Interpersonal communication during preoperative handover

Status of current practices and the effect of a desktop virtual reality intervention for learning handover skills in nursing education

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UiA University of Agder

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My motivation for writing this dissertation stemmed from a desire to create new learning activities and knowledge that would benefit nursing education. Additionally, I was driven by curiosity to explore how different research methods could be utilized to increase understanding, investigate phenomena, and evaluate research outcomes. Throughout my doctoral journey, I found the work intellectually stimulating, touching on nursing and education disciplines, and involving various research methodologies. Moreover, I found it creatively fulfilling, as I had the opportunity to actively shape the project.

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Reflecting on the completion of my doctoral degree, I have come to realize that I can view this period from different perspectives. I've chosen to approach it with a sense of gratitude—gratitude for finding the courage to follow my convictions and stand by my beliefs. Additionally, I am thankful for the lessons I have learned—lessons that extend far beyond academic work and have deepened my understanding of myself, others, and the "academic world." While there are experiences that I wish I had been spared from, I firmly believe that it is possible to emerge stronger from all experiences. I will conclude by expressing my gratitude to God for giving me the strength to complete this journey.

Kristiansand, May 2024

Eva Mari

Summary

Background: When a patient undergoes surgery, a substantial exchange of information occurs among healthcare providers. Structured communication emerges as a crucial skill for healthcare professionals during patient transfers. To enhance such communication, a general, transferrable nontechnical approach, such as the identification-situation-background-assessment-recommendation (ISBAR) approach, can be applied. This necessitates knowledge about effective learning methods and the development of new learning activities in nursing education. One such emerging learning activity is desktop virtual reality (VR). However, successful integration of VR into nursing education requires knowledge of current practices and an exploration of the usability and effectiveness of new learning activities.

Aim: The overall aim of this thesis was to gain knowledge about pre- and postoperative learning activities for nursing students, develop an application in desktop VR to learn interpersonal communication for a preoperative patient handover, and assess the usability and learning outcomes of the developed VR application. The thesis had the following three sub-objectives: 1) to systematically map and summarize the body of knowledge about pre- and postoperative nursing care learning activities for undergraduate nursing students (Paper I), 2) to investigate how second-year undergraduate nursing students evaluated the usability of the Preoperative ISBAR Desktop VR Application (Paper II), and 3) to investigate whether second-year nursing students self-practicing the ISBAR approach during handovers in a preoperative setting in a desktop VR application experienced a noninferior learning outcome compared with self-practicing the traditional paper-based method to sort patient information (Paper III).

Research design, methodology, and samples: This study comprised three separate papers: a scoping review (Paper I), a qualitative study involving observation and interviews (Paper II), and a noninferior parallel group randomized controlled trial (RCT) (Paper III). The scoping review followed Preferred Reporting Items for Systematic Reviews and Meta-Analyses–Extension for Scoping Reviews (PRISMA-ScR) and the modified PRISMA 2020, along with Johanna Briggs Institute guidelines. A desktop VR simulation application was developed, and usability was evaluated by nine undergraduate second-year nursing students using the think-aloud method and focus group interviews, along with the system usability scale (SUS) questionnaire (Paper II). A revised version of the application was used as part of the simulation training sessions for second-year undergraduate nursing students for clinical placements. Students were randomly assigned to self-practice the ISBAR approach for 45 minutes in groups of three using either the desktop VR application (N = 87) or a conventional traditional paper-based (TP) simulation practice (N = 88). The primary outcome was the proportion of nursing students who sorted all patient information in the correct ISBAR order within a time limit of five minutes. The predefined one-sided noninferiority limit was 13 percentage points in favor of TP.

Results: The scoping review (Paper I) identified pre- and postoperative learning activities from case studies, web-based learning, and simulation-based learning. Three papers described virtual simulation. The outcomes measured were knowledge, skills, clinical reasoning, clinical decision-making, experiences, and student stress and anxiety levels. Only three out of seven articles objectively assessed learning outcomes. In the usability study (Paper II), the students said they were more motivated to learn by using self-guided desktop VR. The average SUS score was 83 (range 0–100), which equals a "B" on the graded scale. A few technical issues appeared regarding understanding the application's instructions, the possibility of self-pacing the progress, and too lengthy instructions. The RCT (Paper III) found the revised version of the desktop VR application to be effective, with 36% of the desktop VR group getting everything correct on the primary outcome compared to 22% in the control group (difference of 14.2% points, 95% CI 0.7–27.1 in favor of VR). The VR group repeated the simulation 0.6 times more (95% CI 0.5–0.7) within the same span. More of the students in the VR group reported liking how they practiced, with a 20% difference (95% CI 6.9–31.6). All the other outcomes, including the SUS, indicated no difference between the groups.

Conclusion: The scoping review highlights a notable lack of research investigating the effect of learning activities on learning pre- and postoperative nursing care. The utilization of a newly developed desktop VR application to practice the ISBAR approach in a preoperative handover was found to be useable, noninferior, and more effective than the traditional paper-based learning approach. It is evident that VR simulation has educational potential for nursing students to practice preoperative interpersonal communication skills. However, to gain a comprehensive understanding of the educational impact of these learning activities on pre- and postoperative nursing care, further effect studies are imperative.

Sammendrag [Norwegian]

Bakgrunn: Når en pasient gjennomgår kirurgi, utveksler helsepersonell mye informasjon. Strukturert kommunikasjon er en avgjørende ferdighet for helsepersonell når pasientoverføringer skjer. For å forbedre denne kommunikasjonen kan en generell, overførbar ikke-teknisk tilnærming, som identifikasjon-situasjon-bakgrunn-aktuell tilstand-råd (ISBAR) tilnærmingen, brukes. Dette krever kunnskap om effektive læringsmetoder og utvikling av nye læringsaktiviteter i sykepleierutdanningen. Desktop virtuell virkelighet (VR) er en slik fremvoksende læringsaktivitet. Imidlertid forutsetter vellykket integrering av VR i sykepleierutdanningen kunnskap om nåværende praksis og en vurdering av brukervennlighet og effektivitet av nye læringsaktiviteter.

Mål: Det overordnede målet med denne avhandlingen var å få kunnskap om pre- og postoperative læringsaktiviteter for sykepleierstudenter, utvikle en applikasjon i desktop VR for å lære mellommenneskelig kommunikasjon under en preoperativ pasientoverlevering, samt å vurdere brukervennligheten og læringsutbyttet av den utviklede VR applikasjonen. Denne avhandlingen hadde følgende tre delmål: 1) å systematisk kartlegge og oppsummere kunnskapsgrunnlaget om pre- og postoperative sykepleie-læringsaktiviteter for sykepleiestudenter (Artikkel I), 2) å undersøke hvordan andreårs studenter på bachelor i sykepleie vurderte brukervennligheten til Preoperativ ISBAR desktop VR-applikasjonen (Artikkel II), og 3) å undersøke om andreårs sykepleierstudenter som trente på ISBAR tilnærmingen under overleveringer i en preoperativ setting på egenhånd i en desktop VR-applikasjon, opplevde et likeverdig læringsutbytte sammenlignet med å trene med den tradisjonelle papirbaserte tilnærmingen på egenhånd, for sortering av pasientinformasjon (Artikkel III).

Forskningsdesign, metodologi og utvalg: Avhandlingen består av tre separate artikler: en kartleggingsstudie (Artikkel I), en kvalitativ studie med observasjon og intervjuer (Artikkel II) og en non-inferior parallell gruppe randomisert kontrollert studie (RCT) (Artikkel III). Kartleggingsstudien (Artikkel I) fulgte retningslinjene fra The Preferred Reporting Items for Systematic Reviews and Meta-Analyses–Extension for Scoping Reviews (PRISMA-ScR) og den modifiserte PRISMA 2020, i tillegg til retningslinjer fra Johanna Briggs Institute. En desktop VR-simuleringsapplikasjon ble utviklet, og brukervennligheten ble evaluert av ni andreårsstudenter i sykepleierutdanningen ved hjelp av tenke høyt-metoden og fokusgruppeintervjuer, i tillegg til system usability scale

(SUS) spørreskjemaet (Artikkel II). En revidert versjon av applikasjonen ble brukt som en del av simuleringstreninger for klinisk praksis for andreårsstudenter på bachelor i sykepleie (Artikkel III). Studentene ble tilfeldig inndelt i grupper på tre og fikk selv trene på ISBAR-tilnærmingen i 45 minutter ved bruk av enten desktop VR-applikasjonen (N = 87) eller tradisjonell papirbasert tilnærming (TP) (N = 88). Andelen sykepleierstudenter som sorterte all pasientinformasjon i riktig ISBAR-rekkefølge innenfor en tidsbegrensning på fem minutter, var det primære utfallsmålet. Den forhåndsdefinerte ensidige non-inferiorsgrensen på fem minutter var 13 prosentpoeng til fordel for TP.

Resultater: Kartleggingsstudien (Artikkel I) identifiserte pre- og postoperative læringsaktiviteter fra kasusstudier, webbasert læring og simulering, hvorav tre artikler beskrev virtuelle simuleringer. Resultatene som ble målt, var kunnskap, ferdigheter, klinisk resonnering, klinisk beslutningstaking, erfaringer og stress- og angstnivåer hos studentene. Bare tre av sju artikler som evaluerte læringsutbytter, benyttet objektive tester. I brukervennlighetsstudien (Artikkel II) sa studentene at de var mer motiverte for læring ved å bruke selvstyrt desktop VR. Gjennomsnittlig SUS-poengsum var 83 (av verdi 0-100), noe som tilsvarer «B» på den karakterbaserte skalaen. Noen tekniske problemer oppsto angående forståelse av applikasjonens instrukser, mulighet for selvstyrt progresjon og altfor lange instrukser. RCT-en (Artikkel III) fant at den reviderte versjonen av desktop VR-applikasjonen var effektiv, der 36 % av desktop VR-gruppen fikk alt riktig på hovedutfallsmålet, sammenlignet med 22 % i kontrollgruppen (en forskjell på 14,2 prosentpoeng, 95 % KI 0,7 til 27,1 til fordel for VR). VR-gruppen gjentok simuleringen 0,6 ganger mer (95 % KI 0,5 til 0,7) i samme tidsperiode. Flere av studentene i VR-gruppen rapporterte at de likte hvordan de trente, med 20 % forskjell (95 % KI 6,9 til 31,6). Alle de andre resultatene, inkludert SUS, indikerte ingen forskjell mellom gruppene.

Konklusjon: Kartleggingsstudien fremhever en betydelig mangel på forskning som undersøker effekten av læringsaktiviteter på læring av lære pre- og operativ sykepleie. Bruken av en nyutviklet dekstop VR-applikasjon for å lære ISBAR i en preoperativ pasientoverlevering ble funnet å være nyttig, likeverdig og mer effektiv enn den tradisjonelle papirbaserte læringsmetoden. VR-simulering har pedagogisk potensial for sykepleierstudenter til å øve på preoperative mellommenneskelige kommunikasjonsferdigheter. Imidlertid er flere effektstudier avgjørende for å oppnå en grundig forståelse av de pedagogiske virkningene av disse læringsaktivitetene.

List of papers

Paper I

Andreasen, E. M., Slettebø, Å., & Opsal, A. (2022). Learning activities in bachelor nursing education to learn pre- and postoperative nursing care—A scoping review. *International Journal of Educational Research*, 115, 102033. https://doi.org/10.1016/j.ijer.2022.102033

Paper II

Andreasen, E. M., Høigaard, R., Berg, H., Steinsbekk, A., Haraldstad, K. (2022). Usability Evaluation of the Preoperative ISBAR (Identification, Situation, Background, Assessment, and Recommendation) Desktop Virtual Reality Application: Qualitative Observational Study. *JMIR Human Factors*, 9, e40400. https://doi.org/10.2196/40400

Paper III

Andreasen, E. M., Berg, H., Steinsbekk, A., Høigaard, R., Haraldstad, K. (2023). The effect of using desktop VR to practice preoperative handovers with the ISBAR approach: a randomized controlled trial. *BMC Medical Education*. 23, 983. https://doi.org/10.1186/s12909-023-04966-y

Abbreviations

ABCDE	Airways, breathing, circulation, disability, exposure
ELT	Experiential Learning Theory
FTF	Face-to-face
HMD	Head-mounted Display
ID	Identification
ISBAR	Identification, situation, background, assessment, recommendation
NTNU	The Norwegian university of Science and Technology
PRISMA-ScR	Preferred Reporting Items for Systematic Reviews and Meta-Analyses–Extension for Scoping Reviews
RCT	Randomized Controlled Trial
SPSS	Statistical Package for the Social Sciences
SUS	System Usability Scale
TP	Traditional paper based
UiA	University of Agder
VirSam	[VIRtuell SAMhandling] Virtual cooperation
VR	Virtual reality

List of Tables

Table A The ISBAR approach, including illustrative examples of topics suggested by the Norwegian Directorate of Health 14
Table B Overview of research designs and methods used in this PhD project 30
Table C The observation template used for field notes during the think-aloud sessions...34
Table D Participant demographical characteristics...42
Table E Results of primary outcome and secondary outcomes...........................43

List of figures

Figure A The four-stage learning cycle of experiential learning theory (ELT) explaining learning in virtual reality (VR) simulation...........................20
Figure B An illustration of the application from development to effect testing ...33
Figure C PRISMA 2020 flow diagram summarizing the search and selection of articles 40
Figure D Overall system usability assessment 41

List of pictures

Picture A Desktop virtual reality 23
Picture B Virtual reality 23
Picture C An illustration comparing how each participant sorted the patient information, alongside suggestions for correct sorting 32
Picture D The roles night shift nurse, day shift nurse, and anesthesiology nurse ...32
Picture E Facilitation for repetitions in desktop VR within the given practice time, with opportunity to press the button “practice again” 33
Picture F Desktop VR simulation, which enabled concrete experiences delivering patient data which should be sorted, one at a time 60

Part I: Thesis

Summary iii
Sammendrag [Norwegian] v
Abbreviations viii
1 Introduction 1
2 Aim of the thesis 5
2.1 Paper I 5
2.2. Paper II 5
2.3 Paper III 5
3 Background 7
3.1 Interpersonal communication 7
3.1.1 Key components of interpersonal communication 7
3.1.2 The pragmatic framework of interpersonal communication 8
3.2 Interpersonal communication among healthcare personnel 9
3.2.1 Interpersonal communication as a risk factor in surgical care 10
3.2.2 Preoperative nursing phase and interpersonal communication—handover 11
3.3 ISBAR as an interpersonal communication structure 13
3.3.1 Definition, origin, and prevalence of ISBAR 13
3.3.2 Effectiveness of implementing ISBAR in hospitals 14
3.3.3 Shortcomings of ISBAR 15
3.3.4 Learning the ISBAR approach in nursing education 16
3.3.5 Assessment of competence in the ISBAR approach 16
3.3.6 Current literature gaps on ISBAR effectiveness 18
3.4 Experiential learning theory (ELT) 18
3.5 VR simulation in nursing education 21
3.5.1 Learning activities 21
3.5.2 VR simulation 22
3.5.3 VR simulation in nursing education 24
4 Methods 29
4.1 Philosophical perspectives 29
4.2 Overview of the PhD project's study designs and methodology 30

4.3 Paper I—Scoping review 30
4.4 Paper II—The preoperative ISBAR desktop VR application 31
4.4.1 Development of the preoperative desktop VR application 33
4.4.2 Usability testing 34
4.4.3 Paper III—Testing the learning effect 35
4.4.4 Sample—Papers II and III 37
4.5 Ethics 37
5 Results 39
5.1 Results—Paper I 39
5.2 Results—Paper II 41
5.3 Results—Paper III 42
6 Methodological discussions 45
6.1 Reflexivity and philosophical perspectives 45
6.2 Trustworthiness—Papers I and II 46
6.3 Validity—Paper III 49
6.3.1 Internal validity 49
6.3.2 External validity 52
6.4 Reliability 52
6.5 Specific methodological considerations 53
6.5.1 Bias arising from participant randomization 53
6.5.2 Bias due to deviations from intended interventions 53
6.5.3 Bias due to missing outcome data 54
6.5.4 Bias in the measurement of the outcome 54
6.5.5 Bias in selection of the reported results 54
6.5.6 Overall bias 55
7 Discussions of findings 57
7.1 The development and utilization of VR simulation in nursing education ... 57
7.2 Learning of the ISBAR approach in desktop VR simulation 59
8 Conclusions 63
8.1 VR simulation nursing education—Implications for practice 63
8.2 Teaching preoperative handover skills in nursing education 63
8.3 Implications for future research 64

1 Introduction

Interpersonal communication is a cornerstone for healthcare providers in the clinical field, playing a pivotal role in ensuring patient safety and delivering optimal care (1, 2, 3). The ability of healthcare professionals to accurately convey and comprehend critical patient information is crucial for making informed decisions regarding patient diagnoses, treatment plans, and overall management (4). Within the clinical setting, precise interpersonal communication among team members is paramount for seamless coordination, fostering efficiency in care delivery (5, 6). Interpersonal communication is particularly important in the phase before a patient undergoes surgery (7, 8). During this period, a precise and clear exchange of patient information is essential. From obtaining a comprehensive patient history to conveying crucial details to the surgery team and preparing for home care (7), communication not only ensures the smooth progression of healthcare processes (9) but also directly contributes to patient safety and positive patient outcomes (10, 11).

As future healthcare practitioners, communication skills are not merely beneficial for nursing students but are imperative in delivering quality care and promoting patient safety (12). The education of nursing students undergoing training to become frontline communicators plays a vital role in this context (13). Communication is incorporated as a fundamental knowledge and skill of Norwegian learning outcomes in nursing education (14), and nurses' responsibility involves mastering the complexities of conveying vital information and fostering collaboration among multidisciplinary teams (12). However, studies have identified a deficiency in communication skills among nursing students (15, 16). The inadequate communication skills observed among nursing students may stem from the fact that interpersonal communication in healthcare is a challenging skill in itself (1, 17) or other factors, such as overwhelming learning experiences (18, 19, 20, 21), inadequate facilitation during clinical practice (22), feelings of discomfort and low self-efficacy when speaking in front of others (23, 24), low levels of engagement (25), or fear of potential confusion when communicating with nurses or patients, as discussed by Cowen et al. (26). Yet, when future nurses attain mastery in interpersonal communication, it can yield positive outcomes for patient safety (27, 28, 29).

In recent years, hospitals have undergone a transformative shift toward increased efficiency (30, 31), resulting in reduced training opportunities for undergraduate students in preoperative care. Additionally, there has been a growing drift of discharging surgical patients on the same day (32), further limiting students' exposure to preoperative care. Compounding this issue, surgical wards have experienced a decrease in the number of nurses working in surgical wards (33), which has resulted in limited opportunities for students to learn nursing care for these patients (34). The emergence of day surgical treatment has led to a reduction in hospital beds and a decrease in the nursing workforce in surgical wards (35). Consequently, nursing students find themselves immersed in fast-paced and complex surgical environments, requiring them to navigate intricate patient conditions and respond swiftly to time-sensitive situations (36, 37). Due to these challenges, concise and systematic interpersonal communication of patient information remains of paramount importance in delivering optimal nursing care (38).

The challenges outlined underscore the need for nursing education to adapt the curriculum and provide comprehensive training programs that equip students with the skills needed for concise and systematic interpersonal communication. A technique to ensure concise and systematic communication is the identification-situation-background-assessment-recommendation (ISBAR) approach (39, 40). With the increasing number of nursing students being educated, it has become increasingly challenging to deliver high-quality instruction to all of them (41, 42). To address these issues, there is a growing call for innovative pedagogical approaches in nursing education, such as virtual simulation (43). This demand is driven by patient safety concerns (44) and the limited resources available for hands-on simulations (42, 43, 45). Recognizing the rising demand for educated nurses, the need for various teaching approach solutions is in the rise, including virtual reality (VR) technology, to enhance students' learning experience (46, 47, 48).

The Norwegian strategy for digital transformation in the university and college sectors 2021–2025 (49) emphasizes the potential of digital technology in creating new opportunities for student active learning and teaching processes. One emerging learning activity in nursing education is VR (50), which has unexplored pedagogical potential when learning to share patient information among healthcare providers in a preoperative surgical setting. To prepare nursing students for clinical environments, the enhanced use of student-active approaches is encouraged, aligning with real-world tasks, as emphasized in the white paper on education for transformation (51). Utilizing digital technology is pivotal in fostering more effective teaching and learning practices relevant to healthcare professionals.

2 Aim of the thesis

The overall aim of this thesis was to gain knowledge about pre- and postoperative learning activities for nursing students, develop an application in desktop VR to learn interpersonal communication for a preoperative patient handover, and assess the usability and learning outcomes of the developed VR application. The thesis includes three separate papers and this extended summary.

2.1 Paper I

The aim of the first paper was to systematically map and summarize the body of knowledge about pre- and postoperative nursing care learning activities for undergraduate nursing students. The research questions were as follows: 1) What learning activities are developed for undergraduate nursing students to learn pre- and postoperative nursing care prior to clinical placement, and what characterizes these learning activities? 2) How are pre- and postoperative nursing care content described in the sources? and 3) What outcomes have been measured and reported regarding the learning activities?

2.2. Paper II

The aim of the second paper was to investigate how second-year undergraduate nursing students evaluated the usability of the Preoperative ISBAR Desktop VR Application.

2.3 Paper III

The aim of the final paper was to investigate whether second-year nursing students self-practicing the ISBAR approach during handovers in a preoperative setting in a desktop VR application gave a noninferior learning outcome compared with students self-practicing the traditional paper-based method to sort patient information.

3 Background

3.1 Interpersonal communication

For this thesis, I have drawn upon theoretical perspectives on interpersonal communication from the work of Hargie (52), Watzlawick et al. (53), and Bavelas (54). This chapter provides a comprehensive investigation of interpersonal communication—its definition and theoretical perspectives.

The Latin verb "communicare," which means "to share" or "to make something in common," is the origin of the English word "communication" (52). The sharing of ideas, messages, or information, whether orally, visually, in writing, or by action, is the typical definition of communication (55). Hewes (56) identified two key elements that are central to communication: intersubjectivity, which emphasizes the importance of understanding others and being understood in return, and impact, which measures how much a message influences thoughts, emotions, or behaviors. This thesis's focal point is interpersonal communication. Acknowledging the various interpretations this concept has garnered, interpersonal communication can be described as a complex social process in which people communicate to establish connections, exchange messages, and work toward a common understanding and goals (57).

3.1.1 Key components of interpersonal communication

Theoretical perspectives on interpersonal communication highlight the exchange of messages between individuals, involving dynamic interactions in which each participant is influenced by another (52). Participants perceive each other within a context, interpret situations, and respond accordingly (52). Key components of this process include communicators, messages, channels, codes, noises, feedback, and context (52, 58). Communicators, central to the process, encompass factors such as gender, age, occupation, ethnicity, appearance, and personality (52). Messages carry information that needs organization for transmission, decoded by recipients to attach meaning (52). Channels, bridging communicators, include vocal-auditory and gestural-visual forms used simultaneously in face-to-face (FTF) communication (52). Furthermore, communication approaches vary widely, encompassing everything from FTF communication to communication through digital channels. Electronic communication, such as telephone conversations, presents distinct traits: more filled pauses (using "ums" and "ahs"), vocal feedback cues ("uh hu" and "hmmm"), concise communication, frequent questions, and easier refusal of requests compared to FTF interactions (52).

Video-mediated communication, another form, can complicate sense-making due to the limited perception of social cues, such as mutual eye contact and delays. However, the effects of video-mediated communication are mixed and not fully understood (52, 59, 60). Noise refers to any interference with communication, turning it into a meaning that was not intended (52), stemming from intrapersonal distractions, such as disruptions and intrinsic or extrinsic stress or the press, which is fully present in nurses' working environments (61). Feedback, crucial for skillful interpersonal communication, involves all communicators involved. Contexts encompass physical, social, chronological, cultural, and relational factors (52). Given the thesis's emphasis on practicing preoperative patient handover as an interpersonal communication skill in nursing education (outlined in Section 3.2.2), the key components of interpersonal communication are essential for this thesis. Undergraduate nursing students and their collaborators in the clinical field are communicators, the message is preoperative patient information, desktop VR serves as a channel for practicing interpersonal communication, and the code is the specific interpersonal communication technique, ISBAR (outlined in Section 3.3). Another communication theory relevant to this thesis is the pragmatic framework on interpersonal communication, outlined in the next section.

3.1.2 The pragmatic framework of interpersonal communication

Communication involves the construction, sharing, and comprehension of meaningful messages (53, 62, 63). Watzlawick et al.'s (53) communication framework, characterized as "pragmatic," emphasizes studying language from the users' perspective and examining its impact on other participants. According to Watzlawick et al. (53), communication encompasses the exchange of information, feedback, and redundancy. Bavelas (54) expanded upon her interpersonal communication research, which is rooted in the work she contributed to with Watzlawick et al. (53). Her investigation delves into FTF dialogs in experimental study settings, contextualizing the dynamics of interpersonal communication based on her micro-studies (54). Given the inherently FTF nature of interpersonal communication in clinical contexts and Bavelas's (54) reliance on experimental micro-studies, her approach, derived from the work of Watzlawick et al. (53), is particularly relevant to this thesis. According to Bavelas (54), miscommunication arises when communicators do not share a common understanding, as language can be interpreted differently by different individuals. Watzlawick et al. (53) proposed an underlying cybernetic structure in which communication follows a circular, feedback nature, with information playing a central role. Bavelas (54) elaborated on this by highlighting that participants in a conversation not only share information but also guide each other on how to interpret this information through their communication. Bavelas et al. (64) further redefined the concept of "mutual understanding" in dialogs as an observable system calibration, identified through rapid, overlapping three-step microsequences: 1) the speaker communicates a message, 2) the recipient signals comprehension, and 3) the speaker acknowledges the recipient's correct understanding (64). Additionally, redundancy is crucial in communication because communication is disrupted when disturbed by redundancy (53, 54). Introducing the well-known term "metacommunication," which refers to "communication about communication", Bavelas (54) redefined it as an attempt to create successful communication by using communication to explain the intended message. Bavelas et al. (64) highlighted the constant mutual influence between individuals engaged in conversation, co-constructing dialog through expressions, questions, co-speech gestures, and listener reactions. This back-and-forth influence is evident in how listening shapes the content of subsequent speech. An illustration of this ongoing influence is the demonstration that the way we listen can shape the content of what the other person ends up saying (64).

The work of Watzlawick et al. (53) has faced criticism, including challenges from Bavelas (54) and others (65) on the notion that "everything is communication." Bavelas et al. (54, 66, 67) added to this notion by emphasizing that anything that is conveyed information (which has message value) is indeed communication. Additionally, she rejected the idea of nonverbal communication as a separate communication channel, instead viewing co-speech gestures precisely timed to the spoken communication, consisting of audible and visual linguistic acts: gaze, hand gesture, and facial gesture (54). Despite criticism (65), the well-known principle of "one cannot not communicate" (53) still holds true in Bavelas's (54) view, although it remains untested empirically (65).

3.2 Interpersonal communication among healthcare personnel

Interpersonal communication is crucial for nurses working among healthcare personnel. Nurses are tasked with articulating information with clarity and precision (27). Through interpersonal communication, patients' needs, concerns, and symptoms form the basis for delivering high-quality patient care and contributing to patients' overall well-being (68). Furthermore, written communication through documentation is a vital aspect of nursing practice (69, 70). Accurately recording observations, care plans, and patients' responses forms a vial part of communication for nurses in the clinical field, ensuring continuity of patient care (70, 71). Communication plays a crucial role in enhancing patient safety and is recognized as one of the essential nontechnical skills competencies for nurses (72, 73). This skill becomes even more critical in high-stress scenarios in which nurses are required to manage numerous tasks concurrently (74). The ability to impart clear instructions, offer support, and collaborate seamlessly in clinical situations is vital (75). To communicate effectively, information should be presented in a logical sequence that aligns with the natural cognitive patterns of the human brain (76).

3.2.1 Interpersonal communication as a risk factor in surgical care

Surgery care is "procedures performed in operating theatres that require general or regional anesthesia or profound sedation to control pain" (77, p. 201). As populations age and grow, the frequency of surgeries is also anticipated to increase (78, 79). Worldwide, an estimated 313 million surgical procedures are performed annually, with high-income nations conducting operations at an average rate of 11,168 per 100,000 people each year (80). Adverse incidents occur in approximately 10% of inpatient stays, with surgical procedures being a common source of in-hospital adverse events (81, 82, 83). While the overall number of patient injuries is decreasing, the extent of injuries among patients undergoing surgery remains substantial (84). A report from the Norwegian Directorate of Health from 2023 indicates a decrease in patient injuries at Norwegian hospitals over a decade, with approximately 8,000 fewer hospital stays involving patient injuries (84). However, a comprehensive number of injury types related to surgery revealed their presence in 4.3% of all hospital stays in 2022. Poor communication between healthcare providers has, over the years, been identified as the leading cause of mistakes and adverse incidents, as indicated by root analysis (85, 86). A study from the United States that measured adverse events in surgical procedures found that 56% of these events were associated with human performance deficiencies (87). Notably, communication failures between healthcare providers accounted for 12.5% of these events (87). This is also supported by Jung et al. (88), who found miscommunication among healthcare providers in the operating room to be a significant threat to patient safety. Similarly, Lingard et al. (89), reported that communication failures in a surgical setting have apparent consequences, such as team conflict, inefficiency, resource waste, procedural errors, and patient dissatisfaction. A review of failures in communication between healthcare providers in a surgical setting found adverse patient incidents to be the resulting outcomes (90), but only a few studies have established a link. There is also a high risk of communication failures during the transfer of surgical patients in acute situations (91, 92), which can lead to treatment-related adverse events (93). Nursing care provided in the preoperative stage becomes pivotal in ensuring patient safety, given the inherent risks associated with surgical procedures.

3.2.2 Preoperative nursing phase and interpersonal communication—handover

In the preoperative stage, nurses play a crucial role in caring for patients scheduled for surgery until they are fully monitored in the surgical unit (94). This phase involves collecting, organizing, and prioritizing patient data (95), comprehensive assessments of the patient's physical and psychosocial well-being, preoperative preparation, and identification of risk factors that may lead to complications during the intraoperative or postoperative phase (94, 96, 97). The transfer of a patient from a surgical ward to the operating room is a pivotal moment, where the quality of care hinges notably on the thorough completion of preparatory tasks (98). These tasks entail mapping out the surgical path, ensuring that all prescribed duties are fulfilled, and facilitating clear and comprehensive interpersonal communication (98). In the preoperative nursing care setting, interpersonal communication involves exchanging vital information among nurses and other healthcare professionals, including surgeons, anesthesiologists, and other team members (99). Concise and systematic communication is vital in this setting to ensure patient safety, optimize efficiency, and enhance the overall quality of care (100). The complexity of the surgical environment introduces challenges in interpersonal communication, emphasizing the need for communication approaches (101).

The preparation and transfer of patients for surgery involve substantial information exchange between healthcare providers, known as "handover" or "handoff" (102, p. 1). The handover process serves three primary objectives: 1) to transfer responsibility for patient care, 2) to establish an audit or end point in care among providers, and 3) to transmit information to enable patient care to continue patient care, where interpersonal communication plays a vital part (103). Meth et al. (104) identified six content categories encompassing a handover: 1) patient identification, 2) symptoms/clinical impression, 3) procedure and/or treatment, 4) explanation, 5) rationale, and 6) directives for anticipated events. Applying the theoretical perspective on interpersonal communication proposed by Watzlawick et al. (53), Bavelas (54), and Hargie (52), patient data in a handover functions as the main information conveyed, feedback serves as the response from the receiver, and redundancy or noise refers to any extra information or disruptions that distort the intended message, thereby impeding effective communication (95).

Desmedt et al. (105) shed light on the intricate nature of handover processes, emphasizing the risks of inadequate communication. Their review of reviews underscores the consequences of suboptimal handovers, such as incomplete information exchange, diagnostic errors, treatment errors, and delays. Healthcare personnel involved in a handover may not always share the same understanding regarding the task at hand and the roles of the team members, which could be influenced by cultural and organizational factors (3). Handovers in the surgical field are specifically sensitive to errors and inaccuracy. Nurses are tasked with multiple responsibilities during handovers, including caring for patients while exchanging critical information (38). Moreover, multiple handovers occur during a single surgery, involving numerous personnel during shift-to-shift changes and surgery transitions (106). In addition, most handoffs are brief and informal, include complicated content, and often lack written documentation (103, 107). Distractions and interruptions further exacerbate communication challenges (108). To prevent complications, and limit them, concise and systematic communication between healthcare providers at preoperative handoff points is crucial (109).

Human errors leading to adverse events have prompted the increased implementation of surgical checklists (110, 111, 112). The World Health Organization surgical safety checklist, introduced in 2008 (113), is now globally employed in surgery rooms to enhance teamwork and is associated with better communication, reduced surgical complications, and improved detection of possible safety issues (114). However, prior research indicates that such a checklist may not necessarily enhance the quality of teamwork and interpersonal communication (115). Research has also indicated that interpersonal communication failures often start in the preoperative phase (116). Implementing concise and systematic interpersonal communication reduces the risk of miscommunication and errors (38, 117) and has emerged as a widely adopted technique for effective interpersonal communication, ensuring that all team members are well informed about relevant and important patient information (11).

3.3 ISBAR as an interpersonal communication structure

This chapter addresses ISBAR. Its definition, origin, prevalence, and a detailed summary of research investigating implementation effectiveness within hospital settings will be outlined. Furthermore, it delves into the efficacy of ISBAR training interventions, evaluates the outcomes of ISBAR training, and highlights the research gaps that have been identified in this domain.

3.3.1 Definition, origin, and prevalence of ISBAR

The ISBAR approach serves as a concise and systematic communication approach for healthcare professionals to facilitate shared understanding and communicate effectively with a clear structure (118). ISBAR does not rigidly adhere to a singular communication theoretical framework; rather, it aligns cohesively with broader patient safety principles and crisis resource management (8), which are rooted in the aviation industry for optimal team performance and contribute to the optimalization of team performance in the conveyance of critical information (118). ISBAR was initially developed by the United States military for communication between nuclear submarines and was later adopted by the public health sector during the 2000s to enhance patient safety by mitigating the potential risks associated with errors, misunderstandings, and adverse events (119, 120, 121). ISBAR starts with *I = identification,* including self- and patient identification, followed by *S = situation* description and contextual *B = background*. Next, the *A = assessment* of the patient's current status is provided, and finally, the *R = recommendation(s)* for future action or treatment are given (40, 119).

ISBAR is implemented and used widely as a standardized communication approach across various regions (11, 122, 123, 124) and is recommended by the Norwegian Directorate of Health (125) to be used as a standardized communication approach among Norwegian healthcare providers when patient data are shared in handovers.

Globally, various ISBAR acronyms, such as SBAR, SBARR, ISBARR, SBAR-R, K-ISBAR, ISOBAR, ISBARE, ISBAR-ICU, and SBARQ, have been used in the literature (11, 118, 126, 127, 128, 129). However, this diversity has led to confusion due to inconsistent usage (130). Conversely, I opted to utilize the term *ISBAR* in this thesis. This decision is based on the observation that the disparities between acronyms and their implications appear minimal. Additionally, previous research has consolidated existing knowledge under a single term (10, 11). Moreover, the acronym ISBAR aligns with the recommendation of the Norwegian Directorate of Health (125).

Table A presents the ISBAR approach, including illustrative examples of topics suggested by the Norwegian Directorate of Health (125) within each category.

Table A. The ISBAR approach, including illustrative examples of topics suggested by the Norwegian Directorate of Health (125)

ISBAR category	Content
I – Identification	Introduce yourself by name, title, and role Department unit Patient's name and date of birth
S - Situation	Brief description of the problem or situation and the reason for contact This description should capture the recipient's attention
B - Background	Provide a concise medical history of all relevant points up to now This could include diagnoses, clarifications, treatments, and so forth
A - Assessment	Describe the current status based on vital parameters following the airways-breathing-circulation-disability-exposure (ABCDE) summary Inform about any recent changes in the patient's condition State what you believe the issue is Further treatment
R - Recommendation	What assistance do you need? How urgently do you require help? Does the person you are seeking help from need to come immediately? Agree on a shared plan. Repeat and ensure there is a mutual understanding of the next steps or recommendations

Note: Translated to English by the author.

3.3.2 Effectiveness of implementing ISBAR in hospitals

Implementing standardized tools, such as ISBAR, holds promise in addressing communication disparities among nurses, physicians, surgeons, and other healthcare staff (118). Its versatility spans various contexts, including shift transitions, hospital transfers, reporting sessions, emergencies, and patient transitions outside hospitals (131), facilitated through practices such as pocket cards (123). This structured approach extends to written modes, encompassing reports, memos, and other relevant documentation (118).

Recent research, particularly Müller et al. (11), has revealed the potential of ISBAR to enhance patient safety. Their systematic review, incorporating eight before-after studies and three randomized controlled trials (RCTs), examined 26 patient outcomes. Positive improvements were observed in communication errors, unexpected deaths, hospital transfers, avoidable hospitalizations, intensive care unit admissions, readmissions, patient falls, and anticoagulation values. Despite these promising findings, high-quality research, particularly RCTs, investigating patient outcomes resulting from ISBAR implementation, remains limited (11).

Leonardsen et al. (132) explored perceptions of handovers between the operating room and the postanesthesia care unit. ISBAR implementation markedly enhanced handover quality perception, fostering adherence to logical structure, effective documentation use, and comprehensive information communication. Lo et al. (133) emphasized the need for a broader assessment of ISBAR's impact, highlighting that successful implementation often involves complementary strategies, such as early warning scores and fast response systems. This is also in line with Møller et al. (98), who found that preoperative handovers involve multiple factors, indicating that there is no straightforward solution to handle this challenge. Future research should delve deeper into ISBAR and its integrated strategies for a holistic understanding of healthcare improvements (134).

3.3.3 Shortcomings of ISBAR

While the ISBAR approach offers a range of advantages for enhancing communication among healthcare professionals to enhance patient safety, the literature also underscores certain potential shortcomings and challenges. These include documented instances of resistance to adopting the ISBAR approach (135) and the risk of rigidity when applied to intricate clinical situations, which may lead to prolonged handovers (135, 136). Moreover, while nursing students at a master's level may receive sufficient training in the ISBAR approach, its application in clinical settings could face challenges because hospitals may lack an established ISBAR communication approach (136). In addition, while the ISBAR approach is straightforward, its effective application demands more than just interpersonal communication skills; it also demands clinical reasoning, encompassing situation awareness, decision-making proficiency, and assessment skills (137).

3.3.4 Learning the ISBAR approach in nursing education

The integration of ISBAR training into higher education nursing programs has been widely acknowledged for its potential to improve the handover process among upcoming nursing professionals (138, 139). Educators have explored diverse instructional strategies to facilitate the acquisition of ISBAR competencies. Desmedt et al. (105) underscored in their review of reviews the prominence of role-playing and simulation as primary instructional approaches for teaching ISBAR. In recent studies, lectures, small-group discussions, role plays (140), and phone simulations (141) have been evaluated as effective means of imparting ISBAR skills. Furthermore, virtual simulation has been employed to simulate real-world scenarios in nursing education (124), but only one single study is identified for teaching ISBAR (143), finding promising results. Burgess et al. (119) provided pivotal guidance for educators, emphasizing the importance of thorough preparation, comprehensive patient data collection, and available educational support, such as pocket cards. Moreover, Burgess et al. (119) advised including the fact that ISBAR adoption hinges on mutual engagement by both the communicator and the recipient in the curricula.

3.3.5 Assessment of competence in the ISBAR approach

The effective assessment of ISBAR is a pivotal aspect of ensuring secure patient handovers and of evaluating the learning outcomes of nursing education programs. Such an assessment would not only allow for the assessment of learners' knowledge, skills, and competence but also serve as a means to evaluate the curriculum itself. Despite numerous interventions targeting concise and systematic interpersonal communication (6, 10), a review of the literature reveals a dearth of assessment tools tailored specifically to distinct handover competencies (11). The existing assessment tools exhibit significant heterogeneity due to variations in specialty, profession, handover context, and institution (11). Davis et al. (140) collaborate this notion in their recent study, highlighting the ongoing difficulty in evaluating the effectiveness of communication skills.

Davis et al. (144) and Müller et al. (11) highlighted challenges concerning evaluator training, experimental conditions, and potential study biases in the assessment process. A systematic review of Müller et al. (11) noted that only a limited number of studies reported the reliability and/or validity of assessment tools capable of evaluating competency-based training involving ISBAR. Similar observations were made by Gordon et al. (138) and Gordon et al. (145) concerning assessment instruments for handover competencies, despite frequent evaluations of their effectiveness and practicality. Recent efforts have also been made in the development and testing of assessment instruments for ISBAR training (146, 147, 148, 149). These instruments encompass a range of communication-related variables, including communication clarity, communication ability, report clarity, capacity to identify roles, communication accuracy, confidence, clinical competence, and critical thinking (148, 149).

In recent studies, instruments have been developed and tested, demonstrating good reliability and validity (146, 147). Davis et al. (146) introduced and tested a 10-item scoring rubric for learner assessment. This scoring rubric was utilized to assess videos observing in which ISBAR was employed in interprofessional simulation team training events for health profession education programs. Similarly Michael et al. (147) developed and tested a behavioral assessment instrument using items from simulation video recordings featuring medical students using ISBAR.

Recent research has illuminated the outcomes and implications of ISBAR-based nursing curricula. Yun et al. (148) conducted a systematic review of studies investigating the learning effects of ISBAR-based simulation programs. The review emphasized the importance of clear interpersonal communication and improved critical thinking skills. While benefits were reported to be related to communication proficiency, critical thinking, confidence, perceived learning efficacy, and attitudes toward patient safety, variations were observed in the extent of improvement across different studies (148). Notably, the study highlighted the importance of ensuring fidelity to ISBAR in simulation programs to replicate clinical scenarios authentically. This stems from the fact that studies conducted in real clinical settings display mixed outcomes in communication enhancement (148).

In a study conducted by Moi et al. (136) within a master’s degree program in specialist nursing in Norway, focus group interviews were employed to investigate the impact of using the ISBAR approach in clinical settings for students. The study findings revealed a noticeable transformation in students’ communication patterns upon the integration of ISBAR within clinics. This transformation was characterized by heightened awareness, enhanced organizational skills, amplified clarity in communication, and a notable increase in communication predictability.

3.3.6 Current literature gaps on ISBAR effectiveness

Current research highlights the potential benefits of ISBAR in enhancing communication and patient safety (11, 105), as well as the effectiveness of ISBAR training interventions (138, 148). Despite these positive findings, certain research gaps persist within this domain. The limited availability of high-quality RCTs investigating patient outcomes from ISBAR implementation impedes a comprehensive understanding of its overall effectiveness (11).

Based on research from Lo et al. (133), the complex relationship between ISBAR and complementary approaches, such as early warning scores and fast response systems, requires further investigation to determine the specific impact of patient safety improvements. In alignment with Desmedt et al. (105), the absence of standardized criteria for assessing handover techniques, including ISBAR, underscores the need for developing a universally applicable evaluation framework.

To comprehensively ascertain ISBAR's effectiveness, it is essential to delve into its varying efficacy across distinct clinical specialties and contexts, ensuring its adaptability and relevance. Currently, only one research study has explored the potential benefits of nurses using desktop VR to learn ISBAR, which concluded that there was a comparable increase in communication skills among participants using VR compared to those in the control group (143). However, an existing research gap pertains to the scarcity of studies exploring the impact of VR on learning the ISBAR approach, specifically in the context of a preoperative handover involving undergraduate nursing students.

3.4 Experiential learning theory (ELT)

The concept of learning has been the subject of extensive research and inquiry across various disciplines (150), including nursing education (151). Learning serves as the primary aim when employing desktop VR simulation in nursing education, necessitating the integration of relevant learning theory into this thesis. While the literature underscores a prevailing trend in which digital learning initiatives are often driven more by technology than by theory, there is limited integration of theoretical frameworks into the increased use of VR in nursing education (152). Incorporating such a theory acknowledges the broader role of VR simulations in shaping knowledge, skills, and attitudes (153). In experiential learning theory (ELT), learning is divided into two main aspects: cognitive, which pertains to theoretical knowledge, and experiential, which involves the practical application of that knowledge (151, 154). ELT stems from the recognition that educational institutions have historically prioritized the content of learning over the process of learning itself (154). When developing a VR simulation for nursing students and testing the usability and learning effects of using VR simulation in education, as in this thesis, it is vital to reflect on the underlying mechanisms of learning involved, encompassing the acquisition of knowledge, skills, and attitudes (155). ELT has previously been applied in studies investigating the use of VR simulation (153, 156, 157).

The notion of experiential learning rests on six fundamental propositions outlined by Kolb (157). First, learning is viewed as an ongoing process rather than a fixed outcome, and feedback plays an integral role. Second, learning involves a constant cycle of assimilating and relearning, challenging learners' existing beliefs with new ideas and perspectives. Third, conflicts, differences, or disagreements drive the learning process as individuals engage in resolving conflicts and disagreements to deepen their understanding. Fourth, learning involves adapting to the environment through feeling, thinking, perceiving, and behaving in specific ways. Fifth, learning occurs through the assimilation of new experiences into existing concepts, and vice versa, creating a synergistic transaction. Finally, learners contribute to the creation of new knowledge. According to Kolb et al. (156), learning cannot occur without experience, but experience alone is insufficient to catalyze learning; it necessitates supplementary activities, preferably in a cyclical manner: 1) experiencing new things, 2) reflecting on those experiences, 3) forming abstract concepts based on those reflections, and 4) applying those concepts in new situations.

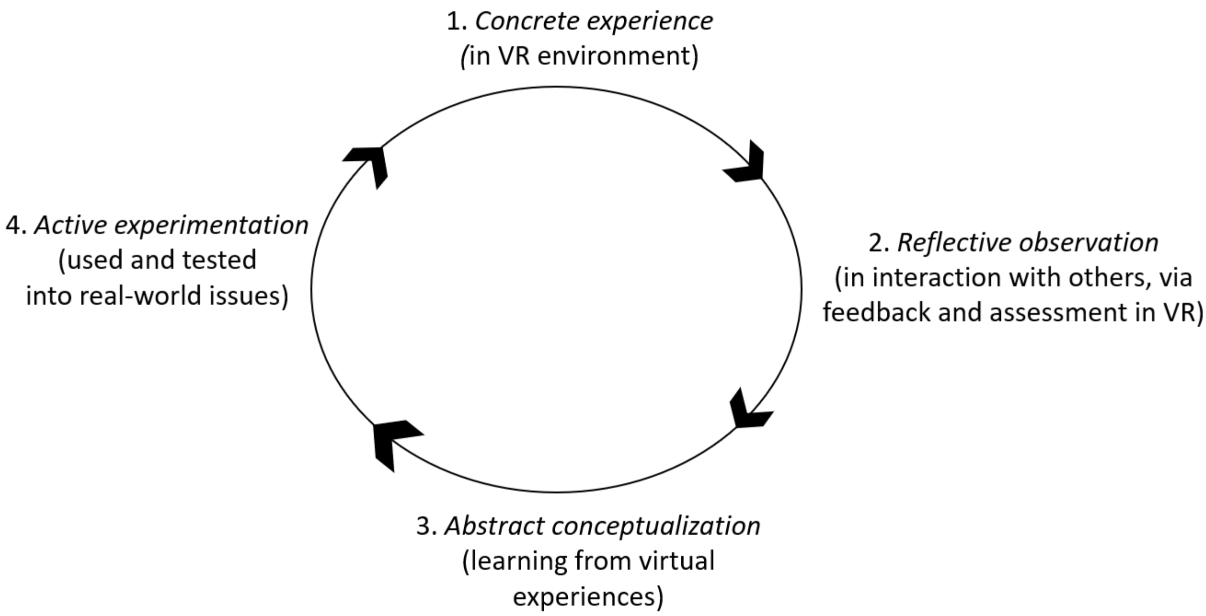


Figure A. The four-stage learning cycle of experiential learning theory (ELT) explaining learning in virtual reality (VR) simulation.
Note: Based on the work of Woon et al. (158).

When integrating ELT into the context of this thesis, I applied the revised four-stage learning cycle of ELT explaining learning in VR simulation, based on the work of Woon et al. (158) (Figure A). Initially, learners engage in concrete experiences within novel VR environments (158), where simulations encourage active engagement and participation (159, 160, 161, 162, 163, 164, 165). VR simulations offer concrete situations for learners to interact with and learn from, providing a sense of presence (166, 167). Subsequently, learners reflect on and analyze these experiences from several perspectives within the VR environment, engaging in interaction and dialog through collaborative processes (168). Learners receive feedback during tasks (169) and through participation in debriefing sessions (164, 170, 171, 172), where feedback can be given through other participants and from the VR itself (173, 174). Third, learners synthesize their observations into abstract conceptualizations, using them as a framework to guide their actions in the VR environment and solve real-world problems through practical experiences (168). Finally, VR can offer educational environments conducive to experiential learning, providing students with hands-on learning experiences (150), realistic scenarios (165), and opportunities for practice within a safe learning environment (175).

ELT has faced criticism from several researchers. Morris (168) raised concerns regarding the ambiguity surrounding the definition of “concrete experience” and how educators should interpret it. Additionally, various researchers have questioned whether Kolb’s work accurately describes an individual’s learning style or process (150). Despite these critiques, ELT provides a comprehensive perspective on learning for this thesis, encompassing experience, perception, cognition, and behavior (157).

3.5 VR simulation in nursing education

3.5.1 Learning activities

Learning can be supported by many different learning activities. According to Eurostat’s classification of learning activities in education (176), learning activities refer to “any activities of an individual organized with the intention to promote his/her knowledge, skills and competences” (p. 10). Effective learning activities are purposefully planned, with specific learning objectives, a facilitator, and a teaching approach (176). Effective learning activities should be designed to build upon students’ prior knowledge and skills, aligning them with the desired learning outcomes (155). Additionally, assessments should align with the learning activity and the intended learning outcomes (155), prioritizing student-centered approaches that enable active engagement in the learning process rather than passive reception of information from lectures. This approach is rooted in constructivist learning theory (177), which emphasizes the importance of both declarative and functional knowledge. Declarative knowledge represents information stored in a student’s memory, emphasizing the “what” aspect of understanding. It allows students to recognize, identify, or describe concepts without immediately applying them in practice. In contrast, functional knowledge extends beyond the mere acquisition of facts. It encompasses the capacity to effectively employ declarative knowledge to execute tasks within real-world contexts, thereby equipping students with the requisite skills and proficiencies for practical performance (155).

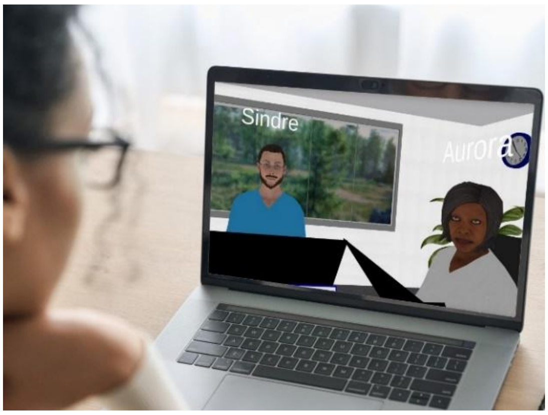
While conventional learning approaches, such as demonstration and discussion, retain their significance, the realm of nursing education has witnessed a remarkable shift toward simulation-based techniques (178, 179, 180). Embracing the principles set forth by the INACSL Standards Committee (181), simulation-based learning immerses participants in realistic clinical scenarios. Simulation training has demonstrated the potential for improved communication, experiential learning, cost reduction, and enhanced patient outcomes (45). Of all the topics simulation training should include to improve patient safety, nontechnical skills are listed as one of the top five topics recommended for emphasis in healthcare education (73).

To truly enhance students' competence, accurate selection and design of learning activities are crucial (155). Various factors play a role in defining what makes a learning activity effective for students' learning. The National League for Nursing Jeffries Simulation Theory (182) emphasizes participant factors, including age, gender, anxiety level, personal goals, preparedness, tolerance for uncertainty, self-confidence, readiness to learn, and cognitive load as important considerations. In addition, intrinsic motivation has been identified as a notable element connected to academic success among nursing students (183). Therefore, it is crucial to ensure student satisfaction and engagement in learning activities when utilizing new learning activities. Generation Z nursing students are often understood as highly comfortable with technology and may prefer shorter, visually engaging content and value practical hands-on learning (184), necessitating an approach to harness the benefits of modern technology and investigating its potential for refining the effectiveness of learning activities in nursing education. This exploration could potentially yield insights into optimizing pedagogical strategies, ultimately advancing the field of nursing education and practice, specifically in the field of nursing care for surgical patients. The Association for Medical Education in Europe underscores authentic and efficacious e-learning designs that mirror real-world dynamics (185). A confluence of drivers, including the necessity for remote teaching, the pursuit of enhanced flexibility, and the request for educational excellence, has propelled a shift in higher education learning approaches (42, 186). The COVID-19 pandemic accentuated the impact of remote and flexible learning approaches, with the rise in virtual simulation growing and being established as a learning approach for nursing education (187). As nursing education evolves, the integration of innovative and clinically relevant learning activities is crucial (188). Embracing the already implemented simulation-based strategies in nursing education and the expanding domain of VR, attention has been drawn to the potential learning effect. Anchored in a student-centered approach and enriched by technological innovations such as VR, nursing education has the potential to empower learners and contribute to the amplification of positive patient outcomes (189).

3.5.2 VR simulation

VR employs three-dimensional computer technology to create an interactive environment that enables users to engage with a simulated world (190). In VR, there are many hardware (physical components of a computer) alternatives, ways to transmit information to the senses, techniques to make people feel present, and a variety of software (collection of instructions that run on hardware) options (191). Jerald (191) described a well-designed VR experience as a collaboration between users and machines, where software and hardware cooperate to offer an intuitive user experience. VR has, in the health professions, been used in medical training (192), surgical training (193), dental education (194), radiology (195), and nursing education (196). The literature on VR primarily centers on the design of VR for educational purposes. According to Aebersold and Dunbar (197), four essential components are encompassed in VR: the virtual environment's structure (context and rules), the level of immersion (feeling of presence), sensory inputs (visual and haptic feedback), and user engagement (responsiveness to input). In VR learning environments, instructional support is essential due to the unique visual environment. However, it is worth noting that an overflow of virtual information can impede the learning process (198).

A desktop VR simulation refers to a form of VR in which the simulation is displayed on a computer screen, allowing users to observe and interact with the virtual world on the screen (152). Input devices, such as headsets, speakers, microphones, keyboards, and mouse or handheld controllers, enable navigation and interaction within the virtual environment (152). To differentiate desktop VR from VR, VR provides a head-mounted display (HMD), which can make the experience more immersive (199). Immersion, defined as feeling physically present in a nonphysical environment (200), varies based on the hardware and software used, prompting considerations for categorizing VR applications by immersion level (201).



Picture A. Desktop virtual reality
Picture: Håvard Snarby/UiA

Picture B. Virtual reality
Picture: Geir Otto Johansen

Unlike full-scale VR, desktop VR allows users to experience virtual environments using desktop computers without HMD-based VR systems (202). In multiplayer desktop VR editions, users can engage through avatars, sounds, and movements on the screen (202, 203). Although HMDs offer a simple and natural interface (204), using desktop VR requires only a brief training session and no prior experience (205). In terms of navigation, skills in multiplayer personal computer games may have an advantage (206).

In the realm of nursing education research, when assessing the effectiveness of immersive VR and desktop VR, the line between the two often blurs due to different definitions of advancing technology and intricate virtual experiences (142, 189, 197, 207). This thesis acknowledges the challenge of distinguishing them, especially when aligning findings with existing research that uses these terms inconsistently. Thus, interpreting these outcomes within the broader spectrum of nursing education's virtual experiences becomes crucial (208). While distinct differences remain and should therefore be distinguished (142), this thesis adopts the term VR simulation to encompass both immersive and desktop VR, offering a clarifying distinction when appropriate. Irrespective of the equipment used and the level of immersion achieved, interactivity is a fundamental feature of VR (152).

3.5.3 VR simulation in nursing education

VR simulation in nursing education

As early as the 1990s, VR technology began to make its way into the healthcare and educational sectors (189). Nursing education research on VR commenced with the onset of the new millennium (197). Early investigations explored the use of desktop VR environments such as "Second Life" (Linden Labs) (209), an open-access virtual environment. Other studies have centered on the development and utilization of VR environments created by either users or educational institutions (210). Additionally, during this time, exploratory pilot studies were conducted in health science education using early VR devices (197). However, it was only with the emergence of affordable and widely accessible VR devices, combined with a broader societal embrace of technology, that the potential of this technology was realized (211, 212). Due to the outbreak of the COVID-19 pandemic, nursing education transitioned to online platforms (164). As a result, there is a growing interest in integrating technological learning approaches into nursing education programs today (42, 142, 197).

Learning effect of VR simulation in nursing education

A systematic review measuring the learning outcomes of immersive technologies in healthcare education found learning outcomes to be equal when compared to traditional learning, but the experience of learning increased with immersive technologies (213). VR was the most often used type of immersive technology, while clinical skill instruction accounted for 52% of all uses of immersive technology (213). The findings align with other reviews on VR simulation in healthcare education (142, 214, 215). Several systematic reviews of VR simulation in nursing education have explored the learning effect, yielding insightful findings. Foronda et al. (189) conducted a comprehensive review spanning 1996 to 2018, revealing that VR simulation positively influences learning in both the cognitive and affective domains. Similarly, Shorey and Ng (142) conducted a systematic review of RCTs and quasi-experimental studies. Out of the three types of learning outcomes—skill-based, cognitive, and affective—VR simulation did not yield inferior outcomes when compared to traditional teaching across all learning objectives but emerged as particularly potent in enhancing cognitive aspects, particularly in the acquisition of theoretical knowledge. Chen et al. (175) assessed the efficacy of VR in nursing education across domains such as knowledge, skills, satisfaction, confidence, and the duration of performance through a meta-analysis. They found that VR was more effective in improving knowledge than the control group, whereas the other outcome measures were comparable. Choi et al. (164) supported the educational impact of immersive VR simulation in a systematic review of its effectiveness, emphasizing its role in improving cognitive abilities, learning performance, and psychomotor skills. RCTs on the learning effect of VR simulation in nursing education from the last few years show similar results, either a superior learning effect (216) or a comparable learning effect (217, 218, 219), advising the adoption of VR simulation in education to enhance the effectiveness of existing education for nursing students.

Advantages of VR simulations in the nursing field

VR simulation offers numerous advantages in nursing education, including access to a wide array of patient cases available through either open-access or subscription-based platforms (220). Instructors can leverage various virtual simulation technology solutions to train nursing students across a spectrum of areas (220), for example, procedural skills (161), pain education (221), medical skills (222), soft skills such as empathy (223) and interprofessional education (224), psychomotor skills (196), confidence and stress (225), emergency training (226), and dementia care (227). Another substantial advantage of using VR as a simulation type is that it can create a less intimidating platform for students to develop their knowledge and clinical skills compared to traditional clinical simulations. A high level of satisfaction with the utilization of VR simulation has been reported (142, 163, 228, 229). A review employing a subgroup meta-analysis to examine the impact of simulation design on nursing students' stress, anxiety, and self-confidence found that prebriefing and simulation duration helped reduce anxiety, while prebriefing and debriefing, duration, and virtual simulators all helped students feel more confident (170). These results are further corroborated by a systematic review (164). With VR simulation, there exists a margin for error tolerance, enabling students to refine their skills within a secure environment without endangering actual patients (230, 231). Additionally, VR simulation facilitates immediate feedback (232, 233) and the assessment of students' performance, aiding in the identification of strengths and areas requiring improvement. The incorporation of VR simulation has been shown to enhance students' motivation and engagement by making learning interactive and closer to practice (159, 160, 161, 162, 163, 164). Butt et al. (161) demonstrated that VR simulation facilitated repetition, allowing learners to enhance and retain fundamental skills by practicing more and repeated exposure to the same scenario. VR simulation provides access to diverse learning environments and scenarios (159). Moreover, VR simulation can enhance efficiency in terms of both time and resources, thereby reducing the need for extensive training programs that require substantial involvement from nurse educator staff (42, 234). This assertion is corroborated by Shorey and Ng (142), who underscored the efficiency of virtual environments in their systematic review. They found virtual simulation to be more time- and cost-effective compared to traditional mannequin-based simulations and in-person lectures.

Barriers to VR simulation in the nursing field

Although recent studies support the integration of VR simulation training in nursing education, various barriers have been identified. Research has indicated that students often perceive VR simulations as lacking realism, often accompanied by a sense of low immersion (142). Additionally, Shorey and Ng (142) reported technological issues, with participants expressing frustration due to difficulties in finding what they needed on their computers. These findings are supported by Lie et al. (235), who suggested that the utilization of VR is hindered by individuals' limited technology skills. Immersive VR simulation barriers identified by Choi et al. (164) also include VR technology–related problems, such as challenges faced by left-handed users during practice, discomfort caused by glasses and devices, instances of simulator sickness, and issues with visual comfort. Moreover, VR simulation in the nursing field faces hindrances due to the expenses associated with designing and implementing the technology, including costs related to converting existing materials, equipment, space requirements, and the time-intensive process of training faculty and students (235). Ensuring sufficient equipment supply and integrating VR as a supplementary tool alongside traditional teaching are suggested strategies to mitigate these challenges (235).

Gaps in the current literature on VR simulation in nursing education

Numerous reviews (47, 175, 236) have covered learning activities and virtual simulation within the context of nursing education. However, some of these reviews are constrained to solely emphasizing the early development stages in VR within nursing education (228, 236), exclusively on high-fidelity simulation modalities (237), solely on nontechnical skills in general (47), or on medical education in general (229). None of these reviews specifically address learning activities pertaining to pre- and postoperative nursing care. Although the utilization of VR simulators has expanded in various fields, including technical skills training, biology, and physics, its application for nontechnical skills training, such as communication training among undergraduate nursing students, has remained relatively limited (47, 199). Prior research has explored the use of VR simulation to teach the ISBAR approach for interprofessional communication in nursing education (143). However, there exists a gap in the literature concerning studies specifically addressing the acquisition of handover skills utilizing the ISBAR approach in a preoperative context within a desktop VR simulation in nursing education. Furthermore, the majority of virtual simulation training is available exclusively in English (48), posing challenges for nursing students whose first language is not English (238).

Critics from systematic reviews have underscored the absence of theoretical frameworks explaining the development, utilization, and learning process behind virtual simulation, despite the growing interest among nursing education in using VR (152, 236, 239). Although there have been a considerable number of usability studies on virtual simulation for nontechnical skills, there remains a need for assessments of user experience for newly developed VR simulations before evaluating their learning effects as the primary outcome (47). Furthermore, forthcoming research endeavors should prioritize the description of VR content to offer guidance to nursing educators (229). While numerous studies have highlighted the positive impact of VR interventions on student learning outcomes, further evidence-based research is imperative to establish

VR firmly as a validated learning activity (197). Specifically, Bracq et al. (47), Foronda et al. (189), Foronda et al. (219), and Choi et al. (164) all identified a dearth of RCTs among the included studies. Moreover, many studies incorporated into systematic reviews have small sample sizes, rendering it challenging to generalize outcomes (175, 229). To address these gaps, future research should prioritize RCTs with adequate sample sizes to further investigate the learning effects of virtual simulation in nursing education.

4 Methods

4.1 Philosophical perspectives

In shaping the research design and methodology for this PhD project, it is essential to consider the philosophical underpinnings of science, particularly regarding ontology (the nature of reality) and epistemology (the nature of knowledge and how we acquire it) (240). The papers in this thesis draw from various paradigms, reflecting a methodological pluralism that incorporates both qualitative and quantitative approaches (241, 242, 243). The philosophical foundation guiding this thesis encompasses both postpositivist and pragmatic perspectives.

From a postpositivist perspective, the ontological assumption is that there exists an independent reality that is observable and measurable, regardless of human perceptions (244). This perspective emphasizes objectivity and often employs quantitative methods and statistical analysis while acknowledging that no universal truth is applicable; truth is unearthed (epistemology). It seeks to comprehensively explore a phenomenon (245, 246). However, the postpositivist perspective, with its emphasis on objectivity, stands in contrast to pragmatism (243) and has been criticized for being unachievable (247, 248). This emphasis on objectivity may hinder the exploration of subjective experiences and context-specific elements that are better addressed through qualitative research methods (247). A rigid adherence to postpositivism may result in a narrow understanding of educational contexts (246), overlooking complex interactions and contextual nuances (241, 247).

From a pragmatic perspective, reality is seen as practical and context-dependent and is shaped by human experiences and interactions (243). Pragmatism, considered not as a distinct philosophical stance but rather as a set of problem-solving tools (249), regards reality as dynamic and context-dependent (ontology) (250). Researchers adopting a pragmatic perspective employ the methodological approach that is most effective for addressing the specific research problem under investigation (251). Within a pragmatic framework, reality is ever-changing and influenced by ongoing events, and the world is continually evolving. Action plays a vital role in altering existence and acting as an intermediary in this process (243). However, pragmatism has faced criticism for oversimplification and potentially neglecting important metaphysical considerations (252). Another limitation pertains to its narrow emphasis on practical applications, which could result in superficial conclusions that may not remain valid in varied contexts (253). The design and methodology of this thesis are influenced by the pragmatic perspective for Papers I and II and the postpositivist perspective for Paper III.

4.2 Overview of the PhD project's study designs and methodology

Three separate papers were conducted, each employing different research designs: a scoping review (Paper I), a qualitative study involving observation and interviews (Paper II), and a noninferior parallel group RCT (Paper III). Table B provides a comprehensive overview of the research design and methods used in this PhD project.

Table B. Overview of the research designs and methods used in this PhD project

Paper	Design	Sample	Data collection	Data summarizing or analysis
1	Scoping review	11 reports	Systematic literature search	Data mapped and summarized
2	Qualitative study with observation	9 undergraduate nursing students	Observation Focus group interviews Questionnaire	Qualitative thematic analysis Statistics
3	Randomized Controlled Trial	175 undergraduate nursing students	Questionnaire Written test	Quantitative analysis Statistics

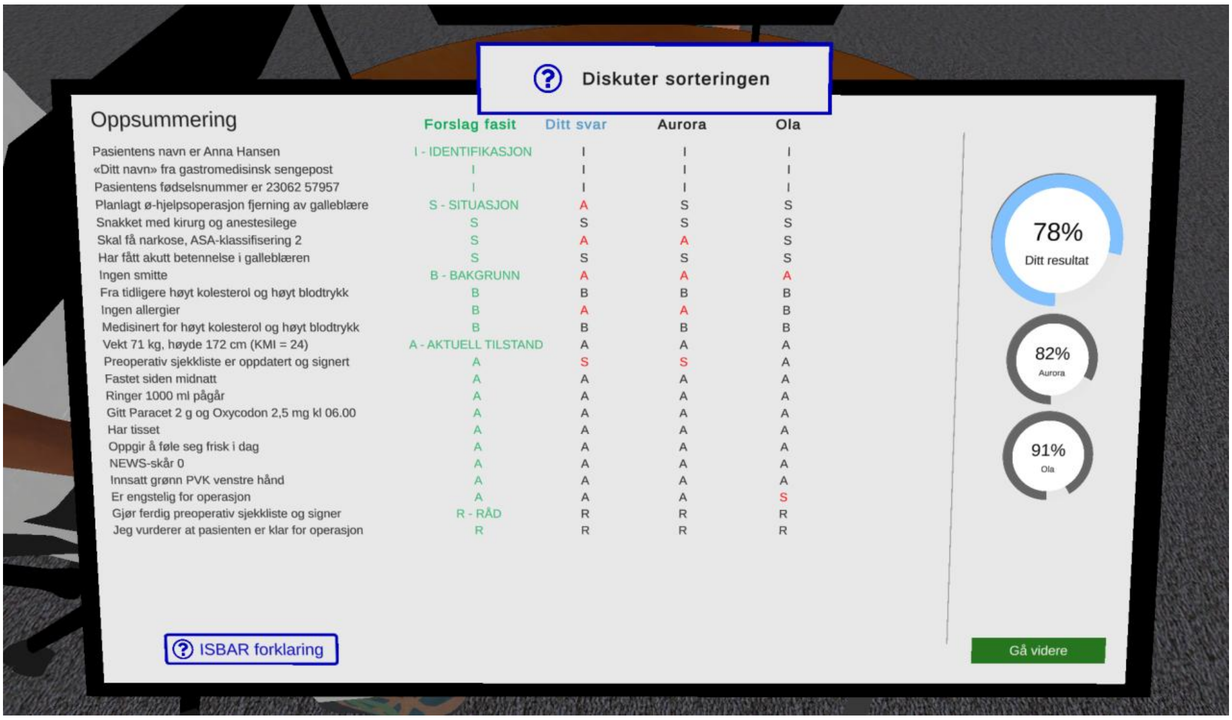
4.3 Paper I—Scoping review

A scoping review was selected to investigate the breadth of literature on relevant learning activities, aiming to provide insights for future research on pre- and postoperative nursing care within bachelor nursing education (254). The scoping review adhered to the established guidelines provided by Johanna Briggs Institute (255), aligning with the instructions of Preferred Reporting Items for Systematic Reviews and Meta-Analyses–Extension for Scoping Reviews (PRISMA-ScR) (256) and the updated PRISMA 2020 guidelines (257). We followed a three-step search process: 1) an initial search in Ovid MEDLINE and CHINAHL Plus with full text and 2) a primary search in CINAHL, ERIC, Scopus, and Ovid MEDLINE in June 2020 and updated in October 2021 (see Appendix A for search terms) and 3) supplementary literature searches by reviewing the reference lists of all the papers included. Gray literature, including reports and dissertations, was searched using the Nursing and Allied Health Database (ProQuest). The primary search for the ultimate inclusion of articles is presented in a PRISMA flow diagram (257). Article selection followed predefined inclusion and exclusion criteria. Two independent researchers assessed titles, abstracts, and keywords and conducted full-text screening. Studies failing to meet inclusion criteria were excluded, and any disagreements between the researchers were resolved through discussion involving the entire research team. We found 1,926 records, including 822 duplicates, which were removed before screening. Subsequently, 100 reports underwent full-text screening.

4.4 Paper II—The preoperative ISBAR desktop VR application

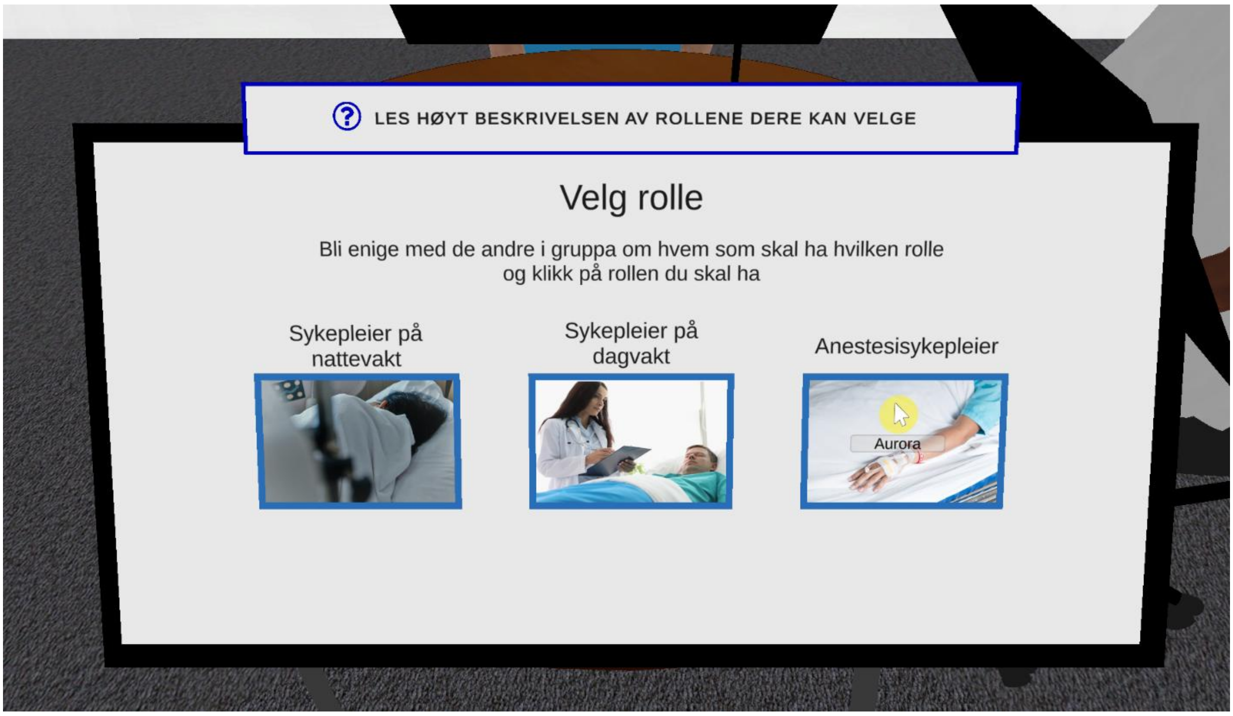
In the initial phases of application development, the findings from Paper I played a pivotal role in determining the topic (preoperative ISBAR) and the type of learning activity (VR simulation). This decision was informed by the findings of Paper I, which revealed a notable gap in both this specific topic and the type of learning activity. "The Preoperative ISBAR Desktop VR Application" (henceforth 'application') was developed as a part of collaboration with an ongoing initiative at the University of Science and Technology (NTNU), aimed at exploring the integration of VR technology into healthcare education. This initiative, known as "VirSam" (Virtual Collaboration) (258), encompassed a range of activities, including scenario creation and environment development within the virtual platform "Second Life" to facilitate communication training (259), as well as the development of VR applications designed for sepsis training (260), and for the practice of the clinical airways-breathing-circulation-disability-exposure (ABCDE) assessment approach (167, 217, 218, 261). Desktop VR was chosen over immersive VR as the platform for the application for two reasons: first, to mitigate potential cognitive overload due to the tasks containing a relatively high amount of written text of instructions and patient information, and second, to ensure accessibility to equipment, allowing students to utilize university computers or their own laptops.

The application was specifically tailored for undergraduate nursing students to hone their skills in delivering and receiving patient information using the ISBAR approach. The simulation began with the participants receiving a prebriefing within the virtual room. Subsequently, they individually practiced sorting patient information according to ISBAR. Afterward, the participants were presented with an illustration comparing their sorting of patient information, accompanied by suggestions for correct sorting (see Picture C).



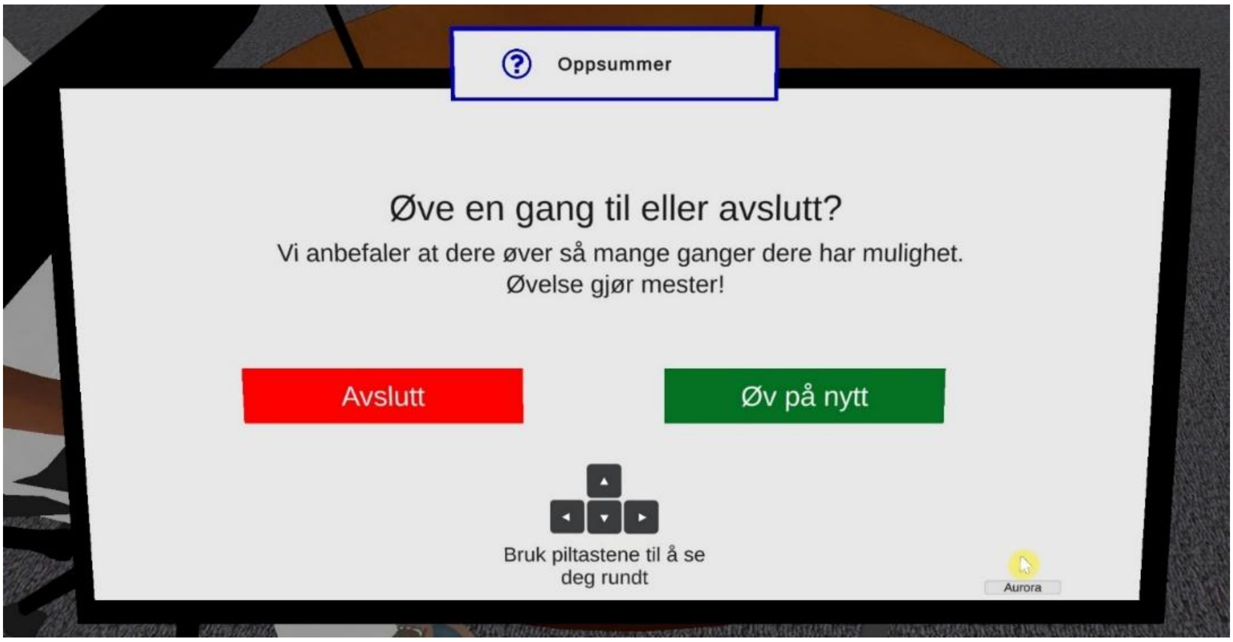
Picture C. An illustration comparing how each participant sorted the patient information, alongside suggestions for correct sorting. Photo: Håvard Snarby

Students then collaborated in simulated scenarios, taking the roles of night shift nurse, day shift nurse, and anesthesiology nurse. Through these collaborative exercises, they engaged in giving and receiving patient information within the desktop VR simulation, adhering to the ISBAR approach (Picture D).



Picture D. The roles of night shift nurse, day shift nurse, and anesthesiology nurse. Photo: Håvard Snarby

A guided debriefing session within the desktop VR environment allowed the participants to reflect on their experiences, discuss key takeaways, and contemplate alternative approaches. The participants were encouraged to engage in further practice, with the option of concluding the simulation at their own choice (Picture E).



Picture E. Facilitation for repetitions in desktop VR within the given practice time, with the opportunity to press the button "practice again". Photo: Håvard Snarby

4.4.1 Development of the preoperative desktop VR application

The development of the application advanced through distinct phases (Figure B). Phase 1 encompassed the initial creation of the application, followed by usability testing (Paper II). During Phase 2, revisions were made based on the findings from Paper II, which were regularly discussed during several meetings between the authors and the hired programmer. These discussions facilitated the identification of the necessary modifications that were subsequently implemented in the application. Next, an updated version of the application was tested within the research group before testing the learning effect (Paper III).

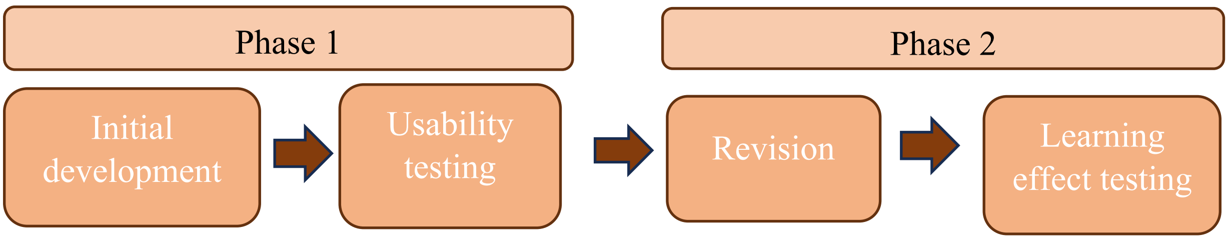


Figure B. An illustration of the application from development to effect testing

4.4.2 Usability testing

Design

Paper II comprised a qualitative usability study incorporating observations, focus group interviews, and the administration of the system usability scale (SUS) questionnaire.

Observation

The observation adhered to guidance from Rubin and Chisnell (262), encouraging the participants to use the think-aloud method (263). This approach involves continuously capturing the participants' thought process (264). The think-aloud sessions were captured via video recordings and supported by field notes created using a predefined observation template (262) (Table C, Appendix B).

Table C. The observation template used for field notes during think-aloud sessions

Time	Type of problem	Cause	Number	Severity	Proposed solution
	Navigation				
	Challenges with usage				
	Misunderstandings				
	Technical issues				

Focus group interviews

Focus group interviews were conducted to collect the participants' perceptions regarding the usability of the application (265). These interviews were guided by an interview protocol (Appendix C), which was crafted based on the study objectives, the predefined observation template, and principles from usability theory (262). Each interview lasted approximately 35–40 minutes and was audio-recorded to capture all the details.

Usability scale (SUS) questionnaire

The SUS questionnaire is a well-established instrument for evaluating the usability of systems (264) (Appendix D). It is also recommended for evaluating educational technology systems (266). This questionnaire consists of 10 items, each offering five response options, ranging from "strongly disagree" (rated as 1) to "strongly agree" (rated as 5).

Analysis

Multiple analysis methods were employed to comprehensively assess various aspects of the data. Task completion times (efficiency metrics) were extracted from a combination of field notes and video recordings, and these findings were summarized using descriptive statistics. Additionally, material such as video recordings, field notes from think-aloud sessions, and transcribed focus group interviews underwent analysis, following the guidelines outlined by Rubin and Chisnell (262). The first author transcribed all the audio content. The transcribed content was analyzed through reflexive thematic analysis (267), ensuring consistency with the field notes and video recordings to provide width and depths. This dual approach to analysis, supported by ongoing review and discussion within the research team, was adopted to ensure that the analysis was as exhaustive and trustworthy as possible (267). In terms of the SUS questionnaire, the average score was computed following Brooke's (264) procedure and presented with mean values and standard deviations. These scores, ranging from 0 to 100, were then translated into grades (A–F) based on predefined acceptability criteria (264, 268). Additionally, the average adjecting score, ranging from "worst imaginable" to "best imaginable," was determined following Lewis's (269) guidelines.

4.4.3 Paper III—Testing the learning effect

Design

A noninferior parallel group assessor blinded RCT was conducted at three education sites as part of simulation sessions designed to prepare students for clinical placements. Due to the potential drawbacks of VR simulation compared to traditional practice (239), a noninferior approach was adopted.

Intervention

The intervention involved practicing the ISBAR approach in a simulation practice, either in an interactive desktop VR application or in a traditional paper-based (TP) practice. In both groups, the instructors offered minimal assistance. The participants began with a 20-minute introductory session, followed by a randomization allocation to self-practice the ISBAR approach for 45 minutes in groups of three.

Randomization and allocation

Randomization lists, separate for batches of students, were generated using the Microsoft Excel RAND function. Identification (ID) stickers with allocation codes were then distributed, and the students were visibly labeled with these ID stickers. The allocation was rechecked upon the students' entry into the simulation sites.

Outcomes and data collection

Data collection occurred in two stages. First, baseline characteristics were collected via an online questionnaire administered before the simulation (Appendix E). Subsequently, outcome data, including a written test, were collected immediately following the simulation (Appendices F-G). The written test assessed the participants' knowledge and skills by requiring them to sort patient information from a written patient case into the correct ISBAR categories. During the test, the participants were instructed to recall ISBAR categories without visual aids. The primary outcome concerned the proportion of nursing students who accurately sorted all 11 statements of patient information in the correct ISBAR order within five minutes. Secondary outcomes included the correct arrangement of ISBAR categories and the participants' self-perceived learning experiences, including the SUS questionnaire (264).

Sample size calculation

The predefined, one-sided, noninferiority limit was 13 percentage points and was chosen for the sample size calculation (Sealed Envelope Ltd., 2012), guided by earlier studies on clinical observation assessment (217, 218, 270, 271). With a power (beta) of 80% and a significance level (alpha) of 0.05, this limit necessitated a sample size of 236 participants. However, practical limitations restricted the maximum number of available students to 210.

Analysis

Descriptive statistics were employed to present participant characteristics, with independent sample proportion tests for categorical data and an independent sample t-test for continuous data. The absolute difference was reported. None-inferiority was assessed using a one-sided p-value with confidence intervals (CIs) for the primary outcome, declaring noninferiority if the lower limit of the one-sided 95% CI in absolute difference did not exceed 13% in favor of the control group. Additionally, the results from a two-sided test with CIs are presented conventionally. All analyzes, employing available data, were conducted using the IBM Statistical Package for the Social Sciences (SPSS) version 28.0.0 (IBM Corp).

4.4.4 Sample—Papers II and III

Participants for Papers II and III comprised second-year undergraduate nursing students enrolled in nursing study programs at the participating universities. These students had limited or no prior exposure to supervised clinical practice in somatic hospitals.

To facilitate independent practice within the VR environment as part of the nursing curriculum, ensuring user friendliness and adaptability was crucial, especially for individuals with limited experience in VR simulation or computer gaming. The sample for Paper II included nine second-year undergraduate nursing students from one university, encompassing diversity in terms of age, gender, and anticipated levels of technology expertise. These individuals were organized into three-person groups, totaling nine participants. This number of participants was considered sufficient to obtain a thorough understanding of perceived usability and to comprehensively assess individual perspectives on the application, as recommended by Tullis (272).

Paper III included second-year undergraduate nursing students enrolled in nursing education programs at one university in Southern Norway (with two sites) and at another university in Western Norway. The eligibility criteria were participants with no or limited experience with clinical placements at somatic hospitals, as well as students who had received prior training in preoperative nursing care, interpersonal communication, and the ISBAR approach.

4.5 Ethics

The study protocol for Papers II and III was approved by the Education Sector Service Provider (SIKT/NSD, Reference 305866, Appendix H). Throughout the usability study and the RCT, the protocol remained unchanged. Approval for the study was also obtained from the Faculty Ethics Committee at UiA (Appendix I), as well as from the head of the nursing study program at the Department of Health Sciences at UiA and at NTNU. Additionally, in May 2023, the study for Paper III was registered in the ISRCTN registry under trial number ISRCTN62680352 (273).

For Paper II, information about the study was verbally provided in a mandatory lecture for second-year undergraduate nursing students at the included university. Additionally, a web-based noticeboard featured written details and recruitment invitations. Individuals interested in participating were asked to contact the researchers. Upon reaching out, the participating students were provided with additional information about the study and scheduled for training and data collection sessions.

For Paper III, participation in the RCT was linked to simulation sessions incorporated into the curriculum for each study program for second-year undergraduate nursing students at the included universities and approved by the course and study program leaders. A week prior to the lesson and at the beginning of it, the participating students were verbally and textually informed that they would take part in simulation sessions, also involving a research study, in which they would be assigned to various ISBAR practice simulations.

In Papers II and III, the participants were informed of their rights, including the option to withdraw from the study at any time without explanation. They were provided with details about the study's objectives and the necessity of their consent to participate, following the guidelines outlined by Grady (274). In Paper II, the participants provided their consent by signing a document containing the study's objective and the requirement for their consent to participate (Appendix J). In the case of Paper III, the participants indicated their consent after receiving verbal and written information about their rights by providing baseline data on their characteristics before engaging in the practice and pressing "send" (Appendix E). Prior to giving their consent, the participants had the opportunity to clarify any doubts and ask questions. Consent was obtained from all the participants, and all procedures were conducted in accordance with relevant regulations and laws to ensure data ethics and security (275).

5 Results

This chapter provides a condensed overview of the primary findings extracted from the thesis's three papers. A more extensive elaboration of these results can be found in their respective papers.

5.1 Results—Paper I

In the scoping review, 11 articles that met the predefined inclusion criteria were identified (Figure C). The papers were geographically originating from North America (four articles), Europe (three articles), and Asia (four articles). In terms of research design, seven papers employed diverse methodological approaches, including quantitative (four articles), qualitative (two articles), and mixed methods (one article) designs. The quantitative studies encompassed RCTs with pre- and posttests and a descriptive design involving questionnaires. The qualitative studies used approaches that were descriptive, observational, and phenomenological. Lastly, four articles provided descriptions and evaluations of learning activities but lacked empirical evidence based on rigorous scientific methods.

The learning activities examined in the articles included simulation-based learning, virtual simulations, web-based learning, and case studies. Among these, medication administration and assessment emerged as the most frequently addressed topics, followed by postoperative nursing assessment and preoperative nursing assessment. Additionally, the articles covered aspects such as patients' emotional needs, patient safety, and team communication. Various outcomes were measured, including nursing students' knowledge, skills, clinical reasoning, clinical decision-making, student experiences, stress levels, and anxiety levels. However, most articles concentrated on subjective outcomes, with only three articles objectively assessing outcomes, particularly regarding nursing students' stress, anxiety, knowledge, skills, and clinical reasoning.

The results underscored the necessity for additional learning activities, especially in concise and systematic communication training for safe surgical patient care, as the review revealed gaps in current practices. Moreover, the increasing interest in incorporating technologies into education, such as virtual simulation, suggests a rising trend in the integration of virtual learning activities into nursing education programs.

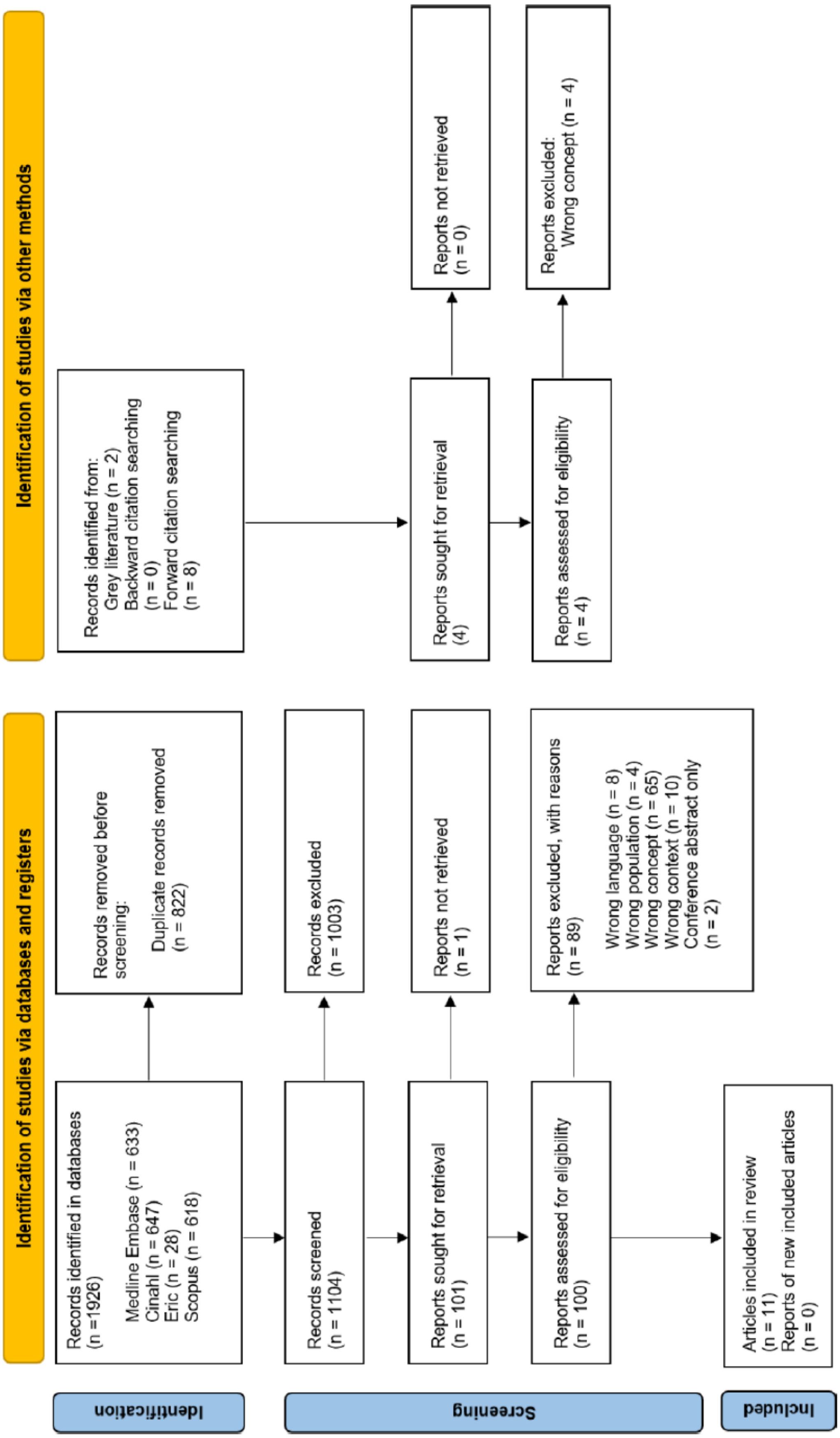


Figure C. PRISMA 2020 flow diagram summarizing the search and selection of articles.
Note: Originally published in Paper I

5.2 Results—Paper II

Nine participants, comprising seven females and two males aged between 22 and 29 years, took part in the usability study. They self-reported their technological proficiency at levels two and three on a scale of one to four. Completion times varied—28, 37, and 48 minutes—with an average of 38 minutes. The application received an average score of 83 on the SUS, demonstrating that it was deemed "acceptable," equivalent to a "B" grade scale rating, and "excellent" on the adjective rating (Figure D).

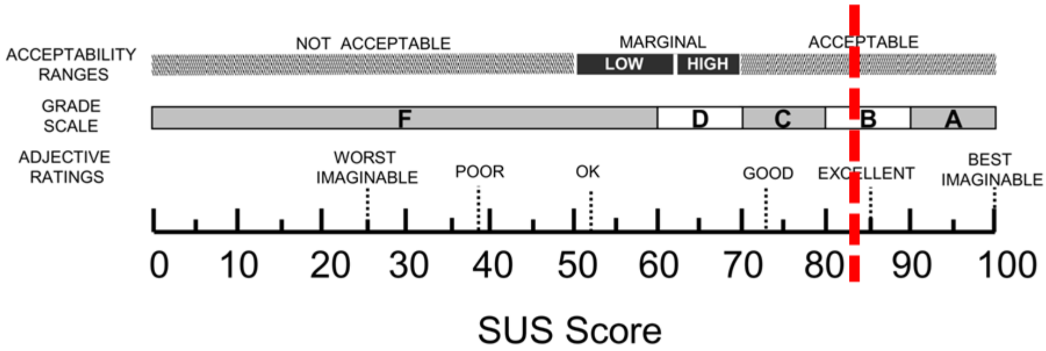


Figure D. Overall system usability assessment
Note: The vertical dotted red line (83 on the 0-100 scale) shows the mean system usability score (SUS) (n = 9), reproduced with permission from Bangor et al. (276) (Appendix K), and originally published in Paper II. SUS = system usability scale.

Insights from the reflexive thematic analysis revealed two main findings: 1) more motivational than standard learning activities and 2) technical and comprehension issues. The participants complimented the application for its motivational attributes, citing interactive features such as automatic visualized feedback and avatars with the participants' voices, offering the VR simulation as closer to real clinical practice. However, the study also uncovered the technical and comprehension challenges faced by the participants. While most of the participants expressed a smooth navigation flow and easy task completion, technical challenges, such as application restarts and microphone accessibility, were noted. Additionally, comprehension difficulties arose due to lack of self-pacing, lengthy instructions, and reluctance to open pop-up windows. During task completion, two participants sought clarification on whether tasks should be addressed individually or as a group, suggesting areas for improvement in task clarity and guidance.

Usability concerns were addressed through various adjustments made to the application. To tackle time inefficiencies, specific tasks were assigned time limits. Distractions during instructions were mitigated by muting the participants. A 10-second delay was added before enabling the "Next" button to prevent premature clicks. Additionally, pop-up windows were expanded, and both the instruction and task sequences were changed to open windows, enabling the participants to read or reread information at their own pace. The participants rated the usability of the application as "excellent," emphasizing its effectiveness in promoting active participation and motivation, which ultimately enhanced their perceived learning outcomes. Prior to its use in an upcoming RCT to assess the learning effect, the application underwent further enhancements in technical functionality and comprehension support based on participant feedback and suggestions.

5.3 Results—Paper III

Of the 210 eligible second-year undergraduate nursing students, 35 did not attend, resulting in 175 participants (87 in the VR group and 88 in the TP group) for the RCT (Paper III). Demographically, the groups were similar, but the VR group tended to be slightly younger with more PC-gaming experience (Table D).

Table D. Participant demographic characteristics

Participant characteristics	**All (*N* = 175)**	**VR group *N* = 87**	**TP group (*N* = 88)**
	N (%)	**N (%)**	**N (%)**
Sex			
-Male	32 (18.3)	17 (19.5)	15 (17.0)
-Female	142 (81.1)	70 (80.5)	72 (81.8)
-Other	1 (0.6)		1 (1.1)
Age			
-20-24 years	122 (69.7)	63 (72.4)	59 (67)
-25-29 years	29 (16.6)	15 (17.2)	14 (15.9)
-30 years or older	24 (13.7)	9 (10.3)	15 (17)
Mother tongue			
-Norwegian	157 (89.7)	80 (92.0)	77 (87.5)
-Other	18 (10.3)	7 (8.0)	11 (12.5)
Have you previously (number answering yes):			
-Worked in healthcare?	164 (93.7)	79 (90.8)	85 (96.6)
-Worked in a surgical ward?	25 (14.3)	13 (14.9)	12 (13.6)
-Been taught the ISBAR approach?	167 (95.4)	85 (97.7)	82 (93.2)
-Practiced using the ISBAR approach?	143 (81.7)	72 (82.8)	71 (80.7)
-Played multiplayer PC-games?	76 (43.4)	45 (51.7)	31 (35.2)

Abbreviations: *VR* = desktop virtual reality; *TP* = traditional paper-based simulation.
Originally published in Paper III.

For the primary outcome, which was sorting patient information based on ISBAR, VR practice (36% perfect scores) was deemed noninferior to TP (22% perfect scores), with a 14.2 point difference (one-sided 95% CI: 2.9–14.2) (Table E). In secondary outcomes, the VR group excelled in sorting ISBAR categories, particularly in the "A – assessment" category (19% difference, 95% CI: 4.3–32.6) (Table E). In other secondary outcomes, the VR groups averaged 1.8 practice runs compared to 1.2 runs in the TP groups, resulting in a mean difference of 0.6 (two-sided 95% CI: 0.5–0.7, P-value < 0.001). Student feedback favored the VR group reporting liking this type of practice, with 20% more students reporting satisfaction (95% CI: 6.9–3.6). Perceived usability in the VR group, assessed by the SUS scale (276), was noninferior to the TP group, with both groups receiving grade C.

Table E. Results of primary outcome and secondary outcomes

Outcome measures of the number of participants who:	**VR group** ***N*** **= 86** **N (%)**	**TP group** ***N*** **= 87** **N (%)**	**Difference in % points (95% CI)**	***P*-value**
Primary outcome: sorted 11 statements of patient information in the correct ISBAR order within a time limit of five minutes	31 (36.0)	19 (21.8)	14.2 (0.7 to 27.1)	0.039*
Secondary outcomes:				
placed the correct patient information within its correct ISBAR category:				
-Identification	77 (89.5)	84 (96.6)	-7 (-15.6 to 0.9)	0.069
-Situation	48 (55.8)	37 (42.5)	13.3 (-1.6 to 27.3)	0.081
-Background	61 (70.9)	51 (58.6)	12.3 (-1.9 to 25.8)	0.090
-Assessment	44 (51.2)	28 (32.2)	19 (4.3 to 32.6)	0.011*
-Recommendation	77 (89.5)	80 (92)	-2.4 (-11.6 to 0.66)	0.583
Arranged ISBAR words correctly	87 (100)	84 (97.7)	2.3 (-2.2 to 8.1)	0.153
Proportion who sorted all five pieces of patient information correctly	60 (69)	61 (70.9)	-2 (-15.4 to 11.6)	0.778

Abbreviations: *VR* = desktop virtual reality; *TP* = traditional paper-based simulation.
*$p < 0.05$. Note: Numbers (%) of participants for each group and difference in percentage points with a two-sided 95% confidence interval (95% CI) between the groups. Originally published in Paper III.

6 Methodological discussions

6.1 Reflexivity and philosophical perspectives

In my dual role as both researcher and co-designer of a virtual simulation (Papers II and III), I actively engage with the reality I seek to understand, underscoring the need for reflexivity throughout the research process. Recognizing the influence of my values, background, knowledge, experience, and theoretical standpoint on interpretations, research questions, and observations is crucial for the integrity of this thesis (277).

I have a background as a registered nurse practicing in surgical, medical, and psychiatric hospital wards, where I have cared for patients of all ages, from children to the elderly, and those facing serious illnesses. Throughout my clinical practice, I have observed and been involved in instances where communication mistakes have negatively affected patients. Early in my scientific journey, pursuing a master's degree in clinical health science, I strongly believed in the pureness of objectivity, aiming to avoid personal biases as much as possible. This conviction strengthened during my tenure as a university lecturer while I was writing my doctoral thesis. In this role, I have facilitated nursing students in high-fidelity simulation training and evaluated their clinical practice achievement in hospitals, being mindful of the prevalence of ongoing subjective assessment processes. However, I acknowledge that my personal involvement in this research project, including substantial time investment in its desktop VR application development and investment, may present challenges to maintaining objectivity.

In the initial stages of this PhD project, a decision was made to conduct an RCT and implement student assessments with an objective effort. The postpositivist perspective aligns with this approach and Paper III, with the use of accurate metrics for learning effects and the use of statistical methods. However, the postpositivist perspective contributes less to understanding human experiences and perspectives, which are best explored through qualitative research designs. For Paper II, I opted for a more nuanced perspective. Pragmatism serves as a complementary perspective to postpositivism in this project, emphasizing its practical relevance when investigating the usability of desktop VR application (278). The data from Paper II may not be objectively or entirely accurate but are presented to show breadth, depth, and usefulness through the authors' perspective, explaining how information was interpreted and why it is important (279).

During this PhD journey, I have gained a more nuanced understanding of research and the different philosophical underpinnings on which the work in this thesis is based. Initially, I believed that research could strive for objectivity. However, as I have been progressing working on this PhD, my mindset has shifted to acknowledging the limitations of my knowledge and a concern for ensuring enough openness to the presence of nonvalid results and recognizing the inherent biases in all research endeavors. I have come to understand that perfect validity in empirical research is an unattainable goal; rather, the aim is to achieve an approximate high level of validity (280). Furthermore, my perspective on conveying truth in science has shifted. Despite employing high-quality research designs and ensuring good research validity, science only provides a snapshot of reality (281).

6.2 Trustworthiness—Papers I and II

In the qualitative study with observation (Paper II), the assessment of trustworthiness remains pertinent. The relevant assessment for this thesis encompasses criteria including credibility, dependability, confirmability, transferability, and authenticity (277). When applicable, the trustworthiness of the scoping review (Paper I) will also be assessed.

Credibility refers to the trustworthiness of the data and the interpretations (277) and was rigorously upheld through the scoping review (Paper I). Prior to systematic search and data collection, comprehensive preparation was undertaken following guidance from Pollock et al. (254), Page et al. (257), and Peters et al. (255). This involved collaboration with an experienced librarian, selection of broad search terms, identification of relevant databases, and a detailed description of the methodological steps, as explained by Page et al. (257) and Peters et al. (255). The blinded screening process of articles further enhanced the rigor (282). Additionally, a team-based approach ensured consistency in the process of extraction, descriptive numerical summary analysis, and presentation of results, adhering to recommendation practices (255, 257, 282). A larger number of papers could potentially have influenced the results and conclusions. The credibility of the results in the qualitative study with observation (Paper II) was derived from the reflexive thematic analysis, which depends on the availability of rich, pertinent, and well-saturated data (277, 283, 284). Before the data collection, extensive preparation was carried out in line with recommendations for qualitative studies (283), including preparation of the data collection process and sampling strategy. Collaborative discussions with the research team before data gathering revealed an awareness of potential positive perceptions among the volunteered nursing students toward the application. When designing an interview guide, deliberate efforts were made to inquire repeatedly and in various ways about how the application could be better. Open-ended questions were posed during the focus group interviews to encourage the participants to articulate their perceptions freely. A part of credibility is documentation of the researcher's background (277) (see Section 6.1). In the usability study (Paper II), a notable strength in terms of credibility was the use of a questionnaire, which facilitated the comparison between the results of the qualitative data and responses from the questionnaire from the same participants.

Dependability refers to the consistency of data over time and conditions (277). In the context of the scoping review (Paper I), expanding the exclusion criteria to include aspects of specific surgery types as a type of context could have broadened the scope of inclusion. Additionally, following the guidelines from Pollock et al. (282) by extracting additional sections of the included sources, such as the introduction, discussion, and conclusion sections, might have enhanced the comprehensiveness of the results section. For Paper II, concerning the consistency of data across different participants, the study adhered to the recommended number of participants (272). However, it is likely that similar results could have been achieved with nine other second-year undergraduate nursing students, as the participants interviewed agreed with what was said. However, evaluating a different application would not have yielded similar results due to its unique design, pedagogy, and alignment with the nursing curricula of the application under evaluation.

Confirmability involves ensuring agreement among independent individuals regarding the accuracy and relevance of the data and ensuring that interpretations are not influenced by researchers' biases (277). It emphasizes the need for findings to authentically reflect the participants' voices and the inquiry conditions rather than the researcher's subjective perspectives. During the reflexive thematic analysis in Paper II, I aimed to examine the meanings across the various informants' voices, demonstrating how the findings represented a variety of realities in the data. Moreover, all available materials from the data collection were used in the reflexive analysis, including transcribed focus group interviews, field notes from think-aloud sessions, and video recordings from the training sessions (285). Additionally, I engaged in reviewing and discussing the findings with the entire research group (267). I also aimed to highlight conflicting viewpoints or experiences related to the overarching themes. In addition, quotations are provided in the results section (267). Moreover, during the data collection phase, the video recorded think-aloud sessions were observed, recognizing potential distractions that could compromise data credibility (277). The video recordings were a good support for securing trustworthiness in the observation session, and this strategy may have contributed to enhancing the validity in Paper II (277). However, think-aloud sessions can be affected if participants fail to self-report their thoughts or if they articulate more conventional communication by explaining the process instead of thinking aloud using their "inner speech" (263). Moreover, some participants may find it easier to vocalize their thoughts than others, potentially impacting verbal reports (263). Prior to the think-aloud sessions, the participants were prebriefed on the concept and instructed on how to engage in thinking aloud while practicing. In retrospect, the participants could have benefited from a think-aloud exercise in addition to prebriefing (286) to ensure the comprehensive inclusion of all thoughts during the think-aloud sessions.

Transferability pertains to the extent to which study results can be applied to other contexts, populations, groups, or settings (277). A methodological limitation of Paper I is the inclusion of a limited number of articles, totaling only 11. This limitation may have implications for the presented results and conclusions. The results encompassed learning activities from various regions worldwide. However, the relevance for nursing education in Norway warrants discussion, such as the content and learning outcomes, and language within these learning activities differs from Norwegian contexts. In Paper II, comprehensive field notes were taken, utilizing an observation template for field notes during the think-aloud sessions (Table C in Section 4.4.2). However, as only one desktop VR application was evaluated, and the results are confined to this specific application, there may be limitations in the transferability of the findings. Furthermore, as technology inevitably evolves, there may be a point at which the application becomes outdated, potentially impacting the user experience. Consequently, transferring the findings of Paper II beyond the current technological time poses a challenge.

Authenticity in research refers to the extent to which researchers faithfully portray a diverse array of realities (277). Authenticity is demonstrated in research when it effectively captures the emotional tone and experiences of the participants (277). In Paper II, efforts were made to achieve this by prioritizing reflexivity during thematic analysis (267). Additionally, participant quotations were included within each theme to encompass a wide spectrum of reactions and thoughts regarding the usability of the application.

6.3 Validity—Paper III

In this PhD project, a series of research questions have been formulated, each of which pertains to different aspects of the research project. To evaluate the adequacy of addressing these research questions, it is essential that the drawn conclusions demonstrate a reasonably high level of certainty or validity (280).

6.3.1 Internal validity

This section will explore the potential threats to the RCT (Paper III). As outlined by Creswell (287), potential threats to the internal validity related to the participants will be identified: history, maturation, testing, instrumentation, statistical regression, selection bias, experimental mortality, selection–maturation interaction, and expectancy (p. 345–7). These threats will be discussed in this section, along with potential concerns related to treatment and the utilization of a written test to measure the primary outcome.

In terms of history, no unexpected incidents occurred during the experiment. Maturation was not deemed a concern since there were no ongoing processes affected by the passage of time, given that it was a single-time testing. Potential threats related to testing were addressed, as the participants were unaware of the outcome measures, preventing them from recalling answers postintervention. The main outcome, assessed using a written test (Appendix G), was administered only after the completion of the practice, ensuring that no pretest influenced the intervention's effect. Introducing a pretest might have increased participant awareness or sensitivity to the impending intervention, potentially diminishing its impact, as repeated assessments can lead to reduced learning outcomes (288). Opting solely for only a posttest helped alleviate this threat to validity. Concerns about instrumentation were minimized since only one test was administered. Thus, the threat of instrumentation was considered low, as the risk of changes in instrument calibration was mitigated by blinded scoring conducted by two independent researchers, one of whom was external to the research group. Any discrepancies in scoring were resolved through consensus with two other researchers in the group. Regression, a concern linked to the selection of groups based on extreme scores (287), was not applicable as the participants were randomized.

Selection bias, which stems from the nonrandom selection of comparison groups (287), was eliminated through the random selection of the comparison group. Experimental mortality, involving the loss of participants for nonrandom reasons (287), was evenly distributed between the experimental and comparison groups, with one participant lost in each group. The notion of selection–maturation interaction, which considers that time affects one group differently than another (287), was not applicable as this was not a nonequivalent group design. Expectancy, which refers to the anticipation that certain participants will perform better (287), was addressed by hypothesizing that the experimental group would perform noninferior to the comparison group, with no expectation of superior performance by either group (VR or TP). However, the "Hawthorne effect," in which individuals modify their behavior positively when aware of being observed, potentially resulting in actions that do not accurately represent their typical conduct and consequently impact the actions and affect the outcomes measured (289), merits consideration. Nonetheless, as both groups were observed and were unaware of the experimental conditions of the other group, this potential bias was mitigated. Additionally, the novelty factor inherent in the VR simulation group could have influenced the participants' efforts. Engaging in an innovative and unique activity might have influenced their performance in both task performance and test outcomes. Although previous research regarding RCTs examining the learning effect of VR simulation does not offer documentation of this phenomenon, it remains a factor worth acknowledging.

Potential threats related to treatments used in the RCT (Paper III) have been assessed, including diffusion of treatment, compensatory equalization, compensatory rivalry, and resentful demoralization (287, p. 323-327). Diffusion of treatment was not a concern since the experimental and control groups were unable to communicate after allocation. Compensatory equalization, which occurs when only the experimental group receives an intervention, was not applicable, as both groups received interventions (VR or TP). Compensatory rivalry and resentful demoralization could have been potential threats if the group assignments for the experimental and control groups were publicly announced, potentially leading the control group to perceive themselves as disadvantaged and thus exert more effort (287). However, this risk was mitigated, as the participants were informed before practice that there were various ways to practice ISBAR and that their participation was part of a study, without specifying the VR group as the experimental group. Consequently, the threats of compensatory rivalry or resentful demoralization were deemed minimal in this study.

The use of a written test to measure the primary outcome (Paper III)

The utilization of a written test as a means to evaluate the primary outcome (Paper III, Appendix G) prompts a discussion on its adequacy when assessing a multifaceted concept, such as the skills involved in giving and receiving structured information exchange within a nursing care context, which necessitates both declarative and functional knowledge (155). The learning outcome was aimed at acquiring structured ISBAR communication skills for a handover. To assess this outcome, a written test was developed, comprising tasks such as extracting and sorting patient information from a written patient case and structuring this patient information according to the ISBAR approach. The primary outcome seeks to evaluate skills by requiring students to apply their knowledge in retrieving and sorting patient information, transcending mere knowledge or memory recall (290). Nevertheless, the written test did not cover functional learning on mastering the ISBAR approach in a handover to the fullest. While information structure is an integral component of the broader outcome that ideally should have been assessed, the metrics used in this study only addressed a segment of the handover process at a declarative level, lacking comprehensive coverage of functional competency skills (155). Testing functional knowledge could have involved verbally conducting a handover to a nurse in a preoperative clinical context. This discussion underscores the broader debate surrounding the variability of existing assessment tools for interpersonal communication skills (11, 140, 291). Other studies have operationalized the same main outcome differently, utilizing video recordings as a behavioral assessment tool (146, 147). The chosen primary outcome in this thesis also presents challenges within the light of the framework of ELT theory, particularly given that learning is best understood as a process rather than just outcomes (154). Interpersonal communication comprises a multifaceted set of competencies that require time for development and mastery (52). Since a test score may not accurately reflect one's ability or performance (292), Paper III would have been strengthened by assessing participant performance in a clinical setting, encompassing the full complexity of the functional skills required for effective patient information exchange using the ISBAR approach. Nonetheless, the RCT design necessitated controlled settings for measuring the learning effect, and the selected operationalization of the primary outcome was deemed the most suitable option available, with the design evaluated for its likelihood of being most free of potential bias.

6.3.2 External validity

External validity refers to the extent to which the observed effects of a study can be generalized to populations, settings, or treatment (292). Creswell (287) identified threats to external validity, including the interaction of selection and treatment, the interaction of setting and treatment, and the interaction of history and treatment (p. 348–9). This section will discuss these threats in the context of the RCT (Paper III). The generalizability of the findings from Papers I or II is limited by their respective study designs (277). The interaction of selection and treatment poses a challenge when attempting to generalize beyond the specific participant group involved in the intervention (287). In this study, the participants were undergraduate nursing students from three different campuses, and the intervention occurred in an arbitrary teaching environment, with all students consenting to participate. Consequently, the participants represent a cross-section of second-year undergraduate nursing students. The interaction of setting and treatment poses a threat to external validity when seeking to extend findings beyond the scope of simulation in undergraduate nursing education. Additionally, the interaction of history and treatment emerges as a threat to external validity when applying findings to historical or future situations (287). Generalizing the results from Paper III to a period when digital competence was low among nursing students would compromise external validity.

6.4 Reliability

Reliability refers to the dependability and consistency of data collected in a study, achieved through the use of data collection instruments, with the goal of minimizing the likelihood of measurement errors (287). Factors that may contribute to unreliable data include unclear or ambiguous items in the instruments, as well as participant-related factors, such as nervousness, misinterpretation of questions, or guessing on tests (287). All outcome variables for Paper III were based on earlier research (217, 218) and underwent testing in the pilot study described in Paper III. Adjustments to scoring rules for the primary outcome were made following the pilot study to ensure clarity, conciseness, and ambiguity in the test. Instructors were available to address any queries during data collection, and the intervention itself was designed to cultivate a safe learning environment for participants during the self-practice simulation sessions.

6.5 Specific methodological considerations

The Cochrane risk-of-bias tool for randomized trials tool provides a framework for assessing the risk of bias in a study's outcome from a randomized trial (293). The domains encompass 1) bias arising from the randomization process, 2) bias due to deviations from intended interventions, 3) bias due to missing outcome data, 4) bias in the measurement of the outcome, and 5) bias in the selection of the reported result (293).

6.5.1 Bias arising from participant randomization

During the randomization process reported in Paper III, only the expected number of students for the teaching program was known. To ensure random allocation sequence generation, the RAND function in Microsoft Excel, recognized as an accepted and unbiased random number generator, was employed to computer-generate randomizations lists and develop stickers with ID numbers and allocation codes. These stickers were then printed and placed in separate containers. To maintain the concealment of the allocation sequence, the evaluation of bias is contingent on the procedures that follow. Due to practical constraints, the actual allocation needed to take place at the commencement of the teaching session. The generated ID stickers were kept concealed until the allocation moment. The allocator then opened the container and randomly selected an ID sticker for each student as they entered the lecture room (at one site), or the stickers were distributed to students after they had taken their seats in the lecture room (at two separate sites). To prevent any influence on the allocation process, the order of students entering the lecture room was beyond influence and inherently random. In cases where stickers were distributed after students had taken their seats, the stickers were drawn from the container to ensure a random order. To facilitate inspection and ensure adherence to their assigned groups, the students prominently displayed the ID stickers they were given. Despite variations in baseline characteristics among the groups, the overall comparison suggested comparability in group characteristics. Notably, individuals in the intervention group tended to be slightly younger, and a higher proportion of them had prior experience playing multiplayer PC games. The lack of substantial discrepancies in baseline characteristics between participants serves as evidence of a robust randomization process, thereby supporting the argument for a low risk of bias in the randomization process (293).

6.5.2 Bias due to deviations from intended interventions

In the RCT (Paper III), the participants were informed of their assigned interventions during the training introduction, which clearly outlined the specific practice to be followed. To prevent nonadherence, such as group switching, the students were physically grouped upon allocation, and their ID stickers were monitored by staff during the practice sessions. During the practice sessions, the presence of staff members precluded the possibility of additional interventions, as they closely observed the students. Although the staff were aware of the assigned interventions, they strictly adhered to written instructions dictating their actions and speech, thereby minimizing practical opportunities for any unplanned interventions. Moreover, the staff underwent training in various scenarios to ensure consistency in their approach across all interventions. Given that no deviations from the planned interventions were identified, the risk of bias in this domain is considered low.

6.5.3 Bias due to missing outcome data

In the RCT (Paper III), the occurrence of missing data for various variables derived from questionnaires was less than 5%, with most variables approaching 0%. Importantly, the missing data appeared to be random and evenly distributed between the study groups. As a result, no data manipulation techniques, such as imputation, were employed. In this domain, the risk of bias is considered low.

6.5.4 Bias in the measurement of the outcome

Errors in outcome measurement can arise from inaccuracies in the measurements themselves or in how they are recorded (293). In the RCT (Paper III), the method for measuring outcomes was standardized, with all students undergoing identical practical tests and responding to the same questionnaires. Consistent measures and classifications were applied to all the participants. Any potential errors, although unlikely, would have been equally distributed across the study groups. Therefore, the risk of bias in this domain is considered low.

6.5.5 Bias in selection of the reported results

Bias in the selection of reported results can occur when researchers choose to publish certain findings or select results based on the direction of the outcomes (293). In the scoping review (Paper I), the usability study (Paper II), and the RCT (Paper III), all available results are presented. In the RCT (Paper III), the results were analyzed as planned in the study protocol before the data were generated. Therefore, there was a low risk of bias regarding the selected results.

6.5.6 Overall bias

Based on the bias assessment review and the guidance provided, the RCT (Paper III) is considered to have a low risk of bias. However, considering the research design of the scoping review (Paper I) and the usability study (Paper II), along with the mentioned concerns, the risk of bias for these papers is deemed to be high.

7 Discussions of findings

The overall aim of this thesis was to gain knowledge about pre- and postoperative learning activities for nursing students, develop an application in desktop VR to learn interpersonal communication for a preoperative patient handover, and assess the usability and learning outcomes of the developed application. The discussion of the findings is structured into two main sections: the development and utilization of VR simulation nursing education and the learning of the ISBAR approach in desktop VR simulation.

7.1 The development and utilization of VR simulation in nursing education

This thesis contributes to the development of innovative learning activities for undergraduate nursing students, particularly in the realm of pre- and postoperative nursing care (Paper I). Additionally, it examines the usability of a novel desktop VR simulation designed to enhance preoperative handover skills in nursing education (Paper II). Through a comprehensive scoping review (Paper I), a wide array of pre- and postoperative learning activities employed in nursing education were identified, comprising case studies, web-based learning, and simulation-based learning, including virtual simulation. The emphasis on diverse learning activities (Paper I) aligns with broader trends in educational research, which recognize that a combination of learning approaches is beneficial for fostering both declarative and functional learning, including learners' capacity to apply knowledge in a professional context (155).

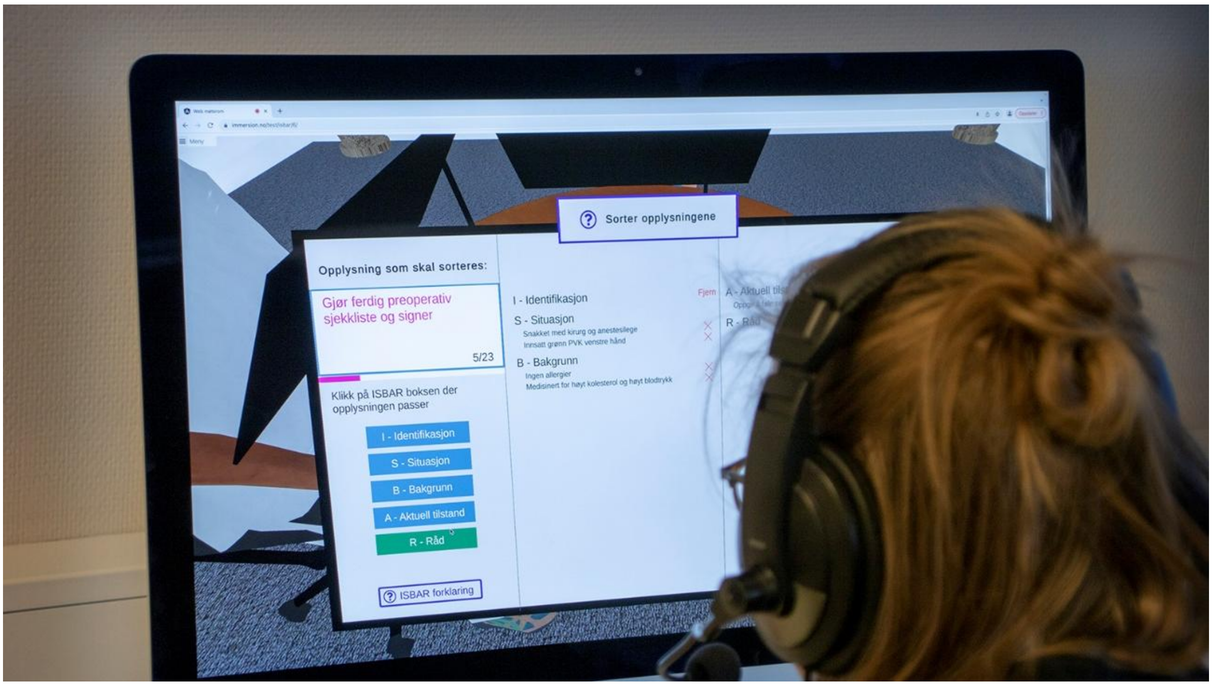
This thesis contributes to the advancement of nursing education through the development of a newly designed VR simulation that students find both relevant and engaging. In the context of creating a self-guided desktop VR aimed at enhancing preoperative handover skills (Paper II), the students expressed increased motivation for learning when using desktop VR and rated its usability as excellent. However, the study also identified certain technical challenges, including difficulties in understanding application instructions, the need for self-paced progression options, and the presence of overly lengthy instructions. These issues were addressed and improved before the RCT (Paper III) was conducted. The observed positive impact on student motivation is particularly noteworthy in light of the challenges facing higher education in engaging students and ensuring the relevance of curricula to the workforce (51, 294). Education plays a critical role in shaping students' attitudes toward learning, aiming to cultivate positive attitudes and enthusiasm toward learning (154). The increasing adoption of educational technology reflects both learners' and educators' demands for tools that enhance learning experiences and improve the quality of nursing education (295, 296, 297). Technological advancements have opened up opportunities for innovative teaching methods that foster more interactive learning experiences (235). Given the growing demand for clinical placements (298), and the resource-intensive nature of high-fidelity simulation, including space and human resource requirements (219, 299), leveraging VR simulation to enhance students' interpersonal communication skills is essential. VR simulation holds strong potential for nursing education but also for postgraduate nurses seeking to develop and maintain competence (300). As learning is a lifelong process shaped by individual experiences (154), ongoing updates are essential for postgraduate nurses to uphold high academic standards and relevance in nursing competence (14, 301).

The integration of VR simulation into nursing education has predominantly been explored for experimental and developmental purposes, with limited integration into regular teaching practices (239). Despite this limitation, Shorey and Ng (142) underscore that there is strong potential for VR simulation to enhance nursing education, serving as a catalyst for further research exploration. However, effectively incorporating VR into nursing education requires careful consideration of various aspects throughout the planning and implementation processes. Nursing educators need solid support teams that encompass both leadership and technical assistance to facilitate the seamless integration of VR leadership and technical assistance (197, 302). According to Reed and Aebersold (302), allocating funds to initial development, overseeing management and research, and demonstrating leadership competence and dedication to supporting VR simulation are essential priorities. Collaboration among nurse educators, researchers, the VR industry, and healthcare experts is imperative to enhance content comprehension and simulation development (229). Insights from this project underscore the importance of successful cooperation processes involving computer programmers, healthcare practitioners, and nursing education to ensure technical and academic quality. Moreover, despite the strong potential of VR simulation for self-practice, successful implementation, and maintenance of VR technology in nursing education depend on the presence of individuals who exhibit exceptional dedication and enthusiasm, colloquially referred to as "go-getters." These individuals require ongoing support to navigate challenges and updates related to VR applications (303, 304).

The excellent (Paper II) and good (Paper III) usability identified in the self-guided VR simulation facilitates independent practice with the application, suggesting the potential of the desktop VR application to serve as a self-directed learning activity. This enables users to revisit ISBAR skills multiple times without the need for additional instruction. These findings align with Berg et al. (167) and Butt et al. (161), underlining the importance of self-practice applications and user-friendly VR learning environments. However, it is worth noting that the application was initially designed for beginners, featuring a single patient case and a straightforward pedagogical structure. As users become familiar with both the application and the ISBAR approach, there is a recognized need for more advanced training, as emphasized by Berg et al. (167). Enhancing the learning experience involves tailoring guidance to the participant's proficiency level and introducing additional scenarios, increasing complexity due to the participants' ISBAR skills, and expanding options within the application. For example, incorporating communication "noise" and interruptions as features within the application could enrich the learning experience, making it more reflective of real-world scenarios, such as the bustling environment of a surgical hospital and featuring elements in interpersonal communication (52). Another relevant upgrade could be the ability of the last participant (the nurse anesthetist) to deliver the handover using the ISBAR approach in a postoperative context-specific situation. This option could ensure that all participants are equipped to both provide and receive handovers, thereby optimizing the overall learning experience.

7.2 Learning of the ISBAR approach in desktop VR simulation

The exploration of the learning effects within this thesis yielded substantial insights. The scoping review (Paper I) informed diverse outcomes yet highlighted a notable scarcity of objective assessment methods. This lack of rigorous evaluation reflects broader trends in nursing educational research, emphasizing the need for more vigorous assessment methodologies to comprehensively test the effectiveness of learning activities (305, 306). The results from the RCT (Paper III) further demonstrated that self-practicing the ISBAR approach in desktop VR resulted in a superior learning effect compared to traditional practice methods. Additionally, the participants engaging in desktop VR reported higher levels of satisfaction and achieved more repetition than those utilizing traditional practice methods. These findings underscore the potential advantages of VR in handover skills training. However, a clear understanding of the mechanisms explaining why the VR group performed better is still lacking. Elements that distinguished the VR environment included mechanisms such as the delivery of information during simulation, individual feedback, avatar representation, automated guidance, and facilitation of repetitions, which are specifically discussed in Paper III. Further research is needed to gain more insight into the distinctions between the differences between VR and a traditional learning experience, as received by the control group. This section will contain a broader discussion of the learning effects of desktop VR simulation in light of the four-stage learning cycle in ELT (156) and interpersonal communication theories (52, 54, 60).



Picture F. Desktop VR simulation, which enables concrete experiences delivering patient information that should be sorted one at a time. Photo: UiA

The utilization of desktop VR simulation facilitated the delivery of concrete experiences by presenting patient data to be sorted one at a time (Picture F), gradually assembling them into a comprehensive overview (see Picture D in Section 4.4.1). This approach to conveying concrete information could be particularly advantageous, given the novelty of the ISBAR approach to learners (168). Reflective observations were facilitated through direct peer observation within the VR simulation, specific feedback on individual patient data sorting, and structured debriefing sessions involving input from both peers represented as avatars and the VR system itself. Providing individual feedback can help participants maintain an active role and enhance learning, as supported by Morris (168) and Hattie and Timperley (307). The additional information provided in the desktop VR simulation enabled observers to witness all steps involved in selecting patient handovers for those conducting preoperative handovers. Kolb (154) asserted that observation is crucial for a productive learning process, a perspective corroborated by the existing literature (308, 309). According to Kolb (2014), imitation is viewed as a reciprocal interaction between an individual and their environment.

Abstract conceptualization was facilitated in the VR simulation through animated video instructions preceding each new task and through interactions with other students. Fromm et al. (150) suggested that video explanations can be used to transform theory into practice. Additionally, abstract conceptualization was fostered through debriefing sessions, as discussions during debriefing sessions in simulations are crucial for promoting learning (310). Active experimentation was specifically encouraged within the desktop VR environment, and the VR simulation allowed for increased repetitions within the given practice time (see Picture E in Section 4.4.1), enabling cycles of active experimentation (158) and relearning, which are fundamental aspects of the learning process, according to Kolb (157). Moreover, the participants expressed that the VR simulation closely resembled real-life practice (Paper II), offering realistic scenarios that could be applied to real-world problems and situations, a crucial aspect of learning, as emphasized by Morris (168). This notion is supported by Fromm et al. (150), highlighting VR's potential in clarifying how theoretical knowledge could translate into practical relevance in future work life.

When discussing the learning effect favoring desktop VR simulation (Paper III), it is essential to acknowledge the distinct communication channels employed in the two learning approaches: desktop VR simulation and traditional paper-based simulation, each offering unique communication channels. Hargie (52) highlighted that electronic communication possesses unique characteristics, including increased filled pauses, vocal cues indicating attentive listening, succinct communication formats, and a higher frequency of questions compared to FTF communication. Communication via digital channels often involves less redundancy (52), potentially streamlining the handover process. However, virtual environments may fall short of replicating the physical presence crucial for effective communication, as emphasized by Bavelas and Chovil (66), as well as Hargie (60). Facial expressions and gestures, integral components of FTF dialogue (66), are compromised in virtual settings, potentially diminishing the depth of communication experiences (60). By foregoing FTF interpersonal communication, nonverbal cues and recipient reactions may be missed. Further exploration and research into these aspects of interpersonal communication skills training are needed to provide insights and guidance for enhanced communication training practices.

In this study, the learning outcomes were tested immediately after training (Paper III). Despite the observed learning effect in the desktop VR group (Paper III), its implications for clinical learning environments and long-term effects remain unexplored. Franko et al. (311) highlighted variations in the ISBAR communication one year postinstruction, signaling a need for longitudinal assessments. Such methods of communication skill acquisition are notably limited, with most assessments primarily concentrating on affective reactions and knowledge acquisition rather than on behavioral outcomes or results, as noted by Bracq et al. (47). Nevertheless, more studies measuring the long-term effects of communication training are needed.

8 Conclusions

8.1 VR simulation nursing education—Implications for practice

This thesis enhances the understanding of learning activities within nursing education, specifically targeting preoperative handover communication training for undergraduate nursing students. It is evident that there is a growing trend toward incorporating learning activities, particularly in virtual formats. Moreover, this thesis offers valuable insights into the development of innovative teaching methods. By creating a VR simulation, this thesis provides insights into usability- and learning outcomes evaluations when using desktop VR as a learning activity to learn interpersonal communication and handover skills in nursing education. The interactive desktop VR proved effective in enabling second-year nursing students to self-practice the ISBAR approach. However, the integration of this tool requires a prioritization of funding for VR simulation development and research. Moreover, leadership within nursing education institutions must exhibit competency and dedication in supporting the implementation of VR simulations. Successful VR implementation hinges on dedicated individuals, often referred to as "go-getters," within nursing education who require support in navigating technical challenges and VR application updates. Considering the continuous need for competence development and staying current with clinical advancements, VR simulations have the potential for self-practice.

8.2 Teaching preoperative handover skills in nursing education

The findings from this thesis offer recommendations for educators teaching preoperative handover skills in nursing education. Nurse educators should prioritize the development and improvement of interpersonal communication- and handover skills among nursing students, particularly when teaching pre- and postoperative nursing care. Additionally, facilitating practical handover skills training is crucial, ensuring that students actively participate in their own learning. This can be achieved through activities such as role plays, case studies, or VR simulations. Considering that nursing students prefer learning approaches that closely resemble clinical practice, the learning approach should align with this need. However, structured communication alone may not suffice if the conveyed information or assessments are incorrect. Therefore, supplementing ISBAR approach training with other training, such as preoperative assessment- and preparations, is essential.

8.3 Implications for future research

This thesis addresses a research gap concerning the limited evidence base available to guide nurse educators in teaching pre- and postoperative nursing care through effective learning activities. It makes a valuable contribution by identifying and addressing this gap through usability evaluation and an RCT involving desktop VR simulation with a preoperative patient case. Additionally, the thesis discusses efficacy outcomes from an experimental theory perspective, shedding light on the learning process within desktop VR simulations—an aspect previously overlooked in research. The use of desktop VR demonstrated notable benefits, surpassing traditional paper-based simulation teaching approaches. Based on these findings, ensuring the sustained integration of desktop VR simulation into nursing education for preoperative communication skills acquisition training requires further evidence-based research, supported by data from RCTs, as well as qualitative studies to deepen our understanding. Interpersonal communication and handovers are particularly complex when it comes to teaching and competency assessment, warranting additional studies to explore alternative methods for measuring the learning effects of communication training. Further research is needed to delve deeper into the mechanisms underlying VR simulation-based learning. By examining the relationship between the learning effect when utilizing VR simulation and factors such as satisfaction, individual feedback, representation by avatars, information provision, and repetition, a more comprehensive understanding of its potential to enhance interpersonal communication skills can be attained.

During the process of preparing this extended summary, " Chat GPT" (312), an AI-based tool for proofreading and linguistic enhancement, was initially employed to identify and correct grammatical errors, as well as enhance sentence structure. Subsequently, a proofreading service, Scribendi (313), was employed to identify and correct grammatical errors in the text.

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Paper I

Learning activities in bachelor nursing education to learn pre- and postoperative nursing care—A scoping review.

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Learning activities in bachelor nursing education to learn pre- and postoperative nursing care—A scoping review

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ABSTRACT

The aim of this scoping review was to systematically map and summarise the existing literature on learning activities in pre- and postoperative nursing care for undergraduate nursing students. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses–Extension for Scoping Reviews (PRISMA-ScR) and the Johanna Briggs Institute guidelines were applied. Eleven articles were included in the scoping review. The learning activities involved simulation-based learning (including human patient simulation and virtual simulation), web-based learning and case studies. A range of pre- and postoperative content was applied in the learning activities. Students' knowledge, skills, clinical decision making, clinical reasoning, experiences and stress and anxiety were measured. The review highlights findings for nursing educators planning teaching methods for pre- and postoperative nursing care.

1. Introduction

Worldwide, an estimated 4664 surgical procedures occur per 100,000 people each year (Rose et al., 2015). Pre- and postoperative nursing competence is essential to ensure surgical patients' safety during hospital stays (Danko, 2019; Nilsson, Gruen, & Myles, 2020). The preoperative phase includes nursing patients who are to undergo a surgical procedure until they are fully monitored in surgery unit (Kaasa, 2019). In this phase, nurses carefully assess a patient's condition, physically and psychosocially prepare the patient for surgery and define the patient's risk components that could lead to complications during surgery (the intraoperative phase) or in the post-operative phase (Kaasa, 2019; Powell et al., 2016). The postoperative phase is the time immediately after the surgical procedure and the subsequent period (Kaasa, 2019). Postoperative nursing is concerned with re-establishing the patient's physiological equilibrium, providing pain relief, and preventing complications (Pache, Addor, & Hübner, 2020).

The acquisition of pre- and postoperative nursing competence for undergraduate nursing students is complex. It demands clinical decision making, knowledge and reasoning and psychomotor skills, all essential to safeguard high-quality patient care (Kaasa, 2019), but has been described as poorly integrated within nursing education (Danko, 2019; Yang et al., 2020). More efficient patient care and shorter hospital stays have impacted nursing students' learning conditions during surgical placement (Ljungqvist, Scott, & Fearon,

Abbreviations: Preferred Reporting Items for Systematic Reviews and Meta-Analyses – Extension for Scoping Reviews, (PRISMA-ScR); virtual reality, (VR).

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2017; Sibbern et al., 2017). In addition, the number of nursing students in education programmes is increasing (Hayden, Smiley, Alexander, Kardong-Edgren, & Jeffries, 2014). COVID-19 and the resulting cancellations of elective surgery (Collaborative CoVID-Surg, 2020) have created additional challenges for students' learning opportunities during placements (Morin, 2020; Ulenaers, Grosemans, Schrooten, & Bergs, 2021).

Nursing education should adjust curricula and teaching methods according to structural changes in surgical placements. When students are more prepared for clinical placements, they can better achieve the intended learning outcomes (Shin, Sok, Hyun, & Kim, 2015).

Learning activities provide opportunities to transfer knowledge to clinical situations through independent exercises and reflections (Gaberson, Oermann, & Shellenbarger, 2015). Eurostat (2016, p. 10) defines *learning activities* as 'any activities of an individual organised with the intention to improve his/her knowledge, skills and competences'. A learning activity has a predetermined purpose, where the intention of learning is formulated and organised with a facilitator and a method of instruction (Eurostat, 2016). A designed learning activity should build on existing knowledge and should be devised to fit the learning outcome (Biggs & Tang, 2011). The assessment should be facilitated to align with the learning activity and the learning outcome (Biggs & Tang, 2011).

Overall, there are several ways to use learning activities in nursing education, and the methods vary widely (Gaberson et al., 2015). Using a literature review, Crookes, Crookes, and Walsh (2013) investigated what teaching techniques are in use in general in nursing education to create meaningful and engaging teaching. These techniques include technology/online education, simulation, gaming, art, narrative, problem/context-based methods and reflection. Systematic reviews have summarised digital learning and simulation knowledge in nursing education (Männistö et al., 2020; Rouleau et al., 2019; Smith et al., 2018; Stoffels, Peerdeman, Daelmans, Ket, & Kusurkar, 2019), but to our knowledge no systematic reviews have summarised learning activities with pre- and postoperative nursing care content. Therefore, this study is needed to inform future research on pre- and postoperative nursing in bachelor nursing education.

This study aims to systematically map and summarise learning activities for undergraduate nursing students learning pre- and postoperative nursing care prior to clinical placement. The study addresses the following research questions:

1 What learning activities are developed for undergraduate nursing students to learn pre- and postoperative nursing care prior to clinical placement, and what characterises these learning activities?
2 How are pre- and postoperative nursing care content described in the sources?
3 What outcomes have been measured and reported regarding the learning activities?

2. Method

2.1. Design

A scoping review was chosen to explore the breadth of the literature of relevant learning activities to inform future research on pre- and postoperative nursing care in bachelor nursing education (Peters et al., 2020; Pollock et al., 2021). As the initial searches revealed few relevant studies, a meta-synthesis or meta-analysis was not possible. Therefore, we decided that a scoping review was appropriate for mapping and summarising the existing literature and for answering our three research questions.

This review was performed in accordance with the Joanna Briggs Institute guidelines (Peters et al., 2020; Pollock et al., 2021), which aligns with the PRISMA-ScR (Tricco et al., 2018) (Appendix A) and the updated PRISMA 2020 (Page et al., 2021).

2.2. Search methods

When preparing the searches, the population, the concept of interest and the context framework were used, as recommended by Peters et al. (2020).

2.2.1. Population

In this scoping review, undergraduate nursing students of any age, study year or demographic characteristics were considered for inclusion. Sources focusing on inter-professional collaboration were excluded as these were not of interest for this review. Sources focusing on other health-related education or further education were also excluded.

2.2.2. Concept of interest

The concept examined here is the planned and implemented learning activities arranged by educational nursing institutes that precede clinical placements. No uniform definition of learning activities was required for inclusion. Therefore, there were no limits regarding the frequency or duration of the learning activity.

2.2.3. Context

This review considered papers that reported on learning activities concerning pre- and postoperative nursing care. If only pre-operative or postoperative nursing occurred, the source was still included.

2.3. Information sources

The sources sought for inclusion were original research studies (qualitative, quantitative and mixed-methods designs), reviews, original reports, unpublished evidence and grey literature. The sources had to be published in English. The search period spanned from January 2010 to October 2021. Table 1 shows the specific inclusion and exclusion criteria.

2.4. Search strategy and selection of studies

We used a three-step search strategy comprising (1) an initial search, (2) a main search and (3) a search for additional literature based on the reference lists of all included studies. The first step was initially limited to searches in Ovid MEDLINE and CINAHL Plus with full text (EBSCOhost), followed by an analysis of the words in the titles and abstracts and of the index terms used to describe the articles. A main search was conducted in June 2020 and updated in October 2021 using the four reference databases CINAHL, ERIC, Scopus and Ovid MEDLINE (Appendices B–E). All identified keywords and index terms used was performed in consultation with a health science librarian. The database searches comprised of a combination of search words with a method emphasised sensitivity over specificity in the search itself to not miss studies (Both, 2016). We did a manual screening afterwards and removed irrelevant studies through this manual screening. Appendices B–E show the search words used in the databases. All the identified articles were transferred to Endnote Reference Manager X9.3.3 to gather the articles and remove duplicates. They were then exported to Rayyan (Ouzzani, Hammady, Fedorowicz, & Elmagarmid, 2016) to screen titles, abstracts, and keywords.

The search for grey literature were done with an additional search conducted in August 2020 and updated in October 2021. The grey literature was defined as reports (documents providing relevant information) or dissertations (Bonato, 2018), and the Nursing and Allied Health Database (ProQuest) were used as a search database.

After identifying articles, forward and backward citation tracking was conducted. The citation tracking was done in Google Scholar in November 2021. Fig. 1 presents the PRISMA 2020 flow diagram of the search results from the main search to the final inclusion of studies (Page et al., 2021).

2.4.1. Inclusion criteria

Articles were included if they reported learning activities for undergraduate nursing students with a content of pre- and/or postoperative nursing care.

2.5. Data collection process

The data collection process was performed based on the pre-specified inclusion and exclusion criteria described above. Both the reading and full-text screening of titles/abstracts/keywords were performed independently by two reviewers (EMA and AO). Full-text studies that did not meet the inclusion criteria were excluded. All disagreements between the reviewers at each stage were solved via discussion amongst all researchers.

2.6. Mapping and summarising data

Data were mapped and summarised based on the study aim and the research questions. The results are presented in the data extraction fields (Table 2) and are accompanied by a narrative summary of the information extracted. A descriptive summary of the evidence includes a map of the data extracted from the included papers in tabular form. For this review, a draft charting table was developed and piloted at the protocol stage. The critical information was further refined at the review stage, and the charting table was updated accordingly, as shown in Table 2. A data charting sheet was developed to organise the charted data. Each article was screened and charted according to (1) the author(s), year of publication and origin/country of study; (2) the aim of the article; (3) the design and sample; (4) the learning activities; (5) the pre- and postoperative nursing content; and (6) the measured and reported outcome(s). Data were extracted by one reviewer (EMA), and quality was ensured by the other two reviewers (AO and ÅS).

Table 1
Inclusion and exclusion criteria.

Criterion	Inclusion	Exclusion
Types of articles/ literature	Original reports, original research studies (qualitative, quantitative, and mixed-methods designs), reviews, unpublished evidence, and grey literature	Textbooks
Language	English	Other languages
Time period	From January 2010 until October 2021	Before 2010 and after October 2021
Types of participants	Undergraduate nursing students	Non-nursing education, further education, or interprofessional collaboration
Type of concept	Learning activities prior to clinical placements	Learning activities during clinical placement or connected to psychiatric/mental placement, community care, or primary health care placement
Type of context	General pre- and/or postoperative nursing care	Intraoperative* nursing care, which is not a focus in the Bachelor of Nursing curriculum. Specific pre- and postoperative nursing care to patients with a diagnosis that is not transferable to patients who undergo surgery in general

*The intraoperative phase extends from the time the patient is admitted to the operating room and until the patient is transported to the recovery room or postanaesthetic care unit (Cuming, 2019).

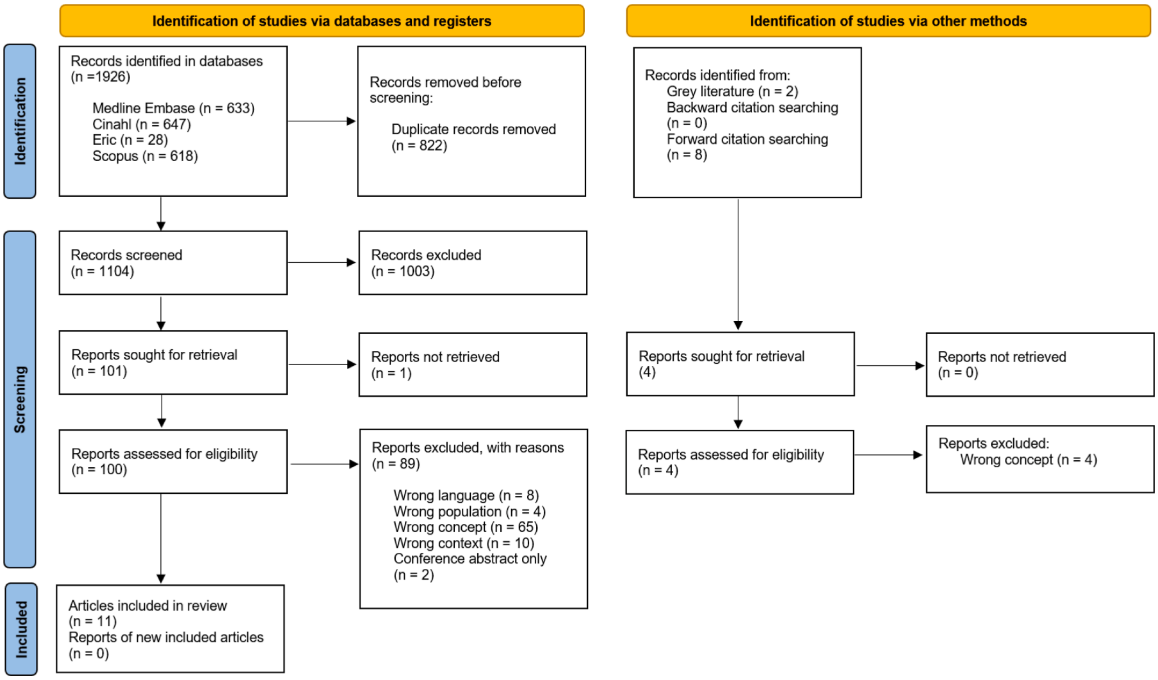

Fig. 1. PRISMA 2020 flow diagram summarising search and selection of articles.

3. Results

3.1. Study selection

After conducting database searches, 1926 records were identified, including 822 duplicates that were removed before screening. The titles and abstracts of the remaining 1104 records were screened, and 1003 records were excluded because they did not meet the inclusion criteria. In this stage one record was excluded because it was not retrieved. The remaining 100 reports were considered for detailed assessment of the full text, and 89 were ultimately excluded (see Appendix F for exclusion reasons). Eleven articles were included in the scoping review (Fig. 1).

3.2. Learning activity types

Six articles described the use of simulation-based learning (task trainers, manikin and standardised patient) (Brooks, Moriarty, & Welyczko, 2010; Burke, 2010; Durmaz, Dicle, Cakan, & Cakir, 2012; Evans & Mixon, 2015; Nakayama, Ejiri, Arakawa, & Makino, 2020; Parvis, Badowski, & Martin, 2021) and three articles described the use of virtual simulation (Kim, Lee, & Lee, 2021; Koivisto, Multisilta, Niemi, Katajisto, & Eriksson, 2016; Tjoflåt, Brandeggen, Strandberg, Dyrstad, & Husebø, 2018). Two articles described the use of web-based learning (Durmaz et al., 2012; Edeer, Vural, Damar, Yasak, & Damar, 2019) and one article described case studies (Byrne, Root, & Culbertson, 2016) (Table 2).

Different approaches were used for the simulation-based learning. Brooks et al. (2010) used academic staff as a standardised patient and a manikin when the students performed interventions. Burke (2010) used both task trainers at skill stations (low fidelity) and human patient simulators (medium fidelity). Evans and Mixon (2015), Nakayama et al. (2020) and Parvis et al. (2021) used high-fidelity simulations, which are life-sized manikins with correct anatomy, pathophysiological and pharmacological responses and sophisticated interactive capability. Durmaz et al. (2012) used a static manikin and had a final-year student act in the role of the patient.

The articles applying virtual simulation are explained in detail. Tjoflåt et al. (2018) used *vSim® for Nursing*, a web- based virtual simulation with the intention of allowing participants to learn planning and complexity and achieve learning outcomes in clinical nursing practice. Koivisto et al. (2016) used a 3D simulation game consisting of patient scenarios and related events. In the game, each participant acted as the nurse working in a hospital patient room. The patient in the game was a 3D character with authentic reactions. The game intended to be interactive; focused on the patients' concerns; and gave the player immediate and cumulative feedback in the form of points, patient responses and in-game facilitators' comments (Koivisto et al., 2016). Kim et al. (2021) used virtual reality (VR) with wearable devices with the intention to let the students experience how it is to walk in the shoes of a surgical patient through sights, hearing and touch. The VR simulation was a part of a blended learning programme (Kim et al., 2021).

Durmaz et al. (2012) and Edeer et al. (2019) used web-based education (referred to as e-learning) that included specific textual

Table 2
Extraction fields.

Learning activity type	Learning activities	Author(s) (year of publication), origin/country of study	Aim of article	Design and sample	Pre- and postoperative nursing content	Measured and reported outcome(s)
Simulation-based learning	Problem-based learning activities with simulation (manikin and academic staff acting as the patient)	Brooks et al. (2010), UK	Explore the development and implementation of a simulated practice learning exercise in the curriculum and expound on the advantages and disadvantages of the approach	Design: Not described in line with scientific requirements; data analysis not described Sample: Third-year preregistration nursing students	Preoperative patient assessment, postoperative care, care for an anxious patient, nursing documentation	No in-study information provided
Simulation-based learning	Task trainers and human patient simulation (low and medium fidelity); five areas: 1. Drill and practice 2. Advance organisers (in simulation) 3. Problem-solving activities 4. Case-based reasoning 5. Collaborative groups	Burke (2010), USA	How analysis, design, development, implementation and evaluation apply to developing a simulation programme	Design: Not described in line with scientific requirements; data analysis not described Sample: No in-study information provided	Provide patient safety, identification, postoperative assessments, assessing pain and medication record, administering pain medication, ensuring patient adheres to fasting, offering emotional support, documentation	No in-study information provided
Simulation-based learning	High-fidelity human patient simulation in postoperative pain management Scripted sequence of events, definitions of pain and pain assessment, measurement and management Structured briefing and debriefing	Evans and Mixon (2015), USA	Assess undergraduate nursing students' postoperative pain knowledge after participation in a postoperative pain simulation scenario	Design: A quantitative, descriptive study Sample: First-year (second semester) nursing students (N = 117)	Postoperative pain with fear of addiction	Students' pain knowledge
Simulation-based learning	High fidelity human patient simulation in postoperative patient management, personal and peer-led simulations Structured briefing and debriefing Organised in personal and peer simulations	Nakayama et al. (2020), Japan	To incorporate peer learning into simulation learning and to clarify the differences between stress and anxiety during personal and peer simulations	Design: An observational study Sample: Third grade undergraduate nursing students at two nursing universities (N = 109)	A postoperative patient with central venous catheter, oxygen masque, urethral catheter, wound dressing and indwelling abdominal drain Postoperative assessments through auscultation, inspection, and palpation	Stress and anxiety in nursing students between individual and peer simulations Stress and anxiety measured by heart rate variability
Simulation-based learning	High fidelity human patient simulation Prior to simulation-day activities: introduction to the simulation, learning objectives, a simulated patient's medical history and physical examination, a video recording of a sterile gowning and gloving demonstration, and reading assignments of a total hip arthroplasty and malignant hyperthermia crisis PowerPoint® presentation one week prior to the simulation Structured briefing and debriefing	Parvis et al. (2021), USA	To describe a simulated perioperative clinical day for prelicensure nursing students	Design: Not described in line with scientific requirements; data analysis not described Sample: Prelicensure Nursing students (N = 45)	Three separate simulations: preoperative, intraoperative, and postoperative phases (intraoperative not described due to the research question) Preoperative: patient interview, completion of a surgical checklist, administering medication, ensuring patient safety, patient education Postoperative: assessment to recover patient, responsibility of monitor's and patient recovery documents from anaesthesia, performs SBAR (Situation, Background, Assessment, Recommendation) hand-off to receiving nurse, evaluation of patient dischargement	Satisfaction, self-confidence, learning, collaboration simulation design through evaluation questionnaires

(*continued on next page*)

Table 2 (*continued*)

Learning activity type	Learning activities	Author(s) (year of publication), origin/country of study	Aim of article	Design and sample	Pre- and postoperative nursing content	Measured and reported outcome(s)
Virtual simulation	A virtual reality blended learning program of five weeks duration Four sessions: 1. Educational lectures 2. Problem-based learning I (individual activities) 3. Problem-based learning II (team activities) 4. Virtual reality simulation with wearable device	Kim et al. (2021), Korea	Nursing students learning experience and outcomes in a virtual experience of simulating a perioperative patient	Design: A phenomenological study, focus group interview Sample: Second-year nursing students (N = 21)	Preoperative: Intravenous injection, use the bathroom while connected to an intravenous pole, transfer to the operating room stage while lying on a stretcher, and expose and confirm the pre-marked breast surgery site Postoperative: catheterization procedure	Students' experience being a perioperative patient through virtual reality
Virtual simulation	Virtual 3D simulation game of 30–40 minutes' duration to increase the clinical reasoning process Single-player game, player took the role of nurse, patient was a 3D character in a 3D environment representing a hospital ward Interactive elements, feedback given, guidance given when playing	Koivisto et al. (2016), Finland	Investigate nursing students' experiences of learning clinical reasoning by playing a 3D simulation game	Design: A quantitative, descriptive cross-sectional study Sample: Nursing students from the first (13%), second (85%) and third (2%) year of a surgical nursing course (N = 166)	Postoperative patient scenarios in the ward (spinal surgery)	Students' clinical reasoning
Virtual simulation	Virtual reality web-based simulation of two hours duration Organised in terms of learning objectives, planning, complexity and cues Simulation instructions on e-mail to students one day in advance Structured briefing Students worked in pairs to allow discussions and interactive learning Interactive elements, feedback given	Tjoflåt et al. (2018), Norway	Evaluate nursing students' experiences with a virtual clinical simulation scenario in surgery using *vSim for Nursing*	Design: a quantitative and qualitative study, descriptive and convergent mixed method Sample: Second-year nursing students (N = 65)	Postoperative patient scenarios in the ward (ruptured appendix)	Students' experience
Web-based learning	Experimental group: Screen-based computer e-learning: textual information, pictures, flowcharts, tables, sample cases, videos, simulation Control group: Skill laboratories similar to clinical environments	Durmaz et al. (2012), Turkey	Examine the effect of screen-based computer simulation of knowledge, skills and clinical decision-making process in pre- and postoperative care vs. skill laboratories	Design: A randomised controlled study Sample: Second-year nursing students (N = 82): intervention group (n = 41), control group (n = 41)	Preoperative: Psychosocial and physical preparation, patient education about postoperative exercises Postoperative: Assessments and interventions aimed at preventing complications	Students' knowledge, skills, and clinical decision making
Web-based learning	Experimental group: Web-based education (e-learning): specific textual information, images, flowcharts, tables,	Edeer et al. (2019), Turkey	Explore the effect of web-based pre- and postoperative care	Design: A randomised controlled study (double blinded)	Preoperative: Nursing interventions, patient education, psychosocial and physiological assessments, pain management, patient preparation	Students' knowledge, skills and clinical decision making

(*continued on next page*)

Table 2 (*continued*)

Learning activity type	Learning activities	Author(s) (year of publication), origin/country of study	Aim of article	Design and sample	Pre- and postoperative nursing content	Measured and reported outcome(s)
	reminders, sample case studies, videos, and feedback section for participant questions Control group: PowerPoint presentations, case discussions, question- and-answer methods and presentations viewed in the classroom			Sample: Second-year nursing students (N = 305): intervention group (n = 155), control group (n = 150)	Postoperative: Potential intraoperative complications, pain assessment, interventions, observations for potential complications	
Case study	No in-study information provided	Case study where clinical topics were highlighted, categorised by the concept they pertained to	Byrne et al. (2016), USA	Provide resources for nurse educators to create perioperative case studies	Design: Not described in line with scientific requirements; data analysis not described	Oxygenation (obstructive sleep apnoea and obesity), safety (screening, mobility, thermoregulation, time out, correct site surgery, transition of care venous thromboembolism prevention), posttraumatic stress disorder, pain, nutrition, patient education for home care, team communication training
Student learning outcomes identified, case study strategy developed and implemented for the learning outcomes		Sample: No in-study information provided				

information, images, flowcharts, tables, reminders, case studies, and videos. In addition, Edeer et al. (2019) included opportunities for students to ask questions during the learning activity. Byrne et al. (2016) used case studies.

3.3. Characteristics of identified sources

As summarised in Table 2, four articles originated from North America, three from Europe and four from Asia (Table 2). Seven papers were articles with qualitative, quantitative or mixed-methods designs. Of the papers with a quantitative approach, two were randomised controlled studies with pre- and post-tests (Durmaz et al., 2012; Edeer et al., 2019). Two used a descriptive design with questionnaires (Evans & Mixon, 2015; Koivisto et al., 2016), and one used a mixed-methods approach with qualitative and quantitative data (Tjoflåt et al., 2018). One article had an observational design (Nakayama et al., 2020) and one study had a phenomenological design (Kim et al., 2021). The remaining four articles included descriptions and evaluations of learning activities (Brooks et al., 2010; Burke, 2010; Byrne et al., 2016; Parvis et al., 2021) but did not include empirical evidence in accordance with scientific methods.

3.4. Considerations for designing learning activities in pre- and postoperative nursing care

The articles described various considerations and structural challenges when planning a learning activity (Table 2). Seven articles described the learning activity as part of a surgical nursing course (Brooks et al., 2010; Burke, 2010; Byrne et al., 2016; Edeer et al., 2019; Kim et al., 2021; Koivisto et al., 2016; Tjoflåt et al., 2018). One article described the learning activity as an alternative to traditional clinical learning (Parvis et al., 2021). Seven of the eleven articles suggested a sequence of theoretical considerations before the learning activity (Brooks et al., 2010; Burke, 2010; Durmaz et al., 2012; Evans & Mixon, 2015; Kim et al., 2021; Parvis et al., 2021; Tjoflåt et al., 2018). Briefing and debriefing were suggested as part of the pedagogy in the majority of the articles describing simulation-based learning as the learning activity (Brooks et al., 2010; Burke, 2010; Evans & Mixon, 2015; Nakayama et al., 2020; Parvis et al., 2021).

3.4. Pre- and postoperative nursing care content

Six articles contained both pre- and postoperative content (Brooks et al., 2010; Byrne et al., 2016; Durmaz et al., 2012; Edeer et al., 2019; Kim et al., 2021; Parvis et al., 2021), and five articles had only postoperative content (Burke, 2010; Evans & Mixon, 2015; Koivisto et al., 2016; Nakayama et al., 2020; Tjoflåt et al., 2018). Pre- and postoperative content was described in detail in four of the articles together with a clear explanation of the learning objectives (Burke, 2010; Byrne et al., 2016; Edeer et al., 2019; Parvis et al., 2021). Medication administration and/or assessment was the most phrased nursing content in the articles overall (Brooks et al., 2010; Burke, 2010; Byrne et al., 2016; Edeer et al., 2019; Evans & Mixon, 2015; Kim et al., 2021; Parvis et al., 2021), thereafter postoperative nursing assessment (Burke, 2010; Durmaz et al., 2012; Edeer et al., 2019; Kim et al., 2021; Parvis et al., 2021) and preoperative nursing assessment (Burke, 2010; Byrne et al., 2016; Edeer et al., 2019; Kim et al., 2021; Parvis et al., 2021). Care for emotional needs was a recurring theme in five articles (Brooks et al., 2010; Burke, 2010; Byrne et al., 2016; Durmaz et al., 2012; Edeer et al., 2019). Patient safety was mentioned in three articles (Burke, 2010; Byrne et al., 2016; Parvis et al., 2021) and team communication/-hand-off was mentioned twice (Byrne et al., 2016; Parvis et al., 2021).

3.5. Reported measurements and outcome(s)

As summarised in Table 2, six of the eleven articles reported outcomes. Only three articles (Durmaz et al., 2012; Edeer et al., 2019; Nakayama et al., 2020) assessed measurements other than self-reported data, specifically students' stress and anxiety in individual and peer simulations (Nakayama et al., 2020) and students' knowledge, skills and clinical decision making (Durmaz et al., 2012; Edeer et al., 2019). Various instruments were used to measure learning outcomes (Ferrell & McCaffery, 2012; Jenkins, 2001; Karayurt, Mert, & Beser, 2009).

Koivisto et al. (2016) investigated clinical reasoning using a questionnaire. The students in the study stated they learned how to collect information and act but were less successful in establishing goals for patient care or evaluating interventions. The students reported they learned the most about applying theoretical knowledge and the least about applying previous experiences when learning in a gaming context. Further, the students felt they could make mistakes when playing. The students' prior experience with non-digital or educational games was not significantly associated with learning the clinical reasoning process when playing. Finally, those students playing digital games daily or occasionally reported learning clinical reasoning better compared to those who did not play at all.

Tjoflåt et al. (2018) developed a questionnaire using quantitative and qualitative data from previous research on students' experiences with *vSim® for Nursing*. The majority of the students reported that working with the virtual simulation was good preparation for their clinical placements in surgical wards. The content was relevant to their roles as nurses, and most of the students recommended virtual simulation for future use. Overall, the qualitative data indicated that *vSim® for Nursing* was realistic and successful, with high student satisfaction in regard to learning. The students who did not recommend *vSim® for Nursing* reported difficulties with understanding how to navigate the programme and with the programme not being in their mother tongue.

Kim et al. (2021) examined students' experiences simulating as a surgical patient through VR. The students reported positive experiences of being in the patient's shoes. They gained understanding of the perioperative patient, developing nursing competencies and patient-centred care. The students expressed enhancement for a new and vivid teaching method.

4. Discussion

4.1. Considerations when designing future learning activities

The results of this scoping review indicated several factors that should be considered when designing learning activities to promote students' competence in pre- and postoperative nursing. Samples from the first, second and third study years were represented in the included sources. According to Shin et al. (2015), nursing students value early exposure to practice prior to entering placements. Burke (2010) stated that learning activities should depend on the curriculum content. If students have acquired relevant competence in advance of the learning activity, they will benefit more from the training (Biggs & Tang, 2011). The preparation and assessment of the surgical patient is a complex process (Danko, 2019; Kaasa, 2019; Nilsson et al., 2020). Timing should be considered, as it is important in terms of knowledge transfer and successful implementation of the learning activity.

Both Koivisto et al. (2016) and Tjoflåt et al. (2018), who used new technology in the simulation training, highlighted the possibility of repeated training. An integrative review of the education literature revealed that repetitive interventions rather than single interventions, were superior for learning outcomes (Bluestone et al., 2013). A limitation of initial training is the rapid loss of skills (Bang et al., 2016). Repeated practice can lead to the retention of healthcare-related skills (Kim, Park, & Shin, 2016), which is needed when providing care in the pre- and postoperative phase (Yang et al., 2020).

An interesting finding was the gradual improvement in fidelity in simulation-based training (Evans & Mixon, 2015; Kim et al., 2021; Koivisto et al., 2016; Tjoflåt et al., 2018). Badash, Burtt, Solorzano, and Carey (2016) indicated that the advancement of digital technology provides opportunities to create realism and complexity when designing surgery simulations. Advances in digital and virtual technology have resulted in a paradigm shift in health education, with the use of technology growing as a pedagogical approach. It demands fewer physical resources than traditional manikin-based simulations, making learning activities more flexible (Fogg, Kubin, Wilson, & Trinka, 2020).

4.2. Pre- and postoperative content

The pre- and postoperative content described and defined in this scoping review mostly comprised concrete preoperative preparations and pre- and postoperative assessments related to surgery. Some of the pre- and postoperative content could also be described as general nursing competence, such as thinking systematically about the safe delivery of patient care and medication assessment and administration (European Federation of Nurses Associations, 2015; Satu, Leena, Mikko, Riitta, & Helena, 2013). Still, both safety and medication assessment are particularly important when caring for surgery patients (Burke, 2010; Byrne et al., 2016; Parvis et al., 2021). The literature highlights medication patient safety as crucial during the pre- and postoperative parts of the surgical pathway (Storesund et al., 2020; Tobiano, Chaboyer, Teasdale, Raleigh, & Manias, 2019).

Students need both specific skills related to a surgical patient and general nursing skills. The results of this study and the literature support this (Cheng et al., 2020; Kaasa, 2019; McGarvey, Chambers, & Boore, 2000; Nilsson et al., 2020). By breaking down complex pre- and postoperative nursing skills into their component parts and describing them in detail, there is a danger that students' learning outcomes will be defined by and reduced to a score on a test related to a specific skill (Raaheim, 2011). The gap between theory and practice become even more visible in hospital settings where students get to test what they can do and experience the complexity of caring for patients.

The results from this review revealed a scarce of team communication training as it was only mentioned in two articles (Byrne et al., 2016; Parvis et al., 2021) (Table 2). The exchange of relevant clinical information from one provider to another is crucial for the surgical pathway as missing information and incorrect data transfer can lead to adverse patient outcomes (Nagpal et al., 2012). Poor communication amongst health care providers has been identified as the third leading root cause of sentinel incidents (The Joint Commission, 2016). Structured and precise communication is essential in clinical handover between healthcare providers to avoid necessary information get lost (Gardiner, Marshall, & Gillespie, 2015). With structured communication training nursing students can learn essential skills to promote patient safety.

4.3. Measurement methods

The measurement methods demonstrated an over-reliance on self-reported data. Although students' self-reported data can provide valuable information (Evans & Mixon, 2015; Kim et al., 2021; Koivisto et al., 2016; Tjoflåt et al., 2018), the evidence from these studies did not indicate whether the students achieved learning outcomes through the learning activities. Earlier research has suggested a poor correlation between students' self-reported assessment performance and objective measures (Liaw, Scherpbier, Rethans, & Klainin-Yobas, 2012; Ruzafa-Martinez, Leal-Costa, Garcia-Gonzalez, Sánchez-Torrano, & Ramos-Morcillo, 2021; Snibsøer et al., 2018). Self-reported assessment alone may not be a valid predictor of clinical performance (Liaw et al., 2012; Ruzafa-Martinez et al., 2021).

According to Maul, Irribarra, and Wilson (2016), there are difficulties when measuring certain aspects because to some extent they are defined by socially, culturally and historically situated perspectives and concerns. Even if one acknowledges that such elements can be shaped as quantities, they are resistant to standard techniques of (physical) empirical falsification. This arguably eliminates them as candidates for 'fundamental' measurement (Maul et al., 2016). The data for students' learning outcomes is contextual (Navas-Ferrer, Urcola-Pardo, Subirón-Valera and German-Bes, 2017; Ruzafa-Martinez et al., 2021). Therefore, it is problematic to compare cases and data in ways that meet the standards of pure science and controlled experiments. When measuring outcomes, the presentation, interpretation and generalisation of the outcome results should receive particular focus, as assessment depends on the context

(Navas-Ferrer et al., 2017).

4.4. Strengths and limitations

This study aimed to map and summarise learning activities for undergraduate nursing students learning pre- and postoperative nursing prior to clinical placement. One strength of this study is the broad and comprehensive search of electronic databases and the inclusion of all available articles from the last 11 years. Further, this study used an updated and recommended methodological framework method for the search strategy and data extraction. The articles included cover several methods and originate from three regions of the world.

The study has also some limitations. First, only articles published in English were included. Articles written in other languages could have provided additional information. Second, different terms were used to describe the pre- and postoperative nursing content in the curriculum and learning activities in nursing education. Therefore, additional terms were included in the search to identify relevant literature. However, it is possible that we inadvertently excluded studies with pre- and postoperative content and/or contexts in which learning activities were used in the curriculum. Third, due to the design (scoping review) no critical appraisal was made. Four of the articles describing learning activities are without a method section. The articles were considered valuable for inclusion because they had a comprehensive description of the learning activities. Finally, our study results may not be applicable to nursing students caring for patients undergoing specific surgeries that may be associated with concerns that differ from those about surgery in general.

5. Conclusion

This scoping review maps and summarises learning activities for undergraduate nursing students learning pre- and postoperative nursing prior to clinical placement. In particular, this work contributed new knowledge regarding the scope and features of existing learning activities in this specific area of nursing education. The results showed that simulation-based learning (task trainers, manikin and standardised patient), virtual simulation, web-based learning and case studies are used as learning activities. A range of pre- and postoperative content was applied in the learning activities. In the articles with outcome measures, students' knowledge, skills, clinical decision making, clinical reasoning, experiences and stress and anxiety were measured. It is likely that due to the COVID-19 pandemic which is resulting surgery cancellations and restrictions on clinical placements, the quantity and quality of research on learning activities to improve competence in pre- and postoperative nursing will increase. There is a need to develop more learning activities with pre- and postoperative nursing content to prepare nursing students for clinical placement. There is also a need for pre- and postoperative learning activities with structured communication training as this skill is needed for safe surgery patient care. The study results showed a trend towards using new technology such as 3D and VR, which can have implications for planning future curricula. Although developing virtual simulations is costly, these learning activities are advantageous because they can be used as self-practice without the expense of facilitators. Therefore, we anticipate that nursing education will gradually incorporate more of these interactive learning activities into the curriculum in the near future.

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Supplemental material

Appendix A. PRISMA-ScR Checklist.
Appendix B. Embase (Ovid) and MEDLINE (Ovid) (search conducted October 2021).
Appendix C. Cinahl Ebscohost (search conducted October 2021).
Appendix D. ERIC (search conducted October 2021).
Appendix E. Scopus (search conducted October 2021).
Appendix F. Full-text articles, excluding reason.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ijer.2022.102033.

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Paper II

Usability Evaluation of the Preoperative ISBAR (Identification, Situation, Background, Assessment, and Recommendation) Desktop Virtual Reality Application: Qualitative Observational Study

Original Paper

Usability Evaluation of the Preoperative ISBAR (Identification, Situation, Background, Assessment, and Recommendation) Desktop Virtual Reality Application: Qualitative Observational Study

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Abstract

Background: Systematic communication, such as the ISBAR (identification, situation, background, assessment, recommendation) approach, comprises a generic, transferable nontechnical skill. It can be used during the handover of patients set to undergo surgery and can be practiced in various ways, including virtual reality (VR). VR increasingly has been implemented and valued in nursing education as a positive contribution to teach students about pre- and postoperative nursing. A new nonimmersive 3D learning activity called the Preoperative ISBAR Desktop VR Application has been developed for undergraduate nursing students to learn preoperative handover using the ISBAR approach. However, the usability of this learning activity has not been studied.

Objective: This study aimed to investigate how second-year undergraduate nursing students evaluated the usability of the Preoperative ISBAR Desktop VR Application.

Methods: This was a qualitative study with observation and interviews. The inclusion criteria were undergraduate second-year nursing students of varying ages, gender, and anticipated technological competence. The System Usability Scale (SUS) questionnaire was used to get a score on overall usability.

Results: A total of 9 second-year nursing students aged 22-29 years participated in the study. The average score on the SUS was 83 (range 0-100), which equals a "B" on the graded scale and is excellent for an adjective-grade rating. The students expressed increased motivation to learn while working in self-instructed desktop VR. Still, a few technical difficulties occurred, and some students reported that they experienced some problems comprehending the instructions provided in the application. Long written instructions and a lack of self-pacing built into the application were considered limitations.

Conclusions: The nursing students found the application to be usable overall, giving it an excellent usability score and noting that the application provided opportunities for active participation, which was motivational and facilitated their perceived learning outcomes. The next version of the application, to be used in a randomized controlled trial, will be upgraded to address technological and comprehension issues.

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KEYWORDS

desktop virtual reality; handover; ISBAR; preoperative; undergraduate nursing students; usability evaluation; usability; nursing; health care education; student; medical education; medical training; VR; virtual reality; surgery; surgical; System Usability Scale; communication; self-instruction; self-guided; nurse; training; undergraduate; health care professional; health care provider

Introduction

The exchange of relevant clinical information from one provider to another (eg, handover) is crucial for the surgical pathway because missing information and incomplete handover can lead to adverse patient outcomes [1,2]. The ISBAR (identification, situation, background, assessment, and recommendation) approach is an evidence-based approach to ensure consistent, structured communication [3] and can be used in inter- and intraprofessional collaboration for patients about to undergo surgery [4-8]. Studies have reported that using ISBAR can improve communication between health care providers [9,10] and reduce communication errors [11].

Considering that a lack of clear communication directly or indirectly can endanger patient safety, the evidence suggests that ISBAR skills acquisition should start early in nursing education [12,13]. ISBAR traditionally is learned through role-playing in simulations or in classroom settings [14,15]. The past few years have seen an increased interest in virtual reality (VR) as a method to learn structured communication [16-18].

Desktop VR is a computer-generated 3D environment presented on nonimmersive desktop and laptop PC screens [19]. Desktop VR typically is built around user interaction, such as moving avatars, typing commands, and interacting with others while completing a task [19]. The advantage of desktop VR is that it has potential for letting users practice without supervision while receiving audio and visual instruction and has instant feedback from the VR application itself in a safe environment [17]. VR has been increasingly implemented and valued in nursing education as a positive contribution to curricula to teach students about pre- and postoperative nursing [20-22]. Using desktop VR as an active learning method also aligns with studies that have recommended interactive teaching strategies in curricula [23]. However, to the best of our knowledge, no published research exists on desktop VR solutions that practice handover using the ISBAR approach in a preoperative setting [24].

Perceived usability is essential when developing such solutions [25-27]. The International Organization for Standardization has defined *usability* as “the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use” [28]. Furthermore, the degree of learnability is defined as part of the usability assessment [28]. We developed the Preoperative ISBAR Desktop VR Application (henceforth “application”), which is intended to be used in a randomized controlled trial. Thus, its usability needs to be tested to optimize the application for virtual simulation in nursing education.

This study aimed to investigate how second-year undergraduate nursing students evaluated the application’s usability.

Methods

Design

This was a qualitative observational study with interviews. The usability test was conducted during the fall semester of 2021.

Preoperative ISBAR Desktop VR application

The application was part of a research project focusing on the use of VR in health care education [29]. It was created to teach handover skills when using the ISBAR approach and is based on cognitive principles from the 4-component instructional design (4C/ID) [30] guidelines, comprising (1) a learning task, (2) supportive information, (3) procedural information, and (4) part-task practice. Instructions and tasks were based on evidence-based knowledge of learner-centered teaching [31-33] and national ISBAR guidelines [34]. A version of the application still under development was used.

The various sequences in the application are presented in Table 1. The students were organized into groups of 3 who played together in VR through 3 main activities. The first activity was to sort patient information individually using the ISBAR approach and compare and discuss the participants' individual sorting to clarify the ISBAR approach. The second activity was to perform handovers using the ISBAR approach, which was between a nurse on a night shift and a day shift, and between a nurse on a day shift and an anesthesia nurse. The third activity was a debriefing that focused on the experience in general and on selecting the most important patient information to communicate first.

Table 1. Presentation of the Preoperative ISBAR[a] Desktop VR Application.

Number	Sequence	Content
1	Instruction: register name and select group number	A screen with a visible square to insert the participant’s name. Group allocation number visible with instruction to choose groups
2	Instruction: introduction to ISBAR	Animation with a voiceover explaining briefly what ISBAR is, presenting the learning objectives, and providing a brief overview of the tasks
3	Task: familiarization with desktop VR[b] and each other	A screen displays instructions on how to use the arrow keys to look around in the desktop VR and introduce the players to each other
4	Instruction: sort patient information	Animation with a voiceover instructing how to sort single pieces of patient information according to the ISBAR approach and how to get additional information in pop-up windows
5	Task: sort patient information	A screen with an area displaying 1 piece of patient information, buttons for each ISBAR letter to select where the patient information should be sorted, and a list containing patient information sorted in the order of the selected ISBAR letters with the opportunity to delete the patient information and to sort it again. An explanation of the ISBAR approach is available as a pop-up
6	Task: discussion of experience with sorting	A screen displays a comparison of how each participant sorted the patient information and a suggestion for correct sorting. The percentage of patient information sorted similarly to the suggested solution is displayed for each player
7	Instruction and task: patient case and choose a role	Animation with a voiceover presenting a patient case, the 3 roles involved (nurse on night shift, nurse on day shift, and nurse anesthetist), and how to choose a role
8	Instruction and task: role description and choose a role	A screen with a written description of the 3 roles involved and pictures symbolizing the roles to be clicked to select a role. When a player clicks on a role, the frame changes to green for that player and red for the other players
9	Instruction: handover role play	Animation with a voiceover instructing how to complete the next task and a handover role play in which participants give and receive patient information in their active roles (nurse on night shift, nurse on day shift, and nurse anesthetist) using the ISBAR approach. Instruction on active participation for both the giver and receiver in handover (sender starts with the selected patient information, and the receiver requests additional patient information)
10	Instruction: handover role play	A screen displays a written summary of the next task
11	Task: handover role play	A screen displays a list of all patient information and a virtual phone. The text states that the player should select the patient information to be presented first and then call the next nurse to perform the handover through the virtual phone. The phone and handover checklist are visible to the receiver of the handover. An explanation of the role play is available as a pop-up for all players during handover practice. The participant's screen with the active role is visible to the other participants in the group. ISBAR explanation available as a pop-up
12	Instruction: debriefing 1	Short animation with a voiceover describing what should be done during the debriefing session
13	Task: debriefing 1	Text stating that they should discuss each participant’s experience doing the tasks in general and that they will discuss each participant in detail afterward
14	Instruction: debriefing 2	Animation with a voiceover with instructions to debrief what each participant chose to highlight and say first during the handover
15	Task: debriefing 2	A screen displays a list of all patient information, with the patient information that the participant had clicked on as the information to present first in bold (highlighted). Suggested bullet points on what to discuss during the debriefing are visible as a pop-up explanation. An ISBAR explanation is available as a pop-up
16	Instruction: debriefing closure	Animation with a voiceover with encouragement to practice again
17	Task: final practice and ending	A screen with available options: to practice again or end the practice. If selecting to practice again, it starts at sequence 2

[a]ISBAR: identification, situation, background, assessment, and recommendation.

[b]VR: virtual reality.

Participants and Recruitment

The aim was to include undergraduate second-year nursing students with variations in age, gender, and anticipated technological competence. With 3 students participating in each group, 9 participants were viewed as adequate for robust usability to get a measure of the perceived usability and to get a good assessment of how people see a system or a product [35].

Information about the study was presented verbally in a compulsory lecture for the second-year nursing students at a university in Norway. Furthermore, written study information and recruitment invitations were displayed on a web-based notice board. Those interested were asked to contact the study, and if they did, they received more detailed information about the study, and an appointment for a test time was set. The students were assigned to the 3 groups based on the order in which they signed up for the study.

Procedure and Data Collection

Overview

The whole learning activity comprised watching a 9-minute video introducing ISBAR [36] and practicing within the application. Three students in each group were placed in separate rooms to ensure that all communication happened in the application, mimicking a situation in which the students were in different locations. One researcher was present in each room to observe and provide support if needed.

Data were collected through (1) background questions, (2) observation, (3) the System Usability Scale (SUS), and (4) focus group interviews.

Background Questions

The participants were asked about their gender, age, and whether they had participated in compulsory ISBAR teaching (yes/no). The participants were also asked about their self-reported technological competence, measured on a 4-point graded scale developed for this study, ranging from level 1 (*low competence*) to level 4 (*high competence*).

Observation

The students were encouraged to think aloud, that is, verbalize their thoughts, constantly [37] while using the application. The think-aloud sessions were video-recorded, and field notes were taken based on a predefined observation template covering navigation errors, ease of use, apparent misunderstandings, and technical difficulties (Multimedia Appendix 1). If the students were unsure of how to proceed with the application, they were encouraged to do what they would find most intuitive before being assisted, as Rubin and Chisnell [25] recommended.

System Usability Scale

The participants were asked to complete the SUS [38] after they finished using the application. SUS is a recommended tool for evaluating educational technology systems [26], comprising 10 open-ended items with 5 answer options ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). The final mean score ranges from 0 to 100, and the score can be reported as an A-F grade using a curved grading scale [39], and as an adjective score, ranging from *worst imaginable* to *best imaginable* [40].

Focus Group Interviews

After completing the SUS, a focus group interview was conducted with each group. An interview guide—which was developed based on the research question, predefined observation template, and usability theory [25]—was used (Multimedia Appendix 2). Examples of questions asked included, "What did you like the most about learning Preoperative ISBAR in desktop VR?," "What did you like the least about learning Preoperative ISBAR in desktop VR?," and "Was there anything that exhausted you during the learning activity? If so, what caused the exhaustion?" Furthermore, the interviews addressed specific usability issues observed when the participants completed the application. Each interview lasted approximately 35-40 minutes, and the interview sessions were audio-recorded.

Analysis

The data were analyzed using different approaches. The average score from the SUS questionnaire was calculated using the procedure described by Brooke [38], presented as mean and SD values, and then given a graded score (A-F) based on the acceptability range. The average adjective score was calculated as recommended [40]. Data on task completion time (efficiency) were gathered from field notes and video recordings and presented with descriptive statistics.

All material (video recordings, field notes from the think-aloud sessions, and transcribed focus group interviews) was analyzed together as recommended by Rubin and Chisnell [25], for completeness and to obtain an overview during analysis. The first author transcribed all audio-recorded material (think-aloud sessions and focus group interviews). The transcribed material was analyzed with the field notes, as recommended by Rubin and Chisnell [25], for completeness and to obtain an overview during analysis. A reflexive thematic analysis [41] was conducted to identify in-depth usability issues, with an emphasis on participants' experiences. The first author led the analysis of the audio-recorded material and field notes to ensure consistency, but the coauthors reviewed and discussed the analysis until an agreement between the coauthors and the first author was reached.

Ethical Considerations

Permission was obtained from the head of the nursing study program at the Department of Health and Nursing Sciences at the University of Agder, the Faculty Ethics Committee at the University of Agder, and the Norwegian Center for Research Data (305866).

Results

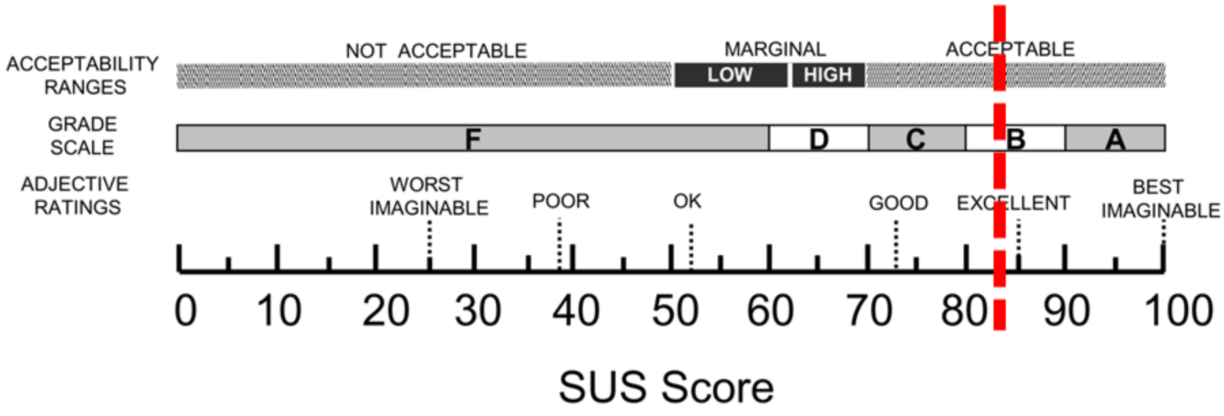
Participants

A total of 9 students responded, and all were included, comprising 7 females and 2 males ranging in ages between 22 and 29 years. All participants previously had taken part in compulsory ISBAR teaching in nursing education. The participants reported their technological competency to be either level 2 (n=5) or level 3 (n=4).

Overall System Usability Assessment

The overall mean SUS score for the application was 83 (SD 18.8; Figure 1), which rates as *Acceptable* on the acceptability range, *B* on the graded scale, and *Excellent* on the adjective rating scale (Figure 1).

Figure 1. Overall system usability assessment. The vertical dotted red line (83 on the 0-100 scale) shows the mean system usability score (SUS) (n=9) (reproduced with permission from Aaron Bangor [42]). SUS: System Usability Scale.



Time

The 3 groups took 28, 37, and 48 minutes to complete all sequences in the application once, with a mean time of 38 minutes. The group that took 48 minutes had one participant who spent 15 minutes sorting patient information (Table 1, sequence 5), while the other participants used 3 to 5 minutes on this task.

In-depth Usability Issues (Thematic Analysis)

The qualitative findings were categorized into two themes: (1) more motivational than standard learning activities and (2) technical and comprehension issues.

More Motivational Than Standard Learning Activities

All participants recommended this learning activity to others and said it was a motivational way of learning ISBAR. The participants said the application helped them learn ISBAR through the self-instructed exercise, discussions with other participants, observing how others performed the tasks, and when the instructions told them to reflect on their performance together with the others.

> *It was good to practice ISBAR instead of just reading. It is actually better to do it. It is more like reality and a lot more fun. Communication is a skill. By reading about ISBAR, you will never be good at communicating. It is a skill that must be practiced. By using this, you are practicing communication. You can memorize the letters in ISBAR, but you cannot use it if you haven't practiced.* [ID 07, self-reported technological competence level 2]

All the participants concluded that the application's features, such as the automatic visualized feedback, motivated them to complete the exercise. Some of them said that being represented as avatars with their own voices and not having to reveal themselves on camera was a good way to practice. Furthermore, some commented that communication through the virtual phone call made them realize that they needed to speak clearly and loudly.

> *I feel that I am more invested in it because it is a PC program. It could be a desire for learning or a competitive instinct, but I want to complete this program. I liked the feeling of progression and the structure. Everyone knew what we were going to do, and we knew what to do. It is systematic, and you go on and on and on and on.* [ID 02, self-reported technological competence level 3]

Some also described it as being closer to clinical practice compared with standard learning activities.

> *It was simulated in a way that made me feel that I got something out of it, and it was a good way to go from theory to practice. It is like a clinical procedure; you do not know how to do it by reading the procedure, but by doing it. You learn to use ISBAR during clinical practice, but having a good start like this can make you learn faster and better.* [ID 01, self-reported technological competence level 3]

Technical and Comprehension Issues

All groups managed to complete the application and all the users were able to complete the tasks "Familiarization with desktop VR and each other" and "Sort patient information" at the first attempt. Screen transitions were crisp and smooth, with no apparent technical lag times that may have led to negative usability. Through the interviews, most participants said it was easy to follow the application's flow and complete the tasks.

> *Technically, it is very easy to understand. For me, it looks like anyone could have managed this. If a technical manager had assisted, that person would not have needed to help them much. It was obvious.* [ID 05, self-reported technological competence level 3]

However, in 2 of 3 usability tests, the application was restarted. In 1 test, a participant had trouble getting access to the microphone on the computer, so the other participants had to wait until this was solved. During another test, a participant clicked on the "Next" button on the screen at a point when they are supposed to introduce themselves to each other (Table 1, sequence 3). Thus, they were instructed to restart the application. When these 2 issues were resolved, the groups completed the tasks.

> *The "technical" problems that occurred were frustrating. I was terrified of doing something wrong. I understood that if you clicked "Next," everyone must start again. So, I got stressed because of the disturbances initially when we had to start over again. Then I thought that I would not ruin it for everyone else. And then I just got even more stressed.* [ID 04, Self-reported technological competence level 2]

Some participants said they had problems understanding parts of each task. One reason was that they did not hear the voiceover instructions (Table 1, sequences 2, 4, 7, and 9) owing to other participants commenting or asking questions during the instructions. Another reason given was reluctance to open the available pop-up windows to repeat the instructions for fear of appearing slow or incompetent to other participants. Finally, some said that the most prolonged instructions contained too much information (Table 1, sequences 8 and 10), making them forget what was said.

> *I did not really understand whether we should include everything or not. That was the hardest to understand. I think it was because I did not read the instructions before. I was stressed, feeling the others may read faster than me. And I am slow, so I just had to hurry, right? And then I did not read the instructions.* [ID 09, self-reported technological competence level 2]

During task completion, 2 of the 9 participants asked for instructions from the observer in the room. The requested instructions were in sequence 5 (Table 1), when it was unclear whether they should answer individually or in a group, and in sequence 11, when someone asked for instructions on how to solve the task regarding whether they should sort all patient information or only some of it.

Discussion

Principal Findings

This study aimed to identify the perceived usability of the application as evaluated by second-year nursing students, who found the learning activity to be usable overall, rating it highly, although with some technical and comprehension issues that impeded the experience for some testers.

Recommended Changes to the Preoperative ISBAR Desktop VR Application

As described, usability issues were found, and it is recommended that such issues be addressed by making changes to the application. Some participants took an unnecessarily long time to complete some tasks, for example, trying to perfect their answers. However, this may be due to the experimental task given and not a usability issue. Nevertheless, it is recommended to impose a time limit for some tasks (Table 1, sequences 5 and 11, with a time limit of 5.5 minutes and 1 minute, respectively) to more accurately reflect the practical context (eg, time pressure, stress, and workload).

Considering that participants were disturbed when other participants talked during the instructions, it is recommended that participants be muted while instructions are given (Table 1, sequences 2, 4, 7, and 9). To avoid the participant clicking on the "Next" button too early, a 10-second delay after the spoken instructions are completed before "Next" can be clicked is recommended. Furthermore, it is recommended that each written instruction sequence and task sequence start with the informative pop-up windows open so that they only can be closed manually to allow all participants to read or reread through the information at their own pace, which is an appealing approach for students [43].

VR as a Learning Technology

All participants found the VR application to be a motivational way of learning ISBAR. Using desktop VR for learning purposes seems to fit the targeted users, which is perhaps not surprising, as they all were born in the mid-1990s as part of a demographic termed Generation Z [44]. This generation grew up with access to the internet and digital technology from a young age [45]. According to Chicca and Shellenbarger [45], this generation is supported during the learning process when technologically advanced and visually engaging and exciting activities are provided.

Some students said that the application helped them learn the ISBAR approach better than traditional activities, mainly because they could participate actively and experience the training closer to practice. This supports Huang and Liaw [46], suggesting that a well-designed VR learning environment can bridge the gap between theoretical and real-life learning, providing learners with a more authentic learning experience. The results indicate the application's utility, providing self-reported improvement in the performance of the ISBAR approach compared to conventional training, which could be mediated by the interaction experience and the pedagogical support in the application [47]. Thus, the learning outcome must be further studied using a suitable design to measure the learning effect.

Even if the application's evaluation primarily was positive, the participants also reported some challenges due to negative stress when task completion did not progress as intended. Technological usability issues affect the participants' experiences [43,47]. Furthermore, the individual differences in how people react to using VR for learning [46] need to be considered when designing learning activities.

The students stated that they were reluctant to open the pop-up windows for explanations when everyone in the group was watching. Others' influence has been noted in extant research when participants are observed performing tasks, a phenomenon explained by the social facilitation theory [48,49]. The assumption is that others' presence can both promote and hinder one's performance, which also is supported by Strojny et al's [50] investigation of copresence in VR. In an earlier study, it was suggested that self-paced learning be taken into account during instruction through desktop VR because it generates autonomy [51].

Methodological Strengths and Limitations

This study's strength was that the participants were the intended user group, who varied in age, gender, and self-reported technological competence. This variation can enhance the generalizability of the results [25]. Nevertheless, some caution is needed because the participants were self-recruited, which could mean they were overly positive about VR and technology-based teaching [52].

Although the SUS is a recommended tool for evaluating educational technology systems and is suitable for a small sample size [26], the scale was not developed specifically to evaluate learning activities in desktop VR. Therefore, the think-aloud method and focus group interviews were supporting methods in this study.

Conclusions

The second-year undergraduate nursing students rated the application's usability as excellent and provided opportunities for active participation, which was motivational and facilitated their perceived learning outcomes. The next version of the application, to be used in a randomized controlled trial and further as a part of clinical preparation in nursing education, will include better technological and comprehension support.

Acknowledgments

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Authors' Contributions

EMA, HB, AS, RH, and KH contributed to the study design. EMA and KH performed the data collection, and EMA, HB, AS, RH, and KH performed the analysis. EMA drafted the manuscript, and HB, AS, RH, and KH contributed during the manuscript development process. All authors read and approved the final version of the manuscript.

Conflicts of Interest

None declared.

Multimedia Appendix 1

An avatar represents each participant, and the interaction takes place in the desktop virtual reality (VR).
[PNG File , 757 KB-Multimedia Appendix 1]

Multimedia Appendix 2

A picture of the screen for the task of sorting patient information. One part of the patient information is shown in the upper left part and is sorted by clicking on one of the ISBAR letters. To the right, the patient information already sorted is displayed.
[PNG File , 1135 KB-Multimedia Appendix 2]

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Abbreviations

ISBAR: introduction, situation, background, assessment, and recommendation
SUS: System Usability Scale
VR: virtual reality
4C/ID: four-component instructional design

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Paper III

The effect of using desktop VR to practice preoperative handovers with the ISBAR approach: a randomized controlled trial

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The effect of using desktop VR to practice preoperative handovers with the ISBAR approach: a randomized controlled trial

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Abstract

Aim The aim was to investigate whether second-year undergraduate nursing students practicing the Identification-Situation-Background-Assessment-Recommendation (ISBAR) communication approach in a desktop virtual reality (VR) application had a non-inferior learning outcome compared with the traditional paper-based method when sorting patient information correctly based on the ISBAR structure.

Methods A non-inferior parallel group assessor blinded randomized controlled trial, conducted in simulation sessions as part of preparation for clinical placements in March and April 2022. After a 20-minute introductory session, the participants were randomized to self-practice the ISBAR approach for 45 minutes in groups of three in either an interactive desktop VR application (intervention) or traditional paper-based (TP) simulation. The primary outcome concerned the proportion of nursing students who sorted all 11 statements of patient information in the correct ISBAR order within a time limit of 5 min. The predefined, one-sided, non-inferiority limit was 13 percentage points in favor of traditional paper-based simulation.

Results Of 210 eligible students, 175 (83%) participated and were allocated randomly to the VR ($N=87$) or TP ($N=88$) group. Practicing in the desktop VR application (36% of everything correct) was non-inferior to the traditional paper-based method (22% everything correct), with a difference of 14.2 percentage points (95% CI 0.7 to 27.1) in favor of VR. The VR group repeated the simulation 0.6 times more (95% CI 0.5 to 0.7). Twenty percent more (95% CI 6.9 to 31.6) of the students in the VR group reported liked how they practiced. All the other outcomes including the System Usability Scale indicated non-inferiority or were in favor of VR.

Conclusions Self-practicing with the ISBAR approach in desktop VR was non-inferior to the traditional paper-based method and gave a superior learning outcome.

Trial registration number ISRCTN62680352 registered 30/05/2023.

Keywords Desktop virtual reality, ISBAR approach, Nursing students, Preoperative handover, Self-practice, Structured communication, Traditional paper-based

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Background

Handover of patients from one healthcare professional or organization to another is a situation in which patient safety can be threatened [1]. Handovers require sharing patient information, coordinating care, and transferring accountability and authority to the next team [2]. Structured handovers reduce patient complications, medication errors, and adverse patient events [3], whereas poor handover skills are related to misunderstandings between healthcare providers and can lead to severe consequences for patient safety [2].

When a patient undergoes surgery, a structured handover is an essential skill for healthcare workers [4–6]. Although electronic surgical checklists and digital tools to support preoperative handovers are implemented increasingly [7], previous research has demonstrated that these tools do not always improve communication and collaboration [8]. Utilization of the Identification-Situation-Background-Assessment-Recommendation (ISBAR) approach has been recognized internationally and widely adopted as a handover tool to enhance patient safety [9, 10]. ISBAR is used in clinical practice [7] and has been implemented in training and education [11].

Within nursing education lie challenges related to resources, e.g., time, instructors, and available simulation locations to practice skills, such as the ISBAR approach [12]. Furthermore, during student ward practice, there is insufficient time at clinical sites due to a decrease in number and length of hospitalization of surgery patients [13]. To help overcome some of these challenges in the educational setting, one possible solution is to use desktop virtual reality (VR) [14, 15].

VR utilizes 3D computer technology to construct an interactive virtual world, allowing users to engage with a simulated environment [16]. The level of immersion experienced by users in a virtual world may differ based on the hardware and software employed. This has led to suggestions for how to best define VR applications according to the level of immersion [17]. There are also other types of applications that have been termed desktop, screen- or computer-based VR which has been classified as non-immersive compared with VR solutions that use a head-mounted display [18]. In this publication, the term desktop VR is used. Desktop VR implies that individuals use a computer's keyboard and mouse to observe and interact with a virtual environment displayed on the computer screen [19]. In multiplayer desktop VR versions, users can interact with each other through a representation of an avatar, sound and movement on the screen [18, 20].

Desktop VR has been used in situations, such as computer-based simulation [21], practicing surgical skills [22], and in health care education [23] for enhanced learning. However, a significant literature gap exists regarding rigorous studies with a large sample size to investigate the learning effect of using VR in nursing education [24, 25]. One study have been identified, which explored the potential benefits of nurses using desktop VR to learn handover [26]. This was a randomized controlled trial that found non-inferiority in communication performance using desktop VR for training when compared with live simulations. No studies have been found on desktop VR's effect with learning the ISBAR approach in a preoperative handover situation with undergraduate nursing students [27].

Therefore, the aim was to investigate whether second-year nursing students self-practicing the ISBAR approach during handovers in a preoperative setting in a desktop VR application experienced a non-inferior learning outcome compared with self-practicing the traditional paper-based (TP) method to sort patient information.

Method

Study design

A non-inferior, parallel group assessor blinded randomized controlled trial (RCT) was conducted at three education sites. The non-inferior approach was chosen because desktop VR simulation is done virtual and thus may have some disadvantages compared with real-life skill practice [23, 28]. The study took place in March and April 2022, and was approved by the Education sector's Service Provider (SIKT, Reference No. 305866) and the head of the pertinent study programs. No changes were made to protocols after the study commenced. The study was registered 30/05/2023 with trial number ISRCTN62680352 in the ISRCTN registry [29].

Setting

The study was conducted as part of simulation sessions that prepared second-year undergraduate nursing students for clinical placement in medical-surgical settings. It took place in nursing programs at a university in Southern Norway (two sites) and at a university in Western Norway (one site). At the fall semester in 2020, there were 175, 153 and 145 students enrolled at the three sites, respectively. However, about half of these students were eligible, as only those undergoing clinical placements at somatic hospitals during that period could be included, in accordance with the curriculum and learning outcomes.

At all the universities, the students had been taught preoperative nursing care for surgical patients, communication between health care providers, and the ISBAR approach before the research study was launched.

The simulation set-up at each site comprised one lecture room with 12 computers with headsets for virtual desktop simulation and a room for paper-based simulation (one large room or smaller group rooms). Four instructors were used to facilitate the sessions and collect data for the study.

Usability and pilot study

A usability study of the desktop VR application, used in the intervention in this study describes details regarding the development of the intervention [30]. In short, nine second-year undergraduate nursing students participated in the study and found the application usable overall, giving it an excellent usability score. Some technological and comprehension issues were identified, and a revised version was used in the present study.

A pilot study was conducted in February 2022 with 15 third-year undergraduate nursing students at two of the sites to try out the planned RCT activities. The pilot study's results indicated that the planned RCT activities worked well, but it was found that the primary outcome's difficulty level was too low. It was estimated that 20% of the participants in both groups would get everything correct on the primary outcomes [31, 32], which were used as the basis for the sample size calculation. However, in the pilot study, 80% of participants scored correctly on the primary outcome. The difficulty level was increased, and a revised test was piloted on five nursing educators, two nurses and two third-year undergraduate nursing students, all with moderate knowledge of ISBAR. In the revised test, 20% of the participants scored everything correctly, and this difficulty level was used for the present study.

Participants

The inclusion criteria were second-year undergraduate nursing students enrolled in the nursing study program at the participating universities who had no or limited experience in supervised clinical practice in somatic hospitals. Third-year undergraduate nursing students with substantial experience in supervised clinical practice, indicating a level of competence already surpassing the specific learning outcomes targeted in this intervention, were excluded.

Recruitment

General information about the simulation session, including that the students would be asked about participating in this study, was presented verbally during a lecture and presented in the digital learning management system for the study program. Specific information about time and place, in addition to repetition of general information, was provided in the study program schedule (at two of the sites) or sent by email (at one of the sites).

Information about the study, including voluntary study participation, was repeated at the start of the simulation session. The students were told that participation allowed the researchers to collect and use their identified data from the simulation session. Consent was provided by pressing "send" on the first questionnaire.

Randomization and allocation

Randomization had to consider practical organization in which students participated at different times in batches of nine, 12, or 15 students; therefore, separate computer-generated randomization lists were made for each batch of students using the Microsoft Excel RAND function. Using these lists, stickers with identification (ID) numbers and allocation codes were printed. The stickers were then put in separate containers for each batch.

To allocate students into the intervention and control groups, students in the same batch got a random ID sticker from the container. Depending on the site, one ID sticker was taken out of the container and given to the student upon entering the lecture room (one site) or the stickers were given to the students after the students were seated in the lecture room (two sites). In the first case, the order the students came to the room could not be influenced and were random, and in the second case, the ID stickers were drawn from the container to ensure random order. The students wore the ID stickers visibly to allow for inspection and ensure that they participated according to allocation. The students were informed that they would be divided into two different groups that would self-practice using the ISBAR approach after the introduction, when the participants were followed to their simulation sites based on the allocation code on their ID stickers. The allocation on each ID sticker was checked again when students entered their designated sites. No errors were reported.

Interventions

Both the intervention and control groups participated in a 20-minute introduction session that comprised information about the simulation's practicalities and the possibility of participating in this study, answering a questionnaire, and watching a nine-minute video that explains the ISBAR approach [33]. The video was made for this study and included general information about the ISBAR approach and why, when, and how to use it. Pre-training was unnecessary and was not integrated into the schedule [20].

The simulation started after the introduction and lasted for 50 minutes. The students were informed that they should resolve any questions they had on their own, as it was a self-training situation. An instructor was present who was given a manual on what to do, including the main directive that they should only help students solve major technical problems and otherwise let the students arrive at solutions themselves.

During the simulation, the participants were divided into groups of three because the desktop VR application used in the study was designed for three participants. Previous studies had reported no difference in performance between groups of three, four, or five participants [34]. Furthermore, dividing participants into smaller groups helped reduce any potential periods of inactivity during the simulation.

Patient case

The patient case used in the simulation was the same for both groups (Table 1). The case was developed through an iterative process involving the research team and a group of seven clinicians and teachers, comprising a surgeon, anesthetist, emergency department nurse, surgery ward nurse, and university lecturers. The research team chose a preoperative setting because nurses play a critical role in giving and receiving patient information during handover before surgery [35]. It was decided to use a patient case in which the patient required acute gallbladder surgery because this is a common condition that typically involves similar procedures performed preoperatively. To involve three participant types and two handovers, it was decided to include nurses working on different shifts (night, day, or nurse anesthetist).

Desktop VR application

The intervention group practiced using a desktop VR simulation called the *Preoperative ISBAR Desktop VR Application*, which was developed specifically for nursing students to practice the ISBAR approach during handover in an acute preoperative setting. The desktop VR application was created as part of a larger VR research project in healthcare education called *VirSam* (*Virtual Collaboration*) [36]. The details of its development are described below, in Supplement 1, and in a previous publication [30].

As the tasks involved a substantial amount of written text, including instructions and patient information, and the relatively little interactions with the virtual environment, it was chosen to use a desktop VR application. The academic content was developed by the research group in collaboration with a panel of seven healthcare professionals and educators. The technical solution was developed by the research group with the assistance of a hired programmer utilizing the *Unity* development platform. Based on experience from earlier application development, onboarding is important in self-practice applications [37]. Thus, the application was designed with integrated introductions for the use of desktop VR. Emphasis was placed on ensuring alignment between the learning outcome, learning activity, and assessment [38, 39], and that the application's activities and available self-guidance covered learning tasks, supporting information, procedural information, and part-task practice [40]. A visualization of the application with the various activities are presented in a science talk [41]. Table 2 provides a summary of the steps that the participants went through in the application. Further details on VR feature design, including descriptions and classifications based on pedagogic and game elements, can be found in Supplementary file 1 [39, 40, 42, 43].

Table 1 The information about the patient case given to the students in both groups[a]

The patient, Anna Hansen, born 230,462 with ID number 57957, went to the emergency ward during the night due to acute gallbladder inflammation. Acute surgery is planned. The patient was transferred to a gastro surgical ward. The patient must be prepared for acute surgery to remove the gallbladder in the surgical ward. The patient previously was diagnosed with high cholesterol and high blood pressure and takes medication for both. It has been decided that the patient will receive anesthesia and was assessed for ASA Classification 2. The patient has no allergies and no known infections. Current measurements have been taken, and the patient's NEWS score is normal. The patient weighs 71 kg and is 172 cm tall (BMI = 24). The patient has a green peripheral venous cannula on the left hand (size 18 G) and fluid (Ringer 1000 ml) is in progress. Paracetamol 2 g and Oxycodone 2.5 mg previously were administered at 6 a.m. *today. The patient has been fasting since midnight. The patient urinated before surgery. She is anxious about surgery.*

Abbreviations: ASA American Society of Anesthesiologists, *NEWS* National Early Warning Score, *BMI* Body Mass Index

[a] Translated from Norwegian by the authors

Traditional paper-based group

The participants in the traditional paper-based group met in-person and were placed around a table in groups of three. Due to uneven numbers, two groups comprised four students. They were given printed papers with the same explanation and tasks––including an explanation of the ISBAR approach and a list of suggestions for correct sorting (Supplementary file 2)––as the VR group (Table 2, Supplementary file 1).

Differences between the groups

The main difference between the groups was that the desktop VR group practiced in a virtual environment. Furthermore, in VR, the participants were represented by avatars, with their names displayed above the avatars' heads, and instructions were delivered through animations featuring voiceovers and pop-up windows. Feedback was provided, allowing for comparing results and suggestions for correct sorting. Furthermore, feedback was also given by highlighting the first statement in each player's handover and through debriefing sessions. Another mechanism unique to desktop VR practice was the automatic guidance between activities, with

Table 2 Description of the different activities in the *Preoperative ISBAR Desktop VR Application*

Number	Activities	Content
1	Presentation of the ISBAR approach and familiarization with the application and each other	Animation with a voiceover explaining ISBAR and presenting the learning objectives, plus a brief overview of the tasks; instructions on how to use the arrow keys to look around and introduction of the players, represented as avatars with their own names.
2	Sort patient information based on the ISBAR approach	Animation with a voiceover instructing how to sort patient information based on ISBAR. Instructions on buttons for each ISBAR category to select where to sort provided patient information. Opportunity provided to delete patient information and sort again. ISBAR explanation available.
3	Discussion of experience with sorting	A screen displays the percentage of correct patient information sorted. A comparison of how the players sorted information is provided, and suggestions on correct sorting are available.
4	Presentation of the patient case and the professionals' roles, and selection of the role to play	Animation with a voiceover presenting a patient case, involving three roles (nurse on night shift, nurse on day shift, and nurse anesthetist), and instructing on how to choose a role. When one player selects a role, it is no longer available to other players.
5	Handover role play	Animation with a voiceover instructing how to complete the handover. Players give and receive patient information using ISBAR sequentially. A list of all patient information and a phone are visible for the player providing patient information during the handover, and this player is instructed to mark the patient information to present first. The phone and a handover checklist are visible to the receiver of the handover. The active role player's screen is visible to the third player not taking part in the specific handover. Explanations of ISBAR and the role playing are available.
7	Debriefing 1 – general	Animation with a voiceover describing what to do during the debriefing session. Text stating that they should discuss how each participant experienced performing the tasks in general and that they will discuss each handover in detail afterward.
8	Debriefing 2 – each player	Animation with a voiceover with instructions on how to debrief what each participant chose to highlight and say first during the handover. A screen displays a list of all patient information, highlighting the patient information that the participant marked as the information to present first. Suggested bullet points on what to discuss during the debriefing are visible. An ISBAR explanation is available.
9	Encouragement to play again	Animation with a voiceover encourages the player to practice again. A screen provides two options: practice again or end the session.

an allocated time limit, indicating progress through the practice sessions. In the VR solution, repetition was promoted through time limits, and by encouraging them to practice again after the session ended by providing a click button to start over.

Data collection

At the beginning of the introduction, the participants completed a baseline characteristics questionnaire online. The outcome data were collected immediately after the simulation training through an online questionnaire and a written test, both with a time limit of 5 min. The ISBAR categories were not visible, i.e., the students had to remember the order and meaning.

During the data collection process, one staff member was present to provide instructions to the participants. They did not interact with the students during the data collection process and were instructed only to answer "do as you think best" in response to any questions from the students.

Outcomes

Written test and scoring rules

The written test (Supplementary file 3) was used for the primary outcome and some of the secondary outcomes, as described below. All the outcomes based on the written test were scored independently by the first author and a research assistant. The assessors were presented with the set of paper responses arranged randomly in the order of submission, and the scorers were blinded to the group allocation. They both provided the same score on 95% of the participants. For the remaining 5%, two members of the research group, who also were blinded, scored and discussed the results together with the first author until a consensus was reached.

The primary and some of the secondary outcomes concerned sorting patient information within correct ISBAR categories. A score of "Everything correct" was assigned if the patient information was sorted into the correct ISBAR category, independent of the order of the patient information within the category. Furthermore, some of the patient information could be sorted correctly within two of the ISBAR categories (S and A).

Participant characteristics

Participant characteristics included sex, age, mother tongue (Norwegian or other), previous experience working in health care, previous experience working in a surgical ward, previous experience practicing using the ISBAR approach, and previous experience playing multiplayer PC games.

Implementation of the intervention

Technical and other problems were registered by asking the instructors who were present if any such issues were experienced.

Primary outcome

The primary outcome was the proportion of nursing students who sorted all 11 statements of patient information into the correct ISBAR order within a time limit of five minutes on the written test (Supplementary file 3). The statements with patient information were presented in random order, numbered and provided on paper. The students were instructed to "write the number on the patient information in the correct order and write the letter where the information belongs". This outcome variable was based on earlier research [31, 32] and was tested during the pilot study.

Secondary outcomes

- The proportion that placed the correct patient information within each of the ISBAR categories: This outcome reports the results for each ISBAR category and provides additional information on the primary outcome by identifying the category that was best understood, as determined by the highest proportion of correct patient information placements. The outcome variable was based on prior research [31, 32] and tested during the pilot study.
- The proportion that arranged the ISBAR words correctly: This outcome came from the online questionnaire. The students were presented with the five words that comprise ISBAR, sorted in the following order "Recommendation-Background-Identification-Situation-Assessment." They were instructed; "Sort in correct order." A similar outcome was used in earlier research [31, 32] and tested during the pilot study.
- The proportion that sorted five statements of patient information (one for each ISBAR category) correctly based on ISBAR: This outcome was from the online questionnaire. The students were presented with the patient information sorted in the following order: "AIRBS" and asked to "sort the patient information correctly based on what you have learned today." This outcome was made for this study and tested during the pilot study.
- Students' experiences with the self-perceived learning outcome on five questions: This outcome came from the online questionnaire:" To which degree did you think: 1. the video about ISBAR gave you enough knowledge before you started to practice; 2. you had enough time to practice; 3. the practice method was likable; 4. the teaching activity (introduction and practice) were a good way to learn the ISBAR approach; and 5. you are confident in conducting communication in the ISBAR approach." Five answer options were provided: 1 (*completely disagree*); 2 (*disagree*); 3 (*neither disagree/agree*); 4 (*agree*); or 5 (*completely agree*). The proportion answering agree/completely agree is reported. These outcomes were used in earlier research [31, 32] and tested during the pilot study.
- The proportion of complete runs of the practice: This outcome came from the online questionnaire. The students were asked to type the number of complete runs of the practice. A similar outcome was used in earlier research [31, 32] and tested during the pilot study.
- The simulation method's perceived usability: This outcome came from the online questionnaire and was measured using the System Usability Scale (SUS) [44]. The SUS has 10 open-ended items, with five answer options ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). The score was created by adding up responses and converting it to a 0 to 100 scale, which can be translated into a curved grading scale from A-F [45]. The SUS was viewed as a reliable test of educational technology usability [46], and the validated Norwegian version was used [47].

Sample size calculation

A non-inferior limit of 13 percentage points was chosen for the sample size calculation based on other studies on clinical observation [31, 32, 48, 49]. Using this limit, a power (beta) of 80%, and a significance level (alpha) of 0.05, the sample size calculation demonstrated that 118 participants were needed in each group (Sealed Envelope Ltd., 2012), totaling 236 participants. For practical reasons, the maximum number of students available was 210.

Analysis

The participant characteristics are presented descriptively. Independent sample proportion tests were used for categorical data, and independent samples t-tests were used for continuous data. The absolute difference is presented. The one-sided *p*-value with confidence intervals (CI) s on the primary outcome for non-inferiority is reported. Non-inferiority was declared if the lower limit of the one-sided 95% CI in absolute difference on the primary outcome in the VR group did not exceed 13% in favor of the control group. To present the analysis in the conventional manner, the results from a two-sided test with CIs are reported. Because none of the outcomes had more than two missing responses, all available data were used in the analyses. All analyses were performed using IBM Statistical Package for the Social Sciences (SPSS) version 28.0.0 (IBM Corp).

Results

Recruitment and baseline characteristics

Altogether, 210 (78, 68, and 64 from each site) second-year undergraduate nursing students were eligible to participate in the study (Fig. 1). No exclusions were made, as only second-year undergraduate students attended. Ultimately, 35 did not show up for the study, so 175 participants were randomized: 87 to a desktop VR simulation group and 88 to a traditional paper-based (TP) group. One student left before the written test in the control group, and one did not return the written test in the intervention group.

The participants' characteristics are presented in Table 3. The sample included 142 females (81.1%), and most participants were 20–24 years old. Nearly all had previously been taught the ISBAR approach, 82% reported having practiced the ISBAR approach, and 43% reported having played multiplayer PC games.

The groups' characteristics were similar, but those in the VR group were somewhat younger, and a larger proportion had played multiplayer PC games earlier (Table 3).

Implementation of intervention

The implementation of both groups was executed without major technical or practical problems. The desktop

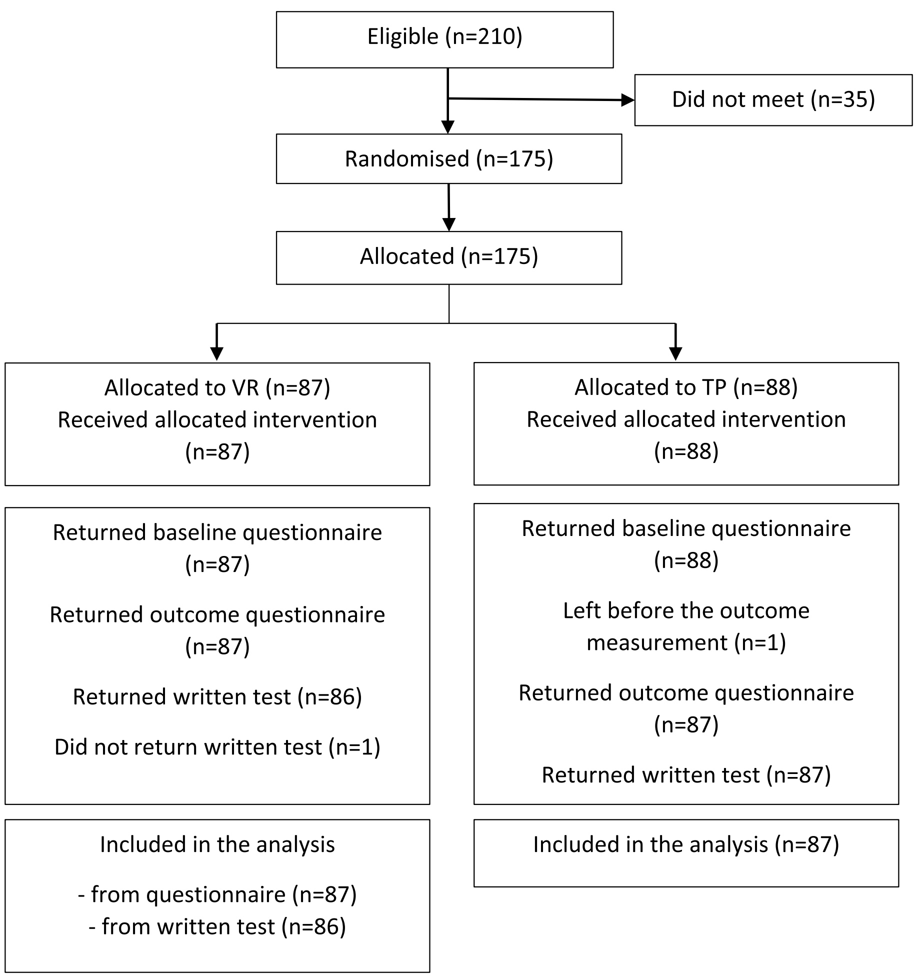

Fig. 1 The flow of participants. Abbreviations: *VR* = desktop virtual reality; *TP* = traditional paper-based simulation

Table 3 Participant characteristics

Participant characteristics	All (*N* = 175) N (%)	VR group *N* = 87 N (%)	TP group (*N* = 88) N (%)
Sex			
-Male	32 (18.3)	17 (19.5)	15 (17.0)
-Female	142 (81.1)	70 (80.5)	72 (81.8)
-Other	1 (0.6)		1 (1.1)
Age			
-20–24 years	122 (69.7)	63 (72.4)	59 (67)
-25–29 years	29 (16.6)	15 (17.2)	14 (15.9)
-30 years or older	24 (13.7)	9 (10.3)	15 (17)
Mother tongue			
-Norwegian	157 (89.7)	80 (92.0)	77 (87.5)
-Other	18 (10.3)	7 (8.0)	11 (12.5)
Have you previously (number answering yes):			
-Worked in healthcare?	164 (93.7)	79 (90.8)	85 (96.6)
-Worked in a surgical ward?	25 (14.3)	13 (14.9)	12 (13.6)
-Been taught the ISBAR approach?	167 (95.4)	85 (97.7)	82 (93.2)
-Practiced using the ISBAR approach?	143 (81.7)	72 (82.8)	71 (80.7)
-Played multiplayer PC-games?	76 (43.4)	45 (51.7)	31 (35.2)

Abbreviations: *VR* desktop virtual reality, *TP* traditional paper-based simulation

VR program had to be restarted for two of the 29 desktop VR groups because the participants could not talk to each other.

Outcomes

For the primary outcome, the group self-practicing on the desktop VR application (36% had everything correct) was non-inferior to the traditional paper-based group (22% had everything correct), with a difference of 14.2% points (one-sided 95% CI 2.9 to 14.2) on the primary outcome (Fig. 2, Table 4). Furthermore, the desktop VR application was superior to the traditional paper-based simulation in providing a better learning outcome (difference 14.2% points, two-sided 95% CI 0.7 to 27.1) (Table 4).

For the secondary outcomes, the desktop VR groups had an average of 1.8 complete runs of the practice (distribution in Table 5), compared with 1.2 runs in the TP group (mean difference 0.6, two-sided 95% CI 0.5 to 0.7, *P*-value < 0.001).

The outcomes placing the correct patient information within its correct ISBAR category were similar in the two groups, except for the category *assessment* (a difference

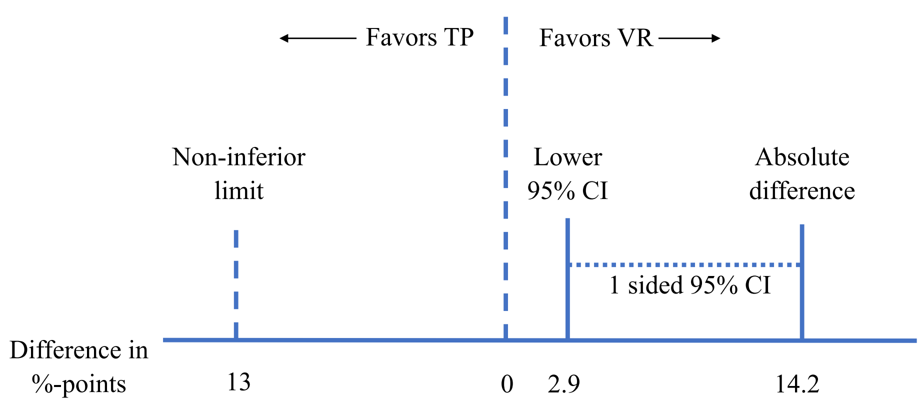

Fig. 2 The difference between the VR and TP groups on sorting patient information, based on ISBAR. Legends: If the horizontal one-sided 95% confidence interval (CI) had crossed or been to the left of the vertical non-inferior limit, desktop virtual reality (VR) would not be non-inferior. Abbreviations: VR = desktop virtual reality; *TP* = traditional paper-based simulation

Table 4 Primary outcome and secondary outcomes. Numbers (%) of participants for each group and difference in percentage points with a two-sided 95% confidence interval (95% CI) between the groups

Outcome measures: number of participants who:	VR group $N = 86$ N (%)	TP group $N = 87$ N (%)	Difference in % points (95% CI)	*P*-value
Primary outcome: sorted 11 statements of patient information in the correct ISBAR order within a time limit of 5 minutes	31 (36.0)	19 (21.8)	14.2 (0.7 to 27.1)	0.039*
Secondary outcomes:				
Placed the correct patient information within its correct ISBAR category:				
-Identification	77 (89.5)	84 (96.6)	−7 (−15.6 to 0.9)	0.069
-Situation	48 (55.8)	37 (42.5)	13.3 (−1.6 to 27.3)	0.081
-Background	61 (70.9)	51 (58.6)	12.3 (−1.9 to 25.8)	0.090
-Assessment	44 (51.2)	28 (32.2)	19 (4.3 to 32.6)	0.011*
-Recommendation	77 (89.5)	80 (92)	−2.4 (−11.6 to 665)	0.583
Arranged ISBAR words correctly	87 (100)	84 (97.7)	2.3 (−2.2 to 8.1)	0.153
Proportion who sorted all five pieces of patient information correctly	60 (69)	61 (70.9)	−2 (−15.4 to 11.6)	0.778

Abbreviations: *VR* desktop virtual reality, *TP* traditional paper-based simulation. *$p < 0{,}05$

Table 5 The number of completed runs (briefing-rehearsal-debriefing)

Number of completed runs	VR group $N = 87$ N (%)	TP group $N = 86$ N (%)
0		1 (1.1)
1	19 (21.8)	67 (76.1)
2	65 (74.7)	16 (18.2)
3	3 (3.4)	2 (2.3)

Abbreviations: *VR* desktop virtual reality, *TP* traditional paper-based

of 19 percentage points in favor of VR, two-sided 95% CI 4.3 to 32.6). The other outcomes on arranging the ISBAR words and pieces of patient information correctly were similar in the two groups.

The outcomes from the students' experiences with the self-perceived learning outcome indicated that the desktop VR group performed either non-inferior or better than the TP group (Table 6). The VR group participants reported that they liked this type of practice better (difference: 20% points). For the perceived usability of the simulation method, the VR group provided an SUS mean score of 78.6, which was non-inferior to the TP group, with a mean of 76.3. Both groups got a Grade C based on Bangor, Kortum [47] grading scale.

Table 6 Secondary outcomes on the students' experiences with self-perceived learning outcomes and perceived usability of simulation methods. Numbers (%) of participants for each group and difference in percentage points with a two-sided 95% confidence interval (95% CI) between groups

Outcome measures	VR group $N = 86$ N (%)	TP group $N = 87$ N (%)	Absolute diff. in % points (95% CI) Mean (SD)	*P*-value
Number of participants who reported (%):				
- Enough training from the ISBAR video before practicing	67 (77.7)	66 (76.7)	0.3 (−12.2 to 12.8)	0.750
- Had enough time to practice	67 (77)	66 (76.7)	0.3 (−12.2 to 12.8)	0.750
- The practice method was likable	75 (86.2)	56 (66.7)	19.5 (6.9 to 31.6)	0.003*
- Training and practice were good ways to learn the ISBAR approach	74 (86)	63 (75.9)	10.1 (−1.7 to 21.9)	0.110
- Were confident communicating with the ISBAR approach	50 (57.5)	37 (44)	13.4 (−1.5 to 27.6)	0.056
Perceived usability of the simulation method: - System Usability Scale (range 0–100, higher better) mean score (standard deviation SD)	Mean 78.6 (SD 14.2)	Mean 76.3 (SD 18.4)**	Mean diff. 2.3 (−1.8 to 6.4)	0.272

Abbreviations: *VR* desktop virtual reality, *TP* traditional Paper-based. *$p < 0{,}05$. **$N = 84$

Discussion

There was a superior learning outcome of the *Preoperative ISBAR Desktop VR Application* on sorting patient information correctly based on the ISBAR approach used for handovers in a preoperative setting, compared to traditional paper-based simulation. Most of the other outcomes indicated that desktop VR was non-inferior, but those practicing with desktop VR liked the practice better and practiced more.

More likeable, yet better learning outcome

It was somewhat surprising that desktop VR was found to be superior to traditional practice. The study was designed as a non-inferior study, as VR can offer some disadvantages due to technical and comprehension issues [30, 50], along with a lack of face-to-face communication when practicing in desktop VR [51]. Furthermore, one review of randomized controlled trials investigating desktop virtual simulation compared with traditional learning found no clear differences when measuring learning outcomes [15], and another review found that virtual simulation provided a non-inferior outcome on teamwork attitudes when learning interprofessional team communication [26]. This study's findings were not in line with expectations and the review's findings. Thus, more studies that elicit a superior outcome from desktop VR are required before the review findings' conclusion can be challenged.

Although desktop VR has the same learning outcome as traditional simulation, in this study and others [23, 52], participants reported VR as being more likable. However, even if this study found that the participants' preferred simulation method (desktop VR) resulted in a better learning outcome, this does not seem to be the general rule. Previous systematic reviews on e-learning that investigated objective learning outcomes and satisfaction found a negative association between these two factors [53, 54], i.e., higher satisfaction is associated with lower learning outcomes. In an RCT, it was found that students who participated in an active learning approach self-reported lower learning outcomes than those in a passive learning approach [55]. However, when objective measures of learning were assessed, students in the active learning group demonstrated higher learning outcomes than their peers in the passive learning group. This indicates that student satisfaction with learning and self-reported learning are not accurate indicators of objective learning outcomes.

Potential mechanisms behind the findings

Aside from the possibility of a chance finding, we suggest five possible mechanisms to explain the superior effect and likability of desktop VR found in this study.

The first is automated individual feedback. A VR application, like the one in this study, can be programmed to provide instant feedback. Feedback on performance is crucial to learning and can be enhanced by timely, specific, and learner-targeted feedback [56]. Drawing on the theoretical perspective of deliberate practice, feedback can function as a stimulus to continuing practicing [57], thereby promoting learning. Several studies have found feedback to be a mechanism for learning through technological learning activities [58] and game-based learning [59–62].

The second mechanism is that in a virtual environment, players are represented by avatars, which can create a sense of anonymity that can increase enjoyment of the experience [63]. Furthermore, learners in a traditional face-to-face learning environment have reported that they may feel self-conscious about speaking up in front of others, fearing judgment or criticism [64]. Based on Chen and Kent [65], one reason can be that the anonymity provided through avatars can create a sense of security that can shield learners from feeling embarrassed or singled out when making mistakes. Another aspect is that avatars can create a more neutral learning environment by reducing the impact from physical attributes, e.g., sex [66] and ethnicity [67], to help prevent unconscious biases.

The third suggested mechanism is related to how information is provided during the simulation. The use of visual instructions as a tool for learning has been investigated in several studies, and it has been found that both visual appearance of educational content in VR [68] and displaying extra information when practicing can benefit learning [69].

The fourth mechanism is automatic guidance supporting progression during practice. Automatic guidance in VR can exert both positive and negative effects on learning, depending on the context and the type of guidance provided [70]. For example, excessive automatic guidance can lead to a phenomenon known as the "guidance paradox" [70], in which learners become overly reliant on guidance and fail to develop necessary skills and knowledge to perform tasks independently. However, the observed effect in this study indicates that the positive aspects of helping learners navigate the simulation can overcome negative aspects if automatic guidance is used optimally.

The fifth and final mechanism that we suggest is repetition. A notable finding in this study and others [71] is that those practicing in VR repeated the simulation more often during the same practice session. Repetitive simulation practice has been found to enhance learning outcomes [72, 73].

Strengths and limitations

This study's main strength was the randomized controlled trial design, a relatively high number of students and a blinded assessment of the primary outcome. However, although recent findings suggest that blinding is less important than previously thought [74], this study's limitation was that it was not possible to blind the students due to the study's nature. Furthermore, the study evaluated only one type of desktop VR application, which may limit the findings' generalizability to other VR applications. Finally, the learning outcome was measured immediately after practice, which means that the intervention's long-term impact was not measured.

Conclusion

This study was designed to investigate whether nursing students, self-practicing the ISBAR approach in desktop VR, achieved a non-inferior learning outcome compared with self-practicing traditional practice, which was confirmed. However, it also was found that desktop VR provided superior learning outcomes. Furthermore, the students preferred using desktop VR and practiced more within the given time limit. This interactive desktop VR can be recommended as a practical and engaging way for second-year undergraduate nursing students to self-practice the ISBAR approach.

Abbreviations

ASA	American Society of Anesthesiologists
BMI	Body Mass Index
ISBAR	Identification, Situation, Background, Assessment, and Recommendation
NEWS	National Early Warning Score
SUS	System Usability Scale
TP	Traditional paper-based
VR	Virtual reality.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12909-023-04966-y.

Additional file 1. Presentation of the Preoperative ISBAR Desktop VR Application with the desktop virtual reality feature description and classification according to pedagogic- and game elements.

Additional file 2. ISBAR practice – sorting and role play.

Additional file 3. Individual final assignment and scoring rules.

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Authors' contributions

All the authors helped design the study. EMA and HB collected the data. EMA, HB, and AS analyzed and interpreted the data. All the authors helped write the manuscript and read and approved the final version.

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Availability of data and materials

The datasets used during the current study available from the corresponding author on reasonable request. It is also available from the Service Provider for the Education Sector (SIKT, reference 305866) repository at https://sikt.no/veiledning-bestille-data, where the persistent web link can also be found.

Declarations

Ethics approval and consent to participate

The study protocol was approved by the Service Provider for the Education Sector (SIKT, reference 305866). Study permission was obtained from the head of the nursing study program at the Department of Health and Nursing Sciences at the University of Agder, the Faculty Ethics Committee at the University of Agder, the head of the nursing study program at the Department of Health Sciences, Norwegian University of Science and Technology. The participants were informed both in writing and orally of their rights, the study's purpose, and that they had to provide consent to participate. The participants were given opportunity to ask questions and seek clarifications before providing their consent. Informed consent was obtained from all students participating in the study. All methods were carried out in accordance with relevant guidelines and regulations to ensure ethics and data security.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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Publisher's Note

Appendix A

Search terms

Cinahl Ebscohost (Search conducted October 2021).

#	**Query**	**Results**
S1	(MH "Students, Nursing") OR (MH "Students, Nursing, Baccalaureate")	37,407
S2	(Nurs* N5 (student* OR undergraduat* OR baccalaureate OR bachelor*))	63,077
S3	S1 OR S2	63,077
S4	(MH "Models, Educational") OR (MH "Teaching+") OR (MH "Learning Methods+") OR educat* OR learning OR teaching OR simulate* or simulat* or manikin* or Mannequin* or mannikin* OR "standardized patient*" OR "standardised patient*"	1,067,903
S5	(MH "Education, Non-Traditional")	10,651
S6	instruct* OR pedagog* OR didactic* OR curricul* OR flipped OR flipping OR blended OR blending OR inverted OR class OR classes OR classroom* OR game OR games OR gaming OR virtual* OR virtually OR "VR" OR "AR" OR augmented OR "webbased" OR internet OR online OR "role play*" OR video OR "station based" OR "high fidelity" OR "low fidelity" OR "think aloud" OR "case stud*" OR "inquiry based"	515,657
S7	S4 OR S5 OR S6	1,387,803
S8	preoperativ* or perioperativ* or postoperativ* or pre-operativ* or peri-operativ* or post-operative or intra-operativ* or intraoperativ* or preanaesthe* or preanesthe* or surgical or theatre* or "operating room*" or postanesthes* or postanasthes*	455,769
S9	S3 AND S7 AND S8	1,163
S10	S3 AND S7 AND S8 Limiters - Published Date: 20100101-20211231 Search modes - Boolean/Phrase	647

Note: Searches without field codes are searches for words from the databases standard fields, which include words from title, summary, and keywords. Main Heading (MH) field codes are searched for exact keywords. The default fields for unqualified searches consist of the following: Title, Abstract and Subject headings.

Embase (Ovid) and MEDLINE (Ovid) (search conducted October 2021).

Search Strategy: link
https://ovidsp.ovid.com/ovidweb.cgi?T=JS&NEWS=N&PAGE=main&SHAREDSEARCHID=2Y5mcioS4G0jusmDcW8CS4zMblZMvpc6GvkXX5la19Qz0PklucKXo3JrxfMVYAzQL

Search concepts:

1. Nursing students, Search 1 OR 2 OR 3 = search 4
2. Pre- and postoperative, Search 5
3. Teaching methods, learning activities, Search 6-13 = Search 14
4. Search 15 = concept 1 AND concept 2 AND concept 3
5. Search 16 = limit year
6. Search 17 = ovid removing duplicates automatic

Field codes and search tegniques:

- / exact subject headings – use medal = MeSH Medical subject headings
- Use oemez = Emtree, Embase subject headings, exact
- ti, ab = words from title or abstract (text words)
- .hw = words from subject headings, single words, from subject headings phrase
- Adj# = adjacency

1 Students, Nursing/ use medall (27044)

2 (nursing student/ or baccalaureate nursing student/) use oemez (28242)

3 (nurs* adj6 (student* or undergraduat* or baccalaureate or bachelor*)).ti,ab. (64412)

4 1 or 2 or 3 (85612)

5 (preoperativ* or perioperativ* or postoperativ* or pre-operativ* or peri-operativ* or post-operative or intra-operativ* or intraoperativ* or preanaesthe* or preanesthe* or surgical or theatre* or "operating room*" or postanesthes* or postanasthes*).ti,ab,hw. (4999034)

6 (simulate* or simulat* or manikin* or Mannequin* or mannikin* or "standardized patient*" or "standardised patient*").ti,ab,hw. or exp simulation/ use oemez or exp Computer Simulation/ or exp Simulation Training/ (1476076)

7 Models, Educational/ use medall (10424)

8 educational model/ use oemez (8633)

9 exp learning/ (920288)

10 exp teaching/ (187598)

11 (teaching or teach or teacher* or educat* or learning or learn).ti,ab,hw. (3520615)

12 (instruct* or pedagog* or didactic* or curricul* or flipped or flipping or blended or blending or inverted or class or classes or classroom* or game or games or gaming or virtual* or virtually or VR or AR or augmented or web-based or internet or online or "role play*" or video or "station based" or "high fidelity" or "low fidelity" or "think aloud" or "case stud*" or "inquiry based").ti,ab,hw. (3925405)

13 ((situat* or cogni*) adj1 apprenticeship*).ti,ab. (167)

14 or/6-13 (8334264)

15 4 and 5 and 14 (1797)

16 limit 15 to yr="2010 -Current" (1017)

17 remove duplicates from 16 (633)

ERIC (search conducted October 2021).

#	Query	Results
S1	DE "Nursing Students"	1,269
S2	Nurs* N5 (student* OR undergraduat* OR baccalaureate OR bachelor*)	3,889
S3	S1 OR S2	3,889
S4	preoperativ* or perioperativ* or postoperativ* or pre-operativ* or peri-operativ* or post-operative or intra-operativ* or intraoperativ* or preanaesthe* or preanesthe* or surgical or theatre* or "operating room*" or postanesthes* or postanasthes*	4,159
S5	S3 AND S4	61
S6	S3 AND S4 Limiters - Published Date: 20100101-20201231 Search modes - Boolean/Phrase	28

Note: The default fields for unqualified searches consist of the following: Title, Abstract and Subject headings.

Appendix E. Scopus (search conducted October 2021).

TITLE-ABS-KEY (nurs* W/5 (student* OR undergraduat* OR baccalaureate OR bachelor*)) AND TITLE-ABS-KEY (preoperativ* OR perioperativ* OR postoperativ* OR pre-operativ* OR peri-operativ* OR post-operative OR intra-operativ* OR intraoperativ* OR preanaesthe* OR preanesthe* OR surgical OR theatre* OR "operating room*" OR postanesthes* OR postanasthes*) AND TITLE-ABS-KEY (educat* OR learning OR learn OR teaching OR teach OR teacher* OR simulate* OR simulat* OR instruct* OR pedagog* OR didactic* OR curricul* OR flipped OR flipping OR blended OR blending OR inverted OR class OR classes OR classroom* OR game OR games OR gaming OR virtual* OR virtually OR "VR" OR "AR" OR augmented OR "webbased" OR internet OR online) AND PUBYEAR AFT 2009

Results: 618

Appendix B

Observation template

Observasjonsskjema – brukbarhetstest

Observatør: ________________________ Dato: __________ Tid: (fra)__________ (til) _________

Navn deltaker: ________________________________ Alder:__________ Kjønn:_________________

Selvrapportert teknologisk kompetanse fra deltaker (1-4 hvor fire er best): _____________________

Har deltaker deltatt på obligatorisk undervisning i 1. og 2. studieår om ISBAR (kryss av)?____ja _____nei

Tid	Type problem	Årsak	Antall	Alvorlighetsgrad*	Forslag til løsning
	Navigasjon				
	Utfordringer med å bruke				
	Misforståelser				
	Tekniske problemer				
	Annet?				

*Merk: (1 = distraherende, 2 = moderat, 3 = alvorlig, and 4 = ubrukelig)

Appendix C

Interview guide

Intervju guide ISBAR i desktop VR – Brukervennlighet

1. Hva likte du best ved å bruke Preoperativ ISBAR i VR på PC/mac?
2. Hva likte du minst ved å bruke Preoperativ ISBAR i VR på PC/mac?
3. Kan du fortelle om utfordringene du opplevde knyttet til:
   - Navigering?
   - Utfordringer med å bruke?
   - Misforståelser?
   - Tekniske problemer?
4. Var det noe som gjorde deg frustrert under læringsaktiviteten? Hva var grunnen til det?
5. Dersom du anbefaler denne måten å lære på til andre, hva er grunnen til det?
6. Har du andre kommentarer til hvordan vi kan forbedre Preoperativ ISBAR i VR på PC/mac?

Appendix D

System Usability Score questionnaire

Spørreskjema

Velg ett svaralternativ for hvert utsagn:

Utsagn	Helt uenig 1	2	3	4	Helt enig 5
Jeg tror jeg ønsker å bruke dette systemet ofte	○	○	○	○	○
Jeg fant systemet unødig komplisert	○	○	○	○	○
Jeg synes systemet var enkelt å bruke	○	○	○	○	○
Jeg tror jeg vil trenge støtte fra en teknisk person for å kunne bruke systemet	○	○	○	○	○
Jeg fant de ulike funksjonene i dette systemet godt integrert (hang godt sammen)	○	○	○	○	○
Jeg synes det var for mye inkonsistens (uoverensstemmelser) i dette systemet	○	○	○	○	○
Jeg forestiller meg at de fleste vil lære seg å bruke dette systemet svært raskt	○	○	○	○	○
Jeg fant systemet tungvint å bruke	○	○	○	○	○
Jeg følte meg veldig trygg ved bruk av systemet	○	○	○	○	○
Jeg trengte å lære mange ting før jeg kunne komme i gang med dette systemet	○	○	○	○	○

Totalt sett vil jeg vurdere brukervennligheten av dette produktet som	Verst tenkelig ☐	Fryktelig ☐	Lite ☐	Ok ☐	God ☐	Utmerket ☐	Best tenkelig ☐

Appendix E

Baseline questionnaire

Bakgrunnsinfo ISBAR opplæring

1. Skriv inn sifferne som står på din ID-etikett *

Skriv inn svaret

2. Kjønn

- ◯ Kvinne
- ◯ Mann
- ◯ Annet
- ◯ Vil ikke oppgi

3. Alder

- ◯ Under 20 år
- ◯ 20-24 år
- ◯ 25-29 år
- ◯ 30 år og eldre

4. Har jobbet i helsevesenet tidligere eller under studiet? F.eks. sommerjobb på sykehjem

- ◯ Ja
- ◯ Nei
- ◯ Vet ikke

5. Har du jobbet eller vært i praksis på kirurgisk sengepost/avdeling/poliklinikk?

- Ja
- Nei
- Vet ikke

6. Har du lært om ISBAR-metodikken tidligere?

- Ja
- Nei
- Vet ikke

7. Har du øvd på ISBAR-metodikken tidligere?

- Ja
- Nei
- Vet ikke

8. Har du erfaring med å spille multiplayer PC-spill fra tidligere?

- Ja
- Nei
- Vet ikke

9. Er norsk ditt morsmål?

- Ja
- Nei
- Vet ikke

Appendix F

Questionnaire practicing systematic communication

Spørreskjema om opplæring i systematisk kommunikasjon

Ved å sende inn skjemaet samtykker du i å delta i forskningsprosjektet. Det er frivillig å delta. Alle opplysninger er helt anonyme.

Inndeling 1 ...

1. Skriv inn sifferne som står på din ID-etikett

Skriv inn svaret

Inndeling 2 ...

2. Sorter i rett rekkefølge (trykk og flytt)

- Råd
- Bakgrunn
- Identifikasjon
- Situasjon
- Aktuell tilstand

3. Sorter pasientopplysningene i rett rekkefølge etter hva du har lært i dag (trykk og flytt)

- Respirasjonsfrekvens er 10
- Ida Hansen f. 050646
- Bør få tilsyn av lege
- Ingen kjente sykdommer
- Er bevisstløs etter tilsynelatende fall

4. I hvilken grad...

	Helt uenig 1	2	3	4	Helt enig 5
fikk du nok opplæring fra videoen om ISBAR-metodikken FØR du begynte å øve?	○	○	○	○	○
fikk du nok tid til å øve?	○	○	○	○	○
likte du denne måten å øve på?	○	○	○	○	○
var undervisningen (opplæringen og øvingen) en god måte å lære om ISBAR-metodikken?	○	○	○	○	○
føler du deg trygg på å gjennomføre systematisk kommunikasjon med ISBAR-metodikken?	○	○	○	○	○

5. Hvor mange ganger fikk du gjennomført fullstendige gjennomkjøringer av øvelsen (= sortering, kommunikasjon og debrief)?

- ○ 0
- ○ 1
- ○ 2
- ○ 3 eller fler

6. Hvilken rolle spilte du under første gjennomføring?

- ○ Sykepleier på nattevakt
- ○ Sykepleier på dagvakt
- ○ Anestesisykepleier

7. I hvilken grad fikk du lært om ISBAR i den rollen?

	Helt uenig 1	2	3	4	Helt enig 5
Velg svaralternativ	◯	◯	◯	◯	◯

Inndeling 4

Brukervennlighet (System Usability Test)

Med "system" menes måten du øvet på (VR eller table top)

8. For hvert utsagn, marker hvor enig du er i utsagnet.

	Helt uenig 1	2	3	4	Helt enig 5
Jeg tror jeg ønsker å bruke dette systemet ofte	◯	◯	◯	◯	◯
Jeg fant systemet unødig komplisert	◯	◯	◯	◯	◯
Jeg syntes systemet var enkelt å bruke	◯	◯	◯	◯	◯
Jeg tror jeg vil trenge støtte fra en teknisk person for å kunne bruke systemet	◯	◯	◯	◯	◯
Jeg fant de ulike funksjonene i dette systemet godt integrert (hang godt sammen)	◯	◯	◯	◯	◯
Jeg synes det var for mye uoverensstemmelse i dette systemet	◯	◯	◯	◯	◯
Jeg forestiller meg at de fleste vil lære å bruke dette systemet svært raskt	◯	◯	◯	◯	◯
Jeg fant systemet veldig tungvint å bruke	◯	◯	◯	◯	◯
Jeg følte meg veldig trygg ved bruk av systemet	◯	◯	◯	◯	◯
Jeg trengte å lære mange ting før jeg kunne komme i gang med dette systemet	◯	◯	◯	◯	◯

Appendix G

Written test

Individuell avsluttende oppgave

Din ID:____________________ (tallet på ID-lappen)

Du skal gi pasientopplysninger videre til en kollega. Under er informasjonen du ønsker å videreformidle om pasienten. Les igjennom alle opplysningene før du begynner å sortere. Du har 5 minutter, skriv ned i den rekkefølgen som du har lært og øvd på i dag.

For å slippe å skrive så mye tekst, skriv kun **tallet** på pasientopplysningen **i rett rekkefølge** og skriv på bokstaven opplysningen hører til.

Tall	Skriv bokstaven

Informasjon du skal gi videre om pasienten:

Tall	Pasientopplysning
1	Pasienten er operert for venstresidig femurfraktur for åtte timer siden
2	Jeg foreslår at du tar kontakt med lege for å ordne mer smertestillende
3	Pasientens skår på smerteskala (NRS) har nå økt til 7
4	Pasienten har fått smertestillende som forordnet
5	Jeg er sykepleier NN (navn) på ortopedisk sengepost
6	Pasienten har fra tidligere diabetes type 2
7	Operasjonssår ser normalt ut
8	Pasienten heter Harald S. Plassen
9	NEWS-måling er 0
10	Pasienten er født 191040
11	Pasienten er medisinert for diabetes type 2

Appendix H

Approval Education Sector Service Provider (SIKT/NSD)

NSD sin vurdering

Skriv ut

Prosjekttittel
Practising ISBAR approach in preoperative handover by using desktop VR: Content adaption, Usability Testing and A Randomized Controlled Trial

Referansenummer
305866

Registrert
27.08.2021 av Eva Mari Andreasen - eva.mari.andreasen@uia.no

Behandlingsansvarlig institusjon
Universitetet i Agder / Fakultet for helse- og idrettsvitenskap / Institutt for helse- og sykepleievitenskap

Prosjektansvarlig (vitenskapelig ansatt/veileder eller stipendiat)
Kristin Haraldstad, kristin.haraldstad@uia.no, tlf: 90577898

Type prosjekt
Forskerprosjekt

Prosjektperiode
20.08.2021 - 01.04.2024

Status
01.09.2021 - Vurdert

Vurdering (1)

01.09.2021 - Vurdert
Det er vår vurdering at behandlingen av personopplysninger i prosjektet vil være i samsvar med personvernlovgivningen så fremt den gjennomføres i tråd med det som er dokumentert i meldeskjemaet med vedlegg den 01.09.2021, samt i meldingsdialogen mellom innmelder og NSD. Behandlingen kan starte. TYPE OPPLYSNINGER OG VARIGHET Prosjektet vil behandle alminnelige kategorier av personopplysninger frem til 01.04.2024. LOVLIG GRUNNLAG Prosjektet vil innhente samtykke fra de registrerte til behandlingen av personopplysninger. Vår vurdering er at prosjektet legger opp til et samtykke i samsvar med kravene i art. 4 og 7, ved at det er en frivillig, spesifikk, informert og utvetydig bekreftelse som kan dokumenteres, og som den registrerte kan trekke tilbake. Lovlig grunnlag for behandlingen vil dermed være den registrertes samtykke, jf. personvernforordningen

art. 6 nr. 1 bokstav a. PERSONVERNPRINSIPPER NSD vurderer at den planlagte behandlingen av personopplysninger vil følge prinsippene i personvernforordningen om: - lovlighet, rettferdighet og åpenhet (art. 5.1 a), ved at de registrerte får tilfredsstillende informasjon om og samtykker til behandlingen - formålsbegrensning (art. 5.1 b), ved at personopplysninger samles inn for spesifikke, uttrykkelig angitte og berettigede formål, og ikke viderebehandles til nye uforenlige formål - dataminimering (art. 5.1 c), ved at det kun behandles opplysninger som er adekvate, relevante og nødvendige for formålet med prosjektet - lagringsbegrensning (art. 5.1 e), ved at personopplysningene ikke lagres lengre enn nødvendig for å oppfylle formålet DE REGISTRERTES RETTIGHETER NSD vurderer at informasjonen om behandlingen som de registrerte vil motta oppfyller lovens krav til form og innhold, jf. art. 12.1 og art. 13. Så lenge de registrerte kan identifiseres i datamaterialet vil de ha følgende rettigheter: innsyn (art. 15), retting (art. 16), sletting (art. 17), begrensning (art. 18) og dataportabilitet (art. 20). Vi minner om at hvis en registrert tar kontakt om sine rettigheter, har behandlingsansvarlig institusjon plikt til å svare innen en måned. FØLG DIN INSTITUSJONS RETNINGSLINJER NSD legger til grunn at behandlingen oppfyller kravene i personvernforordningen om riktighet (art. 5.1 d), integritet og konfidensialitet (art. 5.1. f) og sikkerhet (art. 32). For å forsikre dere om at kravene oppfylles, må dere følge interne retningslinjer og eventuelt rådføre dere med behandlingsansvarlig institusjon. MELD VESENTLIGE ENDRINGER Dersom det skjer vesentlige endringer i behandlingen av personopplysninger, kan det være nødvendig å melde dette til NSD ved å oppdatere meldeskjemaet. Før du melder inn en endring, oppfordrer vi deg til å lese om hvilke type endringer det er nødvendig å melde: https://www.nsd.no/personverntjenester/fylle-ut-meldeskjema-for-personopplysninger/melde-endringer-i-meldeskjema Du må vente på svar fra NSD før endringen gjennomføres. OPPFØLGING AV PROSJEKTET NSD vil følge opp underveis (hvert annet år) og ved planlagt avslutning for å avklare om behandlingen av personopplysningene er avsluttet/pågår i tråd med den behandlingen som er dokumentert. Kontaktperson hos NSD: Markus Celiussen Lykke til med prosjektet!

Appendix I

Approval Fakultets Etiske Komite (FEK)

Eva Mari Andreasen

Besøksadresse:
Universitetsveien 25
Kristiansand

Ref: [object Object]

Tidspunkt for godkjenning: : 20/09/2021

Søknad om etisk godkjenning av forskningsprosjekt - Øve på ISBAR ved preoperativ pasientrapport ved å bruke VR: Innholdsrevidering, brukervennlighetstesting og randomisert kontrollert studie (RCT)

Vi informerer om at din søknad er ferdig behandlet og godkjent.

Kommentar fra godkjenner:
REK godkjenner under forutsetning at:
1.I informasjonsskriv: Kristin Haraldstad er ikke ansvarlig for personvern, men for prosjektet. Må også påføre tlf. nr til K. Haraldstad

2. Info/samtykkeskriv: Personvernombud Ina Danielsen må byttes ut med Johanne Warberg Lavold (personvernombud@uia.no) tlf +47 38 14 13 28

Hilsen
Forskningsetisk komite
Fakultet for helse - og idrettsvitenskap
Universitetet i Agder

UNIVERSITETET I AGDER

POSTBOKS 422 4604 KRISTIANSAND

TELEFON 38 14 10 00

ORG. NR 970 546 200 MVA - post@uia.no - www.uia.no

FAKTURAADRESSE:

UNIVERSITETET I AGDER,

FAKTURAMOTTAK

POSTBOKS 383 ALNABRU 0614 OSLO

Appendix J

Information letter to participants

VIL DU DELTA I FORSKNINGSPROSJEKTET
PREOPERATIV ISBAR I VR: TEST AV BRUKERVENNLIGHET

FORMÅLET MED PROSJEKTET OG HVORFOR DU BLIR SPURT

Dette er et spørsmål til deg som er andre års bachelorstudent på sykepleierutdanningen ved Universitetet i Agder (UIA) om å delta i studien *Preoperativ ISBAR i VR: test av brukervennlighet*.

ISBAR (Informasjon-Situasjon-Bakgrunn-Analyse-Råd) er en metode å kommunisere på for å sikre systematisk og strukturert kommunikasjon mellom helsepersonell og brukes i klinikken i dag. Hensikten med studien er å utvikle og teste en læringsaktivitet som handler om å lære om preoperativ informasjonsoverføring ved å bruke VR dekstop. Vi trenger hjelp med å teste ut denne læringsaktiviteten i en tidlig fase av designet. Det er ikke deg og dine ferdigheter som vi er interessert i, men hvordan produktet fungerer.

Vi er en gruppe forskere ved Fakultet for helse- og idrettsvitenskap på UiA og fakultet for medisin og helsevitenskap, NTNU som inviterer deg til å delta.

HVA INNEBÆRER PROSJEKTET FOR DEG?

Deltagelse i studien innebærer at du som en del av undervisningen i SYP 220 tester ut Preoperativ ISBAR i desktop VR på pc/mac. Du vil bli satt sammen med to andre sykepleiestudenter i gruppe. Deltakelse innebærer at du prøver ut læringsaktiviteten på din egen pc/mac på et grupperom på campus samtidig som du tenker høyt om hva du gjør. Deretter vil du få et kort spørreskjema du skal fylle ut og til slutt delta i et kort gruppeintervju sammen med de to studentene som du har vært på gruppe med. I gruppeintervjuet vil det stilles spørsmål om hvordan læringsaktiviteten kan forbedres. Utprøving av læringsaktiviteten, utfylling av spørreskjema og intervju vil vare i maksimum 120 minutter.

FRIVILLIG DELTAKELSE OG MULIGHET FOR Å TREKKE DITT SAMTYKKE

Det er frivillig å delta i prosjektet. Dersom du ønsker å delta, undertegner du samtykkeerklæringen på siste side. Du kan når som helst og uten å oppgi noen grunn trekke ditt samtykke. Det vil ikke ha noen negative konsekvenser for deg hvis du ikke vil delta eller senere velger å trekke deg. Dersom du trekker tilbake samtykket, vil ditt bidrag ikke legges til grunn i denne studien.

Dersom du senere ønsker å trekke deg eller har spørsmål til prosjektet, kan du kontakte prosjektleder (se kontaktinformasjon på siste side).

HVA SKJER MED OPPLYSNINGENE OM DEG?

Opplysningene som registreres om deg skal kun brukes slik som beskrevet under formålet med prosjektet, og planlegges brukt til 2024. Eventuelle utvidelser i bruk og oppbevaringstid kan kun skje etter godkjenning fra Norsk samfunnsvitenskapelig datatjeneste (NSD). Du har rett til innsyn i hvilke opplysninger som er registrert om deg, rett til å få korrigert eventuelle feil i de opplysningene som er registrert og rett til å få slettet dine personopplysninger. Du har også rett til å få innsyn i sikkerhetstiltakene ved behandling av opplysningene. Du kan klage på behandlingen av dine opplysninger til Datatilsynet og institusjonen sitt personvernombud. Data vil bli oppbevart uten personopplysninger (anonymisering). Lyd- og bildeopptak vil bli slettet innen prosjektslutt 2024.

Prosjektresultatene vil bli publisert i vitenskapelige tidsskrift, konferanser, og bli omtalt i fagutvikling, undervisning og media.

GODKJENNINGER

Prosjektet er meldt og godkjent av Norsk Senter for forskningsdata (NSD), samt godkjent i Fakultet for helse- og idrettsvitenskap, Universitetet i Agder, sin egen Etiske komité (FEK).

Universitetet i Agder, Institutt for helse- og sykepleievitenskap og prosjektleder professor Kristin Haraldstad er ansvarlig for personvernet i prosjektet.

KONTAKTOPPLYSNINGER

Dersom du har spørsmål til prosjektet, kan du kontakte prosjektleder professor Kristin Haraldstad, kristin.haraldstad@uia.no, 90577898, eller prosjektkoordinator doktorgradsstipendiat Eva Mari Andreasen (eva.mari.andreasen@uia.no, 90642121).

Dersom du har spørsmål om personvernet i prosjektet, kan du kontakte personvernombudet ved Universitetet i Agder: Johanne Warberg Lavold, personvernombud@uia.no, Telefon 38141328, eller datatilsynet: postkasse@datatilsynet.no, Telefon: 4755582117

JEG SAMTYKKER TIL Å DELTA I PROSJEKTET OG TIL AT MINE OPPLYSNINGER KAN BRUKES SLIK DET ER BESKREVET

Sted og dato | Deltakers signatur

Jeg bekrefter å ha gitt informasjon om prosjektet.

Sted og dato | Signatur

Appendix K

Permission using System Usability Scale Score figure

Permission for using figure 1

See attached email correspondence with permission to use the figure from the copyright holder. Figure 1 is not an exact copy of the original resource because of the red cross symbol.

RE: Permission to reuse the SUS figure

BA BANGOR, AARON <ab9629@att.com>
To Eva Mari Andreasen
Cc Phil Kortum (pkortum@rice.edu)

Reply | Reply All | Forward | ...

man. 07.02.2022 17:53

Internal\Normal

You replied to this message on 07.02.2022 18:24.

Hi Eva,

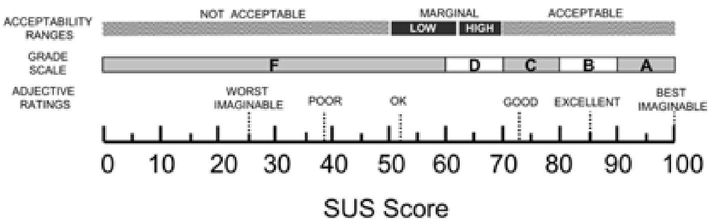
You are free to use the figure, so long as you cite us in the work, which it looks like you're already aware of. Good luck in your work!

Aaron

From: Eva Mari Andreasen <eva.mari.andreasen@uia.no>
Sent: Saturday, February 5, 2022 10:50
To: Aaron_Bangor@labs.att.com
Subject: Permission to reuse the SUS figure

Dear Mr. Bangor

I am writing a usability article as a part of my PhD, and I am asking you for permission to reuse this figure from the article from 2009?



Bangor (2009) will be cited together with *Permission to reuse*.

Yours sincerely
Eva Andreasen
Ph.d.-candidate
Department of health- and Nurse Science
eva.mari.andreasen@uia.no

UiA University of Agder