW)*. 2020, p. 858. DOI: [10.1109/VRW50115.2020.00282](https://doi.org/10.1109/VRW50115.2020.00282). URL: <https://ieeexplore.ieee.org/document/9090557>.
- [61] TheNounProject. *The Noun Project icons*. URL: <https://thenounproject.com/> (visited on 23/04/2021).
- [62] Alison M. Trinkoff et al. "Musculoskeletal problems of the neck, shoulder, and back and functional consequences in nurses". In: *American Journal of Industrial Medicine* 41.3 (2002), pp. 170–178. DOI: <https://doi.org/10.1002/ajim.10048>. URL: <https://onlinelibrary.wiley.com/doi/abs/10.1002/ajim.10048>.
- [63] Unity. *Unity*. URL: <https://unity.com/> (visited on 11/09/2020).
- [64] Valve. *Half-Life: Alyx*. URL: <https://www.half-life.com/de/alyx/> (visited on 04/05/2021).
- [65] Valve. *Valve Index VR headset*. URL: <https://www.valvesoftware.com/de/index/headset> (visited on 18/05/2021).
- [66] verdi. *Zu viele brechen Pflege-Ausbildung ab*. URL: <https://gesundheitssoziales.verdi.de/themen/fachkraeftemangel/++co++46366b8e-7efd-11e8-86d7-525400423e78> (visited on 18/05/2021).
- [67] VRTK. *VRTK Unity Assetstore Page*. URL: <https://assetstore.unity.com/packages/tools/integration/vrtk-virtual-reality-toolkit-vr-toolkit-64131> (visited on 11/09/2020).
- [68] Colin Ware. *Information Visualization: Perception for Design*. 3rd ed. Morgan Kaufmann Series in Interactive Technologies. Amsterdam: Morgan Kaufmann, 2012. ISBN: 978-0-12-381464-7. URL: <http://www.sciencedirect.com/science/book/9780123814647>.
- [69] Sebastian Weiß et al. "Applications of Immersive VR in Nursing Education". In: *Tagungsband der 1. Clusterkonferenz 2018 - Innovative Technologien für die Pflege*. BIS Verlag, 2018, pp. 174–179. URL: <https://www.offis.de/offis/publikation/applications-of-immersive-vr-in-nursing-education.html>.
- [70] Wikipedia. *5G latency*. URL: https://en.wikipedia.org/wiki/5G_Latency (visited on 18/05/2021).
- [71] Wikipedia. *Screen-door effect*. URL: https://en.wikipedia.org/wiki/Screen-door_effect (visited on 11/09/2020).
- [72] Jacob O. Wobbrock and Julie A. Kientz. "Research Contributions in Human-Computer Interaction". In: *Interactions* 23.3 (Apr. 2016), pp. 38–44. ISSN: 1072-5520. DOI: [10.1145/2907069](https://doi.org/10.1145/2907069). URL: <https://dl.acm.org/doi/10.1145/2907069>.
- [73] Adele Pei Ning Woon et al. "Effectiveness of virtual reality training in improving knowledge among nursing students: A systematic review, meta-analysis and meta-regression". In: *Nurse Education Today* 98 (2021), p. 104655. ISSN: 0260-6917. DOI: [10.1016/j.nedt.2020.104655](https://doi.org/10.1016/j.nedt.2020.104655). URL: <https://www.sciencedirect.com/science/article/pii/S0260691720315057>.

A

APPENDIX (CONCEPT
WALKTHROUGH)

A.1 WELCOME LETTER

Willkommen

Sehr geehrte*r Teilnehmer*in,

vielen Dank, dass Sie sich dazu bereiterklärt haben an dieser Untersuchung teilzunehmen! Im Folgenden werden Sie über das Ziel sowie den Ablauf informiert. Sofern Sie Fragen oder Anmerkungen haben, können Sie diese gerne jederzeit einbringen!

Als Teil meiner Masterarbeit an der Universität Konstanz möchte ich eine Virtual-Reality-Anwendung erstellen, die auszubildende Pfleger*innen dabei unterstützt Patiententransfers, auf Basis von Kinaesthetics, zu üben. Dabei soll das Üben eigenständig, ohne menschlichen Übungspartner, sowie ohne großen Aufwand, möglich sein. Für diese Anwendung habe ich ein Konzept erstellt, welches ich gerne zusammen mit Ihnen besprechen möchte, um Feedback und Hinweise für die weitere Implementierung zu erhalten.

Virtual Reality ist als Technologie interessant, da es, gegenüber herkömmlicher zweidimensionaler Darstellung an Monitoren, potenziell diverse Vorteile bietet. Mit Virtual Reality versucht man dem Nutzer eine virtuelle Welt glaubhaft darzustellen (durch stereoskopisches Sehen und egozentrische Bewegung des Nutzers). Beispielsweise wird ein virtuelles Krankenhauszimmer mit einem virtuellen Patienten dargestellt. Der Nutzer soll nun den Eindruck bekommen sich tatsächlich in diesem virtuellen Zimmer mit dem virtuellen Patienten aufzuhalten.

Der Ablauf dieser Untersuchung ist wie folgt:

- Willkommensschreiben, Einverständniserklärung und demographischer Fragebogen
- Darstellung und Besprechung des Konzeptes
- Kurzes Interview, um offene Fragen zu klären

Dauer: ca. 45 min

Vielen Dank für Ihre Unterstützung!

A.2 CONSENT FORM

Teilnehmer ID: _____

Einverständniserklärung (Dozent)

Sehr geehrte*r Teilnehmer*in,

vielen Dank, dass Sie sich dazu bereiterklärt haben, an diesem „Design-Walkthrough“ teilzunehmen! Über das Ziel, den Inhalt und die Dauer wurden Sie bereits informiert.

- 1) Im Rahmen dieser Untersuchung werden durch Audioaufnahmen sowie Fragebogen Daten erhoben.
- 2) Die erhobenen Daten werden pseudonymisiert analysiert und vertraulich behandelt. Die Daten werden ausschließlich zur Auswertung, Analyse, Dokumentation, Präsentation und Publikation wissenschaftlicher Arbeit genutzt. Abseits der genannten Zwecke werden die Daten nicht an Dritte weitergegeben.
- 3) Sie können diese Einverständniserklärung widerrufen. Der Widerruf ist nicht mehr möglich, sofern bereits mit der Auswertung der erhobenen Daten begonnen wurde. Pseudonymisierte Daten, welche bereits in wissenschaftliche Arbeiten eingeflossen sind, können nicht mehr gelöscht werden.

Hiermit erklären Sie sich mit den oben genannten Punkten einverstanden:

(Name in Blockbuchstaben)

(Ort, Datum)

(Unterschrift)

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

(Name in Blockbuchstaben)

(Ort, Datum)

(Unterschrift)

A.3 DEMOGRAPHIC QUESTIONNAIRE

Teilnehmer ID: _____

Demographischer Fragebogen (Dozenten)

Geschlecht _____

Alter _____

Falls vorhanden, Erkrankungen des
Bewegungsapparates aufgrund der Arbeit
im Krankenhaus _____

Arbeit

Aktueller Beruf _____

Arbeitsjahre im aktuellen Beruf _____

Grad der Ausbildung in Bezug zu
Kinaesthetics (z. B. Grundkurs Trainer) _____Selbst besuchte Kinaestheticskurse
_____Jahre an Lehrtätigkeit in Bezug zu
Kinaesthetics _____Jahre an Arbeitserfahrung in Bezug
zu Kinaesthetics _____

Wie schätzen Sie Ihre Kenntnisse im Umgang mit Computern und verwandten Systemen (z. B. Smartphones, Tablets, ...) ein?

sehr schlecht sehr gut
○ ○ ○ ○ ○

Teilnehmer ID: _____

Haben Sie bereits Erfahrung mit digitalen Medien zur Aneignung, Wiederholung oder Lehre von Kinaesthetics gesammelt? Als wie hilfreich empfinden Sie diese Medien?

Sofern Sie bereits Erfahrung gesammelt haben, als wie hilfreich empfinden Sie digitale Medien zu diesen Zwecken allgemein?

gar nicht hilfreich o o o o o sehr hilfreich

Bitte nennen Sie folgend Ihnen bekannte digitale Medien und, sofern Sie mit diesen bereits Erfahrung gesammelt haben, bewerten Sie sie:

(1) _____ gar nicht hilfreich o o o o o sehr hilfreich

(2) _____ gar nicht hilfreich o o o o o sehr hilfreich

(3) _____ gar nicht hilfreich o o o o o sehr hilfreich

A.4 DEMOGRAPHIC QUESTIONNAIRE (REVISED)

Teilnehmer ID: _____

Demographischer Fragebogen (Dozenten)

Geschlecht _____

Alter _____

Falls vorhanden, Erkrankungen des
Bewegungsapparates aufgrund der Arbeit
im Krankenhaus _____

Arbeit

Aktueller Beruf _____

Arbeitsjahre im aktuellen Beruf _____

Grad der Ausbildung in Bezug zu
Kinaesthetics (z. B. Grundkurs Trainer) _____

Selbst besuchte Kinaestheticskurse

Jahre an Lehrtätigkeit in Bezug zu
Kinaesthetics _____

Jahre an Arbeitserfahrung in Bezug
zu Kinaesthetics _____

**Wie schätzen Sie Ihre Kenntnisse im Umgang mit Computern und verwandten Systemen
(z. B. Smartphones, Tablets, ...) ein?**

sehr schlecht ○ ○ ○ ○ sehr gut
○

Teilnehmer ID: _____

Haben Sie bereits Erfahrung mit digitalen Medien zur Aneignung, Wiederholung oder Lehre von Kinaesthetics gesammelt? Als wie hilfreich empfinden Sie diese Medien?

Sofern Sie bereits Erfahrung gesammelt haben, als wie hilfreich empfinden Sie digitale Medien zu diesen Zwecken allgemein?

gar nicht hilfreich sehr hilfreich

Bitte nennen Sie folgend Ihnen bekannte digitale Medien und, sofern Sie mit diesen bereits Erfahrung gesammelt haben, bewerten Sie sie:

	gar nicht hilfreich				sehr hilfreich
(1) _____	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
	gar nicht hilfreich				sehr hilfreich
(2) _____	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
	gar nicht hilfreich				sehr hilfreich
(3) _____	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Wie häufig setzen Sie Kinaesthetics im praktischen Arbeitsalltag, an echten Patienten, ein?

sehr selten sehr häufig

Wie schätzen Sie den Nutzen von Kinaesthetics im praktischen Arbeitsalltag, an echten Patienten, ein?

gar nicht hilfreich sehr hilfreich

A.5 SEMI-STRUCTURED INTERVIEW

- Eigene Einschätzung: wie wichtig könnte meine Anwendung sein, sofern sie wie konzipiert funktioniert bzw wie gut könnte sie praktisch funktionieren?
 - Ist das Training evtl. zu individuell, als dass man es verallgemeinernd in eine App packen könnte?
- Interessante Studien-/Untersuchungsfragen?
 - Gibt es Puppen, die man zum Kinaesthetiktraining nutzen könnte?

- *UI Menü Anfangsauswahl* -> Movement – Scenario (Narrative) – Mode
- *Instrcutions* -> Written, Voice
 - Video?
- *Communication Patient <-> Carer*
- *Feedback*
 - Feedback überhaupt nötig?
 - In welcher Form?
 - Aggregiert am Ende oder eher in Echtzeit nebenbei?
 - Echtzeit: Feedback als aktive Hilfe (proaktiv) als Guide oder eher reaktiv, wenn wirklich Fehler gemacht wurden?

B | APPENDIX (PRIMARY STUDY)

B.1 WELCOME LETTER

Willkommen

Sehr geehrte*r Teilnehmer*in,

vielen Dank, dass Sie sich dazu bereiterklärt haben an dieser Untersuchung teilzunehmen! Im Folgenden werden Sie über das Ziel sowie den Ablauf informiert.

Sie werden ein System in Virtual-Reality (VR) benutzen. Als Teil meiner Masterarbeit an der Universität Konstanz habe ich eine VR-Anwendung erstellt, die auszubildende Pfleger*innen dabei unterstützen soll Patiententransfers, auf Basis von Kinaesthetics, selbstständig zu üben.

VR basiert auf der Stereoskopie. Menschen sehen die Welt dreidimensional, da u. a. aus den versetzten Blickwinkeln der Augen Tiefeninformation gewonnen wird. Zur Nutzung einer VR-Anwendung ist eine VR-Brille notwendig, die sich des Effektes der Stereoskopie bedient. Sie erfahren die dargestellte virtuelle Welt also in 3D. Bewegen Sie sich mit dem Gerät in der echten Welt, bewegen Sie sich im selben Maße auch in der virtuellen. Der Sinn hinter einer typischen VR-Erfahrung ist es eine virtuelle Welt „echt“ erscheinen zu lassen.

Die von mir erstellte VR-Anwendung soll von Ihnen nun getestet werden. Dabei bekommen Sie zunächst die Möglichkeit sich in der virtuellen Umgebung zurechtzufinden. Danach testen Sie zwei verschiedene, aber aufeinander aufbauende, Teile der Anwendung: zuerst werden Sie einen virtuellen Patiententransfer beobachten und danach diesen Transfer selbst in VR durchführen.

Der Ablauf dieser Untersuchung ist wie folgt:

- Willkommensschreiben, Einverständniserklärung und demographischer Fragebogen
- Einführung in VR und grundlegende Konzepte
- Anwendungstest
- Fragebogen, gefolgt von einem Interview, um offene Fragen zu klären

Dauer: ca. 80 min

Sie haben jederzeit die Möglichkeit diese Untersuchung abubrechen. Bitte setzen Sie hierzu einfach die Studienleitung in Kenntnis. Sofern Sie Fragen oder Anmerkungen haben, können Sie diese gerne jederzeit während der Untersuchung einbringen!

Vielen Dank für Ihre Unterstützung!

B.2 CONSENT FORM

Teilnehmer ID: ____

Einverständniserklärung

Sehr geehrte*r Teilnehmer*in,

vielen Dank, dass Sie sich dazu bereiterklärt haben, an dieser Untersuchung teilzunehmen! Über das Ziel, den Inhalt und die Dauer der Studie wurden Sie bereits informiert.

- 1) Im Rahmen dieser Studie werden durch Audioaufnahmen, Videoaufnahmen, Logging (das Speichern Ihrer Interaktionen während der Studie und manuelle Notizen hierzu) sowie Fragebogen Daten erhoben.
- 2) Die erhobenen Daten werden pseudonymisiert analysiert und vertraulich behandelt. Die Daten werden ausschließlich zur Auswertung, Analyse, Dokumentation, Präsentation und Publikation wissenschaftlicher Arbeit genutzt. Abseits der genannten Zwecke werden die Daten nicht an Dritte weitergegeben.
- 3) Als Bestandteil der Auswertung und Analyse werden möglicherweise Teile der erhobenen Daten, zum Zwecke der professionellen Beurteilung, Experten aus dem medizinischen Bereich vorgeführt.
- 4) Für diese Untersuchung wurde ein Hygienekonzept entwickelt, um gesundheitliche Schäden möglichst auszuschließen. Sollten dennoch, trotz aller Vorkehrungen, Probleme auftreten, wird keine Haftung übernommen. Dies schließt abseits der Hygiene auch etwaige mögliche Vorkommnisse wie Stolpern, während der Benutzung des Systems, ein. Während der Nutzung des Systems werden Sie sich bewegen müssen. Aus rechtlichen Gründen muss hierauf verwiesen werden. Folgende Sicherheitsvorkehrungen wurden umgesetzt:
 - a. Der gegenwärtige Raum, in dem die Untersuchung stattfindet, wird regelmäßig gelüftet.
 - b. Alle genutzten Oberflächen und Gegenstände wurden zuvor desinfiziert.
 - c. Der Studienleiter hält stets, wenn möglich, einen Sicherheitsabstand von mindestens 2 m ein. In Ausnahmefällen kann es vorkommen, dass Ihnen der Studienleiter, zur ordnungsgemäßen Nutzung des Systems, helfen muss und hierbei näher an Sie herantritt. Sie werden davor um Erlaubnis gebeten.
 - d. Der Studienleiter trägt stets einen hochwertigen auf Sicherheit geprüften und über geltende Vorschriften deutlich hinausgehenden Mund-Nasen-Schutz. Sie werden darum gebeten, wenn möglich, ebenfalls das Beste zu nutzen, was Ihnen zur Verfügung steht.
 - e. Sie bekommen frische Einweghandschuhe zur Verfügung gestellt, der Studienleiter trägt diese auch.

Teilnehmer ID: ____

- f. Sie bekommen zur Nutzung des Systems eine Gesichtsmaske, die eine direkte Berührung der Geräte um Ihre Augen herum verhindert.
- 5) Sie können diese Einverständniserklärung widerrufen. Der Widerruf ist nicht mehr möglich, sofern bereits mit der Auswertung der erhobenen Daten begonnen wurde. Pseudonymisierte Daten, welche bereits in wissenschaftliche Arbeiten eingeflossen sind, können nicht mehr gelöscht werden.

Hiermit erklären Sie sich mit den oben genannten Punkten einverstanden:

(Name in Blockbuchstaben) (Ort, Datum) (Unterschrift)

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

(Name in Blockbuchstaben) (Ort, Datum) (Unterschrift)

B.3 DEMOGRAPHIC QUESTIONNAIRE (INSTRUCTORS)

Teilnehmer ID: _____

Demographischer Fragebogen (Dozenten)

Geschlecht _____

Alter _____

Falls vorhanden, Sehstörungen (z. B.
Farbenblindheit, Kurz-/Weitsichtigkeit) _____

Falls vorhanden, eingeschränkte
Bewegungsfähigkeit _____

Sie sind ... Linkshänder Rechtshänder

Arbeit

Aktueller Beruf _____

Arbeitsjahre im aktuellen Beruf _____

Grad der Ausbildung in Bezug auf
Kinaesthetics (z. B. Grundkurs Trainer) _____

Selbst besuchte Kinaestheticskurse

Jahre an Lehrtätigkeit in Bezug auf
Kinaesthetics _____

Jahre an Arbeitserfahrung in Bezug
auf Kinaesthetics _____

Falls vorhanden, Erkrankungen des
Bewegungsapparates durch die Arbeit
im Krankenhaus _____

Teilnehmer ID: _____

Wie schätzen Sie Ihre Kenntnisse im Umgang mit Computern und verwandten Systemen ein (z. B. Smartphones, Tablets, ...)?

gar keine Kenntnisse sehr gute Kenntnisse

Haben Sie bereits Erfahrung mit Virtual-Reality-Geräten oder -Anwendungen (z. B. mit Videos oder Spielen auf Geräten wie Samsung Gear VR, Playstation VR oder Oculus Rift)?

gar keine Erfahrung viel Erfahrung

Falls Sie damit bereits Erfahrung mit Virtual-Reality-Geräten oder Anwendungen gesammelt haben, beschreiben Sie diese bitte kurz

Haben Sie bereits Erfahrung mit digitalen Medien zur Aneignung, Wiederholung oder Lehre von Kinaesthetics gesammelt?

gar keine Erfahrung viel Erfahrung

Sofern Sie damit bereits Erfahrung gesammelt haben, nennen Sie bitte die von Ihnen zur Aneignung, Wiederholung oder Lehre von Kinaesthetics genutzten digitalen Medien

Sofern Sie damit bereits Erfahrung gesammelt haben, als wie hilfreich empfinden Sie die von Ihnen zur Aneignung, Wiederholung oder Lehre von Kinaesthetics genutzten digitalen Medien?

gar nicht hilfreich sehr hilfreich

Teilnehmer ID: _____

Welche Lern- oder Lehrmittel stehen Ihnen zur Aneignung, Wiederholung oder Lehre von Kinaesthetics zur Verfügung?

Bitte nennen Sie die von Ihnen zur Aneignung, Wiederholung oder Lehre von Kinaesthetics genutzten Lern- oder Lehrmittel

Als wie hilfreich empfinden Sie die von Ihnen genutzten Lern- oder Lehrmittel zur Aneignung, Wiederholung oder Lehre von Kinaesthetics allgemein?

gar nicht hilfreich sehr hilfreich

Als wie hilfreich schätzen Sie Kinaesthetics im praktischen Arbeitsalltag, an echten Patienten, ein?

gar nicht hilfreich sehr hilfreich

Wie präsent ist das Thema „Ergonomisches schonendes Arbeiten“ in Ihrem Arbeitsalltag?

gar nicht präsent sehr präsent

Wie häufig setzen Sie Kinaesthetics im praktischen Arbeitsalltag, an echten Patienten, ein?

gar nicht sehr häufig

Teilnehmer ID: _____

Falls Sie Kinaesthetics gar nicht oder eher selten im Arbeitsalltag anwenden: was hindert Sie daran, Kinaesthetics öfter anzuwenden?

B.4 DEMOGRAPHIC QUESTIONNAIRE (STUDENTS)

Teilnehmer ID: _____

Demographischer Fragebogen (Auszubildende)

Geschlecht _____

Alter _____

Falls vorhanden, Sehstörungen (z. B. Farbenblindheit, Kurz-/Weitsichtigkeit) _____

Falls vorhanden, eingeschränkte Bewegungsfähigkeit _____

Sie sind ... Linkshänder Rechtshänder

Arbeit

Aktuelle Ausbildung (z. B. Schüler Pflege) _____

Aktuelles Semester _____

Falls vorhanden, Vorausbildung _____

Selbst besuchte Kinaestheticskurse _____

Falls vorhanden, Erkrankungen des Bewegungsapparates durch die Arbeit im Krankenhaus _____

Wie schätzen Sie Ihre Kenntnisse im Umgang mit Computern und verwandten Systemen ein (z. B. Smartphones, Tablets, ...)?

gar keine Kenntnisse sehr gute Kenntnisse

Teilnehmer ID: _____

Haben Sie bereits Erfahrung mit Virtual-Reality-Geräten oder Anwendungen (z. B. mit Videos oder Spielen auf Geräten wie Samsung Gear VR, Playstation VR oder Oculus Rift)?

gar keine Erfahrung viel Erfahrung

Falls Sie damit bereits Erfahrung mit Virtual-Reality-Geräten oder Anwendungen gesammelt haben, beschreiben Sie diese bitte kurz

Haben Sie bereits Erfahrung mit digitalen Medien zur Aneignung oder Wiederholung von Kinaesthetics gesammelt?

gar keine Erfahrung viel Erfahrung

Sofern Sie damit bereits Erfahrung gesammelt haben, nennen Sie bitte die von Ihnen zur Aneignung oder Wiederholung von Kinaesthetics genutzten digitalen Medien

Sofern Sie damit bereits Erfahrung gesammelt haben, als wie hilfreich empfinden Sie die von Ihnen zur Aneignung oder Wiederholung von Kinaesthetics genutzten digitalen Medien?

gar nicht hilfreich sehr hilfreich

Teilnehmer ID: _____

Welche Lern- oder Lehrmittel stehen Ihnen zur Aneignung oder Wiederholung von Kinaesthetics zur Verfügung?

Bitte nennen Sie die von Ihnen zur Aneignung _____
 oder Wiederholung von Kinaesthetics genutzten _____
 Lern- oder Lehrmittel _____

Als wie hilfreich empfinden Sie die von Ihnen genutzten Lern- oder Lehrmittel zur Aneignung oder Wiederholung oder Lehre von Kinaesthetics allgemein?

gar nicht hilfreich sehr hilfreich

Als wie hilfreich schätzen Sie Kinaesthetics im praktischen Arbeitsalltag, an echten Patienten, ein?

gar nicht hilfreich sehr hilfreich

Wie sicher fühlen Sie sich im Umgang mit Kinaesthetics?

gar nicht sicher sehr sicher

Wie präsent ist das Thema „Ergonomisches schonendes Arbeiten“ in Ihrem Arbeitsalltag?

gar nicht präsent sehr präsent

Wie häufig setzen Sie Kinaesthetics im praktischen Arbeitsalltag, an echten Patienten, ein?

gar nicht sehr häufig

Teilnehmer ID: _____

Falls Sie Kinaesthetics gar nicht oder eher selten im Arbeitsalltag anwenden: was hindert Sie daran, Kinaesthetics öfter anzuwenden?

B.5 DEMOGRAPHIC QUESTIONNAIRE (WORKFORCE)

Teilnehmer ID: _____

Demographischer Fragebogen (PflegerInnen)

Geschlecht _____

Alter _____

Falls vorhanden, Sehstörungen (z. B.
Farbenblindheit, Kurz-/Weitsichtigkeit) _____

Falls vorhanden, eingeschränkte
Bewegungsfähigkeit _____

Sie sind ... Linkshänder Rechtshänder

Arbeit

Aktueller Beruf _____

Arbeitsjahre im aktuellen Beruf _____

Grad der Ausbildung in Bezug auf
Kinaesthetics (z. B. Grundkurs Trainer) _____

Selbst besuchte Kinaestheticskurse

Jahre an Arbeitserfahrung in Bezug
auf Kinaesthetics _____

Falls vorhanden, Erkrankungen des
Bewegungsapparates durch die Arbeit
im Krankenhaus _____

Teilnehmer ID: _____

Wie schätzen Sie Ihre Kenntnisse im Umgang mit Computern und verwandten Systemen ein (z. B. Smartphones, Tablets, ...)?

gar keine Kenntnisse sehr gute Kenntnisse

Haben Sie bereits Erfahrung mit Virtual-Reality-Geräten oder -Anwendungen (z. B. mit Videos oder Spielen auf Geräten wie Samsung Gear VR, Playstation VR oder Oculus Rift)?

gar keine Erfahrung viel Erfahrung

Falls Sie damit bereits Erfahrung mit Virtual-Reality-Geräten oder Anwendungen gesammelt haben, beschreiben Sie diese bitte kurz

Haben Sie bereits Erfahrung mit digitalen Medien zur Aneignung, Wiederholung oder Lehre von Kinaesthetics gesammelt?

gar keine Erfahrung viel Erfahrung

Sofern Sie damit bereits Erfahrung gesammelt haben, nennen Sie bitte die von Ihnen zur Aneignung, Wiederholung oder Lehre von Kinaesthetics genutzten digitalen Medien

Sofern Sie damit bereits Erfahrung gesammelt haben, als wie hilfreich empfinden Sie die von Ihnen zur Aneignung, Wiederholung oder Lehre von Kinaesthetics genutzten digitalen Medien?

gar nicht hilfreich sehr hilfreich

Teilnehmer ID: _____

Welche Lern- oder Lehrmittel stehen Ihnen zur Aneignung, Wiederholung oder Lehre von Kinaesthetics zur Verfügung?

Bitte nennen Sie die von Ihnen zur Aneignung, Wiederholung oder Lehre von Kinaesthetics genutzten Lern- oder Lehrmittel

Als wie hilfreich empfinden Sie die von Ihnen genutzten Lern- oder Lehrmittel zur Aneignung, Wiederholung oder Lehre von Kinaesthetics allgemein?

gar nicht hilfreich sehr hilfreich

Als wie hilfreich schätzen Sie Kinaesthetics im praktischen Arbeitsalltag, an echten Patienten, ein?

gar nicht hilfreich sehr hilfreich

Wie sicher fühlen Sie sich im Umgang mit Kinaesthetics?

gar nicht sicher sehr sicher

Wie präsent ist das Thema „Ergonomisches schonendes Arbeiten“ in Ihrem Arbeitsalltag?

gar nicht präsent sehr präsent

Wie häufig setzen Sie Kinaesthetics im praktischen Arbeitsalltag, an echten Patienten, ein?

gar nicht sehr häufig

Teilnehmer ID: _____

Falls Sie Kinaesthetics gar nicht oder eher selten im Arbeitsalltag anwenden: was hindert Sie daran, Kinaesthetics öfter anzuwenden?

B.6 USER EXPERIENCE QUESTIONNAIRE (PLUS KPI EXTENSION)

Teilnehmer ID: _____

Bitte geben Sie Ihre Beurteilung ab.

Um das Produkt zu bewerten, füllen Sie bitte den nachfolgenden Fragebogen aus. Er besteht aus Gegensatzpaaren von Eigenschaften, die das Produkt haben kann. Abstufungen zwischen den Gegensätzen sind durch Kreise dargestellt. Durch Ankreuzen eines dieser Kreise können Sie Ihre Zustimmung zu einem Begriff äußern.

Beispiel:

attraktiv	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	unattraktiv
-----------	-----------------------	----------------------------------	-----------------------	-----------------------	-----------------------	-----------------------	-----------------------	-------------

Mit dieser Beurteilung sagen Sie aus, dass Sie das Produkt eher attraktiv als unattraktiv einschätzen.

Entscheiden Sie möglichst spontan. Es ist wichtig, dass Sie nicht lange über die Begriffe nachdenken, damit Ihre unmittelbare Einschätzung zum Tragen kommt.

Bitte kreuzen Sie immer eine Antwort an, auch wenn Sie bei der Einschätzung zu einem Begriffspaar unsicher sind oder finden, dass es nicht so gut zum Produkt passt.

Es gibt keine „richtige“ oder „falsche“ Antwort. Ihre persönliche Meinung zählt!

Teilnehmer ID: _____

	1	2	3	4	5	6	7		
unerfreulich	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	erfreulich	1
unverständlich	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	verständlich	2
kreativ	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	phantasielos	3
leicht zu lernen	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	schwer zu lernen	4
wertvoll	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	minderwertig	5
langweilig	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	spannend	6
uninteressant	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	interessant	7
unberechenbar	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	voraussagbar	8
schnell	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	langsam	9
originell	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	konventionell	10
behindernd	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	unterstützend	11
gut	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	schlecht	12
kompliziert	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	einfach	13
abstoßend	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	anziehend	14
herkömmlich	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	neuartig	15
unangenehm	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	angenehm	16
sicher	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	unsicher	17
aktivierend	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	einschläfernd	18
erwartungskonform	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	nicht erwartungskonform	19
ineffizient	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	effizient	20
übersichtlich	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	verwirrend	21
unpragmatisch	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	pragmatisch	22
aufgeräumt	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	überladen	23
attraktiv	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	unattraktiv	24
sympathisch	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	unsympathisch	25
konservativ	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	innovativ	26

B.8 CUSTOM QUESTIONNAIRE (MEDICAL CARE PERSONNEL)

Teilnehmer ID: _____

Wie gut war Ihre Erfahrung mit der soeben getesteten Anwendung insgesamt?

sehr schlechte Erfahrung sehr gute Erfahrung

Wie gut war Ihre Erfahrung mit dem ersten Teil der soeben getesteten Anwendung, der Beobachtung des virtuellen Patiententransfers?

sehr schlechte Erfahrung sehr gute Erfahrung

Wie gut war Ihre Erfahrung mit dem zweiten Teil der soeben getesteten Anwendung, der selbstständigen Durchführung des virtuellen Patiententransfers?

sehr schlechte Erfahrung sehr gute Erfahrung

Als wie geeignet sehen Sie die soeben getestete Anwendung zur Lehre und Übung von ergonomischen Patiententransfers an?

gar nicht geeignet sehr geeignet

Auf Basis Ihrer Erfahrung mit der soeben getesteten Anwendung, als wie geeignet sehen Sie Virtual Reality zur Lehre und Übung von ergonomischen Patiententransfers an? Beziehen Sie sich darauf, inwiefern Virtual Reality Ihren Eindruck beeinflusst hat.

gar nicht geeignet sehr geeignet

Wie gut integrierbar wäre die soeben getestete Anwendung in den bestehenden Lehralltag von ergonomischen Patiententransfers?

sehr schlecht integrierbar sehr gut integrierbar

Als wie geeignet sehen Sie den virtuellen Patienten als Ersatz für einen echten Partner zur Übung von ergonomischen Patiententransfers an?

gar nicht geeignet sehr geeignet

B.9 SEMI-STRUCTURED INTERVIEW (MEDICAL CARE PERSONNEL)

Interviewfragen

1. Modus 1
 - a. Gut/Schlecht? -> Warum
 - b. Eventuelle besondere Beobachtungen während der Durchführung???
 - c. Verbesserungsvorschläge
2. Modus 2
 - a. Gut/Schlecht? -> Warum
 - b. Eventuelle besondere Beobachtungen während der Durchführung???
 - c. Verbesserungsvorschläge
3. Empfinden allgemein
 - a. Generelles Empfinden zur App?
 - i. Wie schnell kommt man damit klar?
 - ii. Unverständliche Elemente?
 - iii. Generell gut/schlecht?
 - b. Tatsächliche Eignung zur Lehre/zum Üben?
 - i. Übung mit Aufsicht durch Dozenten vs. Übung alleine?
 - ii. Verbesserungsvorschläge?
 - c. Integration in bestehende Strukturen?
 - i. Verbesserungsvorschläge?
 - d. Trennung der Modi sinnvoll?
 - i. Verbesserungsvorschläge?
4. Erwartungen
 - a. Was wurde evtl. erwartet, aber nicht geliefert?
 - b. Generelle Verbesserungsvorschläge?

B.10 PAYMENT CONFIRMATION

Teilnehmer ID: ____

Auszahlungsbestätigung

Hiermit bestätige ich den Erhalt von 20 € in bar als Kompensation für die Teilnahme an Daniel Schweitzers Studie, im Rahmen seiner Masterarbeit (Universität Konstanz), zur Untersuchung der Eignung der entwickelten Virtual-Reality-Anwendung, zur Übung von ergonomischen Patiententransfers.

(Name in Blockbuchstaben)

(Ort, Datum)

(Unterschrift)

C | APPENDIX (SUBSTITUTE STUDY)

C.1 WELCOME LETTER

Willkommen

Sehr geehrte*r Teilnehmer*in,

vielen Dank, dass Sie sich dazu bereiterklärt haben an dieser Untersuchung teilzunehmen! Im Folgenden werden Sie über das Ziel sowie den Ablauf informiert.

Sie werden ein System in Virtual-Reality (VR) benutzen. Als Teil meiner Masterarbeit an der Universität Konstanz, habe ich eine VR-Anwendung erstellt, die auszubildende Pfleger*innen dabei unterstützen soll Patiententransfers, auf Basis von Kinaesthetics, selbstständig zu üben. Ein Kinaestheticskurs ist regulärer Teil der Ausbildung.

Kinaesthetics beschreibt ein Vorgehen, Patiententransfers auf ergonomische Art und Weise durchzuführen. Dabei sollen sowohl die Pflegekraft als auch der/die Patient*in entlastet werden.

Die von mir erstellte VR-Anwendung soll von Ihnen nun getestet werden. Dabei bekommen Sie zunächst die Möglichkeit sich in der virtuellen Umgebung zurechtzufinden. Danach testen Sie zwei verschiedene, aber aufeinander aufbauende, Teile der Anwendung: zuerst werden Sie einen virtuellen Patiententransfer beobachten und danach diesen Transfer selbst in VR durchführen.

Bei Unklarheiten oder sonstigen Fragen, richten Sie diese bitte direkt an die Studienleitung. Sie können Ihre Teilnahme jederzeit Abbrechen. Abschließend möchte ich mich nochmals herzlich bei Ihnen für die Teilnahme und Unterstützung bedanken!

Der Ablauf dieser Untersuchung ist wie folgt:

- Willkommensschreiben, Einverständniserklärung und demographischer Fragebogen
- Einführung in VR und grundlegende Konzepte
- Anwendungstest
- Fragebogen, gefolgt von einem Interview, um offene Fragen zu klären

Dauer: ca. 80 min

C.2 DEMOGRAPHIC QUESTIONNAIRE (GENERAL POPULATION)

Teilnehmer ID: _____

Demographischer Fragebogen (Fachfremde)

Geschlecht _____

Alter _____

Falls vorhanden, Sehstörungen (z. B. Farbenblindheit, Kurz-/Weitsichtigkeit) _____

Falls vorhanden, eingeschränkte Bewegungsfähigkeit _____

Sie sind ... Linkshänder Rechtshänder

Beruf _____

Höchster Abschluss _____

Falls zutreffend, besuchte Kinaestheticskurse _____

Wie schätzen Sie Ihre Kenntnisse im Umgang mit Computern und verwandten Systemen ein (z. B. Smartphones, Tablets, ...)?

gar keine Kenntnisse sehr gute Kenntnisse

Haben Sie bereits Erfahrung mit Virtual-Reality-Geräten oder Anwendungen (z. B. mit Videos oder Spielen auf Geräten wie Samsung Gear VR, Playstation VR oder Oculus Rift)?

gar keine Erfahrung sehr viel Erfahrung

Falls Sie damit bereits Erfahrung mit Virtual-Reality-Geräten oder Anwendungen gesammelt haben, beschreiben Sie diese bitte kurz _____

Teilnehmer ID: _____

Haben Sie bereits Erfahrung mit digitalen Medien zur Aneignung oder Wiederholung von strukturierten Bewegungsabläufen gesammelt (z. B. Kinaesthetics, Yoga)?

gar keine Erfahrung sehr viel Erfahrung

Sofern Sie damit bereits Erfahrung gesammelt haben, nennen Sie bitte die von Ihnen zur Aneignung oder Wiederholung von strukturierten Bewegungsabläufen genutzten digitalen Medien _____

Sofern Sie damit bereits Erfahrung gesammelt haben, als wie hilfreich empfinden Sie die von Ihnen zur Aneignung oder Wiederholung von strukturierten Bewegungsabläufen genutzten digitalen Medien?

gar nicht hilfreich sehr hilfreich

Haben Sie bereits Erfahrung mit Kinaesthetics oder allgemein Patiententransfers gesammelt (z. B. Pflege Angehöriger)?

gar keine Erfahrung sehr viel Erfahrung

Sofern Sie damit bereits Erfahrung gesammelt haben, beschreiben Sie diese bitte kurz. _____

Sofern zutreffend: wie sicher fühlen Sie sich im Alltag bei der Aneignung, Übung und Wiederholung von strukturierten Bewegungsabläufen (z. B. Kinaesthetics, Yoga)?

gar nicht sicher sehr sicher

Wie präsent ist das Thema „Ergonomisches schonendes Arbeiten“ in Ihrem Arbeitsalltag?

gar nicht präsent sehr präsent

C.3 CUSTOM QUESTIONNAIRE (GENERAL POPULATION)

Teilnehmer ID: _____

Wie gut war Ihre Erfahrung mit der soeben getesteten Anwendung insgesamt?

sehr schlechte Erfahrung sehr gute Erfahrung

Wie gut war Ihre Erfahrung mit dem ersten Teil der soeben getesteten Anwendung, der Beobachtung des virtuellen Patiententransfers?

sehr schlechte Erfahrung sehr gute Erfahrung

Wie gut war Ihre Erfahrung mit dem zweiten Teil der soeben getesteten Anwendung, der selbstständigen Durchführung des virtuellen Patiententransfers?

sehr schlechte Erfahrung sehr gute Erfahrung

Als wie geeignet sehen Sie die soeben getestete Anwendung zur Lehre und Übung von ergonomischen Patiententransfers an?

gar nicht geeignet sehr geeignet

Auf Basis Ihrer Erfahrung mit der soeben getesteten Anwendung, als wie geeignet sehen Sie Virtual Reality zur Lehre und Übung von ergonomischen Patiententransfers an? Beziehen Sie sich darauf, inwiefern Virtual Reality Ihren Eindruck beeinflusst hat.

gar nicht geeignet sehr geeignet

Stellen Sie sich vor, Sie müssten eine*n Angehörige*n privat bei Transfers unterstützen. Als wie geeignet sehen Sie die soeben getestete Anwendung, zur Lehre und Übung, für Sie selbst an? Gehen Sie davon aus, dass es sich um eine inhaltlich vollständigere Version handelt, bspw. mit einer Auswahl an verschiedenen Patiententransfers. Bewerten Sie das Prinzip der Anwendung.

gar nicht geeignet sehr geeignet

C.4 SEMI-STRUCTURED INTERVIEW (GENERAL POPULATION)

Interviewfragen

1. Modus 1
 - a. Gut/Schlecht? -> Warum
 - b. Eventuelle besondere Beobachtungen während der Durchführung???
 - c. Verbesserungsvorschläge
2. Modus 2
 - a. Gut/Schlecht? -> Warum
 - b. Eventuelle besondere Beobachtungen während der Durchführung???
 - c. Verbesserungsvorschläge
3. Empfinden allgemein
 - a. Generelles Empfinden zur App?
 - i. Wie schnell kommt man damit klar?
 - ii. Unverständliche Elemente?
 - iii. Generell gut/schlecht?
 - b. Tatsächliche Eignung zur Lehre/zum Üben?
 - i. Übung privat für private Pflege?
 - ii. Verbesserungsvorschläge?
 - c. Trennung der Modi sinnvoll?
 - i. Verbesserungsvorschläge?
 - d. Hat man nach der kurzen Nutzung jetzt schon etwas gelernt?
4. Erwartungen
 - a. Was wurde evtl. erwartet, aber nicht geliefert?
 - b. Generelle Verbesserungsvorschläge?

D | APPENDIX (CONTENTS SD CARD)

The attached SD card contains the digital versions of the following:

- Master's thesis
- Master's project report
- Master's seminar term paper