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Klara Luisa Brandt, Year 6, Group 1

INTEGRATED STUDY MASTER'S THESIS

Virtualios realybės efektyvumas medicinos mokyme

Effectiveness of Virtual Reality in Medical Education

Supervisor Lect. Rytis Jankauskas

Head of the department or clinic doc. dr. Agnė Jakavonytė-Akstinienė

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Student's e-mail: klara.brandt@mf.stud.vu.lt

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2. PUBLICATIONS

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LIST OF ABBREVIATIONS

XR – Extended Reality

VR – Virtual Reality

AR – Augmented Reality

MR – Mixed Reality

AI – Artificial Intelligence

EI – Emotional Intelligence

EC – Emotional Competence

SG – Serious Games

SG4NS – Serious Games for Nursing Students

ViPATalk – Virtual Patient Talk

SUMMARY

Relevance of the Topic and Scientific Level of Investigation: Extended reality, particularly Virtual Reality, is becoming increasingly important in medical education as it provides an immersive learning environment that enhances both procedural and non-technical skills. Although Virtual Reality is widely applied in the training of technical competencies, its role in developing Emotional Competence and medical history-taking skills remains insufficiently explored. Existing studies are often limited by small sample sizes, short evaluation periods, and non-standardized methodologies. In addition, there is a lack of comparative analysis of different Virtual Reality approaches and their impact on competency development. This study analyses two Virtual Reality–based projects in medical and nursing education in order to better understand their benefits for holistic learning and patient care. The study was approved by the ethics committee.

Aim and Objectives: The aim of this thesis is to evaluate the effectiveness of two Virtual Reality training programs for medical and nursing students regarding user experience, learning outcomes, and pedagogical impact.

Objectives:

1. To analyse how Virtual Reality-based training supports emotional competence in nursing students.
2. To evaluate the effectiveness of Virtual Reality in improving anamnesis skills in medical students.
3. To compare learning experiences, benefits, and challenges of both Virtual Reality approaches.
4. To identify key success factors and limitations of Virtual Reality implementation in medical education.

Subject and Object of the Study: The subject of the study is Virtual Reality in medical education. The objects of the study are two virtual reality programs applied in different medical training contexts.

Materials and Methods: A qualitative research design was applied. Data were collected through semi-structured interviews with eight participants involved in the development or implementation of one of the analysed projects. All participants had at least one year of experience using Virtual Reality in medical education. Since no suitable validated instruments were available for assessing Emotional Competence and anamnesis skills, an individual interview questionnaire was developed. The data were analysed using thematic analysis and qualitative data analysis software.

Main Results: The study results demonstrated that virtual reality provides an immersive and flexible learning environment that supports the development of history-taking and Emotional Competence. The main advantages included the possibility of repeated practice, high student engagement, and structured feedback. Limitations included technical barriers, high costs, and physical side effects. Student feedback was predominantly positive, and experts emphasized that virtual reality increases

learners' self-confidence; however, it is most effective when combined with traditional teaching methods. Future developments are expected to involve broader integration of extended reality and artificial intelligence into medical education.

Conclusion: Virtual Reality is a promising supplementary tool in medical and nursing education. Both analysed projects demonstrated its potential to improve history-taking skills, Emotional Competence, student engagement, and self-confidence. However, successful implementation requires technical infrastructure, institutional support, and integration into study programs. Virtual Reality should complement traditional teaching by providing experiential learning opportunities.

Keywords: medical education, virtual reality, medical students, nursing students, serious games, ViPATalk.

SANTRAUKA

Temos aktualumas ir mokslinio tyrimo lygis: Išplėstinė realybė, ypač virtualioji realybė, tampa vis svarbesnė medicinos edukacijoje, nes suteikia įtraukiančią mokymosi aplinką, gerinančią tiek procedūrinius, tiek netechninius įgūdžius. Nors virtualioji realybė plačiai taikoma techninių kompetencijų ugdymui, jos vaidmuo vystant emocinę kompetenciją ir anamnezės rinkimo įgūdžius vis dar yra nepakankamai ištirtas. Esami tyrimai dažnai apsiriboja mažomis imtimis, trumpais vertinimo laikotarpiais ir nestandartizuotomis metodikomis. Be to, trūksta skirtingų virtualiosios realybės metodų bei jų poveikio kompetencijų ugdymui lyginamosios analizės. Šiame darbe analizuojami du virtualiąja realybe paremti projektai medicinos ir slaugos studijose, siekiant geriau suprasti jų naudą holistiniam mokymuisi ir pacientų priežiūrai. Tyrimas buvo patvirtintas etikos komiteto.

Tikslas ir uždaviniai: Šio darbo tikslas – įvertinti dviejų virtualiosios realybės mokymo programų efektyvumą medicinos ir slaugos studentams, analizuojant vartotojų patirtį, mokymosi rezultatus ir pedagoginį poveikį.

Uždaviniai:

1. Išanalizuoti, kaip virtualiąja realybe pagrįstas mokymas padeda ugdyti slaugos studentų emocinę kompetenciją.
2. Įvertinti virtualiosios realybės efektyvumą gerinant medicinos studentų anamnezės rinkimo įgūdžius.
3. Palyginti abiejų virtualiosios realybės metodų mokymosi patirtis, privalumus ir iššūkius.
4. Nustatyti pagrindinius virtualiosios realybės diegimo medicinos edukacijoje sėkmės veiksnius ir ribotumus.

Tyrimo dalykas ir objektas: Tyrimo dalykas – virtualioji realybė medicinos edukacijoje. Tyrimo objektai – dvi virtualiosios realybės programos, taikomos skirtinguose medicinos mokymo kontekstuose.

Medžiaga ir metodai: Buvo taikytas kokybinis tyrimo dizainas. Duomenys rinkti pusiau struktūruotų interviu metu su aštuoniais dalyviais, kurie dalyvavo vieno iš analizuojamų projektų kūrime arba įgyvendinime. Visi dalyviai turėjo bent vienerių metų patirtį naudojant virtualiąją realybę medicinos edukacijoje. Kadangi nebuvo tinkamų validuotų instrumentų emocinei kompetencijai ir anamnezės rinkimo įgūdžiams vertinti, buvo sukurtas individualus interviu klausimynas. Duomenys buvo analizuojami taikant teminę analizę ir kokybinių duomenų analizės programinę įrangą.

Pagrindiniai rezultatai: Tyrimo rezultatai parodė, kad virtualioji realybė suteikia įtraukiančią ir lanksčią mokymosi aplinką, padedančią ugdyti anamnezės rinkimo bei emocinės kompetencijos įgūdžius. Pagrindiniai privalumai buvo galimybė kartoti praktiką, aukštas studentų įsitraukimas ir struktūruotas grįžtamasis ryšys. Ribotumai apėmė technines kliūtis, dideles išlaidas ir fizinius

šalutinius poveikius. Studentų atsiliepimai daugiausia buvo teigiami, o ekspertai pabrėžė, kad virtualioji realybė didina besimokančiųjų pasitikėjimą savimi, tačiau didžiausias efektyvumas pasiekiamas ją derinant su tradiciniais mokymo metodais. Ateityje tikimasi platesnės išplėstinės realybės ir dirbtinio intelekto integracijos medicinos edukacijoje.

Išvada: Virtualioji realybė yra perspektyvi papildoma priemonė medicinos ir slaugos edukacijoje. Abu analizuoti projektai parodė jos potencialą gerinti anamnezės rinkimo įgūdžius, emocinę kompetenciją, studentų įsitraukimą ir pasitikėjimą savimi. Tačiau sėkmingam diegimui būtina techninė infrastruktūra, institucinis palaikymas ir integracija į studijų programas. Virtualioji realybė turėtų papildyti tradicinį mokymą, suteikdama patirtinio mokymosi galimybes.

Raktažodžiai: medicinos edukacija, virtualioji realybė, medicinos studentai, slaugos studentai, rimtieji žaidimai, ViPATalk.

1 INTRODUCTION

Extended Reality (XR) has been playing a significant role since the 1990s in education across a variety of fields, with one of its earliest and most notable applications being flight simulators. (1) This longstanding use shows that making use of XR for training purposes is not a novel concept. However, the rapid technological advancements of recent decades have opened numerous new possibilities for medical education, positioning XR as one of the most promising developments in this field.

XR encompasses various forms of immersive technologies, including Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR). (2) VR creates a fully computer-generated environment that users can interact with in real time. One differentiates between immersive and non-immersive VR: in immersive VR one can experience the virtual world via special devices, for example by headgear or haptic systems, while non-immersive VR produces the virtual world on a display. AR adds virtual objects to the real environment and therefore augments the real world, the reality, typically requiring devices such as smartphones, tablets, or AR glasses. Lastly, MR combines virtual and real surrounding to a new environment in which the user can interact with virtual objects in the real world. This type of XR requires specialized hardware to be used. (3)

The integration of Artificial Intelligence (AI) into XR environments significantly enhances immersive learning experiences by enabling adaptive and interactive simulations. AI-driven virtual agents, such as avatars or non-player characters powered by Large Language Models, can engage learners in realistic conversational scenarios. This is particularly relevant in medical education, where such systems can be applied to simulate clinical interactions, including anamnesis interviews and patient communication training. Furthermore, AI facilitates the rapid generation of complex learning environments and scenarios, reducing development time while increasing realism. Importantly, AI-based systems can dynamically adapt to the learner's progress and individual learning needs, thereby supporting personalized and competency-based education. (4)

Recently, XR technologies are increasingly integrating a range of sensory experiences - visual, tactile, and beyond - into virtual environments. (1) The versatility of XR has found applications in various domains other than medicine such as research, architecture and construction, industry and manufacturing, and, of course, entertainment, to name just a few.

In the medical field specifically, XR is being utilized across various areas. This includes training in radiology and in surgical simulations, allowing for risk-free practice of complex procedures. (5,6) XR is also proving invaluable for specialized training, such as single extracorporeal membrane oxygenation-cannulation, where precision and repeated practice are critical for patient outcomes. (7)

Recognizing the high potential of these new technologies, the aim of this master's thesis is to evaluate the effectiveness of VR-based training using two programs for medical and nursing students, with a particular focus on user experience, learning outcomes, and pedagogical impact.

The study seeks to systematically examine how XR is applied in medical education, to evaluate its effectiveness, and to determine whether these technologies are currently being sufficiently utilized in medical training. Two specific educational contexts are addressed: first, the extent to which VR-based training can enhance EC in nursing students, and second, the effectiveness of VR applications in improving anamnesis skills in medical students. In addition, the learning experiences, challenges, and benefits of both VR approaches are compared to identify key success factors as well as potential limitations of VR in medical education.

The object of this work is the application and efficacy of VR in medical education, while the subject of the investigation comprises two educational projects conducted in Portugal and Germany. The underlying hypothesis is that VR-based medical education fosters deeper reflection and a more nuanced perception of EC and clinical communication when compared to traditional teaching methods.

The relevance of this topic lies in the growing integration of immersive digital technologies in healthcare education. This thesis therefore provides a comprehensive analysis of the effectiveness of VR in medical education and offers valuable insights for the future development of innovative teaching and learning strategies.

2 LITERATURE REVIEW

2.1 THEORETICAL FOUNDATIONS AND DEFINITION

XR is an umbrella term encompassing immersive technologies such as VR, AR, and MR. VR creates a fully simulated digital environment, offering users a multisensory experience that feels as real as possible using specialized hardware and software. In contrast, AR enhances the real world by overlaying digital content such as text, images, videos, or 3-dimensional models onto the physical environment. MR goes a step further by blending the digital and physical worlds - real objects can be integrated into virtual settings, or digital elements can be placed into the real world, merging natural and artificial perception. To experience these immersive realities, users rely on specific technologies, such as smartphones, tablets, smart glasses, and other wearable devices. (8)

2.2 EXAMPLES OF VIRTUAL REALITY IN MEDICAL EDUCATION

VR is already being applied in many fields of medicine. Examples of successful projects/research outcomes can be found for VR applications in medical education, effectiveness/safety of surgical operations and therapy of chronical diseases.

For the first aspect, especially surgery shows huge potential in which VR is being applied in medical education. VR technologies enable the visualization of anatomical structures in realistic, three-dimensional models, helping students, surgical residents and surgeons to develop a more intuitive understanding of complex spatial relationships. Beyond education, VR also offers significant benefits in surgical planning by allowing precise, patient-specific simulations. This can contribute to greater surgical accuracy and reduce the risk of postoperative complications. (9)

Another striking example of VR's potential lies in the field of telemedicine, where a remote expert surgeon can virtually place their hands within a resident surgeon's field of view, providing real-time guidance and support during a procedure. (10) Another compelling case, published in 2024, involved the use of preoperative imaging data processed through a software to design a personalized osteotomy guide. This guide was fabricated using a 3D printer prior to surgery. During the procedure, a holographic projection of the patient-specific anatomy was visualized in real-time through a HoloLens head-mounted display. The surgery was performed successfully, with no complications, and the integration of VR technologies demonstrably enhanced the precision and safety of the intervention. (11)

Additionally, research has been conducted on using VR in a therapeutical context, for example in Alzheimer's disease. Alzheimer's disease is a progressive, irreversible neurodegenerative condition that severely impacts cognitive functions, daily activities, and behaviour. As the disease advances, individuals increasingly struggle with memory loss, disorientation, and a gradual loss of independence, making everyday life more and more challenging. (12)

Considering these impairments, researchers have begun exploring the potential of VR as a supportive, non-pharmacological tool in the care of affected patients. One promising approach involves immersing patients in calming, familiar environments - such as virtual reconstructions of the streets from their childhood neighbourhoods. These carefully designed scenarios aim to evoke memories and emotions from earlier life stages, potentially stimulating neural pathways and reinforcing cognitive function. Recent studies have already demonstrated the positive emotional effects of VR in patients with Alzheimer's. Immersive experiences have been shown to promote a sense of well-being, reduce anxiety, and create meaningful engagement.

Beyond emotional benefits, VR also offers a therapeutic platform for training problem-solving and navigation skills in a playful, low-risk setting - fostering safe cognitive stimulation. Although still in its early stages, the research suggests that VR holds significant promise as a complementary therapeutic tool. With continued investigation and technological refinement, it may one day become a valuable addition to the treatment and management of Alzheimer's disease and other forms of dementia - working alongside traditional medication to improve quality of life and preserve mental function for as long as possible. (13)

Another example of the application of emerging technologies in therapeutic settings is a systematic review and meta-analysis published in 2022, which examined the effectiveness of VR-assisted movement therapy for targeted motor rehabilitation of the upper extremities in patients recovering from stroke. (14) The analysis compared outcomes between traditional rehabilitation methods and VR-supported interventions, aiming to determine whether immersive technology offers measurable benefits in restoring motor function. The findings revealed that VR-based therapies led to significantly greater improvements in upper limb motor function compared to conventional approaches. One of the key advantages of VR lies in its ability to increase patient motivation and engagement, which in turn fosters better adherence to rehabilitation protocols. Moreover, the immersive environment enables highly repetitive, task-specific training - an essential factor in promoting neuroplasticity and supporting the brain's ability to reorganize and recover motor skills after stroke-related damage. Therefore, this study underscores the potential of VR to serve as a valuable adjunct to standard therapies, offering a more dynamic and individualized approach to stroke rehabilitation.

However, despite these advantages, several challenges still hinder the widespread and reliable integration of XR into everyday clinical practice. These include the complexity of the software, issues with wireless connectivity, and the ergonomic limitations of current wearable devices. (9)

2.3 EXTENDED REALITY USE IN NURSING EDUCATION

Previous studies have shown that simulation-based nursing education is highly effective in developing a variety of nursing practice skills, including thinking and responding in different situations, communication skills, clinical practice competence, empathy, and self-confidence. Future qualified nurses working in a changing and increasingly multicultural society need to acquire practical skills, essential knowledge, values and attitudes that will enable them to provide culturally appropriate and safe care to all citizens. Simulation learning enables this. Simulation learning technologies have improved significantly and include several methods that allow students to learn without real patients, the main methods of learning simulation being VR environments, simulated patients and hybrid simulations. These tools allow learners to practice and master a variety of clinical skills, from basic procedures to complex techniques.

2.3.1 VIRTUAL SIMULATION AND HUMANISATION COMPETENCIES IN NURSING STUDENTS

A quasi-experimental study conducted in 2020 explored whether virtual simulation could enhance nursing students' humanization competencies. (15) Students participated in simulated nursing video consultations with standardized patients and completed assessments before and after the training,

showing an improvement in their overall humanization scores. Six realistic home-care cases were developed, including conditions such as hypertension, post-operative care, anxiety disorders, pressure ulcers, and paediatric illnesses. Students worked in small teams to conduct the consultations while their peers observed online. Humanization competencies were measured using the Healthcare Professional Humanization Scale, which evaluates dimensions such as self-efficacy, sociability, affection, emotional understanding, and optimism. Overall, the results suggest that virtual simulation with standardized patients can support the development of more humanized nursing care and represents a promising educational approach, although further research with larger samples is recommended.

2.3.2 SIMULATION BASED LEARNING AND SELF CONFIDENCE IN NURSING STUDENTS

Simulation-based learning has been shown to significantly enhance the self-confidence of nursing students. A systematic review of 15 primary studies found that simulation improved students' confidence in performing clinical tasks, strengthened teamwork skills, increased assurance in outpatient care, and enhanced communication with both patients and colleagues within the healthcare system . (16) These results suggest that simulation is an effective method for fostering both self-confidence and clinical competence in nursing education.

More broadly, simulation-based training in medical education provides learners with the opportunity to practice clinical scenarios in a safe, controlled environment where mistakes do not compromise patient safety. This approach supports the development of technical skills, such as performing medical procedures, as well as non-technical competencies, including communication, teamwork, clinical decision-making, and critical thinking. Through repeated practice and structured feedback, students can improve their performance and build confidence, particularly in complex or emergency situations. Collaborative simulation exercises further promote interprofessional teamwork and enhance communication within healthcare teams. (16)

Despite these benefits, simulation-based education has limitations. Implementation often requires substantial financial resources, specialized equipment, and trained instructors. Moreover, although simulations closely resemble real clinical scenarios, they cannot fully replicate the complexity and unpredictability of real patient interactions. Nevertheless, the evidence indicates that simulation-based learning is a valuable educational strategy, effectively enhancing self-confidence, clinical skills, teamwork, and patient safety in both nursing and broader medical education.

As clinical simulations represent an effective learning method in nursing, a further distinction can be made between high-fidelity and medium-fidelity simulations. A study shows that students participating in medium-fidelity simulations reported higher levels of satisfaction than those

participating in high-fidelity simulations. (17) However, both types of simulation improved students' communication skills. Medium-fidelity simulation proved to be cost-effective and efficient for acquiring basic skills. High-fidelity simulation does not automatically offer advantages; its benefit rather depends on the students' prior knowledge and experience.

The study recommends the use of simulations of all fidelity levels, as they promote competence development and increase students' motivation to learn by fostering satisfaction with their own performance.

2.3.3 STUDY ON THE EFFECTIVENESS OF VIRTUAL REALITY IN NURSING EDUCATION

Several studies have investigated the effectiveness of VR in nursing education. A meta-analysis of 12 studies with a total of 821 participants showed that VR can significantly improve students' knowledge. However, in terms of practical skills, satisfaction, self-confidence, and completion time, VR showed no advantage over traditional learning methods, indicating the need for further, methodologically sound studies with larger sample sizes. (18)

A more comprehensive systematic review, which analysed 23 studies from nine countries and included a total of 1,929 students, arrived at similar, but in some respects expanded, results. This review showed that virtual simulations can positively influence not only knowledge but also practical skills and affective learning outcomes such as attitudes, engagement, and self-efficacy. Various virtual learning methods were used, including virtual patient simulations, VR software, and game-based learning environments. The evidence suggests that virtual technologies are particularly effective in promoting cognitive and transferable skills and supporting positive learning experiences. (19)

Overall, the studies confirm that VR and virtual simulations make a valuable contribution to nursing education, especially for knowledge transfer, while the effects on practical skills and affective learning domains should be further investigated. The literature included in the review is summarized in Table 1 provided in Annex 1.

3 RESEARCH METHODS

3.1 RESEARCH DESIGN AND RATIONALE

This study adopts a qualitative research design, which is particularly well suited for investigating subjective experiences, perceptions, and meaning-making processes, as qualitative research focuses on understanding experiences and the meanings individuals assign to them (20). The aim is to conduct an in-depth analysis of two VR-based training programs: Serious Games for Nursing Students (SG4NS) with a specific focus on the training of Emotional Competence and Virtual Patient Talk (ViPATalk) with a specific focus on clinical anamnesis skills.

While quantitative research approaches primarily emphasize measurable outcomes, the present study seeks to understand how and why specific pedagogical effects emerge within immersive learning environments. A qualitative, interview-based design therefore appears particularly appropriate to address the exploratory nature of the research and to adequately capture the complexity of teaching and learning processes within VR contexts.

The selection of semi-structured interviews as the primary data collection method allows for both comparability across participants and the necessary flexibility to capture individual experiences and in-depth insights. As the use of VR to foster emotional competence and enhance clinical communication skills remains a relatively young field of research, the openness inherent in qualitative interviews facilitates the emergence of new themes that may not yet be comprehensively addressed in the existing literature.

To ensure a structured and transparent research process, the study follows a multi-stage design that aligns with the qualitative research approach and the overall objectives of the thesis.

The research process was divided into eight consecutive stages, each associated with specific tasks and a defined timeline:

Stage I. Choosing a topic (December 2024):

In this phase, the research topic was defined, including the scope, objectives, and structure of the thesis. The relevance of VR in medical education was established to provide the theoretical foundation of the study.

Stage II. Primary literature analysis (until February 2025):

An initial review of relevant literature was conducted, focusing on VR in medical education. This stage also included a preliminary analysis of the SG4NS and ViPATalk projects.

Stage III. Preparation of the research methodology (until March 2025):

The qualitative research design was developed and the use of semi-structured interviews as the main data collection method justified.

Stage IV. Literature analysis and selection (until April 2025):

A more detailed review of the literature was carried out. Key findings from both selected VR projects were analysed.

Stage V. Preparation of the research instrument and ethical considerations (May- July 2025):

The interview guide was designed, tested, and refined in consultation with the supervisor. This stage also included contacting project partners, organizing interviews, and addressing ethical requirements. Ethics committee approval was obtained.

Stage VI. Collection of empirical research data (July 2025 – December 2025):

Empirical data were collected through semi-structured interviews with stakeholders involved in the selected VR projects.

Stage VII. Data analysis (December 2025 – February 2026):

The collected data were analysed using MAXQDA and interpreted in relation to the existing literature.

Stage VIII. Preparation of results and conclusions (February 2026 – April 2026):

The findings were synthesized and discussed, conclusions were drawn, and the thesis was finalised, including preparation for the defence.

3.2 IDENTIFICATION OF OBJECTS

For the qualitative investigation, two VR projects ViPATalk from Germany and SG4NS from Portugal were deliberately selected, as they address key aspects of the research question on the application and effectiveness of VR in medical education in a complementary manner.

Both projects represent didactically and conceptually different, yet equally relevant, fields of VR application in healthcare education. While ViPATalk focuses on the use of VR to improve communication skills and anamnesis interview techniques among medical students, the SG project aims at the development of EC in nursing students within simulated clinical decision-making situations. In this way, the projects enable a broad and differentiated examination of VR-based learning that includes cognitive, communicative, and emotional learning objectives.

The combination of both projects contributes significantly to ensuring that the research question is not narrowed to a single profession or competency dimension but instead analyses VR as an interprofessional and versatile educational tool. The inclusion of medical and nursing students broadens the perspective of the study and allows for a comparison of different learning needs, didactic objectives, and professional roles in the clinical context. This results in a higher level of insight regarding the transferability and generalizability of the findings.

Another decisive factor in the selection of the projects is the practical feasibility of the study. Existing institutional contacts and cooperation opportunities allow for realistic access to project leaders, educators, and participants, as well as the conduct of interviews within the planned timeframe. However, these aspects do not represent a limitation of the scientific quality but rather ensure a methodologically sound and in-depth qualitative data collection.

In summary, ViPATalk and the SG4NS project were selected because they contribute optimally to answering the research question in terms of content, didactics, and methodology, broaden the thematic scope of VR in medical education, and at the same time enable a realistic and high-quality implementation of the study.

3.3 DESCRIPTION OF THE SELECTED VIRTUAL REALITY PROJECTS

3.3.1 SERIOUS GAMES FOR NURSING STUDENTS PROJECT

The Portuguese project called SG4NS aims to integrate EC into the training of nursing students. It recognizes EC as a fundamental skill to effectively interact with patients and accurately make decisions. In addition, it is an important skill for teamwork and professional relationships. (21)

EC is a term coined by Salovey and Meyer in 1900. They formulate it as “a subset of social intelligence that involves the ability to monitor one's own and other's emotions, to discriminate among them and to use this information to guide one ‘s own thinking and actions”. (22)

In 1995, Daniel Goleman wrote a book about EC, which sets out 5 points for the process of determining EC in five levels, including self-awareness, self-regulation, motivation, empathy and social skills. (23)

Additionally, it is important to discriminate between Emotional Intelligence (EI) and EC: EI refers to the underlying emotional abilities and traits a person possesses, such as recognizing, understanding, and managing emotions. It serves as a prerequisite or foundation for effective emotional functioning. EC, in contrast, is the practical application of EI in real-life situations. It develops from EI and translates emotional abilities into observable behaviours and performance outcomes. (24)

While EI is necessary, it is not sufficient on its own to achieve sustained improvements in academic, professional, or personal performance. Long-term effectiveness requires the development of EC, which builds upon EI and directly contributes to measurable results. (24)

Interpersonal relationships and emotions play a central role in nursing care and have a significant influence on the quality of care. Studies therefore show that it is essential to address this aspect as part of nursing training to prepare future nurses to deal professionally with their own emotions and those of their patients. (25)

To create higher clinical standards, the project has formulated several key objectives. Firstly, a digital prototype platform of the simulated clinical setting was created as well as a comprehensive training program on EC, which can be incorporated into the curriculum. An EC handbook and a SG manual was produced. In addition, reports on the project were disseminated, including publications and advertising.

The SG4NS prototype is implemented as a virtual reality–based escape room with a linear, story-driven structure centred on the characters John and Mary. Players explore a dark, immersive environment and gradually uncover fragments of the narrative through interactive elements such as diary pages and notes, which encourage individual interpretation. The play uses puzzle-solving, object interaction, spatial exploration, and constrained mechanics to maintain engagement and support reflection. The central design principle of the game is to evoke positive and negative emotions. Positive emotions mainly arise from goal achievement and progression, while negative

emotions are triggered through environmental, narrative, auditory, and mechanical elements, including darkness, unsettling visuals, sound effects, and physically or cognitively stressful tasks. Rather than teaching technical nursing skills, the SG4NS prototype aims to immerse nursing students in emotionally charged situations, enabling them to experience, recognize, and reflect on their emotional responses in a safe virtual environment, thereby supporting the development of EC. (26)
Additionally, the platform offers students the opportunity to learn at their own pace. As the platform is reusable, it can be used worldwide, raising the global standard.
The effectiveness of this project depends on specialized training for nursing teachers, who should have competencies in EC, expertise in the use of SG and good pedagogical skills to enable the best possible supervision and teaching of students.
A transnational partnership is sought to realize these goals together. Combining experiences and approaches to nursing education from different European countries helps to achieve a comprehensive exchange of information where each institution can benefit from another. A further advantage is that through this co-operation, culturally sensitive issues and norms of each country can be specifically considered and communicated and taught in the platform.
The SG4NS developers plan to strengthen academic and research partnerships through this project and to enhance existing collaborations with universities in Spain, Italy, Malta and Romania. (27)

3.3.2 VIRTUAL PATIENT TALK PROJECT

The second project on the matter is called ViPATalk and is conducted in Germany. This abbreviation stands for Virtual Patient Talk and was initiated at the medical faculty of Martin Luther University in Halle/Saale. The goal of this project is to teach medical students how to collect a well-structured and complete anamnesis from patients using an interactive software system. The system consists of a chatbot designed as a question-and-answer framework. Speech-to-text technology enables students to ask their questions, which are then recognized by the software. This recognition generates the virtual patient's responses, which are presented in standardized patient videos. To create a more realistic experience, animated videos of actors are used, giving the impression that they are answering the questions. Instead of a computer-generated voice, the answers are prerecorded to enhance authenticity. After the student has completed the anamnesis, feedback is provided, with questions being evaluated according to their level of importance—essential, important, or secondary.
Subsequently, a randomized evaluation study was conducted to compare the success of the platform with previously used role-playing. A video analysis of the patient interviews showed that the ability for a complete medical anamnesis was not reached. Both groups, ViPATalk and role-play, asked a mean of 61,2% and 63,3% of all relevant questions, respectively. Those numbers were statistically tested equivalent, showing no difference in both groups. Only minor differences were observed in the

individual aspects: the role-play group asked slightly more about the psychosocial history, while the ViPATalk group inquired in more detail about the acute symptoms. Overall, the study results indicate that there was no significant difference, but notably ViPATalk as non-inferior.

Additionally, a questionnaire for the students was used to gather feedback. ViPATalk offers the advantage of being used independently of time and location, while showing comparable learning outcomes. Students found the tool useful and expressed a desire to use it at home as well. In the future, it is planned to create more patient cases and to use the platform more extensively. Future students will determine whether the tool can improve the quality of anamnesis interviews. (28)

3.3.3 COMPARISON OF SERIOUS GAMES FOR NURSING STUDENTS AND VIRTUAL PATIENT TALK

Although both projects use virtual reality as an educational tool, they differ fundamentally in their pedagogical focus and implementation strategy.

Table 2: Comparison of the two Virtual Reality Projects

	SG4NS (Portugal)	**ViPATalk (Germany)**	**Key Difference**
Learning Objective	Emotional competence, empathy, reflection, decision-making	Structured anamnesis, communication flow, clinical questioning	Soft skills vs procedural communication skills
Type of Immersion	Emotionally immersive escape-room and virtual (not necessarily clinical) environment	Structured dialogue simulation with chatbot and standardized patient videos in clinical environment	Emotional immersion vs conversational clinical simulation
Feedback Mechanism	Structured and guided reflection with trained teacher	Pre-recorded feedback videos, objective interview evaluation	Reflective debriefing vs structured performance feedback
Scalability	Teacher-dependent, supervision-intensive, educator training	Flexible independent use, suitable for home learning, more scalable	Pedagogically intensive vs operationally scalable

As shown in Table 2, SG4NS primarily aims to foster emotional competence, self-awareness, and reflective practice through emotionally immersive scenarios, whereas ViPATalk focuses on improving structured anamnesis skills, clinical reasoning, and communication techniques through standardized patient interaction. While SG4NS relies heavily on guided reflection and debriefing processes, ViPATalk emphasizes objective feedback through structured evaluation of interview performance.

Furthermore, SG4NS requires stronger educator involvement and teacher training, while ViPATalk offers greater scalability and flexibility through independent use outside the university setting. These differences demonstrate that the effectiveness of VR depends less on the technology itself and more on the specific learning objectives, pedagogical design, and institutional context.

Additionally, SG4NS is already an international project, cooperating with different universities in Spain, Italy, Malta and Romania, while ViPATalk is, until now, a local project of Halle University in Germany.

In previous research, the Portuguese Project was evaluated using a systematic literature review to test for its effectiveness, while the German Project was evaluated using a randomized evaluation study. The results showed that SG4NS and ViPATalk both contribute to the digitalization of medical education for nursing and medical students, respectively.

3.4 STUDY PARTICIPANTS AND SAMPLING CRITERIA

Participants for this study were recruited from three distinct professional groups: educators in medical and nursing education, simulation and project coordinators, and software developers who were directly involved in the SG4NS or ViPATalk projects. These individuals were identified as key informants due to their close and active involvement in the conceptual development, pedagogical implementation, and/or technical maintenance of the VR-based training systems. Their expert perspectives provide particularly valuable insights into the practical, pedagogical, and developmental dimensions of immersive medical education, making them especially well-suited to address the research objectives of this study. Moreover, regarding demographic criteria, it should be noted that there are only very few experts across Europe who possess specialized knowledge and practical experience in this field, resulting in a small and highly exclusive expert population whose expertise is both rare and particularly valuable for research in VR-based medical education.

To be eligible for inclusion, participants were required to have at least one year of experience working with VR in a medical or nursing education context. Additionally, they had to be currently or previously involved in the design, implementation, or further development of one of the two VR programs under investigation and be willing to participate in a qualitative interview conducted in either English or German. Individuals who had only peripheral contact with the VR systems or lacked sufficient hands-on experience were excluded to ensure the relevance, depth, and quality of the collected data.

A purposive sampling strategy was employed to deliberately select participants whose professional roles, expertise, and experiences closely aligned with the aims of the research. This targeted approach is particularly appropriate for qualitative research designs, where the emphasis lies on generating rich,

information-dense data from knowledgeable informants rather than achieving statistical representativeness.

Due to structural and organizational constraints within the two projects, the number of potential participants was inherently limited. For this reason, the calculation of a statistically representative sample size using probabilistic methods, such as Cochran's formula, was considered inappropriate, as such approaches presuppose substantially larger populations. (see Fig. 1) Cochran's formula is a widely used probabilistic method to determine the sample size needed for a study in order to achieve a desired level of precision and confidence. It calculates the minimum number of participants required based on the expected proportion of the population exhibiting a certain characteristic, the acceptable margin of error, and the desired confidence level. (29) However, this formula assumes a large or well-defined population, which is not the case for highly specialized expert groups. (30) Moreover, according to the selected criteria - science, nursing, universities, and VR projects - there are very few specialists worldwide, making this a highly exclusive and rare expert population.

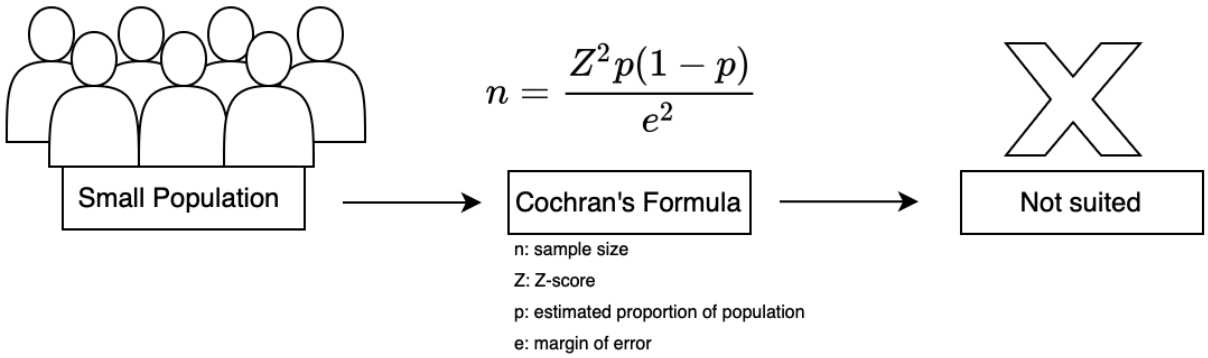

Figure 1: Impracticality of Cochran's Formula in this study (created with draw.io)

Additionally, in qualitative research, sample adequacy is primarily determined by the principle of thematic saturation rather than by numerical sample size. In close consultation with the academic supervisor, it was therefore determined that, given the depth and methodological rigor of the semi-structured interviews and the senior or leading positions held by the interviewees, a relatively small number of in-depth interviews per project would be sufficient to comprehensively address the research questions.

Consequently, the decision to conduct a limited number of interviews was considered a realistic, methodologically sound, and context-sensitive sampling strategy. Potential participants were contacted via email and offered the option to complete the interview in person, via Microsoft Teams, or in written form on a computer. The participant recruitment process followed a structured approach, including identification, screening, and inclusion phases. A total of 18 potential participants were initially identified for the study, including 14 individuals involved in the ViPATalk project and four

participants from the Serious Games project. No participants were removed prior to screening. All 18 participants were screened for eligibility, and none were excluded at this stage. However, not all participants could be reached or agreed to participate. Specifically, nine participants (eight from ViPATalk and one from the Serious Games group) were not retrieved for further participation.

As a result, a final sample of eight participants was included in the interviews, consisting of six participants from the ViPATalk project and two from the SG project. (See Fig. 2)

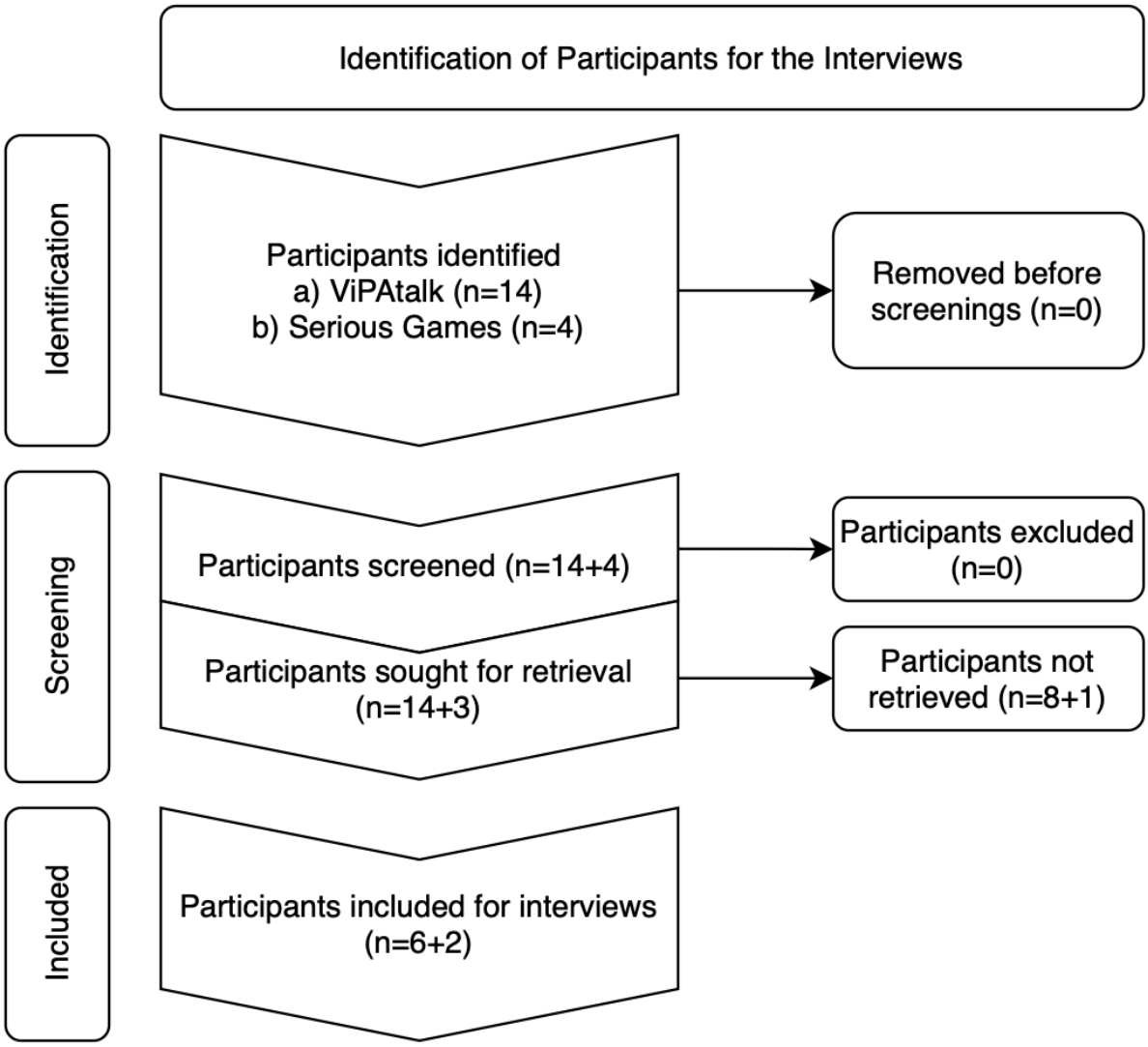

Figure 2: Flow Chart – Identification of Participants (created with draw.io)

The expert status of the participants and their direct involvement in the respective VR projects enabled the generation of rich, detailed, and theoretically meaningful data. Furthermore, the use of semi-structured interviews facilitated an in-depth exploration of complex educational and technological phenomena, thereby increasing the likelihood of achieving thematic saturation within the available sample.

3.5 DATA COLLECTION PROCEDURES

The primary data collection instrument used in this study was a semi-structured interview guide. This interview format combines the advantages of systematic, theory-driven data collection with the openness required in qualitative research. On the one hand, the use of pre-formulated guiding questions ensures that all key aspects relevant to the research question are consistently addressed and that no essential information is overlooked. On the other hand, the semi-structured approach allows for flexible interview dynamics, enabling the interviewer to respond to individual participants, ask follow-up questions, and explore new topics that arise during the conversation. Overall, this approach supports the development of a nuanced and in-depth understanding of the phenomenon under investigation.

As no existing semi-structured interview guide was identified that adequately captured the specific intersection of VR, EC, and anamnesis training in medical education, the interview guide was developed specifically for this study by the author. Its design was closely aligned with the research objectives and aimed explicitly at addressing the overarching research question.

The questions were formulated based on a review of the relevant literature and were designed to ensure scientific relevance, content validity, and alignment with the study objectives.

To ensure content validity and methodological quality, the guide was developed in close consultation with the academic supervisor.

In addition, the underlying research protocol was submitted to and approved by a relevant ethics committee, thereby ensuring adherence to ethical standards and the overall quality of the study.

The interview guide comprised four central thematic areas. At the beginning of each interview, experts were asked about their professional background and their experience with VR technologies. This introductory section served not only to contextualize subsequent responses but also to reconfirm the inclusion criteria. Furthermore, it facilitated a more differentiated interpretation of the data during the analysis phase.

Subsequent sections focused on the development and implementation of the respective VR training environments, as well as on pedagogical assessments of their effectiveness. Topics included didactic concepts, learning objectives, and practical experiences with the use of the systems. In addition, participants were invited to reflect on challenges, limitations, and success factors associated with the use of VR, as well as to discuss potential future developments and perspectives for immersive technologies in medical and nursing education. Table 3, provided in Annex 1, presents an overview of the questionnaire structure, including categories, key elements, sources, and corresponding questions.

This structure ensured a consistent and comparable framework across interviews while still allowing participants sufficient space to elaborate on individual experiences and introduce aspects that may

not have been anticipated by the researcher. The full questionnaire used to guide the interviews is provided in the Annex 2.

Interviews were conducted in either German or English, depending on the participants' preferences. Interview duration ranged from 30 to 60 minutes. To enhance accessibility and accommodate individual preferences and time constraints, participants were given the option to provide their responses either orally in an audio-recorded interview or in written form.

The written responses were collected using the same interview guide and integrated into the analysis as full text transcripts. If there was any uncertainty or a lack of depth in the content, specific questions were asked in order to increase comparability with the oral interviews.

3.6 DATA ANALYSIS

Following transcription, all data were pseudonymised and assigned unique participant codes to ensure confidentiality. The data were then imported into the qualitative data analysis software MAXQDA for data management (coding, retrieval of coded segments). (34) Although MAXQDA is normally a paid software, a free trial of the Pro version was used for this study, providing full access to its features. The analytic interpretations and final theme construction were undertaken by the researcher.

Data were analysed using reflexive thematic analysis following Braun and Clarke's six-phase framework. (35) This framework is illustrated in Figure 3 and was selected because it is particularly suitable for exploring subjective experiences, perceptions, and complex educational processes within innovative learning environments such as VR. Since the aim of this study was not to measure predefined outcomes quantitatively, but rather to understand how participants perceive the pedagogical value, limitations, and implementation challenges of VR in medical education, thematic analysis provided the necessary flexibility and depth. It allowed both expected and emerging themes to be identified across interviews while maintaining a clear connection to the research objectives.

Coding and theme development were conducted primarily inductively and at a semantic level, focusing on participants' explicit meanings and descriptions rather than latent interpretation. The analysis was iterative, moving back and forth between phases as patterns of meaning were developed and refined.

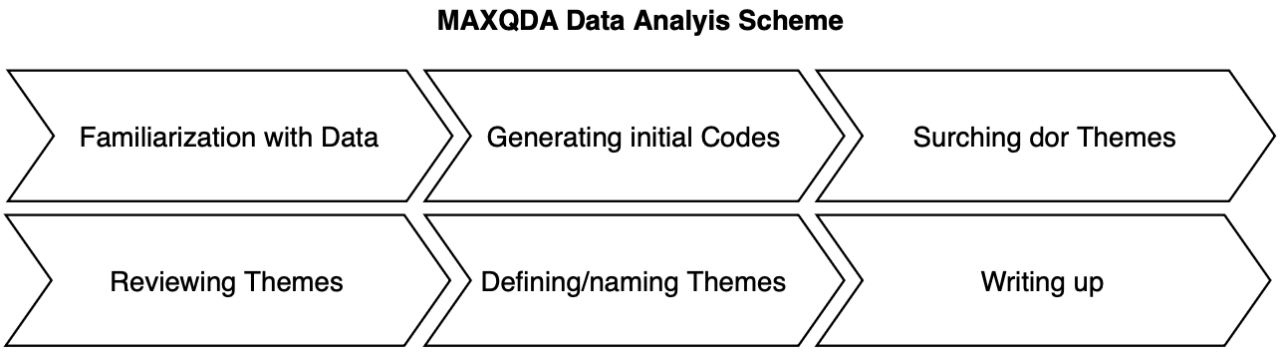

Figure 3: MAXQDA Data Analysis Scheme (created with draw.io)

Figure 3 illustrates the data analysis procedure applied in this study:

1. **Data familiarization:** transcripts were read multiple times to gain an in-depth understanding of the material.
2. **Initial coding:** a systematic, semantic coding process was conducted across the dataset using MAXQDA, with code definitions continuously refined and documented throughout the process.
3. **Theme identification:** codes were grouped into preliminary themes and subthemes according to shared meanings and patterns.
4. **Theme review:** the initial themes were evaluated against both the coded data extracts and the entire dataset, leading to adjustments in their scope and internal consistency.
5. **Theme definition and naming:** each theme was clearly defined by identifying its core concept and ensuring distinct boundaries between themes.
6. **Reporting:** representative quotations were selected, and the themes were linked to the research objectives and existing literature.

Thematic analysis was employed not only to detect recurring patterns within the data but also to organize and interpret the relationships between emerging themes in a structured manner. To improve transparency and methodological rigor, a thematic map was created and is presented later in the results section as Figure 6 on page 30.

To further ensure analytic quality and transparency, the development of themes, including the thematic map as well as the final theme labels and definitions was reviewed in collaboration with the academic supervisor.

3.7 ETHICAL CONSIDERATIONS

This study adheres to established ethical guidelines and was approved by the Ethics Committee of Vilnius University Faculty of Medicine; the approval document is provided in Annex 3. Participants

were fully informed about the aims, scope, and voluntary nature of the study through a detailed informed consent form.

Anonymity and confidentiality were strictly maintained throughout the research process. Participants were identified exclusively through assigned codes, and all personal identifiers were removed during transcription and data storage. Interview recordings and transcripts were stored on a password-protected electronic device. All data will be permanently deleted no later than July 1, 2026. These measures ensure compliance with applicable data protection regulations, including adherence to the official General Data Protection Regulations, and uphold the integrity of the research process. (36)

Figure 4 provides an overview of the individual steps involved in the study's methodology.

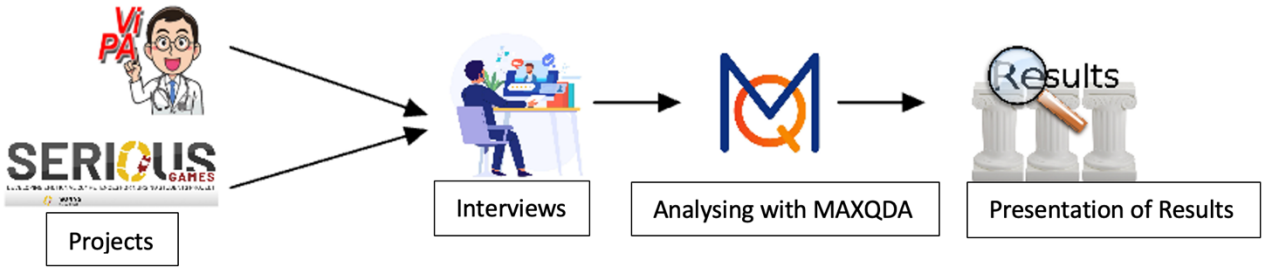

Figure 4: Methodology of Study (created with Microsoft Word)

4 RESEARCH RESULTS

4.1 BACKGROUND OF PARTICIPANTS

The experts interviewed represent a diverse but thematically coherent group whose professional backgrounds include medicine, nursing science, medical didactics, media studies and technical development. All interviewees are actively involved in the development, application or evaluation of VR-based learning formats in higher education and thus have substantial practical experience with immersive technologies in educational contexts.

The participants have been working with VR in medical didactics for several years, with experience ranging from one year to more than nine years, as demonstrated in Table 4.

Table 4: Years of experience using Virtual Reality in medical education

1 Year	1 Participant
5 Years	4 Participants
7 Years	1 Participant
9 Years	2 Participants

This breadth allows for insights from both early adopters and long-time developers of VR-based teaching concepts. Six of the eight interviewees are associated with the German ViPATalk project, while two experts represent the Portuguese SG project.

The professional profiles of the interviewees are diverse and interdisciplinary, as shown by Figure 5.

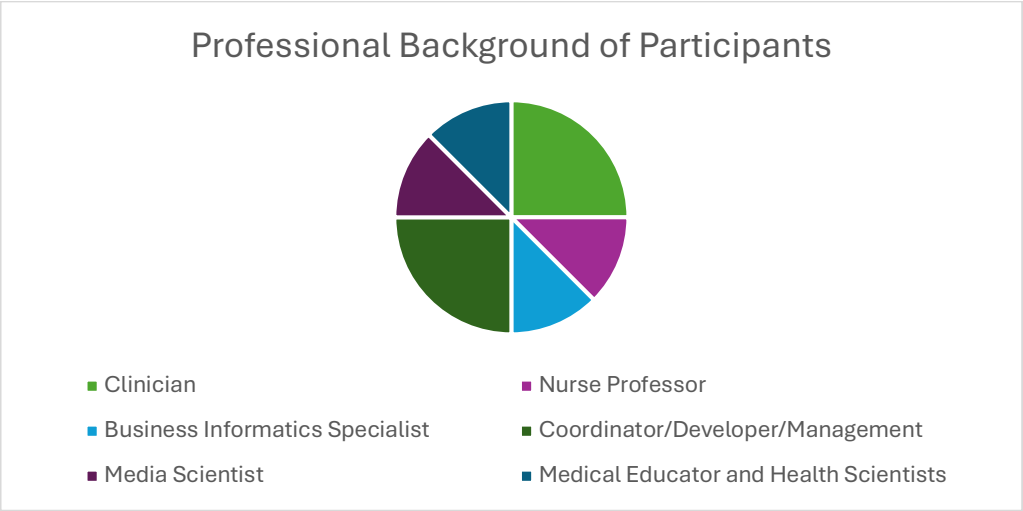

Figure 5: Professional Background of Participants (created with Microsoft Word)

They include media scientists responsible for digitisation strategies and media technology at medical faculties, doctors and medical professionals involved in the design and development of VR-based communication and anamnesis training, business IT specialists, medical educators and health scientists focusing on VR development and implementation, VR developers, project coordinators and managers and initiators of digital education projects.

Overall, the interviewees demonstrate a high level of expertise in the use, development, didactic design and institutional implementation of VR technologies in medical and nursing education. Their combined perspectives provide a comprehensive overview of the technical, didactic and organisational aspects of VR in higher education.

4.2 OVERVIEW OF THEMES

During thematic analysis a thematic map was created, illustrated in Figure 6, showing five overarching themes that collectively explain the role of VR in medical education and its practical implementation. The Map visually represents the hierarchical organization of themes, subthemes, and their interconnections, it illustrates how the central concept - the effectiveness of Virtual Reality in medical education - is embedded within a broader system of interacting factors. The five themes identified are: pedagogical value, limitations and risks, student feedback, key success factors, and difficulties and challenges. These themes are not independent but dynamically interrelated.

For example, pedagogical value is closely linked to subthemes such as immersion, safe learning environments, and structured feedback, which directly contribute to learning outcomes. At the same time, these benefits are influenced and partially constrained by technical and organizational limitations, including costs, infrastructure, and motion sickness. Similarly, student feedback acts as a mediating factor, reflecting both the perceived benefits and the practical challenges of VR implementation.

Furthermore, the theme key success factors - including institutional support, curriculum integration, and trained educators - emerges as a critical condition that determines whether the potential of VR can be effectively realized. These factors are closely connected to the theme difficulties and challenges, highlighting that successful implementation depends on overcoming structural and organizational barriers.

Overall, the thematic map demonstrates that the effectiveness of VR in medical education cannot be understood as a single isolated outcome, but rather as the result of a complex interaction between pedagogical, technical, institutional, and user-related factors. By making these relationships explicit, the thematic map strengthens the analytical depth and transparency of the qualitative findings and directly supports the study’s research objectives.

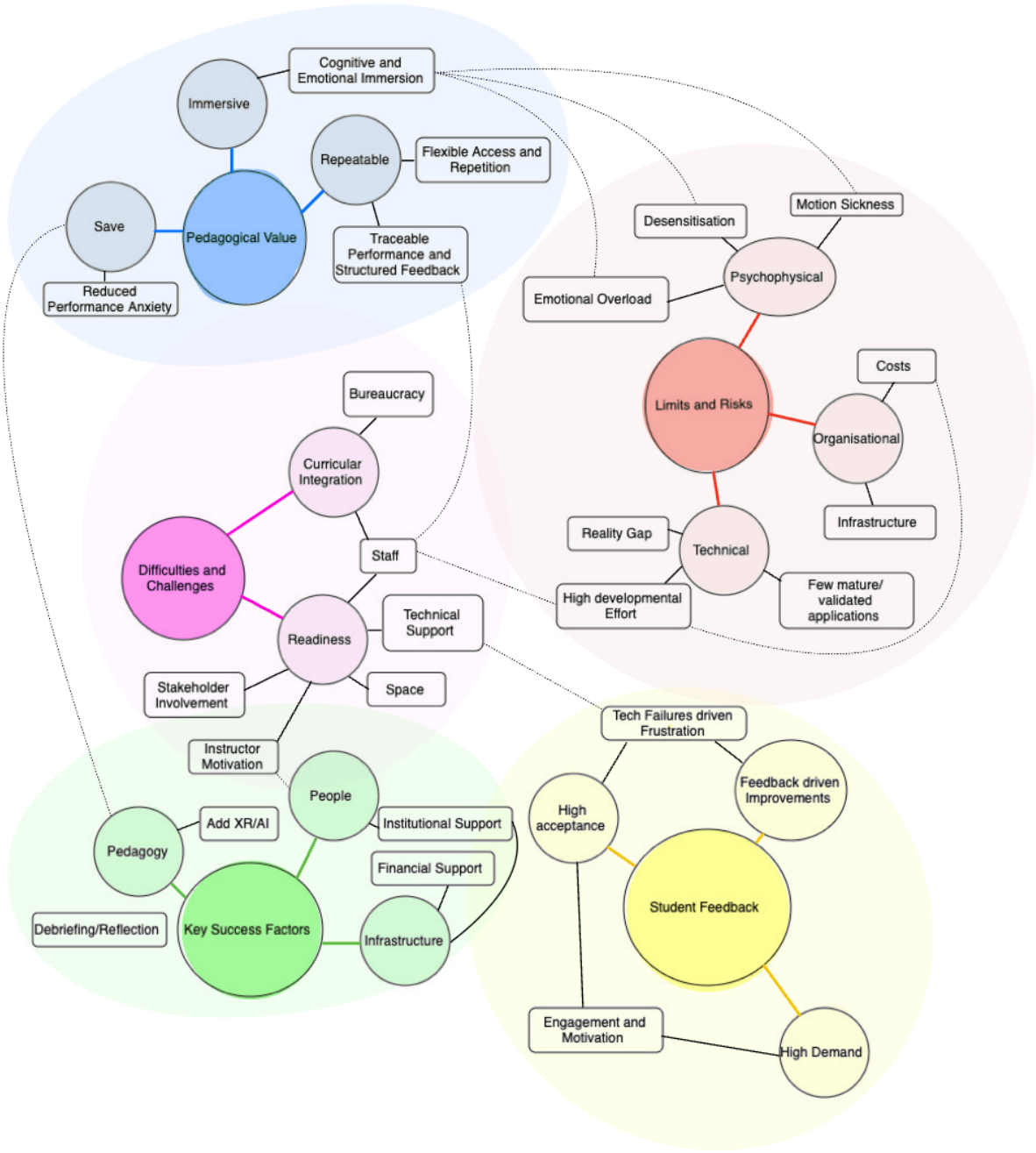

Figure 6: Thematic map representing the core themes, subthemes, and interrelationships identified during the qualitative analysis of Virtual Reality-based learning environments in medical education (created by author using draw.io and Notability)

4.3 ADVANTAGES AND DISADVANTAGES OF VIRTUAL REALITY IN MEDICAL EDUCATION

4.3.1 ADVANTAGES

Across all interviews, VR was described as a technology with significant potential to enrich medical education. A key advantage that was particularly emphasised by the German interviewees is the high degree of temporal and spatial flexibility offered by VR-based learning environments. VR enables

students to train independently of clinical infrastructure, staff availability or access to real patients. This allows for the structured and reliable practice of rare, complex, emotionally demanding or organisationally difficult scenarios that are often underrepresented in traditional curricula. Another key advantage is the safety of the learning environment. VR offers a protected, risk-free space in which learners can practise without endangering patients or themselves. Mistakes can be made and reflected upon without real consequences, which supports experience-based learning and reduces performance anxiety.

Compared to conventional teaching formats such as mannequin simulations or role-playing, the significantly higher degree of immersion offered by VR was highlighted. Learners are involved in the learning process not only cognitively, but also physically and emotionally. This embodied experience increases the realism and can facilitate the transfer of acquired skills into clinical practice. The interactive nature of VR enables active engagement with scenarios instead of passive observation. Another important advantage concerns feedback and evaluation. VR environments allow for the systematic recording of learners' actions, decisions, reaction times and communication patterns. This data can be used for objective, structured and detailed feedback, which is often difficult to implement in traditional teaching settings. Such feedback supports self-reflection and targeted competence development.

In addition, VR promotes self-directed learning and repeated practice. Students can work through numerous scenarios at their own pace, enabling individual learning paths. In communication training in particular, the interviewees emphasised that students could work through significantly more cases in VR than in face-to-face role-plays. In addition, learners often report feeling less socially observed or judged, which contributes to a more relaxed and authentic learning atmosphere. From a curricular and technological perspective, VR has been described as a tool that prepares students for future developments in healthcare. The increasing importance of digital systems, AI, robotics and telemedicine makes technological competence a key professional skill. VR is therefore not perceived as an optional or playful addition, but as a means of preparing future healthcare professionals for relevant digital skills.

The Portuguese project complements this perspective with a stronger focus on emotional learning. VR is described as particularly suitable for a digitally savvy generation of students and as a format that increases engagement and learning effectiveness. The immersive nature of VR allows learners to experience emotionally charged situations in real time and develop authentic emotional responses. This can promote skills in emotional perception, stress management and dealing with uncertainty – skills that are difficult to teach using purely cognitive teaching methods. It is also important to note that VR provides a safe emotional learning space. Students can repeatedly experience challenging situations, reflect on their emotional reactions and learn from them. Especially, the reflection session

following the VR experience was emphasized in one interview as being crucial for enabling the learning process. SG4NS, for example, uses a reflective discussion process (e.g. Gibbs' reflective cycle) to systematically analyse experiences in order to learn from them and improve future actions, as a debriefing method to facilitate reflection and stimulate the learning process. In contrast, ViPATalk employs pre-recorded feedback videos that explain to students' which information would have been essential and why, thereby providing structured feedback.

Overall, the interviews show that VR extends learning beyond the mere acquisition of knowledge by integrating practical skills, emotional involvement and self-reflection. The technology enables realistic, immersive, flexible and safe learning environments while preparing students for an increasingly digitalised healthcare system.

These findings are further illustrated by selected interview statements presented in Table 5.

4.3.2 DISADVANTAGES

Despite these advantages, the interviewees identified several limitations and risks associated with VR-based teaching. The German interviewees focused primarily on technical, organisational and infrastructural challenges. In SG4NS, motion sickness was cited as a limiting factor that restricts the use of VR for some students. Symptoms such as nausea or dizziness can reduce learning effectiveness or lead to sessions being abandoned, as well as the risk of developing claustrophobia.

High acquisition and maintenance costs represent a significant hurdle. VR hardware is expensive, and equipping large cohorts of students – often several hundred medical students per year – is difficult to implement across the board. This problem is exacerbated by rapid technological innovation cycles, as VR devices often become obsolete after only a few years.

It was also stated that, to date, there are only a limited number of pedagogically mature VR applications, and the educational value depends heavily on the quality of the software. The development of high-quality, context-specific VR scenarios requires considerable time, expertise and personnel. In addition, digital fatigue at the administrative level and inadequate technical infrastructure – such as unstable Wi-Fi or limited space – make implementation difficult. The high level of bureaucracy is also highlighted as a core problem. It is difficult to change existing structures and thus supplement or replace traditional learning with innovative VR.

Another recurring criticism was that VR cannot fully replicate the complexity of real clinical encounters. Despite high immersion, VR scenarios inevitably remain simplified representations of reality.

In contrast, the Portuguese project places a stronger focus on health-related, psychological and ethical risks. In addition to physical side effects, potential psychological stress caused by intense sensory and emotional stimulation was also described. A particularly important aspect in the Portuguese context

is the risk of desensitisation. Repeated exposure to simulated patients can unconsciously promote game-like associations and potentially reduce empathy or seriousness in real patient contact. In the long term, this could influence professional attitudes. Certain groups of students – such as highly introverted or emotionally distant individuals – may also have difficulties with emotionally intense VR scenarios.

Overall, the disadvantages can be divided into two main categories: technical and organisational barriers, and health-related or psychological risks. While motion sickness is identified as a common problem, the focus of the projects differs. The German project focuses on structural and implementation-related challenges, while the Portuguese project emphasises emotional, ethical and professional implications. This illustrates that the introduction of VR is not only a technological issue, but also an educational, emotional and professional identity-related one.

An overview of representative interview excerpts supporting both advantages and disadvantages is provided in Table 5.

Table 5: Demonstrative Examples of the Interview Statements about Advantages and Disadvantages of the use of Virtual Reality in medical education

Category	**Subcategory**	**Projects**	**Examples of demonstrative statements**
Advantages and Disadvantages of VR in Medical Education	**Advantages**	SG4NS	> "Students are more motivated to study… they would keep on telling me 'professor, why can't we play more?'" *(IP1)* > "It allows you to create a very immersive environment… emotions are very spontaneous and genuine." *(IP2)* > "VR allows practice in a safe learning environment." *(IP1, IP2)*
		ViPATalk	> "Anytime available, especially for learning scenarios that cannot be planned in reality." *(IP3, translated from German)* > "More practice possibilities than in classical role play." *(IP6, translated from German)* > "More practical relevance, interactive, 'safe' self-experience." *(IP5, translated from German)*

Table 5 continued: Demonstrative Examples of the Interview Statements about Advantages and Disadvantages of the use of Virtual Reality in medical education

	Disadvantages	SG4NS	> "Those students… felt dizzy and motion sickness." *(IP1)* > "Technical issues… sometimes the system doesn't work as expected." *(IP1)* > "There are physical risks… nausea, claustrophobia." *(IP2)* > "Risk of… desensitisation… you are not dealing with real patients, you can have the tendency not to evaluate patients' complaints because you identify them with playability and not value them as human." *(IP2)*
		ViPATalk	> "High development costs and ongoing costs." *(IP3, translated from German)* > "Technical challenges… systems/programs do not run reliably." *(IP3, translated from German)*

4.4 STUDENTS' FEEDBACK AND DEMAND

Student feedback proved to be a central component in both projects, albeit with different focuses and degrees of formalisation. In the German project, feedback is described as a systematic and integral element of course development. Student evaluations are collected regularly and actively used to further develop VR-based teaching formats. These processes enable continuous adaptation and quality improvement of the VR offering.

In several cases, improvements were proactively initiated by teachers based on their own observations, while in other cases changes were made directly in response to explicit student requests. This illustrates a participatory development culture in which students are not only recipients but also active co-creators of innovation. The initial feedback was predominantly positive and characterised by curiosity and openness. At the same time, some students expressed fundamental scepticism about technology-based teaching formats. While many welcomed the opportunity for self-directed learning – especially access from home – others remained cautious about digital solutions in medical education.

A recurring pattern is initial euphoria followed by disillusionment as soon as technical limitations became apparent. Early system errors, usability problems or technical instability led to frustration and, in some cases, rejection of the method.

Overall, the German project can be characterised as highly feedback-oriented, with student evaluations playing a decisive role in the design of VR-based teaching.

In the Portuguese project, student feedback is also predominantly positive but is framed differently. Most students find the immersive and emotionally engaging nature of VR enriching and motivating. At the same time, the interviewee emphasised that a small proportion of students regularly experience physical or technical difficulties such as nausea, dizziness or problems using the VR system, which could lead to them discontinuing the session.

The interviewees interpret these reactions as a 'natural' part of using the technology and not as a failure of the didactic concept. Importantly, these challenges hardly diminish overall acceptance. This is reflected in the exceptionally high demand for VR courses in Portugal. The courses are short, each worth two ECTS credits, yet the number of applicants exceeds the available places by about tenfold, as reflected in interview statements shown in Table 6. This high demand indicates great interest and high perceived relevance. Both projects show that VR-based teaching is generally well received by students and perceived as innovative and motivating.

In comparison, there are differences in the collection, interpretation and integration of feedback. The German project emphasises formalised evaluation structures, iterative further development and the systematic integration of student feedback. Reactions range from enthusiasm to frustration and are heavily dependent on technical reliability and institutional conditions. The Portuguese project, on the other hand, focuses more on subjective learning experiences and general acceptance. Although physical discomfort and technical difficulties affect some students, the high demand indicates a strong perceived benefit.

Overall, the results show that the acceptance of VR does not depend solely on the technology, but significantly on how feedback processes are designed and expectations are managed.

Table 6: Demonstrative Examples of the Interview Statements about Students' Feedback and Demand on Virtual Reality in medical education

Category	**Projects**	**Examples of demonstrative statements**
Students' Feedback and Demand	SG4NS	> "We had 24 places… and more than 200 students wanting to do the course." *(IP1)* > "The number of students that apply… is ten times higher than those we can admit." *(IP2)*

Table 6 continued: Demonstrative Examples of the Interview Statements about Students' Feedback and Demand on Virtual Reality in medical education

	ViPATalk	> "Students reacted very positively." *(IP5, translated from German)* > "Students were curious and open." *(IP4, translated from German)* > "Initial enthusiasm was followed by a certain disillusionment." *(IP7, translated from German)*

4.5 DIFFICULTIES

4.5.1 CHALLENGES

The interviewees described a wide range of challenges in implementing VR in medical education and emphasised that its successful introduction goes far beyond simply providing the technology.

In the German project, technical, organisational and institutional barriers predominate. Key problems include high acquisition and maintenance costs, especially for large student cohorts, as well as short innovation cycles with rapid technological obsolescence. Added to this are limited availability of didactically mature VR applications, high development costs for high-quality scenarios, motion sickness, usability problems and infrastructural deficits such as a lack of human resources, insufficient technical support or inadequate Wi-Fi structures. The Portuguese project focuses more on social and organisational challenges. The active involvement of all stakeholders and institutional support for innovation is particularly relevant. Material resources alone are considered insufficient; commitment, openness and sustainable anchoring at the institutional level are crucial.

The integration of VR into existing curricula is a key challenge in both projects due to structural, organisational and cultural barriers. Both illustrate that VR implementation is a multidimensional process. Successful VR integration therefore requires institutional coordination, acceptance and long-term commitment.

4.5.2 NEED FOR IMPROVEMENT

In both projects, interviewees highlighted that the full potential of VR in medical education is not yet being realised. Key challenges include the need for higher-quality, validated VR applications, limited financial and human resources, and insufficient teacher training in the didactic use of VR. Furthermore, a lack of institutional integration restricts scalability and long-term sustainability. These findings are consistent with the interview statements presented in Table 7, which emphasise the need for improved VR quality, overcoming bureaucratic obstacles, ongoing development based on feedback, and the constraints imposed by limited funding.

Table 7: Demonstrative Examples of the Interview Statements about Difficulties in the use of Virtual Reality in medical education

Category	Subcategory	Projects	Examples of demonstrative statements
Difficulties	**Challenges**	SG4NS	> "Bureaucratic constraints." *(IP2)* > "This is disruptive… people are used to traditional ways of teaching." *(IP2)*
		ViPATalk	> Hardware requirements, supervision, didactical concept." *(IP3, translated from German)* > "In medicine, face-to-face teaching is still the usual form of teaching. Many teachers shy away from the workload of developing complex VR systems… in Germany… VR lessons are not counted towards the teaching obligations of the teachers… VR developments are the teachers' "private pleasure"." *(IP6, translated from German)*
	Need for Improvement	SG4NS	> "We need better serious games with higher quality." *(IP2)*
		ViPATalk	> "The system is continuously developed based on student evaluation." *(IP4, translated from German)* > "Many feedbacks… but not all can be implemented due to missing funding." *(IP5, translated from German)*

4.6 EFFECTIVENESS AND LEARNING OUTCOME

The German interviewees reported predominantly positive effects and great potential of VR on practical skills, clinical competence, and learners' self-confidence. VR was described as supporting procedural confidence, self-awareness, and a better understanding of clinical workflows. These effects were documented through surveys and participant observation, reflecting a structured approach to evaluation. However, one interviewee noted that comprehensive and standardised measurements of learning success are still lacking. Although qualitative and partly quantitative evidence indicates positive outcomes, large-scale and methodologically rigorous evaluations remain limited.

In addition, it was reported that VR-based teaching was perceived as at least equivalent or even superior to traditional role-play formats. Furthermore, VR was described as supporting the consolidation of knowledge through repeated, immersive practice.

In the Portuguese project, the interviewee highlighted that VR enables emotional learning experiences that are difficult to achieve through traditional teaching methods alone. In particular, VR was seen as valuable for fostering emotional intelligence and reflective learning in nursing education.

At the same time, both projects emphasised that VR should not be understood as a replacement for conventional teaching, but rather as a complementary tool that enhances existing educational formats. Overestimating VR carries the risk of treating it as a universal solution instead of using it as a targeted didactic instrument within a broader pedagogical framework.

Overall, both projects demonstrate that VR supports competence-oriented learning and strengthens learners' self-efficacy. Several interviewees also emphasised the overall potential of VR as a future-oriented educational tool.

Table 8: Demonstrative Examples of the Interview Statements about the Effectiveness and Learning Outcome of the use of Virtual Reality in medical education

Category	**Projects**	**Examples of demonstrative statements**
Effectiveness and Learning Outcome	SG4NS	> "The main outcome is to identify emotions and cope with them." *(IP2)* > „It has the potential and mainly addressed to this recent generations… we should invest in it." *(IP 1)*
	ViPATalk	> "Increase of action competence and confidence." *(IP5, translated from German)* > "VR teaching was at least equivalent, partly even better than classical role play." *(IP6, translated from German)* > "Consolidation of knowledge" *(IP 4, translated from German)* > "I see great potential, which will likely remain below its full possibilities due to the high costs and the comparatively small market of medical education." *(IP 8)*

4.7 KEY SUCCESS FACTORS AND FUTURE DEVELOPMENT

4.7.1 KEY SUCCESS FACTORS

Several key success factors were identified by the experts during the interviews. In the German interviews, it was emphasised that the successful implementation of VR in medical education depends

strongly on the openness, motivation, and active engagement of instructors. Teachers need to be willing to integrate VR into their teaching and to identify meaningful use cases with clear clinical relevance. Raising awareness of the didactic potential of VR - particularly through structured faculty training and best-practice examples - was highlighted as a central prerequisite.

In addition, academic recognition of the time and effort required to develop VR-based teaching was described as essential for motivating instructors to engage in such innovations. A stable technical and personnel infrastructure at faculty level further supports sustainability and prevents VR initiatives from remaining isolated pilot projects. Other important factors include the availability of VR equipment, adequate physical space for immersive applications, technical support, and continuous professional development for teaching staff. Moreover, clear learning objectives, curricular integration, and structured reflection phases were identified as key elements for effective implementation.

In the Portuguese project, success factors are more strongly linked to the social and organisational dimension. Interviewees emphasised the need to advocate for VR internally, overcome resistance to change, and promote acceptance of innovative teaching formats. Alongside this, sufficient funding and user-friendly technology were identified as essential conditions for broader adoption.

Across both projects, it becomes evident that the success of VR in medical education relies on the interaction between human, organisational, and technological factors. While the German project places greater emphasis on structural conditions, curricular integration, and long-term institutional embedding, the Portuguese project highlights stakeholder engagement and acceptance as key drivers. These findings are supported by representative interview statements presented in Table 9, which emphasise the importance of funding, staff training, stakeholder involvement, and institutional support.

4.7.2 FUTURE DEVELOPMENT

In the interviews with the German partners, VR in medical education is described as having significant potential for further development, particularly in the expansion of complex serious games and in the transition toward MR and AR. A central objective is to prepare medical students for the digital technologies they will encounter in clinical practice, including AI, robotics, and telemedicine. In this context, VR is not viewed as a supplementary or playful tool, but also as a means of developing essential technological competencies.

The interviewees also emphasised the importance of broader implementation to fully exploit the potential of VR. Opportunities were identified in interdisciplinary and multi-user learning environments, enabling students from different healthcare professions to train collaboratively in immersive scenarios. At the same time, limitations such as high development and implementation

costs, as well as the relatively small market in medical education, were acknowledged as potential barriers. Another important trend is the closer integration of VR-based learning with clinical training to enhance the transfer of knowledge and skills into real-world practice.

The Portuguese perspective complements these developments with a stronger focus on XR, integrating VR, MR, and AR into a more comprehensive educational framework. A key goal is to enable flexible and partly independent learning outside the university setting, while maintaining appropriate levels of supervision. Furthermore, interviewees highlighted the importance of addressing digitally native generations, who are more receptive to immersive and technology-enhanced learning formats. International collaboration and the expansion of XR applications across institutions were also identified as important drivers for future development.

Overall, both projects underline the transformative potential of VR/XR in medical education, while also emphasising that its future success depends on the combination of technological advancement, pedagogical integration, and scalability. The German project focuses more strongly on technological integration and clinical applicability, whereas the Portuguese project highlights flexibility, accessibility, and internationalisation. These trends are reflected in the interview excerpts presented in Table 9, which point to developments such as XR expansion, AI integration, and interdisciplinary learning environments.

Table 9: Demonstrative Examples of the Interview Statements about Key Success Factors and the Future Development of Virtual Reality in medical education

Category	**Subcategory**	**Project**	> **Examples of demonstrative statements**
Key Success Factors and Future Development	**Key Success Factors**	SG4NS	> "We need money… without money we can't do nothing." *(IP1)* > "You have to convince colleagues… resistance to change." *(IP2)* > "Staff training first." *(IP1)*
		ViPATalk	> "Integration into the curriculum, training of teaching staff is necessary, and identification of potential fields of application… flexible access to spaces and technology…Institutional

Table 9 continued: Demonstrative Examples of the Interview Statements about Key Success Factors and the Future Development of Virtual Reality in medical education

			regulations need to be established… funding opportunities." *(IP 3, translated from German)*
	Future Development	SG4NS	> "I think it is the future." *(IP1)* > "The future is XR… not only VR." *(IP2)* > "Integration of VR with AI would be ideal." *(IP1)*
		ViPATalk	> "Isee great potential, which will likely remain below its full possibilities due to the high costs and the comparatively small market of medical education." *(IP 8)* > "An expected trend is interdisciplinary multi-user learning experiences." *(IP 4, translated from German)* > "A significant increase in the simulation of complex serious games, along with a shift toward mixed and augmented reality." *(IP 7, translated from German)*

A consolidated summary of all Interview Results are provided in Table 10 in Annex 1.

5 DISCUSSION OF RESULTS

5.1 SUMMARY OF KEY FINDINGS

Studies provide indications that the use of VR in medical education can be effectively beneficial; however, further research on this topic is repeatedly recommended. (4)

The aim of this work was to investigate the application and effectiveness VR technologies in medical education, as well as to identify the most important success factors in their application based on their examination and research. For this purpose, two immersive educational projects were examined and compared using expert interviews: the SG4NS project from Portugal and the ViPATalk project from Germany. The analysis particularly focused on the perceived learning effectiveness, the user experience, as well as opportunities and challenges in the implementation of virtual reality technologies in medical teaching.

The results show that VR-based learning environments offer several advantages for medical and nursing education. It was emphasized that immersive learning environments enable safe and flexible

training of complex clinical situations. Students can repeatedly practice realistic scenarios without exposing real patients to risks.

In both projects it was reported that immersive simulations can increase learner engagement and can lead to increased self-confidence when dealing with complex clinical situations. The demand and motivation of the students were described as high. In addition, virtual scenarios enable reflection processes, as students can analyse their reactions and decisions in a protected environment.

However, disadvantages of the use of VR were also addressed, including motion sickness, which can be caused by immersive experiences. Furthermore, the risk of desensitization was emphasized as well as technical, financial and organizational or bureaucratic obstacles.

The most important success factors for VR and serious game projects in medical education are motivation and training of teachers, recognition, appropriate infrastructure, curriculum integration, reflection, funding as well as institutional support and stakeholder involvement. Future developments include complex serious games, MR and AR scenarios, interdisciplinary multiuser scenarios, the use of AI and robotics, flexible learning outside the university, international cooperation, technological advancement, pedagogical optimization and a stronger connection to real clinical situations.

5.2 INTERPRETATION OF RESULTS AND COMPARISON WITH EXISTING LITERATURE

Although both projects confirm the educational value of VR in medical education, the different pedagogical functions suggest that the effectiveness of VR is not determined by immersion alone, but by the alignment between technology, learning objectives, and pedagogical design. The findings therefore support the view that VR should be implemented as a targeted educational strategy rather than as a universal teaching solution.

Regarding various advantages of VR use in teaching, the results of this qualitative study are largely consistent with the existing literature. Experts from the German and Portuguese projects particularly emphasized flexibility, immersive learning and the creation of safe learning environments. These aspects are also frequently described in the literature, in which VR is presented as a tool that enables experiential learning without compromising patient safety and allows the repeated practice of complex scenarios. (4) The high level of engagement and motivation observed in the interviews also corresponds to studies showing that immersive environments increase participation and active involvement of learners compared to traditional teaching methods. (37)

The disadvantages identified in this study, however, reflect the ongoing discussions in the literature. Technical problems, limited application possibilities and infrastructure requirements are frequently mentioned as barriers in the implementation of VR. (38) Likewise, health-related burdens such as cognitive overload in immersive simulations or motion sickness or cybersickness have been

documented. (39,40) Interestingly, the German participants in this study emphasized structural and technical barriers more strongly, whereas the Portuguese participants highlighted psychological aspects such as emotional stress and desensitization. This is most likely due to the different learning objectives of the two projects, since one is intended to train hard skills, therefore fewer emotional or psychological problems are addressed by the experts, which are more relevant in the training of EC and soft skills. This difference is less frequently addressed in existing research, as many studies mainly focus on technological limitations and less on emotional risks.

The interviews showed that students generally perceive VR learning environments as immersive and motivating, even though occasional mild discomfort or technical frustrations may occur. These results are consistent with earlier studies showing that students usually report a high level of satisfaction and perceive VR-based learning as engaging and innovative. (41)

Nevertheless, some studies also show more mixed results. Although immersive technologies often receive positive feedback, other research indicates that student acceptance strongly depends on usability, instructional design and technical reliability. (42) This supports the observation of the present study that acceptance largely depends on the design of feedback and technological stability.

The implementation challenges identified in this study correspond to many of the barriers described in the literature. High costs, requirements for technical infrastructure and organizational hurdles were mentioned by participants from both projects. Similar challenges are widely discussed in research on the integration of VR into higher education, where financial investments and institutional readiness are considered central obstacles. (43) However, in existing literature VR is also identified and promoted as a potentially cost-saving solution, by saving space and teaching time. (4)

Another challenge identified in the Portuguese project is the need for stakeholder engagement and institutional support. Although some studies suggest that technological barriers may gradually decrease as VR hardware becomes increasingly affordable and accessible, in contrast the pedagogical integration and curricular embedding may remain long-term challenges even when technological solutions are available. (4)

Furthermore, the expert interviews emphasize the need to expand access and integrate VR more systematically into curricula. While many studies advocate similar improvements, some researchers warn that excessive integration of immersive technologies without clear pedagogical objectives can lead to technology-driven rather than learning-objective-oriented educational strategies. Therefore, the use and integration of such technologies in curricula should be based on solid empirical evidence to employ immersive VR appropriately and fully exploit its potential. (44) This underlines the importance of aligning the implementation of VR with clearly defined educational goals.

At the same time, the literature is not clear regarding the general effectiveness of VR compared to traditional or other simulation-based methods. Some systematic reviews conclude that VR can

improve learning outcomes, but that the differences compared to conventional simulation methods are sometimes only small. (45)

A systematic review, following the PRISMA 2020 statement, has already been conducted, analysing 8 studies on the effectiveness of SG in nursing students, most of which took place in Europe. In addition, one study was conducted in the USA and one in Singapore. The learning material conveyed in the studies is diverse. SG were used in a variety of areas, including first aid, managing complex clinical situations, learning specific techniques, negotiation styles and public health data, to name just a few. However, little attention has been paid to the promotion of "soft skills" such as EC, as evidenced by the small number of studies specifically investigating the development of such skills. Nevertheless, the effectiveness of SG has been recognised as an innovative and motivating learning aid. They have a high level of acceptance among students, demonstrating effective knowledge transfer and the potential of SGs to improve technical and social skills in the care sector, thus providing fertile ground for further research in this area. (21) A recent study on the effectiveness of SG4NS Project was also mentioned during one interview: a recently published article reports on a pilot study investigating the SG prototype, - a VR escape room - designed to enhance EC in nursing students. Participants played the SG and subsequently completed a questionnaire. The study found that VR escape rooms have significant potential to evoke a wide range of emotions, both positive and negative. These findings suggest that this approach could be a valuable pedagogical tool in nursing education. (46)

Other studies emphasize that the effectiveness of VR strongly depends on the pedagogical design and its integration into broader learning concepts and not solely on the technology itself. (32) Moreover, current studies confirm that VR should rather be used as a complement to traditional teaching rather than as a complete replacement. (47)

As one of the most important success factors for the effective use of VR, the participants highlighted the importance of user-friendly technologies and sustainable funding. The literature also emphasizes that usability and accessibility significantly influence the acceptance of VR technologies by both teachers and students. (48)

Regarding future developments, the participants in this study expected a stronger integration of MR technologies, robotics and telemedicine applications and a significant increase in the use of AI in medical teaching. A recent meta-analysis on this topic shows that in clinical education both VR and AI improve knowledge and practical skills, without significant differences being found between the two technologies. Therefore, future research is recommended to conduct direct comparisons between VR and AI, investigate long-term learning effects and develop integrated teaching models that combine the strengths of both technologies. (49)

5.3 STUDY STRENGTHS AND LIMITATIONS

A central strength of the present study lies in the qualitative research design, which enables an in-depth analysis of learning experiences, pedagogical perceptions and implementation processes of VR in medical education. Particularly in a still young research field, this approach allows a better understanding of the learning processes and didactic potentials of immersive technologies that could only be captured to a limited extent through purely quantitative methods.

Another advantage of the study is the comparative approach between two different VR-based training programs that address different competency areas. This makes it possible to identify similarities and differences regarding the promotion of EC and communicative skills in medical learning contexts. In addition, the use of semi-structured interviews allows both a certain comparability of the statements and the capture of individual experiences and new perspectives.

At the same time, several limitations of the study must be considered. One limitation lies in the limited number of participants, which may restrict the transferability of the results to other institutions or training programs. However, this is largely due to the highly specialized nature of the field, as only a small number of experts possess relevant experience in VR-based medical education, making their identification and recruitment inherently challenging. Additionally, a formal audit trail was not maintained; therefore, intermediate analytic decisions are only partially traceable, which may limit the transparency of how themes were refined over time. In addition, the investigation focuses on specific VR applications and learning settings, so the results cannot easily be transferred to all medical specialties. Another aspect is the rapid technological development of VR systems. Since hardware and software are continuously evolving, future applications may offer different didactic possibilities or user experiences than the systems examined in this work. Furthermore, parts of the analysis are based on subjective feedback from the participants, meaning that possible biases in the evaluation of learning experiences cannot be completely excluded.

5.4 FUTURE RESEARCH DIRECTIONS

Future research should investigate the use of virtual reality in medical education with larger and more heterogeneous samples to improve the generalizability of the results. In addition, longitudinal studies would be useful to analyse to what extent VR-supported training has long-term effects on clinical competencies, communication skills and EC.

6 CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

This master's thesis investigated the potential of Virtual Reality for developing both soft and hard skills in medical education. Using a qualitative research design, two Virtual Reality-based training programmes for nursing and medical students were analysed and compared.

1) How VR-based training enhances emotional competence in nursing students:

The expert interviews proof, that emotional competence can be improved by using a virtual, immersive, emotionally engaging, and reflective learning environment, as this has the power to elicit strong emotions in students, negative ones as well as positive ones. An important part of this process is, that later students are able to reflect on them together with their peers and a trained educator. The ability to repeatedly experience and reflect on these situations in a safe setting enhances emotional learning outcomes and has a positive effect on students' general learning motivation. However, the effectiveness of this approach strongly depends on structured reflection phases and pedagogical guidance, highlighting that Virtual Reality alone is insufficient without appropriate didactic integration.

2) The effectiveness of the use of Virtual Reality in improving anamnesis skills in medical students:

The Interview Results indicate that Virtual Reality is an effective tool for improving anamnesis skills in medical students, particularly by enabling flexible, repetitive, and self-directed practice. It allows students to structure clinical interviews and receive objective, standardized feedback. Although it demonstrates comparable outcomes to traditional role-play methods rather than clear superiority, it offers additional advantages in accessibility, scalability, and independent learning. Therefore, Virtual Reality is best understood as a complementary tool that enhances, rather than replaces, existing teaching methods in clinical anamnesis training.

3) How the learning experiences, challenges, and benefits of both Virtual Reality approaches compare to each other:

The comparison of both Projects reveals that learning experiences differ substantially depending on the pedagogical design and learning objectives. Both approaches share key benefits, including increased student engagement, safe learning environments, and opportunities for repeated practice. However, they also face common challenges such as technical limitations, high costs, and the inability to fully replicate real clinical complexity. They differ in the risk of physical side effects, such as motion sickness, which only appears in high immersion technologies. Also, the risk of desensitization is more pronounced in soft skills training. Ultimately, the findings suggest that the effectiveness of Virtual Reality is not determined by the technology itself, but it needs to be adjusted in alignment to meet specific educational goals.

4) Key success factors and potential limitations of Virtual Reality in medical education:

The successful integration of Virtual Reality into medical education depends on several key factors, including technical, pedagogical and institutional aspects. The technical requirements include ongoing development and access to modern hardware and software as well as stable WIFI. At the pedagogical level, the use of increasingly immersive technologies and well-trained, motivated teaching staff are particularly crucial. Institutional success factors include sufficient financial resources, suitable physical facilities and the fundamental willingness of institutions to implement and sustainably establish innovative teaching methods. Furthermore, the removal of bureaucratic hurdles can significantly speed up the introduction of modern technologies. Nevertheless, significant limitations persist, including high costs, technical barriers, limited availability of high-quality applications, and potential physical or psychological side effects.

RECOMMENDATIONS

For nursing and medical education institutions: VR should be integrated into curricula as a complementary tool within structured pedagogical frameworks, with a strong emphasis on educator training and alignment with learning objectives to ensure effective and sustainable implementation.

For health policy makers: Targeted funding, infrastructure development, and the establishment of quality standards are essential to support equitable and effective VR integration.

Healthcare professionals: They should actively contribute to the design of realistic scenarios and foster reflective learning through structured debriefing and interdisciplinary collaboration.

Future research: it should focus on the long-term effectiveness of VR, the transferability of skills to clinical practice and investigate larger and more heterogeneous samples to improve the generalizability of findings.

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ANNEX 1- TABLES

Table 1: Literature Summary of Virtual Reality in medical education

Authors	**Year**	**Journal**	**Study design**	**Key findings**
Bernardo V	2026	TechSonar (EDPS)	Narrative review / report	XR (incl. VR) is increasingly used across sectors; in education it enhances immersive learning and skill acquisition but raises ethical and data concerns.
Yujia G	2025	Surgery (Oxford)	Narrative review	XR is transforming surgical training from traditional methods to immersive simulation; future potential includes improved precision and training efficiency.
Mandal P, Ambade R	2022	Journal of Clinical Medicine	Narrative review	VR/AR improve surgical training in knee arthroplasty by enhancing procedural skills, spatial understanding, and reducing learning curves.
Nakada T et al.	2024	Journal of Clinical Medicine	Case study	XR-assisted surgery improves precision and supports preoperative planning and intraoperative guidance.
Porsteinsson AP et al.	2021	Journal of Prevention of Alzheimer's Disease	Clinical review	Focus on Alzheimer's diagnosis; VR not central but emerging as a supportive tool for cognitive assessment.
Davis E	2024	Meet Life Sciences (Blog)	Narrative article	VR shows potential in memory stimulation in Alzheimer's but evidence is still limited and controversial.

Table 1 continued: Literature Summary of Virtual Reality in medical education

Chen J et al.	2022	Journal of Medical Internet Research	Systematic review & meta-analysis of RCTs	VR-based therapy improves motor function in stroke rehabilitation compared to conventional therapy.
Jiménez-Rodríguez D et al.	2021	Healthcare	Experimental study	Simulation-based digital tools improve humanization skills and communication competencies in nursing students.
Alrashidi N et al.	2023	BMC Medical Education	Systematic review	Simulation significantly improves self-confidence in nursing students in clinical practice.
Alconero-Camarero AR et al.	2021	IJERPH	Comparative study	Nursing students without clinical experience reported higher satisfaction with low-fidelity simulations, while both low- and high-fidelity simulations equally improved communication skills and support competency development.
Chen FQ et al.	2020	Journal of Medical Internet Research	Meta-analysis	VR improves knowledge in nursing education but is not superior to other methods for skills, satisfaction, confidence, or performance time.
Foronda CL et al.	2020	Simulation in Healthcare	Systematic review	Virtual simulation enhances clinical reasoning, knowledge retention, and student engagement in nursing education.

Table 3: Structure of the Questionnaire

Category	Element	Source	Questionnaire questions
Demographic Characteristics	Gender, Age, Education, Professional role, Experience with VR	Compiled by the author (standard qualitative interview practice)	1, 2
Professional Background & VR Experience	Role in project, duration of VR involvement	Compiled by the author; based on qualitative research standards (31)	1, 2
Implementation of VR in Education	Integration into curriculum, frequency of use, implementation process	Adapted from literature on VR in medical education (18,19)	3
Implementation Challenges	Technical, organizational, pedagogical barriers	Based on VR implementation literature (18,32)	4
Feedback and Iterative Development	User feedback, system improvement, adaptation processes	Derived from simulation-based education literature (16,19)	5
Perceived Effectiveness	Learning outcomes, skills acquisition, comparison with traditional methods	Based on meta-analyses of VR effectiveness (15,18)	6, 7
Student Experience & Engagement	Motivation, engagement, behavioral changes	Based on simulation and engagement research (17,33)	8
Evaluation Challenges	Difficulties in measuring outcomes, methodological limitations	Derived from VR evaluation literature (32)	9
Institutional Integration	Organizational support, curriculum integration, infrastructure	Based on implementation frameworks (32)	10, 11, 12

Table 3 continued: Structure of the Questionnaire

Key Success Factors	Pedagogical design, usability, faculty support, scalability	Based on VR adoption literature (32,33)	13
Future Perspectives	Trends, innovation, long-term role of VR	Based on XR trend literature (8,9)	14

Table 10: Summary of Interview Results

Category	German Project	Portuguese Project	Common / Notes
Participants / Background	6 experts, interdisciplinary: medicine, didactics, media, information technology	2 experts, nursing scientist (>29 yrs), VR since 2020	High expertise in VR development, didactics, implementation
Experience with VR	1 year:1, 5 years:3, 7 years:1, 9 years:2	3+ years VR experience	Early adopters to long-term developers
Advantages	Flexibility, safe learning, high immersion, active engagement, structured feedback, self-directed learning, digital competencies	Emotional learning, immersive engagement, safe emotional space, stress & uncertainty management	Realistic, flexible, safe, integrates skills, emotions reflection
Disadvantages / Risks	Technical/org: motion sickness, costs, limited apps, infrastructure, bureaucracy, simplified reality	Health/psychologic: motion sickness, nausea, stress, desensitisation, emotional overload	German = structural; Portuguese = emotional/ethical; overall = technical & health/psych risks
Student Feedback / Demand	Formal evaluations, iterative improvements, co-creation, tech-related frustration possible	Immersive, motivating, high demand (~10x), minor discomfort	Acceptance depends on feedback design and technical reliability

Table 10 continued: Summary of Interview Results

Implementation Challenges	Technical/organisational barriers, high costs, short innovation cycles	Social/organisational barriers, stakeholder engagement, institutional support	Integration into curricula requires coordination and long-term commitment
Need for Improvement	High-quality VR apps, teacher training, infrastructure, institutional support	Broader curriculum integration, access expansion, teacher training	Strategic planning, institutional commitment, didactic integration
Effectiveness / Learning Outcomes	Improves procedural skills, clinical competence, self-confidence; partial evaluation evidence	Supports emotional learning; complements traditional teaching	German focus: technical/procedural; Portuguese: emotional/social; both strengthen self-efficacy
Key Success Factors	Instructor motivation, faculty training, recognition, infrastructure, curriculum integration, reflection, funding	Stakeholder engagement, advocacy, user-friendly tech, funding	Human and structural factors, motivation, institutional support
Future Development	Complex SG, Mixed/AR, interdisciplinary multiuser scenarios, AI/robotics/telemedicine	XR (VR+MR+AR), flexible outside-university learning, international collaboration	Technical advancement, pedagogy, scalability, real clinical linkage

ANNEX 2 – QUESTIONNAIRE

Interview Questions: Qualitative Research on Virtual Reality in Medical Education

Background and Personal Experience

1. What is your professional background, and what role do you play in the VR project?
2. Since when have you been working with VR technologies in medical education?

3. Exploring the Use of Extended Reality in Medical Education
2. How was the VR program integrated into the students' curriculum (e.g., as a supplement, alternative, or replacement to traditional teaching methods)? How frequently was it used?
3. What specific challenges did you face during the implementation of VR?
4. Did you receive feedback from instructors or students that led to adjustments or further development of the VR program?

4. Evaluating the Effectiveness of Extended Reality in Medical Education
6. What advantages do you see compared to traditional teaching methods?
7. What specific learning outcomes have you observed as a result of using VR? Have you done any survey after the VR teaching program?
8. How did students respond to the VR training? Did you notice any changes in their learning behavior or motivation?
9. What challenges or limitations do you see in evaluating the effectiveness of VR?

5. Assessing the Current Use of Extended Reality in Medical Education
10. In your opinion, is the potential of VR in medical education currently being fully utilized?
11. What factors support or hinder the regular use of VR in your institution?
12. Do you believe that sufficient resources (e.g., technical equipment, training, time capacity, funding) are available to implement VR on a broad scale?
13. What are the key success factors for the long-term integration of VR into teaching?
14. How do you see the future of VR in medical education? What new developments or trends do you anticipate?

ANNEX 3 – APPROVAL BY THE ETHICS COMMITTEE OF VILNIUS UNIVERSITY

VILNIAUS UNIVERSITETO
MEDICINOS FAKULTETAS

Klara Luisa Brandt

DĖL MEDICINOS FAKULTETO MOKSLINIŲ TYRIMŲ ETIKOS KOMITETO POSĖDŽIO PROTOKOLO IŠRAŠO IŠSIUNTIMO

Siunčiame Medicinos fakulteto Mokslinių tyrimų etikos komiteto 2025 m. birželio 11 d. Nr.(1.7 E) 150000-KT-454 posėdžio protokolo išrašą.
PRIDEDAMA. 1 lapas.

Greta Zambžickaitė, tel. +370 5 236 6079, el. p. greta.zambzickaite@mf.vu.lt

Išrašas

VILNIAUS UNIVERSITETO
MEDICINOS FAKULTETO
MOKSLINIŲ TYRIMŲ ETIKOS KOMITETAS

POSĖDŽIO PROTOKOLAS

2025-06-11 Nr. (1.7 E) 150000-KT-454
Vilnius

El. balsavimas vyko 2025 m. birželio 10-11 d.

Posėdžio pirmininkas VU MF SMI Visuomenės sveikatos katedros asistentė dr. Jelena Stanislavovienė.

Posėdžio sekretorius VU MF SMI vyr. specialistė Greta Zambžickaitė.

Posėdyje dalyvavo: VU MF SMI Slaugos katedros asist. dr. Aldona Mikaliūkštienė, VU MF TSTI Populiacijų genomikos laboratorijos vyresnioji mokslo darbuotoja Laura Pranckėnienė, VU MF SMI Sveikatos etikos, teisės ir istorijos centro docentė dr. Aistė Bartkienė, VU MF SMI Reabilitacijos, fizinės ir sporto medicinos katedros docentė dr. Aurelija Šidlauskienė, VU MF SMI Optometrijos katedros docentas dr. Saulius Galgauskas, VU MF KMI Akušerijos ir ginekologijos klinikos docentė dr. Diana Bužinskienė, VU MF KMI Anesteziologijos ir reanimatologijos klinikos jaun. asistentas Vaidas Vicka, VU MF BMI Anatomijos, histologijos ir antropologijos katedros lektorė Rūta Morkūnienė, VU MF BMI Fiziologijos, biochemijos, mikrobiologijos ir laboratorinės medicinos katedros asistentė dr. Inga Bikulčienė, VU MF Odontologijos instituto docentė dr. Rasmutė Manelienė. Kvorumas priimti sprendimus buvo, nes posėdyje dalyvavo 11 narių iš 11.

1. SVARSTYTA. Medicinos vientisųjų studijų programos ketvirto kurso studentės Klara Luisa Brandt baigiamojo darbo tyrimo protokolo ir instrumento vertinimas.

NUTARTA. Studentės Klara Luisa Brandt baigiamojo darbo tyrimo protokolo ir instrumento turinys neprieštarauja vykdomojo tyrimo etikos normoms ir VU MF Mokslinių tyrimų etikos komitetas pritaria tyrimo instrumento naudojimui.

VU MF Mokslinių tyrimų etikos komiteto
pirmininkė dr. Jelena Stanislavovienė

Posėdžio sekretorė Greta Zambžickaitė

DETALŪS METADUOMENYS	
Dokumento sudarytojas (-ai)	Vilniaus universitetas 211950810, Universiteto g. 3, 01513 Vilnius
Dokumento pavadinimas (antraštė)	DĖL MEDICINOS FAKULTETO MOKSLINIŲ TYRIMŲ ETIKOS KOMITETO POSĖDŽIO PROTOKOLO IŠRAŠO IŠSIUNTIMO
Dokumento registracijos data ir numeris	2025-06-26 Nr. (1.6 E) 150000-S-578
Dokumento gavimo data ir dokumento gavimo registracijos numeris	–
Dokumento specifikacijos identifikavimo žymuo	ADOC-V1.0
Parašo paskirtis	Pasirašymas
Parašą sukūrusio asmens vardas, pavardė ir pareigos	Greta Zambžickaitė, Vyriausioji specialistė, Sveikatos mokslų institutas
Sertifikatas išduotas	GRETA ZAMBŽICKAITĖ LT
Parašo sukūrimo data ir laikas	2025-06-26 10:12:12 (GMT+03:00)
Parašo formatas	XAdES-T
Laiko žymoje nurodytas laikas	2025-06-26 10:12:25 (GMT+03:00)
Informacija apie sertifikavimo paslaugų teikėją	EID-SK 2016, AS Sertifitseerimiskeskus EE
Sertifikato galiojimo laikas	2024-11-07 17:38:38 – 2027-11-07 17:38:38
Informacija apie būdus, naudotus metaduomenų vientisumui užtikrinti	"Registravimas" paskirties metaduomenų vientisumas užtikrintas naudojant "RCSC IssuingCA-2, VI Registru Centras - i.k. 124110246 LT" išduotą sertifikatą "Dokumentų valdymo sistema Avilys, Vilniaus universitetas, į.k. 211950810 LT", sertifikatas galioja nuo 2024-12-18 09:02:06 iki 2027-12-18 09:02:06
Pagrindinio dokumento priedų skaičius	1
Pagrindinio dokumento pridedamų dokumentų skaičius	–
Pridedamo dokumento sudarytojas (-ai)	–
Pridedamo dokumento pavadinimas (antraštė)	–
Pridedamo dokumento registracijos data ir numeris	–
Programinės įrangos, kuria naudojantis sudarytas elektroninis dokumentas, pavadinimas	Dokumentų valdymo sistema Avilys, versija 3.5.85.2
Informacija apie elektroninio dokumento ir elektroninio (-ių) parašo (-ų) tikrinimą (tikrinimo data)	Atitinka specifikacijos keliamus reikalavimus. Visi dokumente esantys elektroniniai parašai galioja (2025-06-26 10:40:15)
Paieškos nuoroda	–
Papildomi metaduomenys	Nuorašą suformavo 2025-06-26 10:40:15 Dokumentų valdymo sistema Avilys

DECLARATION OF AUTHORSHIP

I hereby declare that this master's thesis entitled "Effectiveness of VR in Medical Education" has been written independently by me and that I have used only the sources and materials indicated in the references. All parts of the thesis that have been taken from other works, either directly or indirectly, have been appropriately cited.

This thesis has not been submitted in the same or similar form to any other university or institution for the award of any academic degree.

I confirm that the work presented in this thesis is my own and that all ethical guidelines for academic writing and research have been followed.

Place, Date: Zwickau, 05.05.2026

Signature: Klara Brandt

Name: Klara Luisa Brandt