Master's Thesis

The Evaluation of Virtual Reality Devices as Training Tool for Nursing Schools in Germany

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2 ALPHABETICAL LIST OF ABBREVIATIONS

Artificial Intelligence	**AI**
Augmented Reality	**AR**
Concerted Action on Nursing	**KAP**
Deep Learning	**DL**
Digital Health Competencies	**DHC**
Digital Health Literacy	**DHL**
Digital Health Technologies	**DHT**
Digital Health Transformation e.V.	**dht e.V.**
Dependent variables	**DV**
European Union	**EU**
Extended Reality	**XR**
Independent variables	**IVs**
Machine Learning	**ML**
Motion-to-photon	**MTP**
Educational Departments	**ED**
Healthcare Workers	**HCWs**
Odds Ratio	**OR**
Perceived Usefulness	**PU**
Perceived Ese of Use	**PEU**
Remote Patient Monitoring	**RPM**
Technology Acceptance Model	**TAM**
Technology Provider	**TP**
the Internet of Things	**IoT**
Virtual Reality	**VR**

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5 ABSTRACT

Hintergrund: Prognosen zufolge werden bis 2035 etwa 500 000 Pflegestellen in Deutschland unbesetzt bleiben. Dies setzt das Gesundheitssystem, vor allem Krankenhäuser und Pflegeeinrichtungen, unter hohen Handlungsdruck. Als Teil eines Aktionsplans wird unter anderem die Digitalisierung des Berufsstands vorangetrieben. Die definierten Maßnahmen umfassen auch die Ausbildung, in der internationale Studien zum Einsatz von Virtual-Reality(VR)-Geräten bereits erste Hinweise auf Verbesserungen aufzeigen.

Methodik: In sechs deutschen Pflegeschulen wurde eine Workshop-Intervention zur Nutzung von VR-Geräten in der Pflegeausbildung durchgeführt. Die Teilnehmer waren Lehrkräfte, Bildungspersonal und. Auszubildende. Nach der Nutzung wurde eine Umfrage mit demografischen Angaben, geschlossenen Fragen auf der Basis eines angepassten Technologieakzeptanzmodells (TAM) und offenen Fragen zur Aufnahme von qualitativem Input durchgeführt. Die Antworten wurden quantitativ mittels logistischer Regression und qualitativ mittels einer systematischen Themenanalyse ausgewertet.

Ergebnisse: Die Analyse der demografischen Eingaben und des angepassten TAM zeigte signifikante Ergebnisse für die Rolle der Teilnehmer innerhalb der Ausbildung (Lehrer und Lernende - OR: 7.54), den Bildungsgrad (Hochschulreife und Berufsausbildung - OR: 5.9), sowie für den wahrgenommenen Nutzen (OR 4.3) und die subjektive Norm (OR: 7.6) bezüglich der Absicht, VR-Geräte als Schulungswerkzeuge zu nutzen. Zudem wurden durch die Teilnehmer die Eigenschaften: fesselnd, optimierend und engagierend als Vorteile sowie uninteressant, nicht zugänglich und unmotivierend als Schwächen genannt.

Schlussfolgerungen: Die Förderung von VR-Geräten in der Pflegeausbildung stellt eine bedeutende Maßnahme dar, den Pflegeberuf auf dem Arbeitsmarkt zu stärken, Gesundheitseinrichtungen zu entlasten und letztendlich eine qualitativ hochwertige Versorgung für Patienten im deutschen Gesundheitssystem zu bieten. Die VR-Geräte dienen hierbei als innovative Werkzeuge, die zur Digitalisierung des Pflegeberufs und seiner Ausbildung beitragen können. Die Nutzer sehen Vor- und Nachteile aus technologischer, systemischer und individuell emotionaler Perspektive, die in den nächsten Schritten der Technologieintegration berücksichtigt werden sollten.

Stichwörter: Virtual Reality, Nursing Schools, Digitalization, Digital Tools, German Nursing Education.

6 INTRODUCTION

The use of virtual reality (VR) in the nursing educational field seeks to strengthen the occupation further and tackle the main issues that the occupation faces. In Germany, the shortage of skilled nurses threatens the current and future ambulatory and in-hospital healthcare ecosystems. Some estimations suggest that if current societal conditions do not change, about 186 000 and 307 000 nurse positions in ambulatory and in-hospital will not be occupied and in need by 2035 (Flake et al., 2018). However, innovative solutions and means to overcome hardships in healthcare systems, such as digital health tools, have risen in the last decades, especially in the past years. The recent COVID-19 pandemic and the change in societal behaviors, such as lockdowns and social isolation, facilitated legislation and societal adaptations to digital means (European Observatory on Health Systems and Policies, 2021). Notwithstanding, even after the fast integration of digital health tools due to the recent pandemic, three-quarters of the German population seems to have problematic or inadequate digital health literacy (Dratva et al., 2024).

Additionally, the contribution of digital health tools to fundamental pillars in healthcare, such as healthcare workers (HCWs) education, has been present for about two decades in diverse formats, e.g., digital simulation training (Bradley, 2006). In a recent context, remote education with VR devices, for instance, showed positive results in clinical education during the recent COVID-19 pandemic (Young et al., 2021). However, this domain remains largely undiscovered. By 2020, only 4 % of clinicians were using VR devices to support the delivery of clinical services, in comparison to 77 % of inclusion to electronic health records (Deloitte, 2020). Nevertheless, the usage of VR devices seems to be increasing in Germany, with expected user penetration of 8.2 % by 2024 and 9.9 % by 2028. This would represent to reach about eight million users by the same year (Statista, 2024b). Additionally, the German healthcare landscape shows to be prepared for this evolving digitalization process. By the end of 2022, about 96 % of the outpatient practices and 99 % of pharmacies had adopted telematic infrastructure. Hospitals were also nearly in the majority connected to telematic infrastructure; otherwise, they would suffer financial sanctions (ECHAlliance, 2024). It has also been reported that German hospitals show a "digital maturity" level similar to hospital peers in the United States, Australia, and Canada when using the International Healthcare Information and Management Systems Society's electronic medical record adoption model (EMRAM) (HIMSS, 2023). Additionally, the German Federal Ministry of Health has developed a national score, named Digital Radar, to assess in detail the maturity of hospitals in Germany. The findings show that, on average, hospitals obtained 33 points out of 100, with larger hospitals performing better than small ones and hospitals in states such as Berlin, Hamburg, and Brandenburg having the largest digital maturity (Digital Radar, 2024). Hence, shedding light on how prepared the German healthcare landscape and its healthcare workers (HCWs) is to implement digital health solutions in its settings in fundamental domains, e.g., nursing education. Hence, German authorities have established digitalization as a necessary tool to attract, retain, and maintain nurses within the profession (Wirtschaft (IW), 2022). In 2019, German legislation enacted the "Digital Healthcare Act" and the "Act for the Digital Modernization of Care and Nursing" (Bundesministerium für Gesundheit, 2019a, 2019b). To leverage this, nurse students are taught digital health competencies (DHC) during their vocational or professional education, with the following consolidation in their future workplaces (McCabe & Timmins, 2016). DHC refers to the skills users will have to maneuver themselves in the digital health environment, such as digital health literacy (DHL) (Rachmani et al., 2022). DHL refers to comprehending and evaluating health contexts to make daily decisions autonomously and actively in a digital context (Vaart & Drossaert, 2017).

In the education continuum, a pivotal role is played by nurse educators, who are responsible for creating engaging and empowering teaching experiences for their students (Ghasemi et al., 2020). Educators and educational institutions should count on identifiable areas of improvement in nursing education and standardized educational programs (T. M. Forman et al., 2020). The standardization of these can ultimately be supported by using new technologies constantly integrating into the healthcare field, such as wearable devices, AI, Machine learning, robotics, VR devices, smart hospital technologies, etc. (Rasoulian-Kasrineh et al., 2021; Risling, 2017). Besides, there is a significant need for improvement in nurses' DHL and DHC. Namely, a group of nurses in Germany reported digital health competencies as the most difficult to achieve, compared with other health competencies, such as patient communication (reported as the easiest to achieve) (Schaeffer et al., 2024). Similarly, it was experienced during the COVID-19 Pandemic that diminished DHL could jeopardize nurses' performances and the exchange of trustworthiness information between HCPs and patients (Messer & Murau, 2020). Nevertheless, enhancing the implementation of these digital means in the education of nurses can enrich the adoption of DHC and DHL for trainees and trainers and in the interaction between them (Lall et al., 2019). To pedagogically succeed, educational frameworks should be oriented, customized, and scalable to nurses' education with innovative technologies, such as VR devices (Nazeha et al., 2020), with fully onboarded and digitally competent educators (Kleib et al., 2022). The inclusion of VR devices as training tools also seeks to support the digitalization of nursing education and encourage trainers and current and prospective apprentices to incorporate digital abilities into their learning process and practice systematically. However, certain challenges arise within this process, such as the complexity of facing new devices or the presence of incomprehensible software or interfaces (Halbig et al., 2022). These conundrums should be overcome by encouraging future users' acceptance of the technology. In the case of VR devices, this could be achieved by presenting potential beneficial results the technology brings, such as acquiring practical skills, theoretical knowledge, interpersonal developments (communication), and personal development (self-confidence and satisfaction) (Birkheim et al., 2023; Jallad & Işık, 2022; Mayor Silva et al., 2023; Plotzky, Lindwedel, Bejan, et al., 2021). Some of the most practiced and researched experiences in clinical settings are the transfer and acquisition of surgical knowledge and skills. Besides, vast evidence reports high satisfaction and engagement in nursing education when using VR devices as training tools in these domains. Additionally, an accurate selection of the educational goals intended with VR devices will play an essential role in the engagement and learning outcomes of the students (F.-Q. Chen et al., 2020). Nurse educators and trainees might also leverage early inclusion in developing apps or platforms as end-users. This can ensure a better fit for them and encourage their acceptance of the technology (J. Brown et al., 2020). Thus, presenting VR devices as training tools to nurse trainees and trainers in German nursing educational departments allows them to familiarize themselves with technology and increases the chance of acceptance of this and other digital means.

The firm Digital Health Transformation e.G. (dht) e.G was assigned the task of bringing VR devices to the nursing schools in Germany that are part of their cooperative with the purpose of digitalizing nursing education. To this, the project "*Virtual Reality in der Pflege*" was initiated, intending to present VR devices to nursing educational institutions and eventually integrate them into the educational curriculum with scalable scenarios. This research evaluates the initial impact of VR devices on German nursing education participants as an adjacent project of dht e.G. Six workshops in the field were performed with a partner provider of VR technology to evaluate the first impressions of VR devices in nursing educational environments as training tools. In these activities, participants were shown on a beginner's level how the technology works and potential educational scenarios. After undertaking this activity, participants were surveyed with closed and semi-open questions. The inputs and impressions were quantitatively and qualitatively analyzed to answer the following primary research questions: : What factors influence the acceptance of VR devices as training tools in nursing education? Secondary research question: Which potentials and drawbacks do users perceive when implementing VR devices as a training tool? The answer to those questions pursues the primary objective: Evaluate the acceptance of VR devices among users as training tools in nursing education after introducing them to the technology, and secondary objective: Explore the potential experienced by users after being introduced to VR as a teaching tool in German nursing schools, respectively.

An adapted Technology Acceptance Model (TAM) has been used in the quantitative analysis as a theoretical framework. This is intended to assess VR device acceptance based on the participants' intention to use (dependent variable (DV)), tested with different factors given in the model (independent variables (IVs)). These are Perceived Usefulness (PU), Perceived Ease of Use, Attitude, Habit, Compatibility, subjective norms, and facilitators. A logistic regression was run on the dependent and independent variables to test the theoretical model on SPSS. Descriptive statistics on the model variables and the demographics have also been conducted and presented. An inductive, exploratory, systematic thematic analysis was conducted in the qualitative analysis. This was done on the software MAXQDA. This type of analysis included reading the clean data process multiple times and a posterior generation of codes, subthemes, and themes. Besides, the qualitative results list which scenarios or clinical applications of VR devices were generated from the participant's suggestions.

This research is distributed in the following sections to contextualize the readers: The first section is an Overview of Virtual Reality Technology. This section grants a general approach to VR and its main features, followed by the main educational methodologies implemented to use VR as a training tool. Subsequently, a section on the usage of VR for training in healthcare settings describes the main usage of VR in education in healthcare environments, such as surgical training. The third section addresses VR in nursing education. This analysis shows to which extent this technology has impacted nurses' education and other results of the usage of this technology. The fourth section is about the Challenges and opportunities in the German healthcare system, addressing the gaps and scientific needs in this field. The fifth section is the methodology, where the research questions, objectives, and tools used to perform this research will be explained. In the sixth section, the qualitative and quantitative results are presented. The seventh, eighth, and ninth sections are discussion, conclusions, and limitations, respectively.

7 OVERVIEW OF VIRTUAL REALITY TECHNOLOGY

7.1 WHAT IS VR?

Virtual Reality is an artificial environment perceived through digital devices such as goggles, helmets, commander gloves, head-mounted displays (HMD), headphones, motion controllers, and optical sensors (Kouijzer et al., 2023). These utensils grant computer and digital images in a three-dimensional (3D) landscape, emulating a fictional environment and allowing users to interact with it (Hamilton et al., 2021; Ifanov et al., 2023). The extended developments of 3D techniques, such as constructive solid geometrics, permit the creation of complex virtual scenarios (Stelios et al., 2023). Although the concept of *virtual* is broader than what is associated with this technology, this study will only be considered as a digital representation of a certain context or reality, emulating a physical one using digital tools (Baranyi et al., 2021).

Understanding the differences between VR with augmented reality (AR) and mixed reality (MR) is also contributory. While AR uses virtual objects in a physical environment to enhance the real or not simulated context, e.g., a mobile app to simulate an object in a real room, VR produces a fully synthetic representation of a scenario with a digital device (Carmigniani & Furht, 2011). In the case of MR, as its name shows, it merges the actual scenario with the virtual one, with those interacting between them as well, to improve appreciation of the perception in the context intended (Rokhsaritalemi et al., 2020). This research will solely focus on immersive VR (IVR) and its application in the educational field of healthcare. This research also uses the concept of technology and devices intermittently when referring to VR. In the scope of this research, they represent the same, acknowledging that they literary have other meanings.

7.2 THE CHARACTERISTICS OF VR

The broad usage of VR in education and other fields can be attributed to its proximity to producing digital scenarios perceived as real by the user and to the immersion sensation that can be reached (Slater & Sanchez-Vives, 2016). VR can range from non-immersive to fully immersive, depending on the isolation level from the real world. The former refers to a simulated reality experienced in a non-immersive context, such as through a desktop or using a mouse to interact (Bevilacqua et al., 2019). In contrast, the latter represents the virtual simulation immersed in a 3D context, entirely blocking the external world (Bailey & Bailenson, 2017).

The VR experience is granted by using up-to-date software that provides a realistic interface (Wee et al., 2021) and a high speed in its response time. This latter is due to the low-latency immersing experience supported by hardware and software in usage in VR (A. Hazarika & Rahmati, 2023). To deliver a digital image that will resemble a real scenario in an accurate time, an alignment between the motion captured by the sensors of the device and the display must occur with the least possible error (J. C. P. Chan et al., 2011). This time difference is also known as the Motion-to-photon (MTP) latency, which is responsible for eventually causing nausea or motion sickness in users when the headset's tracking does not keep up with the users' movement (A. Hazarika & Rahmati, 2023). Additionally, to the features granted by the HMDs, a realistic sensory experience is enhanced with the haptic (or tactile) feedback provided with the use of joysticks or other vibration accessories, taking a special connotation when in education in healthcare (Ng et al., 2023). Moreover, the refinement of computers and digital means and the constant development of artificial intelligence (AI) allows the scalability of training programs by merging these two technologies. The use of AI, machine learning (ML), and deep learning (DL) help create a virtual environment with components such as predictive analytics, AI-teaching bots, and AI-powered avatars in the virtual simulation (K. S. Chan &

Zary, 2019; Shorey et al., 2019). Furthermore, the properties that VR offers as an e-learning tool can also be considered as a natural evolution of computer-assisted education. Thus, evidence shows how it can inspire imagination, and increase levels of understanding (Almusawi et al., 2021). Besides, several other characteristics of VR technology can be highlighted in its usage as a training tool in healthcare. It reduces the risks of practicing clinical procedures, such as different types of surgeries (Kennedy et al., 2023), allows learning by repetition with rather high flexibility (Essoe et al., 2022), and has been proven to increase the level of satisfaction and engagement of learning processes in comparison with traditional methods (Alfalah, 2018; Bonnin et al., 2023; Chiang et al., 2022). Additionally, the use in conjunction of VR with gamification has been reported to have highly positive evaluations among medical students (López Chávez et al., 2020; Nicola et al., 2017).

7.3 LIMITATIONS OF VR TECHNOLOGY AS A TRAINING TOOL

Using VR devices as an educational tool also faces different challenges before and during its implementation. Some of those are the technological conundrums, and side effects after or while its use and the accessibility to it (Ghaliya Al Farsi et al., 2021; Hamad & Jia, 2022). The technological limitation refers to the low standardization of software and interfaces between the different providers of VR technologies, increasing the difficulty for them to interoperate or troubleshoot successfully (Timmerer, 2017). In addition, the limitations of specific software and interfaces in the display in the hardware can affect virtual simulation perception. Besides, other hardware failures such as cable connection issues have also been reported to damage the quality of the interface and therefore the simulation experience (Pérez Fernández & Alonso, 2015; Tastan et al., 2022). Consequentially, some users have experienced side effects such as cybersickness while or after using VR technology. However, this event is user-dependent and can be explained by a mismatch between the real and the virtual motion of the user and its head, predisposition to this sickness (e.g., nausea, dizziness, etc.), or because of an extended time of being on the fully-immerse scenario (Hettinger & Riccio, 1992; LaViola, 2000; Merhi et al., 2007; Rebenitsch & Owen, 2014). Lastly, the accessibility to this technology is still in a rather initial development and is facing different challenges. Some of those are the prices on which VR devices are offered in the market or the inclusion of software and hardware that are friendly to individuals with physical impairments (Teófilo et al., 2018). These and further specific considerations in the nursing educational field, as well as the selection of the adequate educational approach, need to be accounted for to enhance the successful adoption of these technologies.

7.4 VR DEVICES AND THE DIFFERENT EDUCATIONAL APPROACHES

The use of VR devices as an educational tool has been severely studied in different applicational fields (Allison & Hodges, 2000; Almusawi et al., 2021; Antón-Sancho et al., 2022;

Lai & Cheong, 2022). A recent systematic literature review states twelve different types of educational approaches using VR technologies. These are framed as theories, approaches, and methodologies described. These techniques are five educational approaches, one methodology, five learning theories, and one theoretical framework (Marougkas et al., 2023).

The five **educational approaches** are constructivism, gamification of learning, design thinking, learning through problem-solving, and scientific discovery learning. *Constructivism* refers to active participation in the virtual space, constructing in it while following instructions (Aiello et al., 2012). In the case of *Gamification*, users get to actively interact with the virtual context in a hands-on situation by adding game logic, increasing engagement with the learning process (Villagrasa et al., 2014). This has been highlighted as one of the most effective in enhancing positive outcomes of learning processes (Lampropoulos & Kinshuk, 2024), and it could include game-like stimulations to participants, such as the winning of badges, team formations, or performance graphs (Kern et al., 2019). *Design thinking* promotes the involvement of the users in the creation and trial of scenarios based on their creativity, empathy, and own personalized needs for the learning process (Y. Chang et al., 2022). *Learning through problem-solving* encourages users to solve real-world problems preparing them for real situations (Araiza-Alba et al., 2021). Lastly, s*cientific discovery learning* involves direct interaction with scientific concepts, allowing students to explore and experiment directly with them for a more impactful training process (De Jong & Van Joolingen, 1998). Conclusively, although these pedagogic approaches have defined differences between themselves in terms of their implementation, they all seem to put the user at the center of the educational process. The involvement of the student with active participation, creation, and ongoing interaction will stand as the most effective learning method depending on the context or objective of the corresponding task.

When referring to the **methodology,** *experiential learning* proposes that users must get involved with a cycle of concrete experience, reflective observation, abstract conceptualization, and active experimentation. Users should be able to apply those four learning processes to effectively internalize new knowledge and skills (Asad et al., 2021).

The five **learning theories** suggested are the theory of learning by doing, flow theory, cognitive theory of multimedia learning (CTML), cognitive load theory (CLT), and technological pedagogical content knowledge framework (TPACK). *Learning by doing* (also known as John Dawney's theory (Dewey, 1986)) suggests that users get involved with hands-on and experiential approaches to enhance their learning experiences (Sultan et al., 2019). *Flow theory* comprises the full psychological involvement of the participant with complete focus, enjoyment, and immersion in a scenario to the extent that they could eventually forget about themselves. This carries some drawbacks such as the omission of a group interaction (H.

Wang et al., 2023). *CTML* states that students can achieve better results by utilizing multimedia material to support their cognitive knowledge. However, multimedia material would not necessarily include immersion realities, such as in VR (Meyer et al., 2019).

CLT is considered a framework that supports the development of cognitive skills by challenging users' memory capacity. This framework would offer a high cognitive load to test users' retention and processing capacities (Duran et al., 2022). Furthermore, TPACK uses the interrelationship between content knowledge, pedagogy, and technology and how these three interact to enhance engagement in the learning experience (Mishra & Koehler, 2006). These previously mentioned theories comprise diverse methodologies to achieve the learning objectives. However, they all show specific techniques to support and increase the learning experience.

Lastly, the theoretical framework of *social constructivism* highlights how interaction among peers offers opportunities to improve the learning experience. Thus, the acquisition of new knowledge would be highly relevant, as would the exchange of those with interaction and dialogues with others. Although VR technology sheds positive light on this regard by offering virtual rooms for users, physical interaction might be a limitation (Southgate et al., 2019).

Overall, pedagogical approaches using VR share similitudes and defined differences between them. Some pose challenges for the students as individuals or groups, while others include game-oriented approaches to engage their users or encourage interaction as a social learning process. Nonetheless, their use will depend on the target group, capacities, context, and learning objectives. The case of healthcare settings poses unique challenges regarding the educational process and selecting the right methodology. A better comprehension of the healthcare landscape and previous experiences with VR devices might contribute to successfully implementing the technology in nursing schools.

8 VR DEVICES AS A TRAINING TOOL IN HEALTHCARE EDUCATION

VR devices in healthcare education have been acknowledged as a significant opportunity to address current gaps in this field. The digitalization of digital settings and the ongoing shift from institutional-centered medicine to patient-centered offer great opportunities for devices such as VR to integrate into the healthcare landscape (Louw et al., 2017). Besides, healthcare institutions and schools must constantly remain up-to-date with the changes in infrastructure and educational requirements to meet standards of innovative pedagogical goals. VR technology has been recognized as one of the instruments that can support and enhance the modernization of education (Guze, 2015). In this process, some relevant challenges and opportunities portray previous strengths and weaknesses of the technology when considering its implementation. These include increased patient safety and educators' role in nursing education (Schuir et al., 2019). In addition, this section will describe previous experiences with VR devices in healthcare settings.

8.1 Increasing Patient Safety with VR Device Training

Clinical mistakes or medical treatment mistakes are practices that occur regularly in the clinical environment, and they often have detrimental and long-term effects on patients (Donaldson et al., 2021). In Germany, by 2022, more than 13,000 medical mistakes that brought consequences to the patient were reported where only around 2,700 were proven to have occurred and have harmed the patient, with most of the allegations on surgical procedures (Medizinische Dienst, 2023). These can go from unperceivable wrong medications or scars to harmful or life-threatening surgery practices (Institute of Medicine (US) Committee on Quality of Health Care in America, 2000; Tagesschau, 2015). These errors could have different causes and classifications. These might include active errors (direct from the clinician or nurse to the patients), adverse events (related to hospitalization or medication), medical errors, patient safety, etc. (Rodziewicz et al., 2024). To prevent this, VR technology has been suggested as a convenient tool. It has been suggested that by enhancing competencies, including skills, knowledge, and abilities, VR technology might reduce the risks of mistakes in patients' practice and increase their safety (Kennedy et al., 2023). Additionally, with VR device training, users can leverage guidance, objective descriptions, immediate evaluation, and, in many cases, performance measurement settings. This type of measure describes data from the participants before, during, or after the training to adapt the experiences to their necessity and provide the corresponding feedback to the performance (Zahabi & Abdul Razak, 2020). Besides, repeating standardized and tailored processes will allow users to develop skills at their own pace and have the opportunity to repeat the practices in a safe environment (Ruthenbeck & Reynolds, 2015). Providing these conditions for healthcare education might increase trainees' awareness and permit them to reduce practice errors and, therefore, increase patient safety (Mazur et al., 2022).

8.2 Role of the educators in healthcare settings and nursing education

As previously mentioned, the role of educators in nursing education is pivotal in forming trainees. These should grant core competencies such as patient-centered care, teamwork and collaboration, evidence-based practices, quality improvement, safety, and digital ones (FAAN et al., 2017). To do so, educators must be aware of the target group of students they are working with, considering context conditions such as their age and previous experience in the field (W.-S. (Christina) Lee et al., 2002). Besides, digital technologies can improve quality and efficiency in clinical practices. The evidence of a study with nursing students revealed that although they appraised VR devices as a valuable supportive tool, they also believed that no face-to-face (analog) contact with the mentor made the lesson feel distant (Heinonen et al., 2019). VR devices should be a suitable complementary training tool rather than a sole teaching method to mentor nursing students. Hence, nurse educators with digital pedagogic skills are meant to grant DHC to their students so they can keep pace with the technological, demographics, and health system's constant evolvements and requirements (Honkavuo, o. J.; Skiba et al., 2008). However, educators have reported challenges to the adoption of new technologies. Some of these are the teacher's reluctance to switch from traditional analog teaching methods to new digital training tools, the technical constraints experienced, and the loss of analog student-trainer interaction time (Loureiro et al., 2021). However, distance training and remote contact between teachers and learners have also been suggested as positive ways of providing easy and accessible learning resources (Koehler & Mishra, 2009). Therefore, a balanced interaction between remote and present should be encouraged to leverage the best of both modalities, preventing their drawbacks from overtaking them. Additionally, nurse educators have occasionally adapted the teaching mode to digital means, but not necessarily the content in this (S. S. Gardner, 2014). Nevertheless, educators must adapt to evolving technologies and include that in their roles, as professional nurses, researchers, and managers often do as another profile layer (Zlatanovic et al., 2017). For educators to fully implement the transfer of DHC, it has been suggested them teach based on a "Technological pedagogical and content framework." This refers to the transfer of technological characteristics, e.g., how to use software or how this will interact with other users like patients, and the pedagogical aspect refers to which methodology brings the best learning for the trainees. All of this is in a content-specific domain that is being taught (Koehler & Mishra, 2009). Besides, nurses educators will not only transmit different skills and knowledge to nurses but they are also pivotal in engaging and empowering teaching experiences to their students (Ghasemi et al., 2020). Educational institutions also accompany this purpose of nurse educators, and they should constantly identify areas of improvement in the education of nurses and keep their educational programs to technological and contemporary standards (T. M. Forman et al., 2020).

8.3 EXPERIENCES OF TRAINING WITH VR IN HEALTHCARE SETTINGS

8.3.1 PSYCHOMOTOR SKILLS ACQUISITION IN SURGERY

VR as a training tool in healthcare settings is extensive, diverse, and existing from long data (Iserson, 2018). The evidence in this domain is vast, and this section aims to give an overview of it and the main usages experienced. The field of surgery, for instance, has vastly leveraged VR devices as training tools due to its well-evaluated capability of training psychomotor skills (Rourke, 2020). These are defined as physical movement tasks that require cognitive and motor abilities (Psychology Degree, 2024). The practices range from less invasive surgeries such as laparoscopic to more critical procedures such as lumbar puncture (Lilamand et al., 2023; Umoren et al., 2021). Specifically, in orthopedic surgery (e.g., joint replacement), they have leveraged VR devices by integrating live checklists and motion tracking features to the simulations, improving their learning outcomes in skills acquisitions (Agyeman et al., 2020). The field of organ transplantation has taken advantage of the three-dimensional images produced with magnetic resonance images (MRI) to the recreation of organ transplantation VR scenarios, producing realistic and reliable practice scenarios (Ntakakis et al., 2023). A slightly different experience was observed in an experiment on education for laparoscopic varicocelectomy. In this case, participants who trained with VR devices shortened their surgery times (versus the ones who did it with regular methods). Still, they did not meet the learning expectations of improving their results on their learning curve (improving from the learning stage, improving stage, and platform stage) (Z. Wang et al., 2014). Interestingly, the research findings on education with VR devices in laparoscopic colorectal surgery included and evaluated participants from novice, intermediate, and experienced participants. Novice participants considerably improved their results on skills acquisition after training with VR devices versus the similar group who did it with traditional methods (Beyer-Berjot et al., 2016). These results unveil the relevance of the interaction of the trainee's professional experience and the level of development of the virtual scenario to generate an impact on the apprentice. Likewise, in a VR simulation to practice anatomical surgery, medical undergraduates and seniors were invited to five days of practice with VR practice. More than 90% of the participants evaluated the experiment's great value (Narang et al., 2023). Besides, since cadaveric figures are frequently the gold standard for training anatomy, it has been reported positive results when combining virtual training with analog cadavers when practicing anatomical dissection (Chytas et al., 2021; Selcuk et al., 2019). Another interesting report suggested that surgical training with VR devices with repeated training on different days (versus a single training one day) increased trainees' performance scores and speed of skills acquisition (Fahl et al., 2023). Furthermore, several other surgical domains have experienced VR devices as training tools. Some of those are skill training for cardiac surgery (Aslani et al., 2022), craniofacial surgery (Sayadi et al., 2019), education in surgical site infection (Umscheid et al., 2011), remote endovascular surgery (Y. Wang et al., 2018), etc. In the case of cardiac surgery, the VR device was considered an effective complementary tool to improve the learning process. For instance, the outcomes of the cardiac surgery study suggested using VR devices as an effective complementary tool to reduce risks in real scenarios or to prevent vascular perforation tissue with the assistance of a remote expert in the study of remote endovascular surgery with the assistance of a remote expert.

8.3.2 ACQUISITION OF KNOWLEDGE:

The acquisition of knowledge with VR devices has been tested in different domains of healthcare. The contribution of VR technology to this domain was proved in orthopedic surgery, with senior students showing superior scores in their tests after training with VR devices compared to a group that used traditional methods (Lohre et al., 2020). Besides, it has been suggested that training with VR technologies might augment the acquisition of affective and cognitive knowledge when using the technology to practice in evidence-based scenarios (Foronda et al., 2017). Other findings showed how nurse participants trained in VR device knowledge, such as conflict management or problem-solving in a pre-posttest, performed better than their counterpart group (Tschannen et al., 2012). Similarly, medical students who trained themselves to learn heart anatomy showed improved results and more satisfaction with the training when compared to the counter group who had traditional methods (Alfalah et al., 2019). Interestingly, the findings from Souza et al. revealed higher scores (versus traditional analog methods) on knowledge and retention when practicing neuroanatomy with VR devices. The experiment took place partially remotely, which additionally encourages VR technology as a suitable technology for knowledge acquisition remotely (Souza et al., 2020). The findings of a group of medical students showed the feasibility and acceptance of implementing remote education independently and in conjunction with analog training methods. In addition, interaction between students with virtual education was also positively evaluated (Alverson et al., 2008). Further evidence have also reported positive outcomes after using VR devices for their training, such as high satisfaction, self-efficacy (Chiang et al., 2022), high adherence (Zackoff et al., 2020) and self-trust (N. Brown et al., 2023).

8.3.3 ACQUISITION OF PERSONAL EMOTIONS AND COGNITIVE COMPETENCIES:

Training with VR devices has also been used to transmit personal emotions and cognitive skills to users. Nursing education intends to encourage students' emotional qualities such as compassion, empathy, emotional intelligence, resilience, and conscientiousness. They are also encouraged to acquire cognitive expertise, including semantic skills, clinical knowledge, narrative skills, diagnosis reasoning, and information gathering (Murinson et al., 2008). Education with VR devices has proven to be able to train some of these and generate personal emotions. The systematic review revealed how the training with VR devices might mitigate stress in clinical situations and increase provider effect and performance (Meese et al., 2021).

9 VR DEVICES IN NURSING EDUCATION

The study, implementation, and different usages of VR technologies in healthcare education are frequently intertwined between the various occupations of healthcare providers, such as medical doctors, midwives, and nurses. However, describing their interaction with this technology as being isolated is necessary to address their independence. In nursing education, various approaches intend to portray the educational options that training with VR devices offers. An example of this is given by an extensive systematic review that classifies education with immersive VR into four main educational objectives. These are developing learning outcomes in systematic procedures, emergency response, soft skill training, and psychomotor skills. For example, these would be taught domains such as standard operating procedures (SOPs), training of self-confidence in stressful situations, training of empathy and communication, and training tactile procedures, respectively (Plotzky, Lindwedel, Sorber, et al., 2021). However, the selection and implementation of these will depend on the conditions and context of the education. To contextualize, experiences with VR devices are being described in the domains *skills and knowledge acquisition, the standardization of education with VR devices*, *the influence of simulation design with VR devices* and the *sociocultural factors influencing outcomes with VR devices*. These might provide insights into previous VR device experiences to further comprehend how nursing education can leverage technology.

9.1 Skills and Knowledge Acquisition:

Previous evidence about skills acquisition showed that nurse trainees increased their knowledge in score tests after learning and rehearsing with VR devices. Likewise, a parallel group trained with non-VR simulation obtained similar post-training scores (Rourke, 2020). These outcomes suggest the complementary character that VR training might have in some cases. Besides, the obtention of positive learning outcomes might encourage users to accept and adapt the technology seamlessly due to positive learning experiences. Besides, participants of a mixed methods study reported high satisfaction after an educational intervention with IVR. As part of the qualitative part, they suggested using technology to practice and learn clinical skills (Saab et al., 2023). Additionally, VR training in a mechanical ventilation curriculum increased trainee satisfaction, self-efficacy, and clinical reasoning (H. Lee & Han, 2022) underscoring its applicability across nursing education's varied domains (Choi et al., 2022). A recent meta-analysis revealed how VR can be more effective by improving the knowledge of trainee nurses' teaching skills, teaching aptitudes, and academic contentment and increasing their satisfaction. However, it does not show improvement in students' critical thinking (K. Liu et al., 2023). Another study contrasted IVR intervention with a non-immersive VR approach, finding comparable knowledge acquisition levels between the groups despite the IVR group experiencing a higher cognitive load (Lo et al., 2022). Similarly, Ryan et al.'s systematic review further examined VR's educational utility for nurses, noting similar knowledge gains between VR and traditional methods but increased satisfaction, self-confidence, and engagement with VR, advocating for its adoption in nurse training (Ryan et al., 2022). Additionally, other existing evidence has revealed positive results regarding the acceptability and usability. This was tested in undergraduate nursing students who reported IVR as realistic and interactive, and it increased their confidence and reduced anxiety when facing a clinical case of sepsis (Adhikari et al., 2021). A similar outcome was experienced in the research conducted by Bracq et al., unveiling the acceptability of VR to train procedural skills for both non-experts and expert groups based on the behavioral intention of use dimension. In addition, the results showed no effect of demographics such as age, gender, and experience between the groups, suggesting that technology is a prominent methodology in initial training (Bracq et al., 2019). Plotzky et al. describe the learnings of a randomized mixed methods study. Although participants using IVR increased their knowledge, satisfaction, motivation, and confidence, they showed IVR was not ideal for practicing psychomotor skills (Plotzky et al., 2023). In the case of Gasteiger et al., their findings show how VR might help all healthcare staff have a better perception, visualization, and interactivity, which leads to improved learning and satisfaction (Gasteiger et al., 2022). Studies on advanced infection control in neonatal intensive care through VR reported significant boosts in performance confidence, empathy, and presence (Ryu & Yu, 2023). An exploratory analysis of Australian nurses demonstrated VR's role in developing non-technical skills such as communication and teamwork, essential for decision-making processes (Peddle et al., 2019)., emphasizing VR's comprehensive benefits in nursing education's cognitive, emotional, and skill-based aspects.

9.2 STANDARDIZATION OF EDUCATION WITH VR DEVICES

Standardizing educational programs will broaden nurses' capabilities and enhance their professional performance (Nichols, 1981). It has been evidenced that nurse trainees who undergo standardized learning experiences with VR devices in their training before going to a practical performance might increase their engagement in the educational process (Donovan & Mullen, 2019; Komizunai et al., 2020). Likewise, standardized VR training for non-oncology nurses shredded positive results when administering chemotherapy and their offshoots, such as preparing the medication or using waste disposal. In this case, the nurses increased their efficiency of the procedure by learning it with VR devices guided by senior peers (versus the control group who learned through lectures and reading)(C.-Y. Wang et al., 2022). In contrast, a meta-analysis performed by Woon et al. revealed how procedural training was more efficacious in undergraduate nurse trainees when run in multiple, self-guided, short sessions within 30 minutes and considering a low to moderate level of immersion (Woon et al., 2021).

9.3 INFLUENCE OF SIMULATION DESIGN WITH VR DEVICES

It has been suggested that the simulation design can impact the participants' learning outcomes (Cowperthwait, 2020). In the case of training with VR technologies, whether the trainees are using immersive, semi-immersive, or non-immersive VR technologies should be considered. Kim and Kim's findings revealed that less immersive VR training was more efficacious than fully immersive VR training for knowledge outcomes (Kim & Kim, 2023). In contrast, subjects in a study reported equal or improved learning outcomes after highly immersive VR experiences (Farra et al., 2018). Other findings suggest that immersion, in general, could harm the learning outcomes by incurring excessive positive emotions (Parong & Mayer, 2021). A study evaluated the effectiveness of training for chemical disasters using VR technology. The study design included novice to senior apprentices, and a quasi-experimental design was used. The results showed that the intervention and control groups improved their self-efficacy and self-preparedness with the training program and tabletop drills. However, this case highlighted how novice trainees leveraged this methodology more than their senior peers (C.-W. Chang et al., 2022). Similarly, a scoping review addressing nursing education with VR in disaster medicine suggested this technology could potentially improve the trainees' initial skills and engagement (Magi et al., 2023). This highlights the importance of having software and programs scalable to the different levels of education required, e.g., novice or senior trainees. A recent systematic review revealed that IVR training for novice undergraduate nurses and other medical professionals, e.g., doctors and physiotherapists, effectively improved the learning experiences and outcomes of procedural skills and knowledge acquisition. However, its counter group (traditional training methods) showed similar results, which does not support, in this case, the hypothesis that VR technology would be a superior training methodology (J. Y. W. Liu et al., 2023).

9.4 SOCIOCULTURAL FACTORS INFLUENCING OUTCOMES WITH VR DEVICES

The factors influencing the adoption of Virtual Reality (VR) as a training tool extend beyond learning outcomes, objectives, or research design, with sociocultural elements playing a significant role in the integration and adaptation of VR training. Notably, variations in acceptance have been observed among similar demographic groups across different countries. Le Duff et al. revealed how nurses in France showed significant intention to use versus oppositive results to Japanese nurses after testing VR devices to train soft skills. However, both groups acknowledge the usefulness of the technology as an educational material (Le Duff et al., 2023). To further consider this technology in the educational curricula of nurses, previous research assessed the trainees' feedback in different contexts. Hence, these findings suggest how VR could be used in different sociodemographic settings and that these criteria could impact the acceptance of the technology.

10 POTENTIALS FOR VR NURSING EDUCATION IN HEALTHCARE SETTINGS

The usage of VR in nursing education encompasses a variety of domains, with the purpose of enhancing clinical competencies, communication skills, and interprofessional collaboration among professionals. Besides, VR, in conjunction with other technologies such as artificial AI, might increase the chances of leveraging these digital means. These applications of VR technology are designed to meet specific learning outcomes and support nurses at different stages of their education and careers. The following undersections address some of the extensive potentials that VR devices currently benefit from.

10.1 Optimizing Communication Training Among Healthcare Staff

Challenges in communication between nurses and other healthcare professionals, such as doctors, have been documented, often attributed to disparate views due to differences in training and workplace environments (Tan et al., 2017). Successful interaction between nurses staff and nurses and other staff members, e.g., physicians, might support improvement in clinical processes, such as reducing patient readmissions (Townsend-Gervis et al., 2014). Hence improving clinical processes and patient outcomes. To test the training of communication between healthcare staff members, Liaw et al. conducted a randomized control trial (RCT) comparing the training in this domain with VR simulations versus live simulations. The study revealed no significant difference in their effectiveness, suggesting VR as a viable alternative for interprofessional communication training (Liaw et al., 2020). In addition, other evidence indicates that interprofessional team training in communication, knowledge, and other skills might be especially effective in undergraduate students (Nelson et al., 2017).

10.2 Improving Interprofessional Competencies

A mixed-methods study by Liaw, Soh, et al. assessed the perceptions and experiences of a diverse group of healthcare professionals using VR simulations for collaborative learning. The simulations in virtual hospitals with healthcare provider avatars and electronic patient records showed improved interprofessional competencies and teamwork attitudes compared to values before VR technology training (Liaw, Soh, et al., 2019). In another research, Liaw et al. highlight RCT's positive results in assessing interprofessional attitudes and team collaboration after teamwork training with VR devices (Liaw, Wu, et al., 2019). Another study underscored the value of experiential learning through VR training in reinforcing teamwork during interprofessional rounds within a shared mental model conceptualization, emphasizing the importance of individual and collective understanding of responsibilities within healthcare teams to achieve unified patient care goals (Floren et al., 2018).

10.3 Enhanced Health Outcomes with Virtual Avatars and AI in Nursing Training

Virtual environments and avatars are crucial in engaging users and impacting learning outcomes in VR training (O’Connor, 2019). Liaw et al. demonstrated how AI-powered doctor avatars could effectively engage trainee nurses in clinical processes, such as learning about sepsis, compared to avatars controlled by humans (Liaw et al., 2023). Furthermore, Rouleau et al. suggested that VR training could enhance graduated nurses' relational skills, increasing motivation, self-confidence, and reflective practices in patient interactions, notably in sensitive scenarios like communicating human immunodeficiency virus (HIV) statuses (Rouleau et al., 2022). Additionally, the use of avatars in VR scenarios can empower and educate high-risk groups, helping them to prevent HIV transmission by improving the management of their sexual health (Orta Portillo et al., 2023).

10.4 Increased motivation with Gamification training

Hara et al. explored gamification in VR to train communication skills, utilizing interactions with avatars in virtual settings (Hara et al., 2021). The study validated the software's acceptability and appearance, indicating the potential of gamified VR applications in nursing education. VR offers tailored solutions for nurses at various educational and professional stages. These initiatives underscore the technology's versatility in addressing the nuanced nursing education and healthcare delivery needs. Additionally, gamification experiences with VR devices have shown good acceptance by nurse users, increasing their educational motivation and encouraging less tech-savvy trainees to adhere to the technology after sustaining long-term VR practices (Lange et al., 2020). Similarly, nurse students who practice tracheostomy processes with gaming VR devices obtained better test scores than those trained with analog methodologies (Bayram & Caliskan, 2019).

11 Challenges and opportunities in German healthcare systems

The various experiences with VR devices in healthcare settings and nursing education support the opportunity to use this technology to overcome some of the biggest challenges that German healthcare systems face. Hence, understanding these gaps and the country's context is pivotal to generating tailored solutions that are practicable for digitalizing and improving nursing education in Germany.

As one of the largest economies and nations of Europe, with a gross domestic product (GDP) of 3.87 trillion Euros by the year 2022 and a population of about 84.6 million habitants by the end of the year 2023 (Destatis, 2024; Statista, 2023), Germany entails a complex but well-developed healthcare system that allows the estate to provide high-quality services to a vast part of the population. The country invests yearly pro-person in healthcare more than the average given by EU member states. In 2021, the healthcare system in the country paid 5 699 EUR per inhabitant versus the 3 562 EUR average of the EU countries (European

Observastory on Health Systems and Policies/OECD, 2021; Eurostat, 2024). Moreover, the German population's health insurance distribution is about 90% under public health insurance coverage (in German: *Gesetzliche Krankenversicherung, GKV*), and the other 10% in private health insurance (in German*: Private Krankenversicherung, PKV*) or other types of insurances (Bundesministerium für Gesundheit, 2022a). This system is based on five principles: mandatory, solidarity, financed by contributions, self-administered, and no direct payment by the patient (Bundesministerium für Gesundheit, 2022b). Hence, users leverage benefits such as low-share out-of-pocket and universal health insurance coverage (Blümel et al., 2020). Thus, the nation shows to the year 2023 positive results on certain health indicators compared to its peers in the Organization for Economic Cooperation and Development (OECD). 65% of the health systems resources indicators were above the average of the OECD, e.g., Germany provides 12 practicing nurses for every 100 000 habitants versus the 9.2 average of the OECD (OECD, 2023). Nevertheless, despite Germany's robust healthcare infrastructure, the recent highly stressful pandemic and the unceasing chain of humanitarian crises, including forced humanitarian demographics displacements and bellicose events, (Filip et al., 2022; Ghosh et al., 2023; World Health Organization, 2024) reveled and exacerbate the gaps that the German healthcare system deals with (Warmbein et al., 2023). Besides, the COVID-19 Pandemic constrained global medical settings in developing and developed nations in different domains, such as vaccination rates or hospital-bed capacity (Sen-Crowe et al., 2021; Sheikh et al., 2021). Germany was no exception to this, and although the country overcame most of these hardships, e.g., basic immunization of 76,4% and a bed occupancy of 68% in the year 2021 (versus 77,2% the year 2019) (DW, 2022; Federal Ministry of Health, 2023), other setbacks in the system such as the limited digital infrastructure on the healthcare field or the shortage of skilled personnel became highly evident meanwhile the crisis (Jennewein & Geißler, 2022).

Accordingly, the inclusion of digital health technologies, such as AI, the Internet of Things (IoT), wearables, etc., offer tremendous opportunities to overcome adversities in the healthcare field (Stoumpos et al., 2023). For instance, an improvement in appointment patient management has been experienced with online platforms on patients' mobile phones. This allows the coordination of the arrival of patients to the practices to avoid unnecessary gatherings in the same place and to prevent no-shows (Hentschker et al., 2023). Furthermore, a staggered increase in the use of telemedicine was seen in Germany in 2022, with about 1.4 million consultations using this means, compared to 3.000 in 2019 (Jennewein & Geißler, 2022). Additionally, the current vast research and evidence in AI place this technology as a convenient tool to overcome some of the main issues in healthcare. AI can potentially enhance clinical outcomes efficiency and clinical services and permit a larger extent of services to be provided (I. Hazarika, 2020). This and other digital means, such as VR devices, are pivotal in medical settings as innovative, supportive instruments.

As mentioned in the previous section, VR technology has the opportunity to tackle the nurses' shortage in Germany due to several positive outcomes, such as increased engagement, satisfaction, learning outcomes, etc. Additionally, it has been reported that digitalizing healthcare infrastructure can empower current and future healthcare professionals (HCPs)(OECD, 2020). The necessity of including innovative digital solutions to address the nurse shortage in Germany is evident. To integrate these tools, especially VR technology, in nursing education, it is essential to comprehend the landscape of where the lack of nurses in training or occupation threatens the occupation.

11.1 Shortage of skilled nursing personnel in Germany

The performance of nurse occupation is known to be highly demanding globally, and Germany is no exception. The nursing staff reports working on extensive journeys with limited opportunities for recovery and highly emotionally loaded events while working, resulting in an extensive mental health burden for the nursing staff (Bas, 2021). Conditions such as these contribute to a weakened, unstable, and unappalling impression of the nursing occupation. This results in difficulties in fulfilling nursing positions in the different domains they perform. Hence, the decreased job satisfaction in this group has been evidenced as a main driver for abandoning and no longer adhering to the occupation (P. Koch et al., 2020). Additionally, the number of prospective graduate nurse students has decreased in Germany. The number of newly graduated nurses who signed a contract to perform the occupation fell by 7% from 2021 to 2022 (Zeitverlag, 2023). These ciphers and events add up other hardships hospitals face in regular or crisis times, such as limited beds or infrastructure capacity (Ärzteblatt, 2020). As previously mentioned, some estimations suggest that if current societal conditions do not change, about 186 000 and 307 000 nurse positions in ambulatory and in-hospital will not be occupied and in need by 2035 (Flake et al., 2018).

11.2 Graduated nursing occupation and prospective nurses in Germany

The education to become a nurse in Germany has been historically recognized as a vocational traineeship (in German: *Ausbildung*), and more recently, since 2020, it has been included as an academic study in various universities or universities of applied sciences (In German: *Fachhochschule*) (Academics, 2024). Originally, the vocational trainee would offer educational programs to result in three types of graduated nurses: elderly nurses, general nurses, and pediatric nurses. The former was legislated under the elderly care act (In German: Altenpflegegesetz), and the middle and the latter under the Nursing Act (In German: *Krankenpflegegesetz*). However, an update on the legislation has gathered the two acts into one called the Nursing Profession Act (In German: *Pflegeberufegesetz*) (Bundesministerium für Gesundheit, 2024c). After the education is completed, a test recognized nationally must be accomplished to obtain the title and the national permit as a nurse, elderly nurse, or pediatric nurse (Bundesministerium für Justiz, 2024). Once this is obtained, nurses are permitted to effectuate the occupation in Germany and other EU member states, eventually after harmonizations after arrival (European Commission, 2024). An estimated number of 1001 000 nurses were active in the occupation. This includes only graduated nurses with direct contact with patients and excludes midwives, ungraduated nursing students, and non-certificated nurses (Statista, 2024a). This is derived from the fact that about 52.000 nurses graduated by 2022, which is 4.000 less than the year before across the country (- 7%). However, the scenario differs in the federal states (In German: *Bundesländern*). Meanwhile, states such as Hamburg or Hessen faced in the previously mentioned years a decrease in their newly graduated with working contracts of 16% and 15% respectively, Sachsen and Berlin had decreases of 2% and 5% respectively (Statistisches Bundesamt (Destatis), 2024e) — further details to be found in Table 1. Thus, considering the increasing demand for nursing care of about 5 million people in Germany by the end of 2021 (Statistisches Bundesamt (Destatis), 2024a), the healthcare ecosystem in the country is augmenting the necessity for these professionals every year. A report named Nursing Staff Forecast (In German: *Pflegekräftevorausberechnung*) published by the Federal Statistical Office addresses not only the critic ciphers about unoccupied nursing positions in the future but also how the different societal, political, and systemic changes can critically affect the capacities of nurses in Germany. Some findings are that the landscape will be critical in the coming decades if conditions such as demographics in the profession's future do not change (status quo). In contrast, if new behaviors are included, such as higher male participation in the profession, the high need for nursing staff would eventually be buffered (Bundesministerium für Gesundheit, 2024d). Additionally, the Babyboom generation is also influencing the shortage of nurses in Germany. Hence, the extensive number of individuals born after the Second World War, whose working time is soon ending, will leave a significant gap in the working market (Coleman et al., 2006). Besides, the overburden suffered by healthcare settings with limited nursing occupation results in low availability of functional or operating beds. As a consequence, the level of mortalities increases many times; critical patients must be transferred to emergency units due to no capacity for care (Fichtner et al., 2023).

TABLE 1 - NEWLY COMPLETED TRAINING WITH WORKING CONTRACTS ON NURSING EDUCATION (MALE/FEMALE).(STATISTISCHES BUNDESAMT (DESTATIS), 2024E)

Graduated by 31.12	2022	2021	Difference compared with the previous year in %
Germany	52 299	56 259	-7
Baden-Württemberg	5 889	6 480	-9
Bavaria	6 162	6 501	-5
Berlin	2 337	2 469	-5
Brandenburg	1 434	1 512	-5
Bremen	465	513	-9
Hamburg	1 137	1 356	-16
Hessen	2 952	3 492	-15
Mecklenburg-Western Pomerania	1 269	1 461	-13
Lower Saxony	5 199	5 643	-8
North Rhine-Westphalia	14 295	15 711	-9
Rhineland-Palatinate	2 202	1 854	19
Saarland	798	852	-
Saxony	3 375	3 435	-2
Saxony-Anhalt	1 644	1 644	-
Schleswig-Holstein	1 542	1 653	-7
Thuringia	1 599	1 680	-5

11.3 Reasons to explain the increasing shortage of nursing staff

Some explanations for the increasing shortage of nursing staff in Germany include the fast-changing demographic changes such as the aging staff and population and stalling fertility rates (Oulton, 2006; Statistisches Bundesamt (Destatis), o. J.; Winter et al., 2020). In other words, there will be more individuals meeting their pension time and fewer newborns who will be potential individuals to cover the gaps in the labor market. By 2022, every second person in Germany was older than 45, and every fifth was older than 66 (Statistisches Bundesamt (Destatis), 2023). Besides, the aged population has considerable longevity, intensifying the chances of demanding nursing attention by belonging to an age group with more comorbidities (Reiff et al., 2020). Additionally, although the German birth rates have been aligned with the EU average of 1.54 newborns per woman (EU-average 2019: 1.53 newborns per woman), the rates continue to decline. In 2022, there was a fertility rate of 1.46, and the early measures of 2023 indicate a decrease of about 7% compared to the previous year (Statistisches Bundesamt (Destatis), 2024c, 2024b). Interestingly, the presence of freshly settled migrant groups has been evidenced to impact both local fertility rates and the reinforcement of the nursing staff. The presence of migrant groups had a positive impact on fertility rates in the country, contributing to a momentary increase in the previous decade. For instance, in 2015, Germany received a high amount of forcibly displaced refugees, which contributed to having a fertility rate in 2016 of 1.59 newborns per woman. The country's sound economic situation also contributed to this, giving fertile women more confidence (Politico, 2018; Statistisches Bundesamt (Destatis), 2018). However, the current low fertility rate does not bridge the unburdening labor market and the deficit of nursing staff. Parallelly, there are several aspects and layers of the performance of the occupation that could further explain this phenomenon. Working nursing staff have claimed discontent with different aspects of their occupation and how society treats and sees it (Siegfried, 2021). Some aspects include dislike of the wage, excessive working hours, unacknowledged career prestige, and jeopardizing the permanence of currently active nursing staff (Ärzteblatt, 2011). This complicates the retention of currently active, skilled nurses and fails to expand the nursing workforce to meet the growing needs. Unattractive working conditions, such as high stress and workloads, working burnouts, and lack of supportive staff, decrease nurses' satisfaction at work (Lu et al., 2012). A study conducted on professional nurses in several hospitals in Bavaria, Germany, showed that over 50% were dissatisfied with reasons such as the organization of the departments or income situation (Sommer et al., 2024). Additionally, factors in the appreciation and prestige of the tasks performed have also been acknowledged as essential influences on their satisfaction and reminiscence during their occupation in Germany (Reiff et al., 2020). Interestingly, a group of nurses revealed that although the societal opinion of their occupation appears to be high, the opinions among nurses about their occupation seem to be the opposite (Isfort, 2013). Additionally, by 2022, 88 % of the surveyed German citizens rated as highly appreciated general nurses and 85 % as geriatric nurses (dbb Bürgerbefragung, 2022). However, nurses have a negative opinion of their labor, perceiving low prestige and detrimental working conditions (Schmucker, 2020). Other factors, such as contract duration and salary increases, are significant when referring to increased nurses' job satisfaction. However, the rise in salary should be drastic to change the nurse's opinion to a factor of satisfaction (Kroczek & Späth, 2022). Notwithstanding, a recent report with data from Germany reveals that in certain circumstances, an increase in the wage could make the nursing field more attractive. To this, 68% of potential prospective nurses, e.g., trainees, unemployed or tempted to the career, declared that if there were better wage conditions, they would work as professional nurses until retirement (PwC, 2022).

11.4 MEASURES TO BE TAKEN TO OVERCOME THESE HINDRANCES IN GERMANY

The critical availability of nursing staff in the country requires timely and innovative mechanisms to shift the current trend. The encouragement of demographic changes, such as the recruitment of nurses abroad, and the advance of several legislation acts are some of the most significant developments supporting the nursing occupation (Williams et al., 2020). Because of the orientation of the research questions and objectives, this research solely focuses on events directly related to digitalization and the interaction with the needs of nursing education.

The German authorities have recognized these gaps in the field and by 2018 initiated a package in the intersection of the Federal Ministry of Health (In German: *Bundesministerium für Gesundheit (BMG)*), the Federal Ministry for Family Affairs, Senior Citizens, Women, and Youth (In German: *Bundesministerium für Familie, Senioren, Frauen und Jugend (BMFSFJ)*) and the Federal Ministry of Labour and Social Affairs (*In German: Bundesministerium für Arbeit und Soziales (BMAS)*) (Bundesministerium für Gesundheit, 2024a). As an action plan, these entities have launched the **Concerted Action on Nursing** (KAP) (In German: *Konzertierte Aktion Pflege).* The plan has a concrete goal to improve daily working conditions for nurses and, therefore, to make the occupation significantly more attractive. To achieve this, this plan aims to work on five action plans addressing the main issues in the occupation 1) Education and Qualification, 2) Personnel Management, Occupational Safety, and Health Promotion, 3) Innovative Care Approaches and Digitalization, 4) Nursing Staff from Abroad, 5) Remuneration Conditions in Nursing (Bundesministerium für Gesundheit, 2024b). Separately, the German state launched in 2020 the **Nursing Professions Reform Act** (In German: *Pflegeberufreformgesetz*) to make the profession more attractive and modern and to merge pediatric-, geriatric- and general nursing training into one. This act would facilitate and broaden nurses' occupancy conditions and perspectives, ease their professional transitions, and entitle nursing trainees to an allowance during their apprenticeship (Statistik der Bundesagentur für Arbeit, 2023). The development of these legislations has become an act of modernizing nursing education. This plan is meant to provide trainees, trainers, and nurses in occupation with better innovative equipment and the opportunity for more practical experiences during education (BMFSFJ, 2024). Consequently, there are several challenges to the educational and healthcare givers institutions with implementing new acts. There is a need to adapt educational curricula, educators' approach, and employer capacity and distribution of tasks, responsibilities, wages, etc. (Aktuelle Sozialpolitik, 2023). However, digital means might face resistance and institutional adaptation, e.g., infrastructure constraints and budget limitations. Nevertheless, their inclusion is meant to lighten the development of the nursing profession, especially in the educational domain.

11.5 DIGITALIZATION OF GERMAN HEALTHCARE SETTINGS

Digitization and digitalization from clinical services are significant factors in developing robust and appealing nursing careers in Germany. Digitization refers to converting or transcribing data from a non-digital to a digital format, and digitalization refers to using digital solutions to improve and modernize (analog) services and systems (Gobble, 2018; Sabbagh et al., 2012). The digital environment within the German healthcare sector still has considerable room for growth and development. Research conducted in the country revealed how the hospitals have, on average, 33 out of 100 points of digital maturity (Digital Radar, 2021). Other findings suggest that German hospitals digitally perform to a similar level as peer hospitals in the United States of America, Australia, and Canada in certain domains (HIMSS, 2023). Continuously, the initiative impelled by the KAP and its 3rd action plan suggests the use of digital health technologies (DHT), such as telemedicine, telecounseling, and any innovative application, will allow nurses to reduce their physical and psychological burden in their working hours (Bundesministerium für Gesundheit, 2018). The Federal Ministry of Health has launched a Digital Strategy to improve further functioning of German healthcare institutions. This aims to use digital tools to make a patient-centered system, improve the quality of care, and augment the services' cost-efficiency (Bundesministerium für Gesundheit, 2023). Consequentially, nurses witnessing consistent and overarching DHT implementation action plans will eventually result in general trust, empowerment, and acceptance of digital tools (Conte et al., 2023; Huryk, 2010). Thus, achieving trust in the technologies and their benefits, providing proper communication and training to use these technologies, and adapting to existing models will encourage using innovative tools in practice (OECD, 2020). Nevertheless, the proper acquisition of new technologies could, in some cases, be successfully achieved with a proper and long-term implementation plan. Interestingly, some findings from HCPs in Brandenburg revealed the acceptance of new technologies in the healthcare field shows that individuals' emotions and perception towards this technology will influence their level of acceptance. For instance, concerns from HCPs, such as loss of professional autonomy while treating or diagnosing patients or feeling professionally controlled through eHealth apps, generate negative feelings. This can result in the reluctance or not acceptance of the triggering of such emotions (Safi et al., 2018).

11.6 DIGITAL HEALTH TECHNOLOGIES AND THEIR IMPACT ON NURSING EDUCATION

Digital health tools offer vast opportunities to increase adherence to education (F.-Q. Chen et al., 2020). In times of the recent pandemic, nursing trainees in different parts of the world were forced to interrupt their physical education due to curfews and social isolation (Hao et al., 2022). Although this represented a high-stress level for the actors involved, it highlighted the leverage of digital means to offer remote education in different fields. Despite its recent pick with the pandemic, digital learning has been used for decades as a training method (Button et al., 2014; D. Forman et al., 2002). Historically, digital means offer more accessibility and flexibility to access present and distant educational programs (Botelho, 2021). The leverage of digital tools that can be used remotely, such as IVR, AI, IoT, and cloud computing, brings remarkable benefits to healthcare institutions and the usage of their data (Kumar et al., 2021, S. 20). Artificial Intelligence, for instance, is considered a highly supportive tool in the medical field, by improving administrative and effectiveness of processes, and in the overall augment the quality of the patient's experiences and outcome (Dicuonzo et al., 2023). Specifically, in the educational field, AI has been used to integrate software, devices, human-instructors, and an independent teaching or leading unit. When used with human instructors, AI has effectively and efficiently supported processes of reviewing and grading students' tasks and terms (L. Chen et al., 2020). Besides, with AI utilizing Machine Learning and other features such as Deep Learning, teaching curricula can be customized to align with trainees' and students' requirements, with the whole purpose of improving learning outcomes (Jeong, 2020a; Shinde & Shah, 2018). Additionally, technologies such as Chat-GPT, an LLM based on AI, have been successfully demonstrated to support clinical decision-making and assist education in healthcare (Kung et al., 2023). This, combined with data visualization in a 3D context, such as the case of IVR, provides the user with an intuitive and natural sensation to approach the virtual input (El Beheiry et al., 2019). Besides, to fully take advantage of the digital experiences and, in some cases, with the data being processed while using it, it has been suggested that nurses' educational curricula be modified to integrate comprehensive and embracive subjects in the digital domain. For instance, it has been suggested that a detailed inclusion of AI subjects with its offshoots along the continuum of nursing education would increase their ability to leverage the data experienced in real clinical environments (Jeong, 2020b).

11.7 DIGITAL HEALTH TECHNOLOGIES AND THEIR CHALLENGES IN THE NURSING CAREER

The digital transformation in healthcare settings is often hampered by the numerous barriers caregivers perceive within this process. These could be faced simultaneously at technical, institutional, and organizational levels, unveiling the enormous necessity of these entities to encourage their functioning within a digital interoperable architecture (OECD, 2020). The actions to tackle possible hardships in the process of digital transformation require not only cross-sectional policy, legislative, and organizational approaches but also tailored and timely support and digital health literacy for the nursing and the totality of the healthcare staff (Nes et al., 2021). Besides, natural human resistance might rise with arriving unknown mechanisms. Some of the human expressions when facing unknown events, in this case referring to digital health technologies, are a natural rejection of change, discontent or none-comprehension of the technology, technophobia, hesitation about hygiene, age, educational level, etc. (Borges do Nascimento et al., 2023; Moore et al., 2021).

When referring to the challenges on an overarching systemic level, the technical layer can take much time to become one of the first ones recognized since it involves the user's direct interaction with the technology. Often, the lack of awareness or technician skills and immaturity of the technology that reduces users' trust would be predominant vulnerabilities that jeopardize the expedited usage of the devices (K et al., 2023; Kouhizadeh et al., 2021). On the level of institutional challenges, the provision of training, institutional cost-effectiveness management, and adequate infrastructure, e.g., Wi-Fi, Smart Devices, Room availability, etc., will also impact the chances of successful outcomes using the technologies (Tarricone et al., 2017). Lastly, the organizational level challenges include, among others, robust interoperability systems. This will include the secure exchange of information and communication between different participants in a healthcare ecosystem (Reisman, 2017). This way, the different stakeholders in these healthcare ecosystems will be able to comprehend each other's languages, increasing their capacity to react to adversity and improve the use of their data (Iroju et al., 2013). Besides, data protection, software and platform compatibility, and transparency in the usage and exchange of data will play a fundamental role in the effective and successful implementation of DHT in medical facilities (Shrivastava et al., 2021).

11.8 ETHICAL AND INCLUSIVITY CHALLENGES OF USING IVR AS A TEACHING TOOL

Using VR devices raises ethical considerations beyond the ones learned in regular nursing education, e.g., good patient care, compassion, respect, dignity, etc. (Haddad & Geiger, 2024). Training with VR devices has many purposes, such as reliving a real event scenario in a virtual world. Consequently, scrutiny should be held towards its usage in education, considering that VR experiences could highly resemble real analog experiences (Ramirez & LaBarge, 2018). In the context of a virtual surgical training system that closely mimics reality, it is important to establish clear ethical guidelines for students to distinguish between the simulation and the actual clinical environment. This will enable students to make informed decisions and avoid confusion between the two settings. Besides, there are existing gaps in the ethical preparation and content definition of software, such as blood and violence contained in these (Kenwright, 2018).

Finally, VR technologies offer great opportunities to address gender and sexual minority group inclusion. The usage of VR devices might serve as a powerful tool to raise awareness, sensitivity, and comprehension for the LGBTQI+ (lesbian, gay, bisexual, transgender, queer, intersexual, plus others) community (Hannans, 2023). In a specific setting, it has been experienced that nursing education being taught and familiarized about transgenderism and the transgender with VR training has made about 86% of the participants sympathize with this community to create safe spaces in healthcare settings (García-Acosta et al., 2024). Further research would be necessary to assess the inclusion of this or any other individual from the LGBTQI+ group in their inclusion to general or specific medical settings, e.g., gender affirmation virtual surgery (Stanton et al., 2023). Additionally, an underrepresentation of female participants and authors has been reported regarding the usage of VR technologies (Peck et al., 2020). An extensive exploration of this domain is necessary to guarantee users an inclusive virtual environment and ensure that the learning outcome will promote minority groups' inclusion.

12 METHODS

The use of VR devices in healthcare and nursing education in previous settings provides valuable evidence of their potential and acceptance in the field. Consequently, this research evaluates the technology as a training tool in German nursing schools, employing quantitative and qualitative research designs, which are thoroughly described in this section. Additionally, the research questions and objectives designed to support the outcomes of this study are outlined below. This research uses the iterative term intervention or activity to refer to the workshop where VR devices were presented as training tools.

12.1 RESEARCH QUESTION AND OBJECTIVES

Primary Research Question: What factors influence the acceptance of VR devices as training tools in German nursing education?

Primary Objective: Evaluate the acceptance of VR devices among users as training tools in nursing education after introducing them to the technology.

Secondary Research Question: Which potentials and drawbacks do users perceive when implementing VR devices as a training tool?

Secondary Objective: Explore the potentials experienced by users after being introduced to VR as a teaching tool in German nursing schools.

12.2 Context and Settings

This research study was conducted as part of the project "*Virtual Reality in der Pflege*" (Virtual Reality in Nursing Care) from the firm Digital Health Transformation (dht) e.G. to perform a first evaluation of the effects and potentials of VR devices as a training tool in German nursing schools. To do so, 6 nursing educational departments (ED) related to hospital facilities in Germany were invited to be part of this investigation to experience a 2-hour workshop with VR HMD with a following survey as part of the data collection. The Project *Virtual Reality in der Pflege* aims to develop a nursing educational concept where VR devices can be integrated to support training and continuous education. The dht e.G. project aims to increase the satisfaction of nurse teachers and learners, reduce drop-off rates, and increase the number of applicants to nursing education. The implementation of VR devices within the project, the ongoing collection of impressions and experiences in this process, and the data analysis will result in scientific evidence that will ultimately determine whether VR devices and embedded technology shall be permanently included in German nursing education. This is an ongoing project where further developments will be informed through the communicational channels of dht e.G.

12.3 Center Selection

As part of the project Virtual *Reality in der Pflege,* the members of the cooperative to which dht e.G. brings services of digitalization should internally select the nursing educational departments where the intervention of the study will take place. The educational department to be selected needed to count with an active nursing education curriculum, in which there would be an eventual chance to implement VR devices as training tools, count with a minimal level of participants related to nursing education who would engage in the activity. It should be able to provide infrastructure facilities for the activity, such as a physical room adapted to the season conditions (e.g., heating for winter), sufficient space for the subscribed participants, internet connection, beamer, chairs, and desks or working tables. The nursing educational centers to to receive the intervention and evaluation were located in the following regions: *Saarbrücken, Wiesbaden, Koblenz, Bensberg, München and Münster*. Additionally, every member of the cooperative would assign a contact person who would be in regular communication with the organizational team of dht e.G., (project manager and eventually working student), and on the other end, with the participants who would be part of the study. For privacy and data protection reasons, the names of the institutions are not uncovered in this research.

12.4 Participants (Inclusion and Exclusion Criteria)

The eligible participants of this study were all individuals involved in domains of nursing education in the selected educational centers. The inclusion criteria were to be directly or indirectly related to nursing education. To those counted, nursing learners and teachers (regardless of whether the latter had nurse as a profession), nurses in clinical practice, educational coordinators, IT staff working in nursing education, digital health technologies hospital responsible, and quality control nursing educational staff. Moreover, the participant should be older than 18 years old, belong to any binary or non-binary gender identification, and have self-recognition of physical and psychological capacity to test the IVR devices during the workshop. Any factor different than the previously mentioned counts as exclusion criteria.

Seventy-four participants were recruited through the organizer's contact person, adhering to previous inclusion/exclusion criteria 1 month before the activity via person-to-person invitations in staff meetings and lectures. Participants were informed that the activity of this study would not interfere with their regular working and educational activities and would have no effect on studies or work outcomes. After participants confirmed their assistance in following meetings and lectures, they were confirmed and accounted for the upcoming workshops introducing VR devices as a training tool.

12.5 Workshops Description

To introduce the VR devices to the participants, a 2-hour workshop was organized by the dht e.G. team, the technology provider (VIREED), and the educational departments in the nursing educational centers and conducted for all participants. Table 2 gives an overview of the time and activities divided in four parts.

TABLE 2 WORKSHOP SCHEDULE

Total Duration		**Activity**	**Responsible**
2 Hours	10 Minutes	Welcome & Introduction	Nursing School & dht e.G.
	90 Minutes	Introduction to the technology & Testing	VIREED
	5 Minutes	Discussion	VIREED & dht e.G.
	15 Minutes	Survey evaluation & Closing	dht e.G. & Nursing School

The groups should not exceed 10 participants in each cohort. Furthermore, the ED would provide the necessary infrastructure, whereas dht, e.G., and VIREED, would facilitate the content and practical testing. The first 10 minutes included welcoming all participants by the nursing school contact person and the project manager of dht e.G. The former explained the presence of all organizer parties, whereas the latter would briefly introduce the company's approach as a digital health solutions-oriented entity. The second part of the workshop was conducted by technology provider VIREED. This, with an estimated time of duration of 90 minutes, would consist of an introduction to all participants together to describe the HDM piece, the interaction with the haptics, show the software and its interface, and show how the rest of the group could co-observe the experience of the one testing the device through the image being transmitted through the beamer. At this point, the providers present to the general audience the two clinical scenarios embedded in the software: the first scenario, basic life support (Figure 1), and the second scenario, the operation room in an emergency department (Figure 2).

FIGURE 1 BASIC LIFE SUPPORT VR SCENARIO (PICTURE WITH PERSMISSION)

FIGURE 2 OPERATING ROOM IN AN EMERGENCY DEPARTMENT'S VR SCENARIO (PICTURE WITH PERMISSION)

After the participants receive instructions and directions on how to approach the technology and the respective virtual scenarios, they will voluntarily and with no particular order be offered to test the technology by themselves. To this point, personalized instructions would be given on how to mount the HMD in the users' heads and how they should grasp the haptic joysticks. Upon completing those stages, the instructor will verbally lead the participants on how to start the virtual testing. Meaning which settings in the virtual world to choose from and how to displace themselves (or not) in the virtual and non-virtual world while trying the HDM and using the haptics. Once the participants have acquainted themselves with the interface, they get detailed instructions on selecting the first scenario to undertake the practice. Once the scenario is selected and entered, a virtual evaluation dashboard is displayed before starting the simulation, where the users can visualize their scores and advanced and missing stages in the simulation. Upon visualization of the dashboard, the simulation begins. Once in the simulation, the software recognizes whether the tasks were accomplished. In case the tasks were not completed, e.g., the patient was not correctly identified, or an action such as auscultation was not performed properly, the software would show the tasks dashboard again, with a red dot next to the uncomplete task description and show an interface that allows the user to repeat the tasks. The dashboard will be displayed again if the participants complete the tasks successfully. Still, with a green dot next to the complete task description, an interface will be displayed that allows the user to do the following task. This sequence would be repeated until all the tasks in the first scenario were completed, and the participants would be guided to find the interface to enter the second scenario. Modality in the second scenario follows the same procedures as in the first. For instance, the first scenario (Figure 1), presents a patient in a critical clinical state in a hospital room who appears to be experiencing some heart failure condition. Besides completing tasks, the participants can also explore the virtual environment by virtually moving using their haptics or intending a conversation with the patient's relatives. In that scenario, the patient seemed to be in a detrimental physical and general health state, and a female avatar stood next to the patient, showing unpleasant body language. The relative does not communicate back. The operation room of the emergency department scenario (Figure 2) shows a patient lying on the stretcher and shaking in an abnormal pattern. For instance, the user should feel the pulse in the wrist using the haptic joysticks. Moreover, considering that there was solely one VR set (haptics, VR monitor, VR source of energy, and HMD), only one participant at the time could try the device. Each participant would spend between 5 – 10 minutes testing the device, depending on the group size and the user's affinity to the technology. Upon competition of this stage, a final 5-minute discussion to get feedback on the general state of the participants took place. However, this feedback would not be considered in the analysis of this paper. Lastly, in this 15-minute stage, a brief closing message was given by the dht e.G., project manager, with a following evaluation through a survey.

FIGURE 3 WORKSHOP PARTICIPANT TESTING THE VR-SET AND INSTRUCTOR (PICTURE WITH PERMISSION)

12.6 SUITABLE TECHNOLOGY SELECTION

The relevance of selecting a partner is related to the capacity and reliability that the VR set can bring to this initial stage of introducing it to potential users and a future larger scale of implementation. Besides, the provider's capacity and deployment should adhere to the expected standards when finding a digital education tool. The technology should be able to fulfill the technological needs of the educational process. This would mean state-of-the-art equipment and software with scalable interfaces and the capacity to provide realistic and up-to-date virtual scenarios. Besides, other technological accessories that could increase the training experience, such as external monitors or haptic joystick, would positively impact the selection. Another meaningful factor to include a provider is their expertise and experience in previous similar clinical and educational settings. Thus, empirical evidence of their results and learnings portrays their potential capabilities in the domain. Lastly, the provider should be able to maintain a reliable and sustainable partnership to provide services using VR technologies. These aspects include having robust infrastructure, flexibility, and availability to grant their services, e.g., travel disposition or technical assistance. Besides, the capacity to expand and adapt virtual scenarios also plays a positive role in the selection, especially considering the diversity of the nursing students and teachers' population and the vast possibilities of virtual simulation to leverage.

12.7 DATA COLLECTION

The primary data collection of the participants (74) was obtained through a digital 25-item survey. This was offered principally in a digital format for the participants to find through their mobile smart devices. However, analog versions were also offered in case somebody did not have a smart device or would prefer that version over the digital one. The digital version of the survey was designed, obtained, and provided through Google's cost-free software "Forms". The workshops and data collection were conducted continuously on the same day. Each activity day occurred on different dates in each nursing educational center from October to December 2023. The first six items of the survey addressed this domain to collect demographic information from the participants. These were multiple-choice items, and subjects could only select one answer. The digital survey's setting only permitted one answer per item, and the subjects who took the analog survey were informed of this verbally. To capture the participants' impression in the adapted TAM variables, questions of the adapted TAM have been customized to the objectives and technologies studied in this research, considering the essence of the variables. To do so, each variable has a set of items or a single item. The answer could be answered in an interval 7-point Likert scale from strongly disagree (-3), disagree (-2), somewhat disagree (-1), neither agree nor disagree (0), somewhat agree (+1), agree (+2) and strongly agree (+3). The items, including the variables of the adapted TAM and the demographics items, will conform to the quantitative analysis of this research to eventually answer the primary research question. Including a 7-point Likert scale gives the participants a broader range of answers, which can reveal different nuances in their impressions. Besides, including a level of "neither agree nor disagree" prevents the force choice bias from occurring. However, reporting answers or impressions with the Likert scale brings other biases, such as central tendency or acquiescence. These refer to avoiding extreme response categories and the desire to satisfy the researcher instead of showing the real opinion of the participants. However, a 7-point Likert scale is the evaluation length to show some of the highest reliability levels, more accuracy and distinction in the participants' impressions (Taherdoost, 2019). In the case of the open-ended questions, the participants could either digitally type in or analog write in limitless characters, but with the suggestion of writing the answers in bullet points. Once the participants had given their answers, a worksheet with both quantitative and qualitative answers was extracted from both digital platforms. In the case of the analog answer, the researcher transcribed these manually and proved them in a second instance. The data was saved in a company computer secured with an individual and private password.

12.8 QUANTITATIVE ANALYSIS

12.8.1 THEORETICAL FRAMEWORK – TECHNOLOGY ACCEPTANCE MODEL (TAM)

An adapted TAM has been used to assess the impact of VR devices as training tools in German nursing education. Davis initially proposed this model, suggesting that Perceived Usefulness (PU) and Perceived Ease of Use (PEU) would influence the *Attitude* toward a technology, which would directly influence the Actual System Use. To reach that point, Davis based his model on the Theory of Reasoned Action (Dillard & Pfau, 2002). Besides, PEU was hypothesized to influence the PU, (Davis, 1989) as shown in Figure 4. The original variables of the theoretical model are described as follows (Karahanna & Straub, 1999; Venkatesh & Davis, 1996):

- PU = Degree to which an individual believes using a system would enhance performance. Grounded in the theory of motivation, this concept suggests that an individual is more inclined to embrace new technology if they believe the activity will aid in attaining desirable outcomes.
- PEU = It describes an individual's belief that using a particular system would be easy and effortless. Besides, the concept of PEU has also been hypothesized with self-efficacy in the use of technology.
- Attitude toward technology = A Set of favorable or unfavorable feelings, beliefs, and behavioral tendencies that individuals or groups hold regarding technology. It is an individual's negative or positive perception of the consequences of integrating technology.

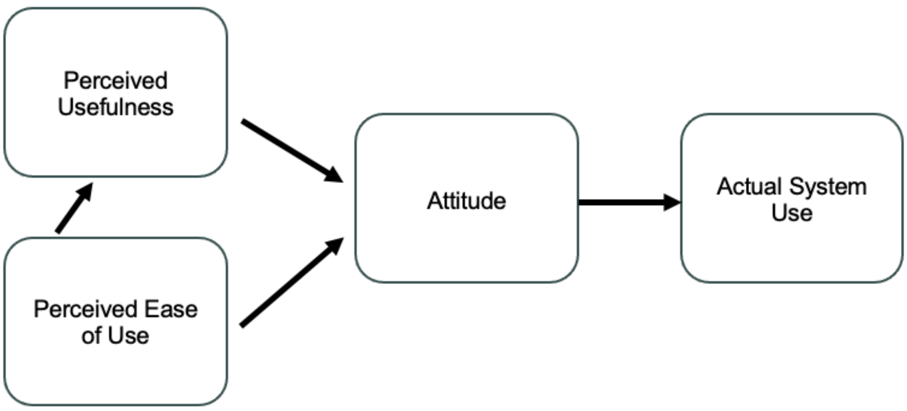

FIGURE 4 ORIGINAL TECHNOLOGY ACCEPTANCE MODEL INTERACTIONS (DAVIS, 1989)

However, PEU and PU are indicated as the strongest direct independent variables (IVs), which leads to the exclusion of the attitude toward the technology when statistically testing the model for not having a significant direct role in determining the actual use of the technology. Besides, the actual use of the technology can be more likely predicted by evaluation as a first outcome of the participants' intention to use the technology. This led to an evolution of the original model to one where the main outcome to measure was the intention of use, influenced directly by the PU, PEU, and their interaction. Figure 5 gives an overview of the updated model. This is an updated version (Venkatesh & Davis, 1996).

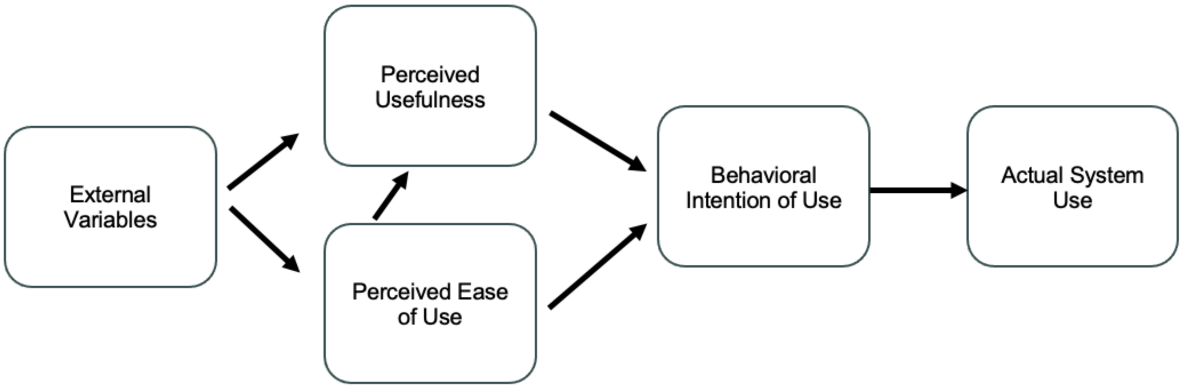

FIGURE 5 UPDATED TECHNOLOGY ACCEPTANCE MODEL (VENKATESH & DAVIS, 1996)

With further updates of the theoretical model, an adapted TAM by Chau and Hu's model was designed with three dimensions: technological context, individual context, and organizational context. The individual context is composed of the variables' *attitude* and *compatibility* (Chau & Hu, 2002). The dimension of technological context is composed of the variables PEU, PU (Davis, 1989), and Habit (B. Gardner et al., 2012). The organizational context includes variables such as *Subjective norms* and *Facilitators* (Gagnon et al., 2012a; Peters & Templin, 2010). The variables of the adapted theoretical model are described as follows (Paiman & Fauzi, 2023; Peters & Templin, 2010; Rogers, 1983):

- Compatibility: It is defined as the congruence between existing and new values and experiences. It is the extent to which an innovation aligns with the current values, requirements, and previous experiences of prospective users.
- Habit: The latter is meant to make automatic responses to certain behaviors. In other words, habit is automatic behavior triggered by specific situational cues.
- Subjective norm: It refers to the approval of relevant peers regarding adopting the technology. It is associated with an individual's social expectations to adhere to a new technology. This combines one's motivations and beliefs with those others perceive.

- Facilitator: It refers to an individual's belief that the organization can provide the technical infrastructure for implementing technology.

Chau and Hu’s adapted TAM model was selected for this research. The three dimensions proposed by Chau and Hu’s model are hypothesized to impact the technology's *Intention to Use*. The theoretical model also suggests the interaction between variables in the different domains. This research will not hypothesize about that different interaction. However, the model has been tested with other DVs that are different from the intention of use to exemplify the flexibility of the model and the further options that need to be considered for eventual implementations of VR devices as training tools. Figure 6 describes the adapted TAM implemented in this research.

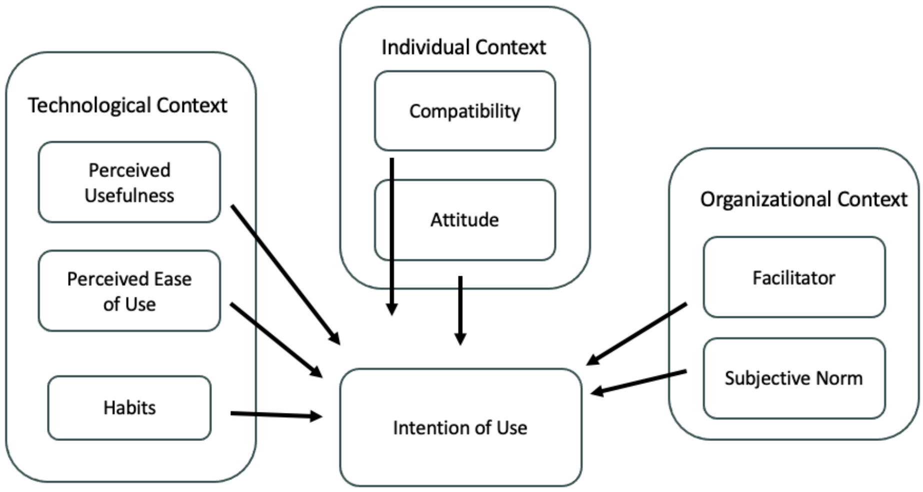

FIGURE 6 ADAPTED TECHNOLOGY ACCEPTANCE MODEL (GAGNON ET AL., 2012B)

12.8.2 QUESTIONNAIRE / SURVEY

Data to address the research questions of this investigation are collected through a 25-item questionnaire that includes 6 items addressing the demographic characteristics of the participants,14 items addressing questions based on an adapted version of the TAM, and five items with open-ended questions. The design of the first 20 Items and the inputs that participants give to these are meant to address the primary research question. The five open-ended items and the inputs participants give to these are meant to address the secondary research question. Appendix 1 entails the entire survey. The questionnaire was sent previously to the intervention to the person responsible for the participants in the different groups, nurses and medical doctors as directors, to be tested. However, not every person responsible for the questionnaire on the different educational facilities gave feedback before the intervention. A reliability test, Cronbach alpha value, was conducted to determine the internal consistency of the survey's multi-items for the variables of the adapted TAM (PEU, PU, and Habit). The reliability of single items shall be tested with a different methodology, such as a reliability re-test with the same participants, taking the survey a second time within a certain time lapse (e.g., 2 weeks in between collection) of difference in the measure (Yohannes et al., 2011). Nevertheless, time and infrastructure constraints would not make this possible in this research. Additionally, a non-parametric correlation Spearman test was run to test the correlation of all survey items with the participants' answers as in the interval Likert scale.

12.8.3 Demographic Items:

To demographically portray the participants' characteristics to eventually understand the target group in the study profoundly and to potentially elucidate whether demographic variables play a role as a factor influencing the intention to use VR devices. The following demographic items have been included in the survey. *Gender* selection is counted as female, male, and diverse options. The *age* included options for those younger than 18, 18 -30, 31 – 40, 41 – 50, 51 – 60, and older than 61. *Years of Clinical Experience* included the options less than 1, 1 – 5, 5 – 10, and more than 10. *Clinical Occupation* included the options of Nurses, Medical doctors, Hospital Administrative Department, Educational department staff, and others. *Highest Educational Degree* included the options High School Degree, Vocational Degree, University Degree and Doctoral Degree. *Role in the education* included the options nursing teachers, nursing learners, no role in the education, or others the options others in the item Clinical Occupation and *Role in the Education* were intended to include staff that indirectly had a relation with the nursing educational department, and that could be involved directly or indirectly in the possible acquisition and/or implementation of the technology in the department (e.g., IT department employees and quality control employees of the hospital). To the range of age and gender items, there were options for younger than 18 years old and diverse genders, respectively. However, since zero participants identified themselves with these options, they were removed and excluded from further analysis.

12.8.4 Statistical methodology

The data was statistically analyzed using the IBM SPSS Statistics, Version 29.0.0.0 (241), provided by the Hamburg University of Applied Sciences. A descriptive analysis using this software was conducted using the demographic information submitted by the participants. A logistic regression was conducted to test the adapted TAM, obtaining odds ratios (ORs), 95% confidence intervals (CI), standard deviation (SD), and p values for the significance test with a threshold of 0.05. This model, through ORs, allows for statistically predicted outcomes of the interaction of intention of use of VR devices as training tools in German nursing schools with the different variables. This type of analysis requires a binary outcome value. The intention of use (dependent variable) was converted into a binary value (nominal value). Because of the group's composition and the research study, which solely had groups who took part in the intervention (no control group), the outcome was measured at two levels to identify nuances in the outcome given by the participants. The first level considered participants' intention to use VR devices and answered somewhat agree, agree, and strongly agree (In the 7-point Likert scale, 5/7, 6/7, 7/7). In contrast, the second level considered only participants who answered strongly agree (on a 7-point Likert scale 7/7). In the binary value for the outcome in the dependent variable (intention of use), for the level 1 (answers in the Likert-scale 5/7, 6/7, 7/7) and the level 2 (answers in the Likert-scale scale 7/7) were assigned a number 1, and answers not belonging to these groups were assigned a 0 for the measure in each level. Demographic variables were transformed into dummy codes to be included in the logistic regression. The outcome of the variables Gender, Clinical Occupation, and Role in the Education (all three nominals), and Age, Years of Experience, and Highest Educational Degree (all three ordinal ranks), each variable was independently grouped to be tested in the model, excluding the counter group of each variable to avoid collinearity. For instance, Clinical Occupation Nurses were dummy-coded and assigned the number 1, and all the other clinical occupations were grouped as 0 before including this category as an independent variable. Other combinations, such as Nurses and Medical Doctors, were grouped and dummy-coded as 1 to test the model further. An internal standardization of the independent variables with multi-items was conducted by reducing the multi-items into factors using SPSS. This is the case for PEU, PU, and Habits, becoming intervals, which will be included in the logistic regression to test the adapted TAM. The original TAM and the adapted TAM were tested with logistic regression to determine the dependent variables (DV) odds ratios (ORs) when testing it with the independent variables. In the first block, demographic variables were tested as independent variables to test them in the model to use them as dependent variables. The following variables of demographic data were tested with logistic regression in separate measures, each DV and each of the levels of the IV:

The intention is to use level 1 (DV) in relation to all the following IVs, and the intention to use level 2 (DV) in relation to all the following IVs:

- Gender (dummy-coded 1 and 0)
- Age: 18 to 30, and 31 to over 61-year-old
- Role in the education: Teachers and learners, no role and other role. For DV level 1, each variable in this domain was tested independently.
- Clinical occupation: nurses, and other than nurses
- Years of clinical experience: < 10, and > 10

- Educational level: high school and vocational education together, as well as university and doctoral education together. For DV variable level 2, each of the variables in this domain was tested independently.

The DV level 1 and 2 (separately) interaction was tested in the following block with the original TAM variables (PEU and PU). On another block, the independent variables of the adapted TAM (PEU, PU, attitude, compatibility, subjective norms, and facilitators) and the DV level 1 and 2 (separately) intention of use were tested with logistic regression. A Nagelkerke R Square value was calculated to test the model's fit. IVs with a single item were dummy-coded in level 1 of somewhat agree, agree, and strongly agree (answers on a Likert scale 5/7, 6/7, 7/7) and level 2 of strongly agree (answers on a Likert scale 7/7). The single-items dummy-coded were tested on each level separately from its counterpart, with the DV level 1 y 2 (separately).

12.9 QUALITATIVE ANALYSIS – SYSTEMATIC THEMATIC ANALYSIS

12.9.1 SYSTEMATIC THEMATIC ANALYSIS

An exploratory systematic thematic analysis was conducted on the answers given by the participants to explore their impressions after the intervention. This methodology aims to find answers to the secondary research question and meet the secondary objectives of this research. To do so, five open-ended questions were part of the 25-Items survey participants took after the workshops. Based on the different outcomes detailed in the literature addressing the usage of VR devices as training tools and the impact that this digital means might have on the users, this research seeks to discover, identify, and analyze the different perspectives that the usage of this technology represents for the users. The reasoning for the development of the questions is based on the objectives of this research, the framework of the theoretical background, and the underlying assumptions of nurses' findings of potentials and conflicts in the usage of new technologies after the first encounter with VR devices as training tools. Besides, including nursing educational staff from the very beginning in the process of adapting or designing a technology might grant the learners a deeper understanding of the technology and more clarity on identifying and addressing potential barriers that this might bring along (Babajani-Vafsi et al., 2019; Kent et al., 2015). The set of data was analyzed based on the six-phase thematic analysis proposed by Braun and Clarke, summarized in Table 3 (Braun & Clarke, 2006). The qualitative data collected from the participants has been grouped according to the five open-ended questions in Table 4. To reduce the risk of informing incomplete data and to increase the transparency and quality of the report, the checklist proposed in the Standards for Reporting Qualitative Research (SRQR) has been followed (Table 3) (O'Brien et al., 2014).

TABLE 3 SIX-PHASE THEMATIC ANALYSIS BY BRAUN AND CLARKE (BRAUN & CLARKE, 2006)

Phase	Description
1. Familiarizing yourself with your data	Transcription and (re)reading of the data
2. Generating initial codes	Codification of relevant and highlightable information from the data set
3. Searching for themes	Defining themes based on the different generated codes
4. Reviewing themes	Checking whether the themes are aligned with the generated codes
5. Defining and naming themes	Producing titles/names for the themes
6. Producing the report	Reporting the outcomes and the process of qualitative data analysis in a scholarly format

TABLE 4 SURVEY OPEN-ENDED QUESTIONS

1. What strengths do you see in the use of VR in the education and training of nursing staff compared to traditional learning methods? (in bullet points)
2. What weaknesses do you see in the use of VR in the education and training of nursing staff compared to traditional learning methods? (in bullet points)
3. What opportunities do you see in the use of VR in the education and training of nursing staff compared to traditional learning methods? (in bullet points)
4. What risks do you see in using VR in the training and education of nursing staff compared to traditional learning methods? (in keywords)
5. What additional clinical application areas/scenarios could VR supportively be used for? (in keywords)

12.9.2 RATIONALE

A thematic analysis methodology has been chosen to identify and analyze units contained in the data set semantically. Besides, this type of analysis enables the researcher to break down data into more detailed and specific pieces (codes and themes), facilitating a systematic description of the narrative in the data set (Vaismoradi et al., 2013). This research utilizes an inductive, exploratory approach. Thus, examining the inputs the participants gave does not follow any previous antecedent, and its generation of codes, themes, and interpretations stems solely from this research data set. An evidence-based approach such as the one implemented in this research will ultimately enable the research to uncover and discuss in depth the implications perceived by the users concerning VR devices as training tools for German nursing schools (Jack, 2006; Thomas, 2014, S. 200). Besides the nature of this investigation, considering the different domains that address, e.g., VR devices as a training tool and nursing schools in Germany, is relatively untapped, which is why an exploratory analysis is considered necessary to further unveil the nurses' appreciation in this domain after undertaking the intervention (Kalu, 2017).

12.9.3 Data Analysis

Following the six-phase thematic analysis previously mentioned, *familiarization of the data* is initiated by its extraction to digital working sheets of the digital platform where participants answered the survey or from the analog version for the subjects with no smart devices with them at the moment of evaluation. The data was transcribed verbatim. Following that, the data was translated from German to English to relate to the language of the article and facilitate prospective readers' comprehension of the data. On a free version, an online translator, DeepL, assisted the author in performing the human translation. Upon translation, answers were transcribed into a document to process. The answers at this stage were assigned to each corresponding question item to start the analysis. After five initial readings of the data, the second phase, the *Generation of Initial codes*, serves as the first stage, where meaningful comments and ideas become the codes that subsequentially will be linked to the themes. At this stage, resemblances in codes, their ideas, patterns, and narratives lead to the generation of themes in the following stages. After defining codes in the clean data set, *Searching for Themes* is the next phase in the processing of the data; this intends to re-read the data and the codes generated from this, collect it, and merge, eliminating or create new codes that describe systematically the outcome found in the data. The *Defining Themes* phase is the stage where the final Themes are generated from this systematic chain of analysis. However, this is described as an iterative process, where the constant (re)reading allows the constant adaption of the codes and themes. Finally, the phase of *Producing the report* creates a narrative and an interpretation of the units, codes, sub-themes, and themes found and described from the data.

12.9.4 Trustworthiness

To ensure the trustworthiness of this qualitative outcome's systematic thematic analysis and report, it is necessary to prove its credibility, transferability, dependability, and confirmability (Lincoln & Guba, 1985; Nowell et al., 2017). *Credibility* has been suggested that the confirmation of readers or coresearcher to the investigated experience can relate to it. It is also described as the fit of what the researcher has portrayed from participants' impressions to what they wrote. This can be assessed, for instance, by reading the thematic analysis by the participants. Due to time and resource constraints, this investigation did not take this measure, but it is highly recommended for similar future studies. *Transferability* addresses the extent to which the findings from this study can inform understanding and practices in similar contexts. By providing a rich, detailed description of the research setting, participant demographics, and the VR interventions used, the study allows other researchers and practitioners to evaluate the applicability of its insights to their contexts. This detailed contextualization ensures that the study's contributions to knowledge about VR in education can extend beyond the immediate research setting (Lincoln & Guba, 1985). This research complies with these criteria by describing the steps taken from the initial to the final point in the investigation. *Dependability* refers to the stability of data over time and under different conditions. In thematic analysis, this is ensured through a transparent, well-documented research process that allows this to be controlled by the readers or other researchers (Tobin & Begley, 2004). *Confirmability* refers to the establishment that the results described by the research are undiscussable extracted from the data. To do so, a clear description of the process followed during the investigation needs to be findable and understandable in the final report. Other evidence recommends stating the reason for choosing theoretical, analytical, and methodological choices as a way of transparent and endorsing the full process (T. Koch, 1994).

12.9.5 Ethical aspects

Collecting primary data from human subjects requires addressing and implementing ethical aspects of the study. Thus, the guidelines on the Declaration of Helsinki were followed, and a consultation and self-conducted test of the ethical committee of the HAW - Hamburg was conducted. The participants verbally agreed to participate in the research after being informed about the activity twice. First, when they were first invited to the workshops by the contact person in the educational department, and second, on the day of the activity. Since the participants signed no written consent regarding their participation in workshops and data collection, this research article will delete participants' data after 6 months of collection. For the same reason, this research will not pursue peer-reviewed publications before clarifying this aspect to an ethics committee. Additionally, digital written informed consent was provided at the introduction of the digital survey, with defined and understandable information about the usage of the data, the right to withdraw at any time with no sanctions, and the contact person in charge of the data in case of any question or inquiry (Please see Appendix 1). To this point, participants could choose their data not to be used. Participants' data, which was denied being used, was not included in any analysis. The data of the participants who were included was defined as anonymized data. There was no possible reverse methodology that, with the participants' answers, could lead to the individuals' identification. Some factors that contribute to this are the age options given in ranges (e.g., 18 – 30) and the years of experience also in ranges (e.g., 1 – 5). Regarding the consultation with the committee of ethics of the HAW –

Hamburg, no ethical approval was provided considering the time constraints that the solicitude had. Although this was sent before the empirical data collection was initiated, it did not comply with the committee's requirements; therefore, no process with them could be started. However, the ethical committee of the HAW–Hamburg offers a self-conducted ethical questionnaire, which provides a detailed orientation on whether ethical approval should or should not be necessary. Furthermore, the auto-evaluation showed that the context, settings, data collection, and interaction with the participants would not require a committee's ethical approval. However, since this is self-implemented, validating this outcome would be necessary.

13 RESULTS

13.1 QUANTITATIVE ANALYSIS

13.1.1 DESCRIPTIVE STATISTICS IN DEMOGRAPHICS

Of the 74 participants who participated in the intervention, only data from 60 (n) were used, considering the answer of their informed consent on data usage and protection. The group was 86,7 % (52) females and 13,3 % (8) males. More than half of the participants were between 18 and 40 years old, and more than half reported having had more than 10 years of experience. Regarding the educational degree, 45 % had high school and vocational degrees. Meanwhile, the rest reported having a university or Ph.D. degree, with three participants in the latter. Most participants reported that they belonged to a clinical or educational nursing department. Table 5 shows the demographic information of the participants.

TABLE 5 DEMOGRAPHIC CHARACTERISTICS OF THE PARTICIPANTS

		Total n = 60	
		n	**%**
Gender	Female	52	86.7
	Male	8	13.3
Age	18 -30	17	28
	31 -40	18	30
	41 -50	12	20
	51 -60	11	18.3
	> 61	2	3.3
Years of Experience	< 1	3	5
	1 - 5	11	18.3
	6 - 10	15	25

	> 10	31	51.7
Higher Educational Degree	High School	4	6.7
	Vocational	23	38.3
	University	30	50
	Doctoral	3	5
Clinical Department	Learners	5	8.3
	Teachers	45	75
	No Role	2	3.3
	Other Role	8	13.3
Clinical Occupation	Nurse	34	56.7
	Medical Doctor	1	1.7
	Hospital Manager	2	3.3
	Education	22	36.7
	Others	1	1.7

13.1.2 Descriptive Statistics – Adapted TAM

Table 7 describes the participant's answers (n = 60) to the closed item of the survey. When considering the answers somewhat agree, agree, or strongly agree, 88 % had the intention of use, whereas 63 % strongly agreed with the intention of use. In the case of PEU, PU, and attitude, 95 % somewhat agreed, agreed, or strongly agreed, versus 53 %, 57 %, and 73 %, respectively, who strongly agreed. Simultaneously, more than half of the participants somewhat agreed, agreed, or strongly agreed with the category's facilitator, habit, compatibility, and subjective norm, whereas 33 %, 37 %, 41 and 37 %, respectively, strongly agreed. The reliability Cronbach alpha value outcomes for multi-items show that PEU and PEU have internal consistency (Cronbach > 0.8). In contrast, Habit does not show internal consistency (Cronbach < 0.8), which is why the answers to the items of this category in the survey will not be included in further analysis. Additionally, the non-parametric Spearman test results showed no significant correlation between the items addressing the category Habit. The variable Habit will not be included in further analysis. The remaining variables are weak to moderate or moderate to strong in correlation to the intention of use. Table 6 summarizes the participants' answers for each category with their means, standard deviation (SD), and their correlation with the dependent variable Intention of Use.

TABLE 6 DESCRIPTIVE ANALYSIS OF THE VARIABLES OF THE MODEL

	IU	PEU	PU	ATT	FAC	HAB	COM	SN
Mean	6.15	6.06	5.9	6.4	5.3	3.4	5.7	5.5
S.D.	1.56	1.15	1.25	1.25	1.83	1.62	1.48	1.55
Correlation with IU	1.0	0.39	0.62	0.36	0.34	0.10*	0.45	0.61

S.D.= Standard Deviation, IU = Intention of use, PEU = Perceived Ease of Use, PU = Perceived usefulness ATT = Attitude, FAC = Facilitator, HAB = Habit, COM = Compatibility, SN = Subjective Norm

(*) = nonsignificant correlation; p-value non < 0,05

TABLE 7 DESCRIPTIVE STATISTICS FROM THE ADAPTED TECHNOLOGY ACCEPTANCE MODEL (TAM)

Variables of the adapted TAM	**Variable Description**	Answers Level 1	Answers Level 2
		n (%)	**n (%)**
Intention of Use	I have the intention to use VR devices as a training tool when it becomes available	53 (88)	38 (63)
PEU	I think that I could easily learn how to use VR devices	57 (95)	32 (53)
PU	The use of VR devices would be useful as a training tool	57 (95)	34 (57)
Attitude	I think it will be positive to adopt VR devices as training tool	57 (95)	44 (73)
Facilitator	I think that my center has the necessary infrastructure to support my use of VR devices	43 (71)	20 (33)
Habit	I feel comfortable with digital tools and VR devices	40 (67)	22 (37)
Compatibility	The use of VR devices will be adaptable to the current classic	46 (78.7)	25 (41)

	learning methods and will improve them		
Subjective Norm	The colleagues will adopt VR devices when it becomes available	43 (71)	22 (37)
Intention of Use	I have the intention to use VR devices as a training tool when it becomes available	53 (88)	38 (63)

13.1.3 Logistic Regression and demographics

To test the theoretical model's fit, a Nagelkerke R Square value has been obtained for the different combinations of levels of agreement in the survey. When testing the intention to use levels 1 and 2 separately, with the demographic's inputs, both cases show a 16 % and 18% explanation of the variation in the outcome variable, respectively. Upon inclusion of the demographic variables and the intention of use in the logistic regression, the interaction between the intention of use level 1 showed significant results in the Role in the education (Teachers and Learners ORs: 7.5 with 95 % CI: 1.05 – 53,7, p-value: 0.044 versus Other or no Role in the education ORs: 0.13, 95 % CI: 0.01 – 0.94, p-value: 0.044). Additionally, there were no significant results in the interaction of intention of use level 1 when the variables teachers, learners, other, or no role were independently tested. To this, when the demographic variables were tested interacting with the intention of use level 2, it showed significant results to the educational level (University or doctoral degree. ORs: 0.16, p-value: 0.018, 95 % CI: 0.03 – 0.73 and high school and vocational level ORs 6.87, p-value: 0.015, 95 % CI: 1.3 – 27.4). Table 8 summarizes these findings. There was no significant result when testing the interaction of the highest degree of education variables independently with the intention of use.

Table 8 Logistic Regression Results with Demographics Inputs

	Intention of use Level 1	Intention of use Level 2
	ORs (95 % CI)	ORs (95 % CI)
Gender (dummy-coded)	0.25	0.40
Age 18 – 30	0.91	1.039
Age 31 - > 61	1.09	0.96
Role in the education (Teacher and Learners)	**7.54 (1.059 – 53.74)***	3.5

Role in the education (Other role and no role)	**0,13 (0,019 – 0,94)***	0.27
Years of clinical experience > 10	0.92	1.65
Years of clinical experience < 10	1.07	0.60
Occupation: Nurse	0.56	0.58
Occupation: Other than nurse	1.7	1.7
Highest educational degree: High School and Vocational	2.1	**5.9 (1.3 -26.3)***
Highest educational degree: University and doctoral	0.45	**0.16 (0.038 – 0.755)***

Significant, p-value < 0,05 = *

CI = Confidence interval (only given for significant values), OR: Odds Ratio.

13.1.4 Logistic Regression and original and adapted TAM

The interaction results of DV levels 1 and 2 and the original TAM are described in Table 9. The original TAM was shown to be good at predicting the intention of use of VR devices as a training tool, showing a model's fit of 42 % (Nagelkerke R Square: 0.42). The results of the interaction between DV level 1 and level 2 (separately) with the original TAM (attitude level 1 and 2 tested separately in each case) showed significant results in DV level 2 for the PU (ORs: 4,1, 95 % CI: 1,5 – 11,15, p-value: 0,006). To further test the interaction of these variables, the PU was transformed into a binary variable and tested as the dependent variable with the original TAM. Hence, the results show significant results for PEU and intention of use (OR: 7.0, p-value: 0.02, 95 % CI: 1.3 – 37.1 and OR: 7.7, p-value: 0.007, 95 % CI: 1.7 – 34 -1, respectively). Table 10 summarizes these findings.

Table 9 Results of the Logistic Regression: original Technology Acceptance Model (TAM)

Original TAM (Nagelkerke R Square: 0.42)	Intention of use Level 1 (OR | 95 % CI)	Intention of use Level 2 (OR | 95 % CI)
PU	6.4	**4.1 | 1,5 – 11.15***
PEU	2.9	1.6

Significant, p-value < 0,05 = *

CI = Confidence interval (only given for significant values), OR: Odds Ratio.

TABLE 10 EXTENDED TESTING OF THE ORIGINAL TECHNOLOGY ACCEPTANCE MODEL (TAM)

	PU binary (Level 2) (OR | 95 % CI)
Intention of use level 2	**7.7 | 1.7 – 34.1***
PEU	**7.0 | 1.3 – 37.1***

Significant, p-value < 0,05 = *

CI = Confidence interval (only given for significant values), OR: Odds Ratio.

Furthermore, the variables of the adapted TAM were included in the logistic regression to test them. To this point, DV levels 1 and 2 (separately) were tested with the variables of the adapted TAM. DV level 1 showed no significant results in any of the interactions with the DVs of the adapted TAM, so its results are not being further described. Table 11 summarizes the findings for DV level 2, with IV level 1. There were significant results for PU (OR: 4.3, 95 % CI: 1.04 - 18.5 p-value: 0.044) and subjective norm (OR: 7.6, 95 % CI: 1.2 -48.2 p-value: 0.03). To further test the model, the interaction of PU and subjective norms level 1 was tested as a dependent variable with the Intention of Use Level 2. This showed significant results in the interaction of the subjective norm with the intention of use as the independent variable (OR: 12.2, 95 % CI: 3.2 – 46.8, p-value: < 0.01). These findings are summarized in Table 12.

TABLE 11 RESULTS OF THE LOGISTIC REGRESSION: ADAPTED TECHNOLOGY ACCEPTANCE MODEL (TAM) IV L1 – DV L 2

Variables TAM level 1 (Nagelkerke R Square: 0.52)	Intention of use Level2 (OR | 95 % CI)
PU	**4.3* | 1.04 – 18.5**
PEU	1.8 | 0.44 – 7.9
Attitude	>999.999 | 0.01 – >999.999
Facilitator	0.22 | 0.03 -1.6
Subjective Norm	**7.6* | 1.2 – 48.2**
Compatibility	0.55 | 0.06 – 5.06

Significant, p-value < 0,05 = (*),

CI = Confidence interval (only given for significant values), OR: Odds Rati, IV L1 = Independent Variable Level 1, DV L 2 = Dependent Variable Level 2

TABLE 12 EXTENDED TESTING OF THE ADAPTED TECHNOLOGY ACCEPTANCE MODEL (TAM) IU L 2 – SN L 1

	Subjective Norm level 1

Intention of use level 2	**12.2 | 3.2 – 46.8***

Significant, p-value < 0,05 = (*)

CI = Confidence interval (only given for significant values), OR: Odds Ratio, IU L 2 = Intention of Use Level 2, SN L1 = Subjective Norm Level 1.

When testing IV level 2 of the adapted TAM and their interaction with DV level 2, subjective norms showed significant results (OR: 18.2, 95 % CI: 1.5 – 216, p-value: 0.021). This model explains 57 % of the outcome variable with the predictors (Nagelkerke R Square: 0.57). Table 13 shows the results of DV level 2 interacting with IV level 2. Subjective Norm was tested as a dependent variable, and the intention of use as an independent variable; the results show significant results for the intention of use (OR: 25.9, p-value: 0.002, 95 % CI: 3.1 – 213.0). These findings are summarized in Table 14.

TABLE 13 RESULTS OF THE LOGISTIC REGRESSION: ADAPTED TECHNOLOGY ACCEPTANCE MODEL (TAM) IV L 2 – DV L 2

Adapted TAM Level 2 (Nagelkerke R Square: 0.57)	Intention of use Level 2 (OR | 95 % CI)
PU	3.8 | 0.78 – 19.2
PEU	1.4 | 0.31 – 6.5
Attitude	1.6 | 0.22 – 11.4
Facilitator	1.8 | 0.29 -11.0
Subjective Norm	**18.2* | 1.5 – 216**
Compatibility	0.56 | 0.071 – 5.038

Significant, p-value < 0,05 = (*)

CI = Confidence interval (only given for significant values), OR: Odds Ratio, IV L 2 = Independent Variable Level 2, DV L 2 = Dependent Variable Level 2.

TABLE 14 EXTENDED TESTING OF THE ADAPTED TECHNOLOGY ACCEPTANCE MODEL (TAM) IU L 2 – SN L 2

	Subjective Norm level 2
Intention of use level 2	**25.9* | 1.4 – 213.0**

CI = Confidence interval (only given for significant values), OR: Odds Ratio, IU L 2 = Intention of Use Level 2, SN L2 = Subjective Norm Level 2.

Finally, the logistic regression included all the predictors, namely demographics and adapted TAM. These were tested as IV interacting with DV (Intention of Use) Level 1 and 2 (separately). Only the interaction with DV Level 2 showed significant results. These were for the PU and subjective norm (OR: 16.0, 95 % CI: 1.1 – 229.7, p-value, 0.041 and OR: 376, 95 % CI: 1.8 –

78066, p-value: 0.029, respectively). Supporting the outcomes of the adapted TAM tested independently.

13.2 QUALITATIVE ANALYSIS

13.2.1 SYSTEMATIC THEMATIC ANALYSIS

A systematic thematic analysis assessed participants' impressions of their inputs to the survey's open-ended questions 1 to 4. Question 5 of the open-ended question sought the participants to give suggestions for future applications and scenarios of educational training with VR devices. Hence, the analysis of that question consisted of categorizing the participants' leading suggestions until data saturation was perceived. The participant's answers to the open-ended questions addressing strengths and opportunities shared codes and resemblances, so they were analyzed as one group. A similar case was experienced with the answers to weaknesses and risks. Findings describe strengths, opportunities, weaknesses, and risks from three perspectives. These are the technological, systemic, and individual's emotions. The themes derived from the iterative review of the participant's inputs generating codes and sub-themes. The themes are the following:

Themes for strengths and opportunities

1. Captivating through Technological Accuracy in Augmenting Users Experience
2. Optimizing Learning experience through Effective Resource Integration
3. Engaging through lightened learning experience

Themes for weaknesses and risks

4. Uninteresting due to sparse technological Scope
5. Inaccessible due to Insufficient resources availability
6. Disengaging due to Emotional overload

13.2.1.1 Theme 1: Captivating through Technological Accuracy in Augmenting Users' Experience

Participant's impressions of VR devices as training tools about strengths and opportunities lead to the code *Increased depth of the training* expressed in phrases such as "*Progress, more intense learning experiences*" or "*More intense experiences, enabling deeper learning.*" Besides, the code *Practical benefits due to repetitive training opportunities* were generated. This was found in expressions of participants such as "*Learning with repetition effects independently of time in a simulation*" or "*Opportunity for frequent repetition also outside of* *class time."* These findings suggested the creation of the subtheme *VR devices enhances practice outcomes through repetitions and depth in training*.

The code, *Resource realistic was generated from* participants' comments, such as "*Scenarios can be depicted more realistically than in previously offered practical simulations*" or "*Confronted with real situations*" after their experience with VR devices in the workshop. Furthermore, participants' reports generated the code *Preference of virtual scenarios versus real patients' practice.* This stemmed from impressions like "*Nursing scenarios that cannot be practiced with patients (e.g., shame/body care)."* Hence, a subtheme *Appealing layout for users* was summarized from those findings.

The subtheme, *Attractiveness due to simulation conditions* stemmed from codes such *Positive outcome due to isolation meanwhile using*. This was generated from comments such as "*You are completely immersed in "this world" and are not distracted by the outside world".*

The subtheme, *Empowering innovative technology* stemmed from codes *such as Innovative learning scenarios.* This was generated from impressions such as "*Earning new situations*" and "*Further development simplifies care situations - Better preparation for emergencies, etc*. Moreover, the code *Friendly usability* was generated from impressions such as "*Easy handling*" or "*Quick deployment possibility, without much preparation effort"* were also embedded in this sub-group.

The subtheme, *Innovative digital contribution to sustainable training* stemmed from codes such as *Modern factor* and *environmentally friendly*. These were generated from participant's impressions such as "*Sustainable approach / positive effect on the environment*", "*Save materials*", "*Modern technology for learners likely provides motivation and fun*" and "*modern*".

13.2.1.2 *Theme 2: Optimizing Learning Experience through Effective Resource Integration*

Participants' impressions of VR devices as training tools about strengths and opportunities lead to the subtheme *Cross-sectional scalable training tool*. This stemmed from the codes *Training flexibility enhanced knowledge acquisition*, *Facilitated transferable knowledge within and across departments*, and *Diverse interdisciplinary training tools*. Hence, these codes stemming from comments such as "*Can learn more relaxed (without pressure) - can practice more often," "Theory-practice transfer," or "Interdisciplinary action possible."*

The subtheme, *Complementary and resource-efficient training tool stemmed from the codes* such as the *Supplementary to existing training tools.* Hence, stemming from impressions such as "*Not to be seen as a replacement for instruction, but as a supplement*" or "*Resources are conserved, and education and training can take place in the shortest possible time."*

The subtheme, *Safety for individuals and encouraging group training,* stemmed from codes such as *Safe training* and *Teamwork encouragement*. These surged from comments such as "*Less dangerous for patient*s" or "*Conveying safety in procedures*."

13.2.1.3 Theme 3: Engaging through a lightened learning experience

Participants' impressions of VR devices as training tools about strengths and opportunities lead to the subtheme of *Constructive emotional triggers.* This stemmed from codes such as *Enhanced learning experience with no fear felt, Reduced emotional distress and development of empathic behaviors.* Hence, stemming from impressions such as "*Being allowed to make mistakes without drastic consequences," "In the area of emergency simulations, fears and nervousness are reduced," or "Deeper empathy with the situation."*

The subtheme, *Creation of independent training space increasing concentration* derived from the codes of *Concentration enhancers* or *Generating scalable and self-oriented training occasions.* Hence, stemming from impressions such as "*Better concentration*" and "*independent learning."*

The subtheme, *Young users and digital generations motivational tool* emerged from codes such as *Empowering tools for new generations* and *Encouraging digital adherents*. Hence, stemming from impressions such as "*Increased motivation among younger generations*" or "*Digital natives are better reached through this method*".

The subtheme, *Joyful and diverting* arose from the codes *Engagement through increased joy*, and *Digitally encouraging for all types of users*. Hence, stemming from impressions such as "*Very good training opportunity that is fun*" or "*Promotion of digital media competencies*".

13.2.1.4 Theme 4: Uninteresting due to sparse technological Scope

Participants' impressions of VR devices as training tools about weaknesses and risks lead to the subtheme *Scarce technological scenarios and inclusive development.* This emerged from codes such as *Reduced scope of usability* and *Sensorial barriers for impaired individuals.* Stemming from participants comments such as "*Handling of patients and instruments needs to be deepened afterward" or "Scenarios are currently limited*" or "*Potential issues for individuals with visual impairments, sensory overload*."

The subtheme, *Limited transferability and associability from simulation to real-world practice* stemmed from the codes *Detachment from the real world because of the isolation* and *Uncertainty of* transfer from virtual simulation to real-world practice. Hence, arising from impressions from the participants such as "*Lack of tactile content in practical exercises*", "*Limited personal contact*", "*Missing the tactile aspect, implementing techniques",* "*Underestimation in real life*" or "*Concrete tactile actions are not trained*".

The subtheme, *Limited and impaired usability* emerged from the codes such *as Existence of communicational barriers*, *Technology complex to adapt* and *Probable to misuse due to distraction in the technology*. These stemmed from participants' impressions such as "*Language function issues*" or "*Lack of communicative exchange*," "*Adapting to the variety of spatial conditions in nursing can be challenging,*" and "*Distraction by more attractive internet applications*."

13.2.1.5 Theme 5: Inaccessible due to Insufficient resources availability

Participants' impressions of VR devices as training tools about weaknesses and risks lead to the subtheme *Poor functionality in use and time*. This was generated from codes such as *Threat to generating workforce, VR devices have reduced continuity in time* and *Poor functionality*. These stemmed from participants' comments such as "Initial hype fades among participants" and "prone to malfunctions."

The subtheme, *Institutionally limited capacity* emerged from codes such as *Time-demanding*, with impressions such as "*Time-consuming to simulate new rooms and situations*". The code *Short in availability* stemmed from impressions such as "O*nly 1-2 students can use it at the same time*" or "*Too few for too many students*". The code *Risk on infrastructure shortages* and *Financial constraints* emerged from comments such as "*Lack of technical equipment regarding stable internet connection*", "*Due to costs, the number of available devices is limited, allowing for only rare and brief use*" or "*More expensive than traditional methods*".

13.2.1.6 Theme 6: Disengaging due to Emotional overload

Participants' impressions of VR devices as training tools about weaknesses and risks lead to the subtheme *Detrimental to triggering emotions*. This stemmed from codes such as *Decreased empathetic emotions when interacting with others* and *Emotionally and psychologically overloaded.* These stemmed from participants impressions such as *"Empathy is lost*" or "*Empathy might be insufficient*", "*Might be too realistic and re-trigger traumas*" or "*Perceiving diverse personal feelings in the environment*".

The subtheme, *Scarce adaptability sensation* emerged from codes such as A*daptability issues, Reduced technological affinity* and *Reluctance to adopt the technology in older generations*. These stemmed from participants comments such as "*Hurdle of adapting to new media/fear of technology*", "*Overwhelmed with technology or drifting into action*", "*Convincing older generations to embrace new technologies*" or "*Older employees may be primarily critical*".

13.2.1.7 Miscellaneous

Participants’ impressions that did not lead to any code, subtheme, or theme were grouped as Miscellaneous. These comments would mainly represent individual and unique impressions and would not form any tendency or trend from the data. This includes comments such as “*The impression is still too short to judge*” or “*No risks*”.

13.2.2 CLINICAL APPLICATION AREAS/SCENARIOS FOR VR DEVICES TO BE SUPPORTIVELY USED FOR

This section will enlist and describe the most mentioned scenarios and areas the participants suggested in the survey after undertaking the intervention. The most described was VR devices in the education of *Practical nursing skills*. This refers to a diverse set of activities that nurses perform in their daily activities described from impressions of the participants such as “*Blood sampling”*, “*Changing dressing”, “Inserting a bladder catheter, situational conversation management, observation functions”* or “Training of nursing techniques”.

Furthermore, the participants also described the perception of a scenario of *Communicational training*. This derived from comments such as “Applications in communication”, “*Dealing with challenging behaviors of a patient e.g., patient with dementia – Communication*” or “*Inserting a bladder catheter, situational conversation management, observation functions*”.

Another perception of the participants was of *Unexplored scenarios*. This includes impressions such as “*Dealing with difficult patients (blind, deaf, demented...), practicing handling patient emotions*”, “*care, larger scenarios like a fire in a patient's room*” or “*Boundary topics in palliative care, practicing better handling of violent situations*”.

Perceptions of using VR devices in *Surgery* were also derived from the participants’ impressions. Hence, stemming from comments such as “*Operation* room”, “Surgery” or “*Anesthesia*”.

VR devices were also suggested for use in scenarios such as emergency services. This stemmed from impressions such as “*Emergencies in the labor ward such as shoulder dystocia,*” “*Emergencies in newborns*,” or “Emergency department.”

Other less frequently named scenarios derived from the participants' perceptions were *Midwifery, Pediatric first aid, Gender-inclusive care, Mental health care, Gastroenterology services, new employees' motivational units, Resuscitation room, Diagnostic area, Gastroenterology Services, Pediatric care, Physiotherapy, Medical Education*, and *Wound management practice*. Further impressions of services were not included in this list since they made no clinical or narrative sense.

14 Discussion

The findings of this research grant new insights into evaluating VR devices as a training tool in German nursing education. In the quantitative analysis, the demographics described a defined population, and the adapted model showed positive results regarding the participants' impressions. The total number of participants in workshops and posterior surveys was 74. The totality of the group answered the survey (100% of the response rate), but only 81 % (n = 60) consented to further utilizing their data for the analysis. The majority of the participants were females, and only 13 % of them were males. This could be expected regarding the historical female formation of the nursing occupation (Statistisches Bundesamt (Destatis), 2024d). Still, at the same time, it could represent an interesting challenge to overcome and potentially attract more males to nursing education to increase prospective nursing students. The distributions of ages were relatively homogeneous, except the group over 61 years old. The small number of this group can be potentially explained by the low acceptance of older generations to digital health (Jokisch et al., 2022; Kalicki et al., 2021), low adherence to the activity, or low participation in nursing education in the visited institutions. This research invited subjects involved in nursing education in the selected institutions. This resulted in most participants being teachers (75 %), and 8 % of them are learners. According to the previous evidence, educators should accept and possess sufficient DHC to successfully transmit this to their apprentices (Jobst et al., 2022). This is why counting with a majority of teachers among the participants could be considered as a positive aspect for them to transmit the experience and ultimately the acceptance of the technology to the students. Furthermore, the majority of the participants, 56 % of them, belonged to the clinical department of nurses. These results relate to the scope of the primary objectives and research question. Interestingly, the majority of the participants, 50% of them, had a university degree, and 5 % had a doctoral degree. This could be linked to the high presence of teachers in the group, who normally have higher educational degrees when achieving this educator position.

When analyzing descriptive data from the original and adapted TAM, participants showed positive results regarding VR devices as a training tool. When paying attention to the different categories of the adapted TAM embedded in the survey and their means with standard deviation, it can be emphasized that participants in every category, besides the Habit, answered as “agree” (5/7) to the affirmation. With the highest score by the intention of use (mean: 6.15; S.D: 1.56) and the lowest being facilitator (mean: 5.3; SD: 1,83). The category habit was not included in the analysis for not showing reliability in their items after calculating the Cronbach alpha value and by showing a nonsignificant correlation with the dependent variable intention of use measuring with a Spearman test. The possible reason for this is that the question of the category variables included an example of what was being asked. However, the example and the question could have different interpretations by the participants or could even mislead them about the purpose of the question. Regarding the Intention of using VR devices as a training tool when this becomes available, 88 % of the participants somewhat agreed, agreed, or strongly agreed with it. This means that about 5 out of 6 participants in this study would accept this technology to some extent. And 63 % of the participants were fully committed to the intention of using the technology. From the original TAM, 95 % of the participants in the variables, PEU and PU, somewhat agreed, agreed, or strongly agreed when asked for them in relation to VR devices as training tools. These categories included relevant questions addressing satisfaction with the PEU of the technology, addressing the technology as easy to use, and implementing it as helpful, rapid, and effective to learn, among other descriptions. Particularly, the categories of facilitator and habit showed the lowest results when considering somewhat agree, agree, and strongly agree on answers and only strongly agree on answers. These indicate that a large percentage of the participants do not fully expect their institutions or providers (facilitators) to be able to provide the infrastructure when VR devices become available. A similar outcome was experienced by habit, where about 1 / 3 subjects were fully convinced that the VR devices could become a routine process for the user. Compatibility and subjective norms also showed discreet results in the group that agreed somewhat to strongly agreed only. The results of compatibility partially resonate with the facilitator, for example, when assessing how prepared the current context of the institution and educational department is for a possible implementation of this technology. The subjective norm showed that a similar number of participants (71 % from somewhat to strongly agreed and 37 % strongly agreed) believed that their colleagues would adopt the technology. This domain has particular relevance, considering that evidence shows how peer recognition and opinions about the profession seem to be one of the big challenges in making the occupation more likable.

Moreover, as previously mentioned, since this research does not count with a control group, the different levels created with the Likert scale level answers were used to distinguish the nuances within the group. Although this does not overcome an interpretation with a “bias of lacking a control group,” it does give a broader perspective on participants’ behaviors and eventually in the prediction of the intention of use. This case could be addressed as research design bias (described in the section on limitations). Therefore, participants who strongly agreed showed full convincement in their experience with VR devices and would eventually be more confident to adopt the technology in the future. Nevertheless, the theoretical model's descriptive findings could potentially be used as a reference when facing similar settings and target groups in future investigations. However, it is worth mentioning that this study does not measure the causality of acceptance of VR devices as training tools but the relation between the dependent and independent variables and the eventual prediction of factors that could influence this.

Moreover, logistic regression permits obtaining statistically significant results, suggesting that the results do not solely occur randomly under the conditions of this research. When testing the different sets of DV and IV previously mentioned (section: methods) with the demographics inputs, the role in the education and the educational level showed significant results with DV levels 1 and 2, respectively. Results showed that intention to use level 1 as a cohesive group, teachers and learners would increase 7.5 their chances of intention of use for belonging to this group. However, these two groups showed no significant results when tested independently with DV level 1. The research and intervention are related to subjects involved in nursing education, but not necessarily one specific target group. The workshop and the subsequent survey used to collect the participants' impressions do not specify whether the questions are for teachers, learners, or others. The findings of this research suggest that although teachers and learners relate to using this technology in education, none of them identify as a unique and independent target group in this investigation. Although this could encourage future developments in the implementation of VR devices as training tools by suggesting an acceptance of this technology by teachers and learners together, addressing those target groups independently would be necessary, considering their very different needs and capacities when adapting VR devices as training tools. In contrast, the results on the group with no role or other role in education suggested that there are 84 % lower odds of having intention of use for belonging to this group. These findings relate to the fact that there is no direct target group for the intervention's general target group (subjects related to nursing education) and that from all the participants, this group would be the least attracted to using VR devices in nursing education.

When the participants' demographics were statistically tested with the DV level 2, the highest educational degree, namely high school and vocational resulted in having 5.9 more chances of increasing their intention of use by belonging to this group. This group usually represents trainees at the beginning of their nursing educations, making them more susceptible to the acceptance and potential adoption of VR devices as training tools. In contrast, the groups with higher educational, university, and doctoral degrees showed 87 % fewer odds of increasing their intention to use VR devices by belonging to these groups. Previous evidence has also shown that individuals with more education could predict and anticipate more obstacles when promoting new behaviors (Tabak & Ozon, 2004). However, although they strongly agreed on using VR devices as training tools, they eventually do not see themselves as end users once this technology becomes available. Similarly, like in previous cases, none of the independent items of the domain's highest role in education showed significant results when tested separately from each other. This resonates with the previously mentioned argument suggesting that this research offers a general first evaluation of users involved in nursing education but does not directly address any of them in the data collection, e.g., the survey addresses users in general and not trainers or trainees specifically. Still, the non-specification of subjects in the nursing education group, e.g., solely nurse students or nurse educators, might not allow this research to capture their impressions as independent groups. That is why these results might be used in the first stage to comprehend the general participants of the group involved in nursing education. However, future research should address them independently to further unveil these groups' specific needs.

The results of testing the original TAM with the intention of using level 2 showed insightful results. The model fits well with the original TAM, and it predicted that participants had 4.1 more chances of increasing their intention of use for every unit that the PU increased. This relates to the previous theory using a similar modified model (Gagnon et al., 2012b). This also resonates with previous evidence on how the PU can impact the acceptance of VR devices and other novel technologies (Godoe & Johansen, 2012; Oyman et al., 2022; Sagnier et al., 2019). After trying the model further, results showed that the intention of use and PEU also influenced the PU when this was tried as a dependent variable. Participants had a 7.7 chance of increasing their PU for every unit of increase in intention of use and a 7.0 chance of increasing their PU for every unit that the PEU would increase. These extensions of the model show its flexibility in how variables can influence each other on the acceptance of VR devices as training tools. To summarize, the intention to use VR devices as training tools in German education is directly influenced by PU and indirectly by the PEU. The users of VR devices in nursing education might accept the technology when they recognize the ease, facing little or the least possible difficulties in this process, and so they can visualize its utility. This remains a challenge for educational institutions to overcome. These should guarantee their nursing educational staff clear communication and guidelines to manage expectations and apprehensions.

After including the variables of the adapted TAM, the results showed that PU has 4.3 times more chances of increasing their intention to use VR devices as training tools and that subjective norm have 7.6 times more chances of increasing the intention to use VR devices as training tools for every unit of its increase. These results resonate with the initial testing of the original TAM and with the existing literature on how nurses highly appreciate the opinions and impressions of their peers. According to previous literature, a more collectivist society's behavior could condition their intention of use based on the group norm (subjective norm) (Le Duff et al., 2023). The argumentation of the PU remains the same as explained, but the subjective norm introduces an additional perspective on encouraging acceptance of VR devices as training tools in nursing education. Further testing of the model showed that the intention of use is a predictor of the subjective norm, with 14.4 more chances of increasing the subjective norm for every unit that the intention of use increases. Once again, although these interactions were not included as a hypothesis of this research, it provides an overview of the flexibility of the model and the many factors that can predict and, therefore, support the intention to use VR devices. The results of this study showed broad confidence intervals to the ORs, potentially explained by the small sample size (M. J. Gardner & Altman, 1986).

Summarizing the quantitative data analysis, the adapted TAM tested with logistic regression showed robust results in answering the primary research question: What factors influence the acceptance of VR devices as training tools in nursing education? When participants strongly agreed on their intention to use VR devices as training tools, the statistical testing of the model showed perceived usefulness and subjective norms as predictors influencing the intention of use and, therefore, the acceptance of VR devices as training tools. Besides, when testing the model even further, it showed its flexibility and how the predictors can influence themselves, such as the intention of use and PEU being a good predictor to increase the PU and the intention of use being a good predictor to increase the subjective norm. These findings might enlarge the scope of the adapted TAM model for this case and provide meaningful insights to future research and possible implementations of VR devices as training tools. It is also considered that the educational degree might also be a predictor of the increasing or decreasing intention of use when the participants strongly agree with the use of the technology. In contrast, the role in education was a good predictor of increasing or decreasing intention of use when participants somewhat agreed, agreed or strongly agreed. Evaluating different nuances in this research could also be a helpful tool for future research or implementations when participants are medium to strongly committed to the new technologies. In those cases, according to the findings of this research, they could be addressed, communicated, and onboarded depending on their level of intention to use the technology and their role in the education or educational degree. Hence, it encourages and provides informative insights to motivate acceptance of technology.

Furthermore, the systematic thematic qualitative analysis revealed the generation of 6 different themes that contain the participants' comments and impressions. The findings of strengths and opportunities highlight VR devices as training tools that are *Captivating through technological accuracy in augmenting users' experiences, Optimizing learning experiences through effective resource integration, and Engaging through lightened learning experiences*. Thus, the secondary research question of which potential users perceive the implementation of VR as a teaching tool is answered in this first with the compacted themes generated as captivating, optimizing, and engaging. The quality of captivation refers to how the technology enchants the users of our intervention. Participants believed this technology would bring them into an extended depth in the learning experiences by easily repeating practices with no or low effort and a high sense of realistic simulations. Previous evidence supports the findings (Flott & Linden, 2016), that the opportunity to undertake repetitive practices with few or little extra costs would attract the students and users to prefer and leverage VR devices versus a traditional learning method, such as books, or plastic simulated human parts. Besides, the previous evidence has also shown positive outcomes regarding skill acquisition, with fewer fails and counter effects on the procedures realized by students who were taught with VR devices versus the ones who used traditional methods (Vidal et al., 2013). Although this research does not evaluate learning outcomes, this evidence suggests that further investigation should address this subject with more complex research methods and designs, e.g., RCT. The quality of *optimizing* describes positive institutional and infrastructural domains that they perceived and foresaw when testing VR devices as training tools. This comprises the necessary systemic and organizational items that will support and leverage VR devices for training and education. Guaranteed accessibility, scalability of training scenarios, availability of devices, and the impression of education with VR devices as safe training encourage a positive impression towards implementing the technology. Previous evidence has also addressed how relevant the facilitator nurses are in helping them adopt new technology. Kiegalde et al. unveiled how the presence and availability of remote HMD was more convenient for students to engage in education with VR as a training tool (Kiegaldie & Shaw, 2023). Furthermore, VR devices as training tools are being thematized as engaging and refer directly to individuals' sensations towards the technology. The idea and experience of training tools that encourage positive emotions such as empathy for the patients and safety practices with no fear of making mistakes where practices are independent, scalable, and self-oriented will provide an unburdened sensation of training and, therefore, a higher engagement to adapt. Swan et al. reported how nurses are willing to use VR as a training tool due to how comfortable they feel with the technology (Swan & Giordano, 2023).

The findings on weaknesses and risks highlight VR devices as a training tool as *Uninteresting due to sparse technological Scope, Inaccessible due to Insufficient availability of resources,* and *Disengaging due to Emotional overload*. Thus, the research question of which potential or drawbacks users perceive the implementation of VR as a teaching tool is answered in this second instance with the compacted themes generated as uninteresting, inaccessible, and disengaging. The theme and belief that VR devices are uninteresting stems from a general skepticism of the participants on the prospective technological feasibility and scope of this technology. The uncertainty of knowledge transferability from the virtual simulation to a real patient practice or the few scenarios available discourage participants' prospective usage. However, this research article's background section presents many scenarios where VR devices have been used as training tools. This suggests that clear and effective communication channels about the known scope of the technology should be considered for future implementations. However, Wu et al. reported that nurse users in VR training claim technological discomfort regarding health problems, including sore eyes and neck. The findings suggest this could cause reluctance for future usage of the technology (Wu et al., 2023). This should be considered as a possible technological drawback for future investigations. The theme and belief of inaccessibility is related to the incapacity to see how the institutions where the technology will be used could fulfill the infrastructural requirements for proper functionality. The several approaches to this domain include the financial solvency of institutions to carry training with VR devices. Lange et al. reported how financial constraints were also perceived as an obstacle for nurse students in a qualitative cohort study when implementing a new technology (Lange et al., 2020). The theme and belief of disengaging relate to the involvement and individual sensation of the users towards VR devices as training tools. Some participants felt that this type of training tool was highly stressful and that an emotional overload could be triggered after using it. These findings are consistent with previous evidence, where a qualitative content analysis study suggested how training with VR can produce intense emotions in the users, often resembling a clinical reality environment and memories (Lie et al., 2023). However, this does not necessarily represent a threat if trainees are prepared and a safe training environment is provided or if they auto disqualify for the use of VR devices as training tools for personal reasons, e.g., physically impaired or mental health issues. Moreover, the participants suggested various clinical scenarios or possible applications for future usage of VR devices. These embrace a broad range from Practical nursing skills to Communicational training or Gender-inclusive care. The participants' suggestions serve as evidence of the diverse usability scope that the usage of VR devices in the educational field could have for them. However, both the educational institutions and the potential users of VR devices should be critical in the feasibility of its implementation. Nursing educational institutions should identify which scenarios are needed in their curricula and real-world practice to plan for possible implementation. This should have a multiperspective approach considering technological, systemic, and individual emotional perspectives.

Overall, the results and impressions of participants after undertaking the workshop show three tendencies in their answers. These are potentials and drawbacks from a technological, structural, and individual’s emotional perspective. This interpretation focuses on how to address and potentially prospectively implement VR devices as training tools for the successful adoption of the users. The users should feel confident in all of those aspects, and for instance, from a technological perspective, feel that hardware, software, and content are supportive and intended to improve the learning outcomes rather than affecting them. From a structural perspective, organizational robustness in terms of the integration of resources shall represent a large endorsement for the users when acquiring a new technology. Lastly, an individual (emotional) aspect could act as a main engine when accepting or not VR devices as training tools. Empathy and satisfaction will depend not only on their own emotions but also on external factors such as technological and structural ones. Whether VR devices as training tools' potential are captivating, optimizing, and engaging or uninteresting, inaccessible, and disengaging will strongly depend on the conditions and ecosystem on which the future users, in this case, nurse trainees and trainers, will be presented to this technology. Furthermore, educational institutions should adopt comprehensive and multi-faceted strategies to meet users' requirements. This approach should encompass technological advancements, systemic improvements, and considerations of individual emotional responses. By integrating these dimensions, educational bodies ensure a holistic response to the diverse needs of the groups related to nursing education.

VR technology is a scalable technology that permits the exploration of unexpected medical and educational fields. This represents an excellent opportunity to cover existing gaps such as a shortage of academics, the risk of practices with patients, or the communication barriers that can be present between staff in the same or other locations. It is then necessary for academia, scientists, policy-, and decision-makers to grant reasonable space and resources to digital technologies, especially virtual reality. The latter has an ongoing deployment in the field, with already positive results in the engagement and compliance of the different educational processes, such as skill- and knowledge-oriented education. However, while VR has been vastly explored in the medical and nursing fields globally, the study of VR technology in the nursing educational field in Germany still has significant scientific gaps that must be addressed. This requires generating substantial evidence specifically of this group and their integration of VR into their educational curricula. To contribute to this, this research has met its objectives of evaluating the acceptance of VR devices among users in nursing schools in Germany, and it has explored the potential and drawbacks experienced and suggested by users after testing VR devices as training tools.

15 LIMITATIONS

This study presents several limitations. The data collection instrument shows various points of improvement. Time constraints in the design and implementation of the survey led to an incomplete external validation of the items included. The lack of timely planning for the review of the data collection instrument resulted in the experts in the field who should validate the items in the questionnaires not giving timely feedback. This led to a decreased robustness of the data collection instrument. Besides, the adapted TAM considered for this research included several items per category (PEU, PU, Intention of use, etc.). Purposely, the number of items in the survey (25) led to having some categories with single items and others with multi-items. This shows less reliability on the items and, therefore, in the data collection instrument. Further studies should address this and include at least two items per category to prevent this shortage. Moreover, a reduced sample size has impacted the broad confidence intervals. Additionally, although this research addresses the topic of education in nursing school from a perspective of health sciences, further approaches and expertise with a specific perspective on education should be included in further research. Moreover, although the selection of the participants has been related to the nursing education in the institutions, the results showed that when the target group is not specified, there are fewer opportunities to address one target group of the subject in the study, e.g., differentiating teachers and learners, or participants with educational degrees high school and vocational. This study intended to evaluate this diverse group's impressions of the participants after experiencing VR devices as training tools for the first time in these settings. However, further research should consider working with defined and differentiated target groups in nursing education. A timely inclusion and submission to the ethical approval committee was missing in this study. Besides, a written consent form was also not provided to the participants before the activity. Limited expertise in the field constrained this study's scope and the survey design.

16 Conclusions and Outlook

Virtual Reality devices are promising instruments to be included in nursing schools in Germany. They seem to increase trainee satisfaction, autonomy, confidence, etc., and educators' engagement with digitalization in nursing education. Besides, they improved learning outcomes by measuring tests post-implementation and comparing them with traditional methods. In addition, the findings of this research shed positive light on the acceptance of VR devices after introducing the technology to a broad target group that included nurses trainees, trainers, and staff related to the education in the institution. Participants also identified several domains of strengths, opportunities, weaknesses, and risks involved in using VR devices compared with traditional learning methods. In addition, the participants suggested various VR scenarios and applications to include in future implementations. Hence, VR technology is a valuable tool in digitalizing nursing education and training. In addition, to enlarge the outreach of this technology, it is necessary to mind users' technological, systemic, and emotional requirements with a multiperspective approach. The groups involved in nursing education can be extensively diverse, having different educational and societal backgrounds, personal beliefs, ages, experiences, etc. Considering their requirements as independent groups might be a resourceful way to succeed in adapting VR technology and ultimately improve conditions in nursing education with the use of digital means. In Germany, identifying the needs of nursing schools per region might also contribute to a more efficient resource distribution by healthcare responsibles and authorities. Besides, the ongoing evolution of technologies globally offers German healthcare educational institutions an excellent opportunity to fulfill users' demands and expectations. The broad use of AI and its Large Language Model software and their interaction with virtual avatars are unique, innovative tools to address each user's evolving needs. Future studies should also consider longitudinal studies with control groups' research design to evaluate their interactions over time with VR devices. Lastly, the study of VR device acceptance as training tools in German nursing schools might support its potential adoption on a larger scale. This could strengthen the nurse's labor market, help decongest healthcare settings, and ultimately lead to the delivery of quality services to patients within the German healthcare ecosystem.

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18 APPENDIX

18.1 EINLEITUNG WORKSHOP - EINWILLIGUNGSERKLÄRUNG – UMFRAGE (GERMAN VERSION – USED WITH THE PARTICIPANTS)

Einleitung

Im Rahmen des Projekts „Virtual Reality (VR) in der Pflege" möchten wir den Einsatz von VR in der Aus- und Weiterbildung von Pflegekräften evaluieren. Hierfür haben wir einen Fragebogen mit 25 Fragen entwickelt. Wir bitten Sie diesen als Teilnehmerin unseres Workshops auszufüllen.

Sie werden voraussichtlich circa 15 Minuten benötigen. Bei Verständnisfragen melden Sie sich gern bei unserem Workshopteam vor Ort. Vielen Dank für Ihre Mitwirkung.

Bevor es losgeht können Sie über nähere Hinweise zum Datenschutz informieren: Link

Informationen und Einwilligungserklärung zum Vorhaben

Bitte lesen Sie die folgenden Informationen sorgfältig durch. Für Rückfragen stehen wir Ihnen gerne zur Verfügung:

- Die in diesem Fragebogen erhobenen Daten werden zur Evaluierung des Einsatzes von VR in der Aus- und Weiterbildung von Pflegekräften genutzt.
- Diese Befragung wird von der digital health transformation eG (dht) durchgeführt.
- Im Rahmen des Vorhabens werden folgende Daten erfasst, gespeichert, verarbeitet und ausgewertet: Fragebogendaten zur persönlichen Haltung und Erwartung an die Virtual Reality-Technologie sowie personenbezogene Daten (Alter, Geschlecht, höchster Bildungsabschluss, Fachbereich und Berufserfahrung).
- Die erhobenen Daten werden bis Projektende aufbewahrt, maximal jedoch 10 Jahre. Die Löschung der Daten wird außerdem alle fünf Jahre geprüft.
- Die Datenverarbeitung erfolgt auf Basis Ihrer Einwilligung. Rechtsgrundlage ist Art. 6 Abs. 1 Unterabs. 1 Buchst. a DSGVO. Die Teilnahme an dieser Befragung ist freiwillig. Eine Nichtteilnahme hat keinerlei negative Konsequenzen für Sie. Daneben haben Sie jederzeit die Möglichkeit, eine gegebene Einwilligung zu widerrufen. Einen etwaigen Widerruf Ihrer Einwilligung richten Sie bitte an: michael.mut@digital-health-transformation.de

Einwilligungserklärung (**bitte ankreuzen**)

- Ich willige in die Verarbeitung meiner Daten zum Zweck der wissenschaftlichen Evaluierung ein. Mir ist bewusst, dass die Verarbeitung auf freiwilliger Basis erfolgt und dass ich mein Einverständnis ohne für mich nachteilige Folgen verweigern bzw. jederzeit mit Wirkung für die Zukunft widerrufen kann, wobei der Widerruf die Rechtmäßigkeit der Verarbeitung nicht rückwirkend beseitigt.
- Ich willige nicht in die Verarbeitung ein. Dies hat keinerlei negative Konsequenzen für mich.

Fragebogen

Kategorie	Frage	Antwort
Demographische Merkmale	Mit welchem Geschlecht identifizieren Sie sich?	m / w / d
Demographische Merkmale	Zu welcher der nachfolgenden Alterskategorien gehören Sie?	< 18 / 18-30 / 31-40 / 41-50 /51- 60 / >61
Demographische Merkmale	Welchem Fachbereich gehören Sie an?	Pflege / Ärztlicher Dienst / Krankenhausverwaltung / Bildungseinrichtung / Sonstiges
Demographische Merkmale	Wie viele Jahre an Berufserfahrung haben Sie in klinischer Umgebung?	<1 / 1-5 / 6-10 / >10
Demographische Merkmale	Was ist Ihr höchster Bildungsabschluss?	Schulabschluss / Berufsausbildung / Hochschulabschluss / Promotion
Demographische Merkmale	Welche Rolle haben Sie in der Aus-und Weiterbildung?	Lernende / Lehrende / Keine / Sonstiges
Habit	Ich hatte bereits im Vorfeld Erfahrungen im Umgang mit digitalen Tools in der Lehre? (z.B. digitale Lernplattform)	Stimme gar nicht zu (1) – Stimme vollkommen zu (+7)
Habit	Ich hatte bereits im Vorfeld Erfahrungen im Umgang mit Virtual Reality (VR)?	Stimme gar nicht zu (1) – Stimme vollkommen zu (+7)
Benutzer-freundlichkeit	Ich empfand die Bedienung der Technologie (VR-Brille) einfach.	Stimme gar nicht zu (1) – Stimme vollkommen zu (+7)

Benutzer-freundlichkeit	Ich habe mich durch die erhaltenen Anleitungen in der virtuellen Umgebung gut zurechtgefunden.	Stimme gar nicht zu (1) – Stimme vollkommen zu (+7)
Benutzer-freundlichkeit	Durch die Nutzung von VR konnte ich mein theoretisches Wissen gut in der Praxis einsetzen.	Stimme gar nicht zu (1) – Stimme vollkommen zu (+7)
Benutzer-freundlichkeit	Ich war insgesamt mit der Benutzerfreundlichkeit der Technologie (VR-Brille) zufrieden.	Stimme gar nicht zu (1) – Stimme vollkommen zu (+7)
Nutzen	Ich bin der Meinung, dass die regelmäßige Nutzung von VR einen positiven Einfluss auf die Lernleistung der Lernenden haben wird.	Stimme gar nicht zu (1) – Stimme vollkommen zu (+7)
Nutzen	Ich bin der Meinung, dass die regelmäßige Nutzung von VR den Lernenden helfen wird, schnell und effektiv zu lernen.	Stimme gar nicht zu (1) – Stimme vollkommen zu (+7)
Compatibility	Ich bin der Meinung, dass die regelmäßige Nutzung von VR im Vergleich zu klassischen Lernmethoden (z.B. dem Einsatz von Lehrbüchern) zu besseren Lernergebnissen führen wird.	Stimme gar nicht zu (1) – Stimme vollkommen zu (+7)
Nutzen	Ich bin der Meinung, dass die regelmäßige Nutzung von VR in der Aus- oder Weiterbildung von Pflegekräften nützlich sein wird.	Stimme gar nicht zu (1) – Stimme vollkommen zu (+7)
Haltung	Ich bin der Meinung, dass Lernende die Bedienung von VR schnell erlernen werden, wenn sie die notwendige Unterstützung erhalten (z.B. Einführungs-Workshop, Anleitungen, etc.)	Stimme gar nicht zu (1) – Stimme vollkommen zu (+7)
Facilitator	Ich bin der Meinung, dass meine Bildungseinrichtung über die notwendige Infrastruktur (z.B. WLAN, geeignete Räumlichkeiten) für den Einsatz von VR verfügt.	Stimme gar nicht zu (1) – Stimme vollkommen zu (+7)
Absicht	Ich habe die Absicht, VR als Trainingsmethode zu nutzen, wenn die Technologie in meiner Bildungseinrichtung zur Verfügung steht.	Stimme gar nicht zu (1) – Stimme vollkommen zu (+7)
Subjektive Erwartung	Ich bin der Meinung, dass meine KollegInnen VR regelmäßig nutzen werden, wenn die Technologie in meiner Bildungseinrichtung zur Verfügung steht.	Stimme gar nicht zu (1) – Stimme vollkommen zu (+7)
Potenziale	Welche Stärken sehen Sie im Einsatz von VR in der Aus- und Weiterbildung von Pflegekräften im	Freitext

	Vergleich zu klassischen Lernmethoden? (in Stichworten)	
Potenziale	Welche Schwächen sehen Sie im Einsatz von VR in der Aus- und Weiterbildung von Pflegekräften im Vergleich zu klassischen Lernmethoden? (in Stichworten)	Freitext
Potenziale	Welche Chancen sehen Sie im Einsatz von VR in der Aus- und Weiterbildung von Pflegekräften im Vergleich zu klassischen Lernmethoden? (in Stichworten)	Freitext
Potenziale	Welche Risiken sehen Sie im Einsatz von VR in der Aus- und Weiterbildung von Pflegekräften im Vergleich zu klassischen Lernmethoden? (in Stichworten)	Freitext
Potenziale	Für welche weiteren klinischen Anwendungsfelder/ Szenarien könnte VR Ihrer Meinung nach sinnvoll eingesetzt werden? (in Stichworten)	Freitext

18.2 Introduction Workshop – Consent Declaration – Survey

Introduction

As part of the "Virtual Reality (VR) in Nursing" project, we aim to evaluate the use of VR in the education and training of nursing staff. To this end, we have developed a questionnaire with 25 questions. We kindly ask you to fill this out as a participant in our workshop. You will need approximately 15 minutes. If you have any questions, please feel free to contact our workshop team on-site. Thank you very much for your cooperation. Before we start, you can inform yourself about data protection details here: [Link]

Information and Consent Declaration for the Project
Please read the following information carefully. If you have any questions, we are at your disposal:
The data collected in this questionnaire will be used to evaluate the use of VR in the education and training of nursing staff.
This survey is conducted by Digital Health Transformation eG (dht).
Within the scope of the project, the following data will be collected, stored, processed, and evaluated: Questionnaire data on personal attitudes and expectations towards Virtual Reality technology as well as personal data (age, gender, highest educational qualification, field of specialization, and professional experience).
The collected data will be kept until the end of the project, but for no longer than 10 years.

Additionally, the deletion of the data will be reviewed every five years. Data processing is based on your consent. The legal basis is Art. 6 para. 1 sentence 1 lit. a GDPR. Participation in this survey is voluntary. Non-participation will have no negative consequences for you. Furthermore, you have the right to revoke your consent at any time, effective for the future, without affecting the lawfulness of processing based on consent before its withdrawal. Please address any revocation of your consent to: michael.mut@digital-health-transformation.de

Consent Declaration (please tick)
I consent to the processing of my data for the purpose of scientific evaluation. I am aware that the processing is voluntary and that I can refuse or revoke my consent at any time without any disadvantages for me, whereby the revocation does not affect the lawfulness of the processing carried out on the basis of the consent until the revocation.
I do not consent to the processing. This will have no negative consequences for me.

Questionnaire

Category	**Question**	**Answer**
Demographic Characteristics	With which gender do you identify?	m / f / d
Demographic Characteristics	To which of the following age categories do you belong?	< 18 / 18-30 / 31-40 / 41-50 / 51-60 / >61
Demographic Characteristics	Which department do you belong to?	Nursing / Medical Service / Hospital Administration / Educational Institution / Other
Demographic Characteristics	How many years of professional experience do you have in a clinical setting?	<1 / 1-5 / 6-10 / >10
Demographic Characteristics	What is your highest educational qualification?	School leaving certificate / Vocational training / College degree / Doctorate
Demographic Characteristics	What role do you have in education and training?	Learner / Educator / None / Other

Category	Question	Answer
Habit	I had prior experience with digital tools in teaching (e.g., digital learning platforms).	Strongly disagree (1) – Strongly agree (+7)
Habit	I had prior experience with Virtual Reality (VR).	Strongly disagree (1) – Strongly agree (+7)
Perceived Usefulness	I found the operation of the technology (VR headset) easy.	Strongly disagree (1) – Strongly agree (+7)
Perceived Usefulness	I found it easy to navigate in the virtual environment with the instructions received.	Strongly disagree (1) – Strongly agree (+7)
Perceived Usefulness	Using VR allowed me to effectively apply my theoretical knowledge in practice.	Strongly disagree (1) – Strongly agree (+7)
Perceived Usefulness	Overall, I was satisfied with the usability of the technology (VR headset).	Strongly disagree (1) – Strongly agree (+7)
Perceived Ease of Use	I believe that regular use of VR will have a positive impact on learners' performance.	Strongly disagree (1) – Strongly agree (+7)
Perceived Ease of Use	I believe that regular use of VR will help learners to learn quickly and effectively.	Strongly disagree (1) – Strongly agree (+7)
Compatibility	I believe that regular use of VR, compared to traditional learning methods (e.g., using textbooks), will lead to better learning outcomes.	Strongly disagree (1) – Strongly agree (+7)
Perceived Ease of Use	I believe that regular use of VR in the education and training of nursing staff will be beneficial.	Strongly disagree (1) – Strongly agree (+7)
Attitude	I believe that learners will quickly learn how to operate VR if they receive the	Strongly disagree (1) – Strongly agree (+7)

Category	Question	Answer
	necessary support (e.g., introductory workshop, instructions, etc.)	
Facilitator	I believe that my educational institution has the necessary infrastructure (e.g., Wi-Fi, suitable premises) for the use of VR	Strongly disagree (1) – Strongly agree (+7)
Intention	I intend to use VR as a training method if the technology is available at my educational institution.	Strongly disagree (1) – Strongly agree (+7)
Subjective Norm	I believe that my colleagues will use VR regularly if the technology is available at my educational institution.	Strongly disagree (1) – Strongly agree (+7)

19 DECLARATION OF MY OWN WORK

I declare that this thesis is entirely my own work, that I wrote it myself without the assistance of others, and that I have used only the materials and sources declared as such within it. I further declare that I have fully referenced all ideas and verbatim quotations taken from other works.

Berlin, 27.03.2024 Rodrigo Silva

[redacted]