Smart Glasses as Supportive Tool in Nursing Skills Training

Jan Patrick Kopetz, Daniel Wessel, Katrin Balzer, Nicole Jochems
University of Lübeck
UzL
Lübeck, Germany
kopetz@imis.uni-luebeck.de, wessel@imis.uni-luebeck.de, katrin.balzer@uksh.de, jochems@imis.uni-luebeck.de

Abstract— In nursing care, correct execution of interventions is crucial, for example, when assisting a patient moving from the bed to a wheelchair. Such interventions promote both the patients' well-being and the nurses' long-term health. Thus, learning the correct techniques forms an important part of skills training in undergraduate nursing education. However, to address the students' learning needs, innovative training methods are required that facilitate effective self-directed training as addition to supervision by tutors. The rapid development in information and communication technologies for example of Head Mounted Displays (smart glasses) raises questions about their use in nursing education. Especially the practical training seems to be an area with large potential. The design of applications regarding acceptance, feasibility and effectiveness must be explored first. We used a Human-Centred Design process consisting of a survey, design thinking workshops to develop prototypes and an evaluation to answers these questions and the results are promising.

Keywords—Nursing Skills Training, Head Mounted Displays, Smart Glasses, Step-By-Step Guidance, Human-Centred Design, Feasibility Study, Before-After-Study, System Architecture, Interactive System

I. Introduction

In many developed countries, including Germany the demographic change and other societal transformations have led to a substantial shortage of nursing staff relative to the number of care-dependent persons [1]. This shortage affects all areas of health care and poses serious risks to the quality and safety of nursing care delivered to patients [2] [3]. Furthermore, while at various levels (national and local politics, health care organisations) efforts are undertaken to increase the number of young people deciding for a career in nursing, e.g. by establishing academic undergraduate nursing education programmes, the capacity of nursing education programmes is limited due to staff shortages [4]. Nursing education institutions, be it at academic or vocational levels, are thus faced with the challenge to provide attractive, high-quality nursing training for a potentially rising number of students while the number of teachers often stagnates or even decreases.

A major objective of nursing education is to provide future nurses with the skills required to safely assist care-dependent persons in their activities of daily living and to promote their autonomy, independence and integrity. This nursing support has to be carried out in line with existing evidence-based recommendation and individual patients' symptom burden, needs and preferences. An important skill for supporting care-dependent people is nurses' ability to promote the mobility in chair- or bed-bound patients and to safely assist them in the repositioning or in transfers from bed to chair or vice versa. In particular, bed-chair transfers do represent a highly challenging task since, if not executed correctly, they may pose risks both to the patients' and the nurses' health [8]. Therefore, there is a high need that nursing students do effectively acquire safe patient handling and movement skills during their education programme.

Development of such skills requires complex learning processes which must be effectively stipulated, promoted and evaluated during nursing education. Although conclusive research-based evidence is lacking on the relative merits of training in simulated clinical practice situations ("skills lab") [5] [6], such teaching formats represent an important component of many undergraduate nursing programmes. However, these trainings are used to be quite resource-intensive as they can often only be conducted with small groups of students, resulting in relatively high trainer-student ratios (e.g. 1 trainer for a group of 10 students). Given the limited staff, the amount of skills lab training that can be offered to students is therefore limited as well and may be insufficient relative to the students' subjective learning needs [7]. Thus, well-developed and well-evaluated training methods are required that effectively support students' self-directed training as addition to supervised training sessions. These training methods should suit the objective learning goals and students' subjective learning needs and be easy and safe to implement.

Modern information and communication technologies (ICT) may hold the potential to support students' acquisition of nursing care skills in addition to supervised skills training. In this article, we present a technical approach to use Head Mounted Displays (HMDs) as a tool to provide in-situ support for nursing students' practical skill training via step-by-step tutorials. Given the need for hands-free interaction, HMDs seem particularly suitable. To examine this thesis, we chose the bed-wheelchair transfer as an exemplary scenario. Fig. 1 displays

Fig. 1. Steps to consider during a bed-wheelchair transfer: (1) communication, (2) preparation of the wheelchair, (3) putting on the brakes and (4) the patient's shoes, (5-6) utilizing the hand grip, (7) supporting the patient in standing up, (8) guide/assist the patient in turning into the wheelchair, and (9) adjust the wheelchair to the patient's positioning and mobility needs.

the single steps of a typical bed-wheelchair transfer as conducted in line with existing best practice and safety requirements.

II. RELATED WORK

A. *Technological Background*

Head Mounted Displays are visual displays worn on the user's head. They have been around for over 40 years. They have been developed since the 1970s, originally for use in military contexts. One main advantage of HMDs is their ability to augment the user's view, turning it into Augmented Reality (AR). Main uses for AR include advertising, entertainment and education [10]. The rapid development in mobile technology experienced in the last decade reduced the size of the required hardware for autonomous systems located in frames themselves. The term smart glasses gradually established itself. A significant step was made by the development of *Google Glass*, but the anticipated success in consumer sector failed. The relaunch (Enterprise Edition) specifically targets manufacturing and logistics [11]. Besides Google, other established manufacturers driving forward the development of smart glasses are, for example, Epson with their device series "Moverio", Vuzix with their devices "Blade" and "M300", and Microsoft with their "Hololens".

B. *Existing Literature*

A number of studies and literature reviews related to the field of medical AR applications have already been published. Dougherty & Badawy [12] systematically reviewed existing literature using *Google Glass* in nonsurgical medical settings (51 studies) and distinguished between patient-centred (21) and clinician-centred (30) studies. They concluded that "more promising results regarding the feasibility, usability, and acceptability of using *Google Glass* were seen in patient-centred studies and student training settings." They further state that their "results suggest that the greatest potential for *Google Glass* implementation to support clinicians lies in student training." Looking at how the training could be provided, none of the reviewed studies examined step-by-step guidance applications.

Schneidereith [13] examined whether *Google Glass* can be used to improve adherence to medication safety procedures in undergraduate nursing students. The device was used to record the administration of an intravenous medication from the students' perspective. Schneidereith described how the videos revealed students' false infusion rates and dosage miscalculations that can be traced back to remedial mathematical problems.

The BMBF project "Pflegebrille" [Careglasses] aims to develop AR applications for intensive home care settings in order to support professional (formal) and informal caregivers in the correct execution of care procedures [14]. The project is still ongoing, and results were not yet published.

The reviewed work suggests that healthcare students appear to be open and ready to use innovative technologies, and positive effects could be shown for the use of AR technology in healthcare settings However, there are still open questions insufficiently addressed by existing studies and projects. For example, more insights are required into the design characteristics determining the feasibility and effectiveness of AR applications for health care students' skills training.

Thus, we focus on the human-centred development of a smart glasses application for use in skills training of nursing students. We aim to provide a step-by-step instruction to support nursing students' skills training for complex nursing interventions. We decided to focus on supporting the patient transfer from bed to wheelchair as a first concrete training scenario for step-by-step guidance. Our goal is to develop an application that is accepted by the students and effective in providing them with hands-free information visualization. To support use in trainings, we also aim to provide the required infrastructure for content management.

III. Method

The human-centred development process we applied is based on ISO 9241:210 [15]. Fig. 2 displays the steps we carried out. We conducted a user and context analysis, developed prototypes and evaluated them in a before-after study. Main research questions were the acceptance of smart glasses for this training, their effects, and how they can be integrated in the training.

Literature Review: As first step of the User and Context Analysis, a review of the literature was conducted to identify related work and suiting devices.

Online Survey: As there was little information available on media usage of nursing students in Germany, an online survey was conducted to provide more insight into the target group.

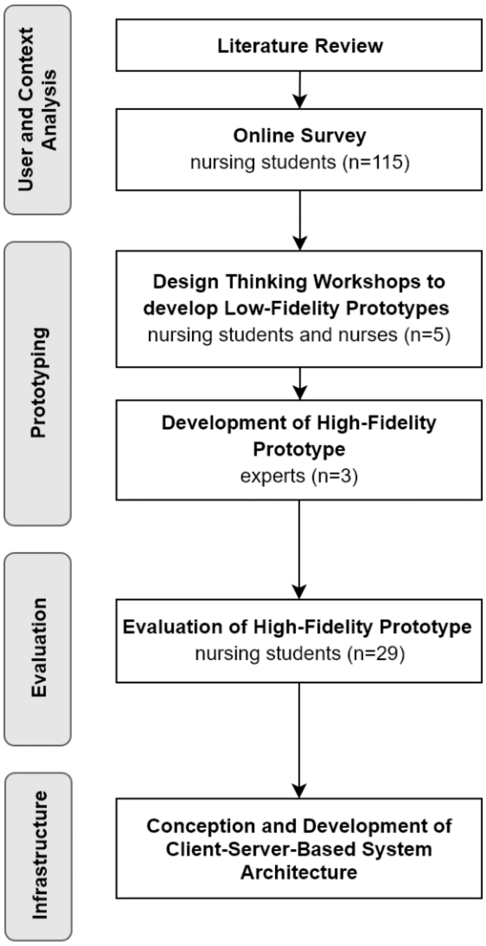

Fig. 2. The applied human-centred development process

Design Thinking Workshops to develop Low-Fidelity Prototypes: With more detailed knowledge about the target group resulting from the survey, two Design Thinking Workshops with nursing students and licensed nurses were conducted to develop paper-based Low-Fidelity Prototypes for the system. The workshops focussed on developing design variants and content that works well with a *Google Glass* application.

Development of High-Fidelity Prototype: Based on the Low-Fidelity Prototypes, a High-Fidelity Prototype of a *Google Glass* application was developed. During its iterative development process, experts were repeatedly consulted to evaluate practical relevance, comprehensibility, and usability.

Evaluation of High-Fidelity Prototype: A before-after study was designed to measure whether the application is (1) accepted by the targeted user group and (2) effective in improving the training (e.g., by increasing user's self-confidence and reducing the error rate). Participants were instructed to assist a simulated patient during the transfer from bed to wheelchair first without help and then supported by the *Google Glass* app. Both iterations were recorded to analyse weather the error rate had changed. Additionally, participants answered demographic questions, whether they noticed something they would change next time, whether and if so, how the application helped them, and the advantages and disadvantages of the application of smart glasses in training and separately during the work with actual patients.

Conception and Development of Client-Server-Based System Architecture: Based on the student and trainer feedback and resulting discussions about infrastructure and implementation, the conception and development of a client-server-based system architecture was initiated and implemented.

IV. Results

Due to its size and capabilities, esp. not obstructing the field of view, *Google Glass* was chosen as a suitable device.

A. *Survey*

115 participants being trained in 8 different German federal states completed the survey. The results provided useful insight into relevant user characteristics (e.g. familiarity with and usage of technology (in private and education contexts) and the user context. Based on these findings, we could define preliminary system requirements to be further discussed in the successive workshops. For detailed results see [17].

B. *Prototyping*

The workshops resulted in two different design variants that were analysed to develop a high-fidelity prototype. The prototype provides a tutorial consisting of twelve different slides containing steps to consider while assisting a patient with the bed-wheelchair transfer (Fig. 3).

C. *Evaluation*

29 nursing students (23 bachelor and 6 vocational students) participated in the evaluation. Results are sorted by main research questions: acceptance by potential users, learning effects, and implications for further development.

The data gathered from the before-after-study indicate that a large proportion of the participating students is interested in the use of smart glasses for skills training.

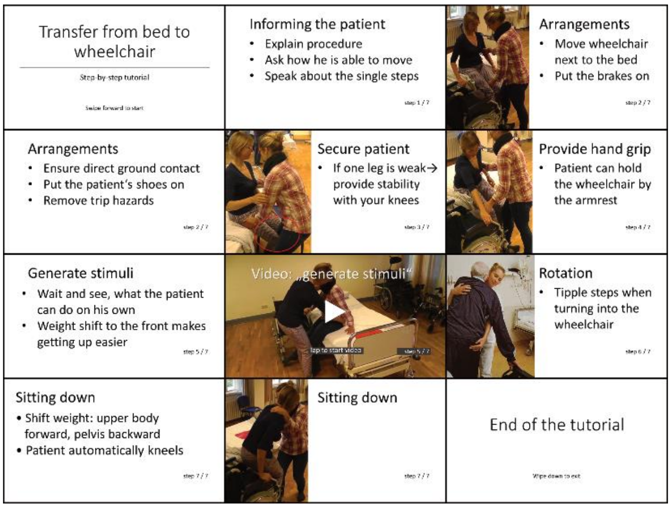

Fig. 3. Slides of the prototypical step-by-step tutorial (translated from German)

Acceptance: Asked whether they could imagine using the system during skills training, the majority agreed. Some of the participants stressed out that more training scenarios would be necessary to provide a reliable statement. However, most of the participants could not imagine using it outside of training in the real-life work context with actual patients.

Participants reported, among others, an *improved self-confidence*, *reminders of important steps*, *facilitating a well-structured procedure* as positive aspects of the system. Possible negative aspects were, among others, *distraction*, *possible interruption of patient interaction*, *increased time*, and *the need to use one hand for interacting with the device*.

Effects: Speaking of improved self-confidence, the availability of the system was seen as useful tool to resort to, checking the procedure if needed, even if they did not use it. Qualified nursing educators reviewed and evaluated the videos of the participant's performances regarding error rates (each pair of videos (training without and with glasses) per student was independently reviewed by two trainers). The results indicate slightly lower error rates while using our system compared to the performance without use of the AR application.

Results relevant for further development: Some participants with regular glasses had difficulties wearing smart glasses and their own glasses at the same time. The touch-based interaction used in the prototype was criticized as unsuitable in the healthcare context with its strict hygiene regulations. Some participants asked for voice control.

D. *Infrastructure*

First steps were made to develop the client-server-based system architecture (see Fig. 4). The tutorials are stored in a database and could also be accessed by students during their training sessions. Focussing on establishing the connection and communication between the components, the concept has been prototypically implemented in a first version that provides the basis for the creation of additional tutorials by nursing experts.

V. Discussion and Future Work

The human-centred design process led to the development of a working app for smart glasses which provides hands-free step-by-step assistance for nursing students training skills for safe patient transfers from bed to wheelchair. Results from User and Context Analysis, Prototyping, and Evaluation all support the feasibility and potential merits of smart glasses in skills training. However, smart glasses seem to be particularly suited for training, not for actual nurse-patient interaction. During the development process, three main issues emerged requiring further reflections and developments: content, content management, and interaction and feedback.

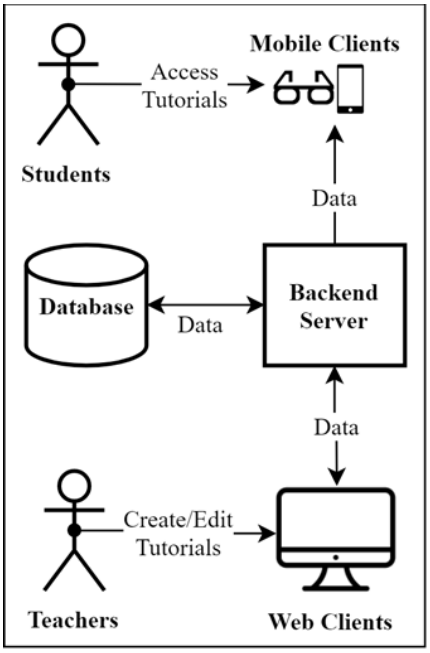

Fig. 4. Client-server based System architecture

A. *Content*

Step-by-step instructions have to be developed to provide nursing students with up-to-date subject information which is accessible at the right time in the right resolution. Especially the workshops proved helpful to develop an information architecture and workflow of virtual index cards. Specialized design guidelines are required, which refer to common developer guidelines for smart glasses but are adapted to the specific context. While the content for the high-fidelity prototype itself was developed as part of a master's thesis in cooperation with experts, future content has to be created by qualified experts themselves. This could be done in interdisciplinary student projects, where advanced nursing students collaborate with computer science students for the development of AR-suitable tutorials. First projects of this kind have been set up by the authors, and preliminary experiences confirm the feasibility of this approach. Within these projects and included evaluation studies further training content will be developed, e.g., for the skills training on changing wound dressings.

B. *Content Management*

The created content must be made available easily, without the need for special technical or programming skills. Thus, a content management system has to be implemented. After the positive evaluation of smart glasses, a first web interface was developed allowing nursing trainers (and students) to add new content. Beyond a purely technical role of providing content, trainers are still needed during skills trainings as supervisors. They have to answer questions, give feedback, and help to solve problems. The system is specifically oriented to support students in addition to supervised skills training.

C. *Interaction and Feedback*

While smart glasses allow for hands-free information visualization, users must still advance the index cards using touch-gestures. For training purposes, a quick tap on the frame was sufficient to view the next tutorial step during our study. Although this approach was proven feasible, there are a number of limitations to consider. Students could learn the wrong habits. Hygiene is a crucial element in healthcare, thus a better form of interaction is required, free of any touch-gestures. First approaches include the use of mid-air gestures (e.g., via Myo armband) or voice control. Both might be useful, at least for training purposes. Additionally, if sensors are used to track the users, the same sensors could be used to provide feedback. Especially for posture tracking the use of sensors seems promising [17].

Other approaches that were brought up during development might be useful too, e.g., the use of other output devices like tablets or projections to display the tutorials.

D. *Conclusion*

Based on these promising results of using smart glasses for skills trainings in nursing education, next steps include the creation of training materials for different scenarios, and experimental studies to assess the applicability and learning outcomes in regular undergraduate nursing education courses.

Acknowledgements

The authors thank all participants, that took part in the survey, the design-thinking workshops and in the evaluation of the prototype.

Literature

[1] Nowossadeck, Sonja. "Demografischer Wandel, Pflegebedürftige und der künftige Bedarf an Pflegekräften." Bundesgesundheitsblatt-Gesundheitsforschung-Gesundheitsschutz 56.8 (2013): 1040-1047.

[2] Jun J, Faulkner KM. Scoping review: Hospital nursing factors associated with 30-day readmission rates of patients with heart failure. J Clin Nurs. 2018;27(7-8):e1673-e1683. doi: 10.1111/jocn.14323.

[3] Aiken LH, Sloane D, Griffiths P, Rafferty AM, Bruyneel L, McHugh M, Maier CB, Moreno-Casbas T, Ball JE, Ausserhofer D, Sermeus W; RN4CAST Consortium. Nursing skill mix in European hospitals: cross-sectional study of the association with mortality, patient ratings, and quality of care. BMJ Qual Saf. 2017;26(7):559-568. doi: 10.1136/bmjqs-2016-005567.

[4] Hessisches Sozialministerium & Institut für Wirtschaft, Arbeit und Kultur (IWAK) der Johann-Wolfgang Goethe Universität Frankfurt am Main (Hrsg.). Hessischer Pflegemonitor. http://www.hessischer-pflegemonitor.de/2017/index.php?id=8, accessed 04.05.2018.

[5] Shin S, Park JH, Kim JH. Effectiveness of patient simulation in nursing education: meta-analysis. Nurse Educ Today. 2015;35(1):176-82. doi: 10.1016/j.nedt.2014.09.009.

[6] Vincent MA, Sheriff S, Mellott S. The efficacy of high-fidelity simulation on psychomotor clinical performance improvement of undergraduate nursing students. Comput Inform Nurs. 2015 Feb;33(2):78-84. doi: 10.1097/CIN.0000000000000136.

[7] Heslop L, McIntyre M, Ives G. Undergraduate student nurses' expectations and their self-reported preparedness for the graduate year role. J Adv Nurs.;36(5):626-34.

[8] Mayeda-Letourneau J. Safe patient handling and movement: a literature review. Rehabil Nurs. 2014;39(3):123-9. doi: 10.1002/rnj.133.

[9] Cornish J, Jones A. Factors affecting compliance with moving and handling policy: Student nurses' views and experiences. Nurse Educ Pract. 2010;10(2):96-100. doi: 10.1016/j.nepr.2009.03.020.

[10] Carmigniani, J., & Furht, B. (2011). Augmented Reality: An Overview. In *Handbook of Augmented Reality* (S. 3–46). Springer, New York, NY. https://doi.org/10.1007/978-1-4614-0064-6_1

[11] Naughton, J. (2017). The rebirth of Google Glass shows the merit of failure | John Naughton. *The Guardian*. http://www.theguardian.com/commentisfree/2017/jul/23/the-return-of-google-glass-surprising-merit-in-failure-enterprise-edition accessed 04.05.2018

[12] Dougherty, B., & Badawy, S. M. (2017). Using Google Glass in Nonsurgical Medical Settings: Systematic Review., Using Google Glass in Nonsurgical Medical Settings: Systematic Review. JMIR MHealth and UHealth, JMIR MHealth and UHealth, 5, 5(10, 10), e159–e159. https://doi.org/10.2196/mhealth.8671, 10.2196/mhealth.8671

[13] Schneidereith, T. (2015). Seeing Through Google Glass: Using an Innovative Technology to Improve Medication Safety Behaviors in Undergraduate Nursing Students. *Nursing Education Perspectives*, *36*(5), 337–339.

[14] Jelonek, M. & Prilla, M., (2016). Motivational Aspects of Using Augmented Reality Glasses in Care. In: Weyers, B. & Dittmar, A. (Hrsg.), Mensch und Computer 2016 – Workshopband. Aachen: Gesellschaft für Informatik e.V. https://doi.org/10.18420/muc2016-ws02-0004

[15] ISO. (2009). 9241-210: 2010. Ergonomics of human system interaction-Part 210: Human-centred design for interactive systems. *International Standardization Organization (ISO). Switzerland*.

[16] Kopetz, J. P., Wessel, D., & Jochems, N. (2018). Eignung von Datenbrillen zur Unterstützung von Pflegekräften in der Ausbildung. *Zeitschrift für Arbeitswissenschaft*, *72*(1), 13–22. https://doi.org/10.1007/s41449-017-0072-9

[17] Hellmers, S., Fudickar, S., Lange, E., Lins, C., & Hein, A. (2017). Validation of a Motion Capture Suit for Clinical Gait Analysis. In Proceedings of the 11th EAI International Conference on Pervasive Computing Technologies for Healthcare (S. 120–126). New York, NY, USA: ACM. https://doi.org/10.1145/3154862.3154884