Study Protocol:
Comparing Mixed Reality, Video-Based, and Instructor-Led Training for Nasogastric Tube Insertion in Nursing Students

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RESEARCH PLAN

1 Literature review

This study focuses on learning clinical skills in nursing education and compares the students' learning outcomes of Mixed Reality Learning, Video-Based Learning and Instructor-led training in Nasogastric Tube (NGT) insertion. Learning clinical skills during nursing studies is known to enhance students' clinical competence and confidence (Gregersen et al., 2021; Edward et al., 2017). Clinical skills in this context are defined as both technical and non-technical skills, such as correct technique of NGT insertion, aseptic technique, patient education and interaction. A literature review by Motta et al. 2021 found that although nasogastric tube insertion is considered a simple procedure, incorrect NGT insertion into the airways or trachea can cause serious complications for the patient. The wrong location can cause discomfort, delayed eating, as well as increase mortality and increase hospital stay. Other adverse events included sinusitis, nasopharyngeal discomfort, nasal septal erosion, pressure ulcer and nosebleeds upon removal. (Motta et al., 2021.) Previous studies have shown that effective training increase students' confidence in correctly performing the steps for NGT insertion, assessing proper placement, and understanding potential complications (Kaltenmeier et al., 2022; Bomozah, 2020; Darawad et al., 2015).

Nursing education needs new teaching methods and strategies that encourage students to actively apply their clinical skills (Handeland et al., 2021; Natarajan et al., 2022). Millennial nursing students, who have embraced virtual learning, acknowledge the significant impact of teaching technology on their attention, knowledge acquisition, critical thinking, and overall satisfaction (Natarajan et al., 2022). Utilizing digital health technologies in education is important. These technologies can enhance and support individual student learning experiences and needs and contribute to sustainable development (European Commission, 2018; Opetus-ja kulttuuriministeriö, 2023; Valtioneuvosto, 2022).

Mixed reality (MR) is a promising tool for teaching clinical nursing skills (Schoeb et al., 2020; Rochlen et al., 2022). MR connects the real world to the virtual world with the help of special devices such as MR glasses. MR provides visual and auditory information and sometimes also sound, haptics, taste, smell, etc. (Speicher et al., 2019.) The term Extended Reality (XR) is also used, which is to describe "all" forms of new realities. XR includes Mixed Reality (MR), Augmented Reality (AR) and Virtual Reality (VR) and their various subforms. (Rauschnabel et al., 2022.) MR glasses are used to successfully perform clinical nursing skills through virtual instructions (San Martin-Rodriguez et al., 2019; Kim et al., 2021). Integrating MR into training allows healthcare professionals and students to practice and improve their technical and non-technical skills, as well as making clinical nursing decisions in critical and constrained situations safely (Frost et al., 2020; Son et al., 2023; Wunder et al., 2020). MR is a promising technique and tool for education to teaching clinical skills because it produces similar learning outcomes as teacher guidance (Schoeb et al., 2020; Ryan et al., 2022). The use of MR glasses has not been studied in nursing students at the NGT insertion.

It has been found the students' new learning experiences with MR can influence their satisfaction with the learning environment and the subject matter, which can lead to an improvement in their learning outcomes. (Almufarreh, 2023). The use of MR can enhance students' motivation and interest in the

subject being studied, facilitate individual learning, and increase the sense of success (Stelter & Kim, 2023; Rochlen et al., 2022). Using MR fostered a better and longer-term absorption of students' knowledge (Kolecki et al. 2022) and students experienced more meaningful learning (Chen 2021).

Usability is theoretically defined as the degree to which the user experiences learnability, efficiency, and satisfaction when using technology system (Shultz et al. 2015). MR can compensate for the shortcomings in VR, such as motion sickness and dizziness caused by isolation from the outside world. Therefore, MR can be used for longer periods than VR. This finding implies that MR can be applied in clinical nursing as the technology advances to integrate virtual and real environments. (Kim et al., 2021.) MR systems usability evaluated in Schoeb study 40.2% of participants (N=57) reported MR glasses difficult to use, and 28.9% believed they could only use the system with the help of the director. In its usability MR glasses still have shortcomings such as short battery life, complex handling as well as the necessary fast, reliable internet connection. (Schoeb et al., 2020.) The challenges of using MR include the novelty and unfamiliarity of the technology for the instructors. In the future, the use of MR should stress the importance of preparation at both the individual and the organizational level, as well as providing technical support to facilitate immersive learning. (Son et al., 2023.) The problem of availability remains, as MR devices are not widely used, and their accessibility should be enhanced (Kolecki et al., 2022).

Educational institutions, students, and health professionals should actively participate in the development of digital health technology (HIMSS, 2021; World Health Organization, 2021) In addition, it would be relevant to assess the usability of Mixed Reality Learning and Video-Based Learning as a learning method in nursing education. Despite some existing research on the topic, MR technology is still novel at the educational level and the potential of MR as a learning method has not been fully explored, especially learning nursing skills in nursing education. Previous research also indicates the need for further investigation into MR use in nursing education.

2 Research objectives and hypothesis

The main objective of the study is to develop Mixed Reality and Video Based Learning interventions and evaluate the results of the interventions. The aim is to assess and compare the learning outcomes of nursing students in nasogastric tube insertion using Mixed Reality Learning, Video-Based Learning and Instructor-led training. The aim is also to assess and compare the MR technology and video usability and to describe students' experiences with MR technology and identify the factors that either facilitate or hinder the learning of nursing skills within an MR environment.

Phases:

1. Development of the intervention; The aim is to develop two interventions. Intervention one is Mixed Reality Learning where the first-year nursing students will use MR glasses and virtual instructions for inserting a nasogastric tube. Intervention two is Video-Based Learning where the first-year nursing students will use video-based learning (VBL) materials to follow the same NGT insertion process. This includes the design, development and testing of the intervention.
2. Evaluation of the intervention; The aim is to assess and compare how different learning methods (Mixed Reality Learning, Video-Based Learning, and Instructor-led training) affect students' learning outcomes in NGT insertion. The study will also compare the usability of MR and video technology and describe students' experiences with MR technology.

The research hypothesis is that Mixed Reality learning (MR) and Video-Based learning (VBL) will both lead to better learning outcomes for first-year nursing students in nasogastric tube (NGT) insertion and clinical skills learning compared to traditional Instructor-led training. The expectation is that MR learning will produce the highest usability scores and most positive learning experiences.

3 Research implementation

The study will be conducted as a randomized controlled trial (RCT) with first-year nursing students in one University of Applied Sciences. In the first phase, the aim is to develop a Mixed Reality and Video- Based intervention utilizing the Medical Research Council (MRC) Framework. The MRC Framework serves as a guide for researchers in designing research projects and aids in the development and evaluation of complex interventions.

The MRC framework 2021 includes four phases of intervention: development or identification of the intervention, feasibility, evaluation, and implementation (Skivington et al., 2021). The students are randomized into three groups, intervention 1 (MR group), intervention 2 (video group), and control (Instructor-led) in a manner where the researcher has no influence on the allocation of the groups. Randomization is done using a computer program. The inclusion criteria are the following: the student is studying to become a nurse, student performing the NGT insertion procedure for the first time and had no theory or pre-material on the treatment procedure. Exclusion criteria include: the student has no previous nursing education (e.g. practice nurse), students have no epilepsy or the pacemaker.

In the second phase students answer questions about demographic information and answer a theoretical exam (pre-test) on nasogastric tube insertion to assess their baseline knowledge and skills. The pre-test is used to measure the homogeneity of the groups. Student performance is measured using a structured NGT checklist (primary endpoint). A structured NGT checklist are used to assess students' clinical competence and performance and based on a checklist to monitor how well students follow non-technical and technical procedural steps. (Kebede et. al 2024.)

After completion students answer the NGT theory post-test (secondary dependents). The usability of MR glasses and video is measured using The System Usability Scale (SUS) questionnaire (primary endpoint), secondary dependents are NASA's Task load index (TLX), User Experience Questionnaire (UEQ), and students' reflective text, where students describe their experiences with MR technology as teaching method and identify the factors that either facilitate or hinder the learning of nursing skills within an MR environment. The detailed description of the intervention:

Development of the intervention

-The intervention of this study follows the intervention development by Schoeb et al. 2020.
-Feasibility assessment such as: availability of time and resources, recruitment of participants, methods of data collection, operating environment such as availability of facilities or equipment (MR glasses) and commitment of participants.
-To develop the NGT insertion material based on evidence-based nursing studies. The material is used for MR, video and instructor-led training.
-A pilot group (teachers and students) will test the intervention.

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Students baseline assessment (M0):

-Demographic information (students age, gender, education and use of previous device background)
-NGT theory pre-test
-Inclusion and exclusion criteria
Randomization according to intervention 1 (MR) group, intervention 2 (video) group and control (instructor) group

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Intervention group 1 (N=60):
-Mixed Reality Learning
MR glasses technical training to students and teachers

Intervention group 2 (N=60):
-Video-Based Learning
Video systems technical training to students and teachers

Control group (N=60):
-Instructor-led training
Introduction of teachers to nasogastric tube insertion

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Students practice nasogastric tube insertion (followed by a teacher assistant)

-Intervention group 1 using MR glasses and virtual instructions
-Intervention group 2 using Video-Based instructions
- Control group practices using Instructor-led training

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Evaluation of intervention

Follow-up assessment after practice post-intervention (M1)
-System Usability Scale (SUS), User Experience Questionnaire (UEQ), NASA Task Load Index, NGT theory post-test
→ students answer after performance
-Students reflection text (only MR group)
-Students move to another room and perform the NGT procedure without instruction.
- A structured NGT checklist → assessed by research assistant or staff

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Follow-up assessment six-month post-intervention (M2)
-Students perform NGT insertion again without instruction.
- A structured NGT checklist → assessed by research assistant or staff

Figure 1. intervention description

The sample size calculation is based on previous research by Schoeb et al., 2020. The calculation employs a delta value of 1,53 points, a standard deviation (SD) of 0,15 points, a type 1 error of 0.05, and a study power of 80%. The calculated sample size is 3 x 55 students, and the planned sample size is 3 x 60 students, based also on the Spring 2025 pilot, to account for potential attrition. A pilot data collection will take place in spring 2025, and the full data collection will occur from autumn 2025 to spring 2027. The detailed implementation of the study is described in the table below:

Paper I: Assess and comparing the learning outcomes of nursing students in NGT insertion using Mixed Reality Learning, Video-Based Learning and Instructor-led training - a research protocol for a randomized trial.
The research question: What kind of learning outcomes can be observed in nursing students in NGT insertion using Mixed Reality Learning, Video-Based Learning and Instructor-led training?
Article I: Assessing and comparing Mixed Reality Learning, Video-Based Learning and Instructor-led training in the context of performance in nasogastric tube insertion for nursing students: A randomized controlled study. Submission for autumn 2027.

Paper II: To assess and compare the MR technology and video usability.
Research question: How students experienced the usability of MR technology and video tools in learning how to insert a nasogastric tube.
Article II: Usability of MR and video technology in learning nursing skills in nursing education. Submission for spring 2027.

Paper III: Describing students' experiences of using Mixed Reality in nursing education.
The research question: What were the students' main experiences with using MR technology to practice nursing clinical skills?
Article III: Nursing students' experiences of Mixed Reality technology in clinical skills learning: A qualitative study. Submission to autumn 2026.

Population	Settings	Data collection	Analysis
First year nursing students (N=180). Intervention group 1 using glasses and virtual instructions (N=60) Intervention group 2 using video instructions (N=60) Control group performs the procedure under the guidance of a instructor. (N=60)	Students practice NGT insertion into mannikin. The instructional material for all groups is the same included content from a technical and non-technical point of view. The only difference between the groups is the technology used to implement it. There is no time limit for students to complete the procedure.	Students answer the questions (M0) about demographic information (students age, gender, educational background) and make NGT theory pre-test. Students' clinical competence and performance assessed using an NGT checklist (primary endpoint). After the NGT was inserted, students answer NGT theory post-test (secondary dependent variable) and answer the questionnaires: System Usability Scale (SUS), User Experience Questionnaire (UEQ) and NASA Task Load Index. The SUS scale is five-point Likert scale (10 questions) and aims to determine which device, glasses or video was easier, more enjoyable, and more effective to use. Higher scores indicate better usability. User Experience Questionnaire (UEQ) scales of the questionnaire cover a comprehensive impression of user experience. Both classical usability aspects (efficiency, perspicuity, dependability) and user experience aspects (originality, stimulation) are measured. NASA Task Load Index (TLX) assesses workload on five 6-point scales, and it evaluates the mental workload and experiences of students while performing the task. Students who use MR glasses send a written reflection after completing the procedure. Student experiences with MR glasses will be collected using a reflective learning journal rubric adapted from the model by Liu, Kitto & Shum (2021). Reflection text	Statistical analyses are performed using SPSS- software. Anova is used to compare the mean scores of the three groups on the total checklist scores and to assess which learning and teaching method influences students' NGT insertion learning outcomes. The P-value will be used to test whether the differences between the teaching methods are statistically significant. SUS and NASA TLX are analyzed with SPSS. Both video and glasses are given SUS and NASA TLX scores between 0-100. The value represents the level of usability and task workload. The results are analyzed with a T-test, which is a common method for comparing the means of two groups. Student reflective analysis is an inductive approach using traditional content analysis of student written reports. Analyzed and coded using the software ATLAS.fi. Statical analysis will be ready spring 2027.

		consisting open-ended questions in which students describe their learning process in their own words. After six -month (M2) students perform NGT insertion again without instruction. Performance assessed NGT checklist.	

Figure 2. implementation of the study

4 Significance of the research

Future learning and the use of technology are developing rapidly both in nursing education and in working life, which is why research is topical from the perspective of both nursing science and education science. The study's purpose is to provide an understanding and knowledge of how MR learning can be used in the future as part of clinical skills learning for nursing students, as well as how usable current MR technology is in nursing education. In addition, the study anticipates the concrete benefits of the educational environment, such as the targeting of teachers and financial resources, considering the individual learning needs of students, and responding to the clinical competence of students also from the perspective of patient safety.

5 Ethical considerations

Research complies with high-quality scientific practice and ethical activities in accordance with TENK's guidelines (TENK 2023.) Ethical approval was obtained prior to the start of the pilot, and research permission was granted by Turku University of Applied Sciences. Participants will receive comprehensive information about the research, emphasizing the voluntary nature of participation, and written consent will be sought. Participants will have the option to withdraw from the study at any point and it does not impact the progress or assessment of studies. To ensure anonymity, students will be assigned numerical identifiers, preventing identification from the results. Collected data will be stored on the researcher's computer with password protection. Research material will be retained for five years after the last article's publication, followed by proper destruction. The REDCAP software designed for sensitive data will be utilized for creating survey forms and collecting data.

6 Nature of co-operation

The research is part of the research sub-program Health Care and Nursing Education within the Department of Nursing Science at the University of Turku. The study is carried out in cooperation with Turku University of applied Sciences. The research is supervised by Prof. Heli Virtanen, Prof. Minna Kyttälä and D.Sc. (Tech.) Teijo Lehtonen. The follow-up group includes Prof. Leena Salminen, PhD Marjo Joshi and PhD Mirka Toivonen.

7 Financing plan

The study period is 8/2024- 7/2028. The study's costs are personnel costs, tools, statistician, translation fees and conference travel. The duration of the work will be occasional, approximately 20 hours/week. In addition to this, as a researcher, I am supposed to take research leave from my own work. There are various grants that I have planned to apply and some of them are interested in funding research about education: The Finnish Cultural Foundation, The Finnish Nurses Association, OKKA Foundation and Turku University Foundation.

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