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Using Technology to Support Nursing Students' Reasoning Skills During Practical Training

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Abstract
Undergraduate nursing students must be equipped with critical thinking skills that will help them provide effective patient care in a safe manner. This paper examines the possibility of a technology-based guidance model that aims at improving critical thinking in clinical practice. The self-directed research employs a multimethod approach and a flexible and exploratory, concurrent strategy to integrate digital tools, structured mentorship, and reflective exercises to enable student learning in actual clinical situations. They were obtained by observations, surveys, and focus group interviews with students and clinical instructors. Results suggest that the model encourages active practice, critical thinking, and decision-making proficiency, and provides flexibility to a wide range of clinical environments. The study identifies the practical concerns that must be addressed in the implementation of technology-supported pedagogical interventions, and specifies the research directions that should be pursued in future to even better optimise the process of developing critical thinking in nursing education.
Keywords: ***Critical thinking, nursing education, clinical practice, technology-assisted learning, student mentorship, reflective learning, feasibility study.***

1.Introduction
Critical thinking development has been one of the highest priorities of modern nursing education as it directly determines the quality of care that nurses provide to patients and the capacity of future nurses to adapt to complex and unpredictable clinical environments. Critical thinking is a set of cognitive abilities that include analysis, evaluation, inference, interpretation and explanation; all of which enable practitioners to evaluate situations, balance evidence, and make informed clinical decisions. In nursing, where life and health are sometimes on the line and fast but correct decision-making is needed, lack of well-developed critical thinking may lead to error, inefficiency, or loss of patient safety. Because of this reason, professional bodies, regulation agencies, and educational institutions around the world have repeatedly pointed out the need to incorporate critical thinking in curricula and in practical training(1). Although this is the consensus, the most appropriate strategies and pedagogical approaches to promote critical thinking in undergraduate nursing students are still debated, and not all scholarly resources agree on the most effective interventions. The research in Europe and elsewhere has tended to focus on analysis and assessment as the most important skill taught in higher education, though methods like immersion and problem-based learning have been embraced to different extents. However, it is repeatedly mentioned in the literature review that there is a paucity of empirical research, specifically studies that could investigate the potential of technological tools to aid in the development of critical thinking in the context of the real-world clinical practice setting. A lack of research on technology-supported interventions is both a challenge and an opportunity in the age when digital technologies continue to enter the healthcare sector. The COVID-19 pandemic, in particular, increased the use of digital solutions in education and clinical practice, which only indirectly confirmed the relevance of studying the use of apps and other digital solutions in promoting learning and professional development in nursing students systematically. It is against this background that researchers have recommended experimental designs, particularly, randomized controlled trials (RCTs) to evaluate and confirm interventions that purport to enhance critical thinking. But feasibility studies and pilot trials are required before starting RCTs to identify whether a particular intervention is practically practicable, whether it is acceptable to the participants, and whether the recruitment, data collection and outcome measurement procedures are practical in reality. Such feasibility studies do not only reinforce the rationale behind future large scale research, but also allow the identification and mitigation of any obstacles, constraints, or dropout causes early in the process.
The current study thus began as a feasibility study of a recently developed intervention referred to as the Technology-Supported Guidance Model (TSGM). The TSGM was developed out of the need to offer systemic

and ongoing support to undergraduate nursing students in the clinical practice setting, which was accompanied by the general aim of improving their ability to think critically. The core of the model is a digital application, the Technology-Optimized Practice Process in Nursing (TOPP-N) application, which, in turn, was created by researchers, nurse educators, nurse preceptors, and students themselves. The application forges the pedagogical tenets of metacognition and constructive alignment, and it is organized in modules of daily mentorship and summative evaluation(2). Through this app, nursing students can organize their learning tasks, record their progress, and get structured feedback on preceptors, and nurse educators can track the performance of students and step in when there are discrepancies or other challenges. In addition to its practical application, the TOPP-N application is a novel approach to integrating reflective practice and ongoing guidance into the daily flow of clinical placements, and thus it is feasible to directly incorporate technology into the mentoring relationship. Notably, the given model will not act as an alternative to conventional supervision, though it will serve as a supplement that will reinforce communication, responsibility, and alignment between learners, mentors, and teachers.

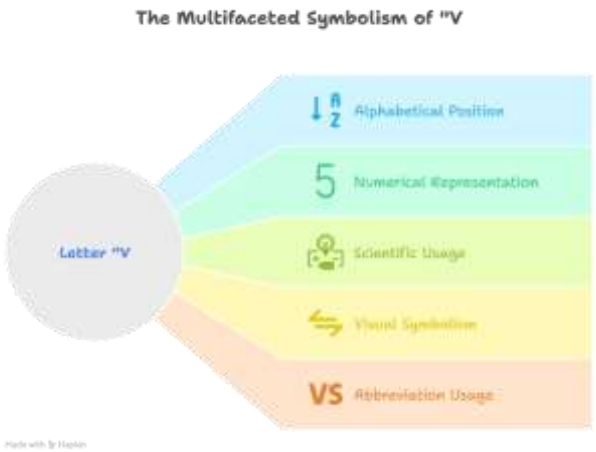

FIGURE 1 The Multifaceted Symbolism of "V

The justification of the testing of TSGM to be performed by means of a feasibility study is complex. To begin with, since the intervention implies the cooperation of several stakeholders (students, preceptors, and educators), the success of the intervention will be premised on the clarity of roles, regular use of the app, and its integration into current workflows. Feasibility then has to be measured in terms of acceptability, adherence and faithfulness to the intervention. Second, since the adoption of technology can be frequently affected by usability problems, perceived workload, or resistance to change, it is important to determine whether the app is perceived to be user-friendly and whether it supports or impedes the clinical learning process. Third, feasibility applies to the research design per se, in the sense that the recruitment methods, data collection tools, and measurement scales should be feasible and sensible. In the absence of such preparatory work, any subsequent RCT will be doomed to failure because of methodological or implementation issues.

The investigation was thus informed by a set of several interconnected research questions which were in line with the overall objective of establishing whether the TSGM intervention was feasible. In particular, the research was aimed at investigating the question of how plausible and acceptable the TSGM model is to students, preceptors and educators; whether the outcome measures used in a future RCT are suitable, whether the recruitment and data collection methodologies used are effective, what obstacles may contribute to dropout or less adherence and, most importantly, what adjustments should be made to make the intervention scalable. Sharing the answers to these questions, the feasibility study was supposed to not only inform the design of the upcoming RCT, but also to add to the broader discussion on how technology can be used to reinforce nursing education. By so doing, it will contribute to the literature already available that identifies the importance of critical thinking in nursing and the dire need to develop new empirically supported ways of developing critical thinking(3).

2.Methods

The methodological design of this feasibility study was thoroughly designed to make sure that the Technology-Supported Guidance Model (TSGM) and its online platform, the Technology-Optimized Practice Process in

Nursing (TOPP-N), could be considered in regards to a variety of dimensions corresponding to nursing education. The study was intentionally designed as a concurrent, exploratory, flexible and multimethod study, rather than a rigid and narrowly defined design. This decision was strategic in the sense that the intervention in itself was at the crossroads of pedagogy, technology, and clinical practice; thus, it needed to be approached in a way that could reflect the multidimensionality of human interactions, the use of digital tools, and institutional settings. By design, this enabled the researchers to combine quantitative and qualitative evidence, which not only quantified numerical measures of feasibility, i.e. recruitment rates and dropout rates, but also revealed the lived experiences, attitudes, and reflections of students, preceptors, and educators who experienced the model directly(4). The aim was to develop a conceptual framework reflecting the complexity of the intervention: adaptive, iterative, and able to produce insights that would be used to plan a larger randomized controlled trial (RCT).

One important methodological choice was the recruitment of participants and sampling. Since the study was designed to test its feasibility, and did not intend to generalize the results to the whole population of nursing students, the nonprobability convenience sample method was employed. Three different and, nevertheless, interrelated groups were targeted in the process of recruitment: first-year undergraduate nursing students at Lovisenberg Diaconal University College (LDUC) and the University of Agder (UoA), registered nurses working as preceptors in cooperating nursing homes, and nurse educators connected to one of the participating institutions. This three-part framework was deliberate because all three groups were required to be actively involved and participate in the TSGM model. The criteria were very clear: students were to be in their first year of nursing programs, preceptors were to be registered nurses supervising students in clinical settings, and educators were to be in charge to supervise students during their clinical placements. The COVID-19 pandemic complicated the way recruitment could occur, as it limited the ability to hold face-to-face interactions. To overcome this problem, the researchers applied virtual recruitment methods, conducting web-based information sessions using Zoom and complementing them with written materials, distributed in Canvas, the learning management system of institutions. Even though recruitment was done on the individual level, site-level factors played an important role, as clinical placements were within a particular nursing home. To eliminate possible disturbance, it was identified that the model should be applied to all the students that were placed in a specific nursing home where the intervention had been initiated so that there would not be a scenario where there were students that received the intervention and others in the same setting were not receiving the intervention. Although in such a set-up, informed consent kept ethical integrity of the research component as voluntary.

TABLE 1 Summary of Methods

Component	Description
Design	Concurrent, exploratory, flexible, multimethod feasibility study
Participants	First-year nursing students (LDUC & UoA), nurse preceptors, nurse educators
Sampling	Nonprobability convenience sampling
Recruitment	Online (Zoom meetings, Canvas announcements); COVID-19 limited face-to-face
Setting	4 nursing homes (1 in Oslo, 3 in Agder)
Intervention	Technology-Supported Guidance Model (TSGM) with TOPP-N app + daily guidance
App Modules	1) Guidance module (daily reports & feedback) 2) Assessment module (mid- & final-term)
Data Collected	Quantitative (HSRT, Self-Efficacy, CLES+T2, TAM-3, MCI, SMCP, app use logs) Qualitative (focus groups, anecdotal feedback)
Analysis	Quantitative: descriptive statistics Qualitative: semantic network analysis + thematic analysis
Ethics	Approved by Norwegian Centre for Research Data; informed consent via Questback

The actual intervention (which is the focus of the Methods section) concerned the implementation and application of the TOPP-N app to the clinical practice. The application included two central modules: a guidance module to be used on a daily basis, and an assessment module to be used during summative evaluations. Nursing students had to fill in structured e-reports at the beginning and end of their clinical shifts. These reports gave them the

motivation to organize learning activities, confidence in their goals and to point out areas where they needed further direction. Preceptors were subsequently asked to respond to these reports by offering specific feedback, both in written form and voice recordings, and both sides filled out a need for guidance scale to assess their perceived need of necessary support. Nurse educators who were somewhat removed in day-to-day operations could monitor student progress using automatic notifications in the app which notified them of discrepancies between student self-assessment and preceptor ratings. This design has allowed teachers to step in where necessary and keep the learning goals and the clinical practice experience aligned. In-app communication tools including direct messaging also increased student-preceptor-educator coordination. Notably, the app was tailored to fit the needs of various institutions: at LDUC, reporting and feedback were required on a daily basis, whereas at UoA, a flexible approach was implemented, allowing students to submit reports at least once a week. This difference captured contextual realities but also provided opportunities to assess the impacts of differences in implementation on feasibility(5).

The process of data collection was developed to have both quantitative and qualitative results. On the quantitative side, the study included several standardized tools that measured constructs, including critical thinking (Health Sciences Reasoning Test), self-efficacy in clinical performance, perceptions of the clinical learning environment, acceptance of technology (Technology Acceptance Model 3), and mentor competence. These were self-administered online using websites like Questback and Insight Assessment which enabled the researchers to monitor change pre- and post-intervention. Data on the use of the TOPP-N app itself were also gathered, which gives a straightforward account of the frequency and patterns of use. In the qualitative corner, each group of participants was interviewed in focus groups. Practical sessions were conducted online as a result of the restrictions imposed by the pandemic; they were approximately one hour long and were moderated by researchers who did not take part in the development of the intervention to limit the biases. Thematic coding and semantic network analysis were used together to analyze transcripts of the interviews and enabled the team to come up with central concepts, relationships, and themes based on narratives provided by participants. This analytic approach was crucial in ensuring that the voices of the participants (enthusiastic, critical, or ambivalent) were methodically incorporated into the findings of the study.

Concerns over ethics and data safety also contributed to methodological rigor of the study. The Norwegian Centre for Research Data and participating institutions and nursing homes gave ethics approval. A digital informed consent was obtained using Questback, where the participants were informed about the aims and procedures of the study and their rights to withdraw. The data was anonymized and stored safely and with AES 256-bit encryption that backs them up. Notably, none of the scholars who designed or oversaw the intervention had a formal evaluative role in the education of the students, thus reducing the researcher-student conflict of interest and power imbalance. They were not given any financial incentives to participate but the educational value of the intervention itself was presented as a benefit.

Methodologically, the feasibility study also aimed to predict and report issues that could befall a future RCT. Such potential problems as dropout, participant fatigue with measurement tools, technical problems with apps installation or sign-in, excessive load on daily reporting, etc. were closely observed. They were designed with support mechanisms (such as assigning a superuser (an older student with an understanding of the app) and the development of a closed Facebook group where participants could pose questions and get those questions addressed in a timely manner). These accommodative approaches indicated the inquisitive and open-minded nature of the feasibility study, which meant that issues could be detected, resolved, and included in the recommendations to be refined in the future(6).

Overall, the Methods section of this feasibility study demonstrates that the intent to achieve a balance between formal and informal elements is an intentional endeavor; it unites conventional methods of conducting research, including standardized tools and statistical processing, with innovative ones, like app-based collection of data and qualitative interview analysis on a semantic network. The concurrent multimethod design enabled the study to not only ask the question of whether the TSGM intervention could work, but how it is experienced among different stakeholder groups, what could sabotage its implementation, and what changes would be necessary to scale it up to a larger trial. The methodological approach established a basis on which more robust forms of research could be conducted experimentally, and yielded direct information about the practical nature of implementing digital guidance tools in nursing education.

3.Results

The feasibility study yielded a plethora of findings that sheds light on both the possibilities and the difficulties of applying the Technology-Supported Guidance Model (TSGM) using the Technology-Optimized Practice Process in Nursing (TOPP-N) app to clinical practice. Patterns were identified across the sample of undergraduate nursing students, nurse preceptors and nurse educators that reflect the reception of the intervention, its consistency of use, and the barriers influencing participation and adherence. Among all 63 people who were invited to participate in the study, 24 eventually provided informed consent, or a very small percentage of the total population. Among these, 15 were nursing students, 5 were nurse preceptors and 4 were nurse educators. Though none of those who gave consent formally did so, dropouts were also seen in other forms, especially non-completion of questionnaires and non-participation in digital reporting. In fact, the dropout figures ranged between 42 and 75 percent regarding the responses to the instruments depending on the group and the tool used to measure the students dropout, which underlines that the study design and the intervention had a substantial dropout factor(7). The sociodemographic characteristics of the student participants were representative of the general composition of first-year groups in Norwegian nursing programs: most of them were women, most of them were first-year students, and most of them had had prior experience working in healthcare, which could have influenced their attitudes towards the intervention and their capacity to reconcile the demands of studying with the expectations of working in healthcare. Information on the application of the TOPP-N offered an objective view of engagement trends. When reporting was required every day as at Lovisenberg Diaconal University College (LDUC), nursing students reported more frequently than at the University of Agder (UoA), where reporting was strongly encouraged, but not required. In LDUC, students made 2- 31 reports over the practice period (mean 17.5, SD 7.16) compared with 0 -13 in UoA (mean 4.4, SD 4.31). The differences were probably impacted by institutional policies and the varying durations of practice placements due to COVID-19 restrictions, but they also indicate that differences in implementation can have a significant impact on fidelity. The use of the app by preceptors fitted into these trends with some never using the digital reporting features, others using them more frequently. Notably, preceptor feedback was not received in a consistent and timely way, which in some instances demotivated some students, as they too were reporting regularly. Direct data on app use and utilization among nurse educators were not available, yet qualitative data indicate that they were more involved in supervisory roles, primarily to monitor discrepancies and perform examinations without getting involved in day-to-day interactions.

TABLE 2 Summary of Results

Category	Findings
Participants	63 invited; 24 consented (15 students, 5 preceptors, 4 educators)
Dropout Rates	42–75% depending on instrument; high attrition in surveys
Student Demographics	Mostly female; majority first higher education; >50% with prior healthcare experience
App Usage (Students)	LDUC (mandatory daily): 2–31 reports (mean 17.5) UoA (flexible): 0–13 reports (mean 4.4)
App Usage (Preceptors)	Varied: some no use, others consistent; feedback often delayed or missing
Facilitating Factors	Clear roles, user-friendliness, structured assessments, overview of progress
Challenges	Time burden, misunderstandings, tech stress, negative attitudes, weak feedback
Needs for Development	Better training, management support, simplified app design, more flexible reporting
Overall Feasibility	Acceptable but uneven; requires refinements before RCT

Focus group interviews provided qualitative data which helped to interpret the quantitative data and identified three general topics: facilitating factors, challenges, and needs to be developed further. Enabling aspects were the clarity of the defined roles and the usability of the app. Students tended to appreciate how the interface was easy to use and how it helped them plan their learning outcomes and reflect on their progress(8). The ability to give a summary of student performance and make supervisory work more visible was particularly valued by the preceptors and educators. The fact that the digital platform simplified and formalized mid- and final-term tests

was pointed out by many participants as a clear benefit compared to paper-based evaluation. The motivational factor also contributed, and teachers indicated that they felt refreshed by involvement in the intervention and that it fit their pedagogical duties.

Alongside these positive factors, there were also many challenges that were reported that influenced feasibility. Time management was chief among them: both students and preceptors said that daily reporting was burdensome and in competition with other commitments. Even though some preceptors claimed that it took them 5 to 10 minutes after getting used to it, many students said that they felt the app was a waste of time that could have been spent interacting with patients. This was made worse by misunderstandings about the use of the app. Other students falsely assumed that they had to carry their mobile phones with them throughout the clinical shifts, and thus become concerned that technology was disrupting patient care. Others believed that once they chose learning objectives at the beginning of a shift they had to strictly follow them, despite unforeseen clinical realities rendering them impractical. Preceptors, in the meantime, usually expected that feedback was possible only at the conclusion of a shift, without even considering the alternative of giving real-time advice. These myths demonstrate the need to ensure clarity in communication and education in adopting digital tools.

The other issue was the technological pressure and overload of the tools. Much of this overload in the range of digital platforms that many students felt they needed to practice with, both institutional documentation systems and work-provided apps, and TOPP-N were added to the frustrating mix. Whereas some participants stated that the app was easy to use, some experienced technical issues like problems with downloading, logging in, or going through the learning point checklists. These barriers not only wasted time but also posed the danger of developing negative attitudes towards the intervention. Moreover, the process of filling in long measurement tools as a research instrument was seen as time consuming and some participants had trouble with accessibility to online questionnaire through incoherence in instructions given or failure of emails. Together, these add to the problem of high dropout rates in completing the survey, decreasing the amount of quantitative data with which to work.

The participants also found some areas in which they felt that improvement was needed to improve the intervention. Students and preceptors stressed the importance of systematized training, especially when new preceptors had been brought on board halfway and did not know well the app. The assistance of a superuser and an existing supportive Facebook community were also welcomed as beneficial, and the respondents emphasized that technical and pedagogical facilitation must be enhanced and better organized. Management anchoring was also presented as a necessity: preceptors and educators believed that institutional powers at nursing homes and universities had to officially endorse and support the intervention, so that supervisors had enough time and resources to work with the app without feeling like it was an extra burden. Recommendations on how the app should develop appeared to simplify reporting requirements, reduce the number of mandatory inputs and even experiment with weekly instead of daily reporting to decrease workload, though researchers reported that such modifications might change the theoretical basis of the intervention.

All in all, the results prove that although the TSGM intervention was generally viable and well-received, its use was disproportionate and strained by time constraints, lack of understanding, and technical issues. Recruitment and data collection strategies were also ambivalent: the initial interest was enough to start the research, but, due to the pandemic phase, web-based recruitment was the only viable choice, and online data collection posed obstacles to its completion. Motivation was associated with retention and adherence, and educators were more actively engaged than preceptors and students, in part because of their participation in the development of the intervention. Notably, the ease of use of the app proved to be a decisive factor in acceptance, which again supports the idea of continuous development.

In short, the findings demonstrate a sophisticated feasibility image. On the one hand, the organized communication, monitoring, and evaluation of the TOPP-N app were seen as an obvious benefit to students, preceptors, and educators. Conversely, the difficulties that arose because of time, workload, technological stress, and role clarity also slowed the implementation process and led to dropout. These results offer an in-depth insight into what succeeds, what fails, and what should be altered, thus, accomplishing the primary objective of a feasibility study: to inform the design of a more robust and large-scale trial and to determine the realities on the ground that must be taken into account to be successfully integrated into nursing education.

4.Conclusion

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The results of this feasibility study present a holistic view of the potential and the constraints of the implementation of a technology-enhanced guidance model to enhance critical thinking among undergraduate nursing students in clinical practice. The Technology-Supported Guidance Model (TSGM), with the centerpiece digital implementation of Technology-Optimized Practice Process in Nursing (TOPP-N) application, was demonstrated to be acceptable and feasible in the entire sample of participants, even though not without major challenges that need to be addressed and then proceed to a randomized controlled trial (RCT). On the positive side, the intervention clarified student, preceptor, and educator roles, established more formalized reflection and evaluation, and offered an accessible online platform, which, as many participants noted, was intuitive and supportive of their learning objectives. The opportunity provided by the app to provide a student with a general picture of his or her progress, adjust the learning goals to the supervision, and facilitate mid and final-term evaluation, proved especially appreciated. All these factors indicate that technology can actually play a positive role in improving the supervisory relationship in nursing education as long as it is wisely planned to supplement existing practice and not to eliminate it. The feasibility cannot however be assessed by the strengths alone but should also take into consideration the obstacles that erode fidelity and adherence. The researchers also found that time management demands, lack of understanding of how the app is supposed to be used, and technological stress were also prevalent demotivators that influenced the experience of the participants. Nursing students frequently reported that daily reporting cost them time with patients, and preceptors reported that they were overwhelmed with work and found it hard to incorporate the use of an app. Misunderstandings, including the notion that the goals chosen at the start of a shift needed to be strictly adhered to or that feedback would be possible only at the end of the day, contributed to frustration and the lack of flexibility desired in the intervention. Furthermore, these challenges are intensified by the larger magnitude of the COVID-19 epidemic that pushed participants to struggle with amplified dependence on digital materials, fewer clinical placements, and broken communication channels. These are some of the contributory factors that led to dropouts and lack of consistency in participation thus, must be eliminated by adopting better training and including communication and institutional support.

At the educational level, the results point to the importance of management anchor and organizational buy-in in the context of introducing a complex intervention. To effectively work with the TSGM, nurse preceptors and educators will need time and resources that are allocated to the implementation of the TSGM. The risk of not having such interventions prioritized by the institution is that online tools will be seen as an addition to other assistive technologies, rather than as integrated ones, thus affecting motivation and compliance. Respondents proposed that regular training, easy access to technical support, and the existence of a special user were important enablers of interaction. These lessons lead to structural changes that may make the probability of success in a bigger trial increase dramatically. Another important aspect that became critical was motivation. Nurse educators were more directly engaged in the process of the intervention development, so higher levels of engagement and enthusiasm were reported, whereas students and preceptors were more ambivalent. Such disproportionate motivation highlights the need to make sure every stakeholder is invested in the intervention and sees its value. Future versions might consider how co-design processes can be more proactive in designing app features and reporting routines by allowing students and preceptors to participate in the process of creating them and engaging with them.

The methodology of future research is also brought to focus in the study. Although online recruitment and data collection became a necessity due to the constraints associated with the pandemic, it was a big task, which resulted in low response and high turnover. The participants were also not able to access online questionnaires easily or were not able to complete the data sets due to taking up too much time. In the case of a future RCT, digital and in-person mixed strategies could be more successful, as researchers can offer instant clarification, technical support, and motivation to respondents filling out surveys. No less important, the balance of the quantitative and qualitative data collection will remain considerable, as it is the qualitative feedback that would provide the most substantial information regarding the experience of the specified intervention and the changes that were to be implemented.

Collectively, these results support the idea that the TSGM intervention has much potential as a model of critical thinking development in nursing education but that it needs to be refined prior to large-scale testing. Clarification of user roles in order to reduce misunderstandings, simplification of app functionality to decrease perceptions of time burden, reinforced technical and pedagogical support, and institutional leader resource allocation and support of the intervention are areas where the most attention is needed. To ensure the digital resources remain up-to-date and at the forefront of the requirements of the users, it will be necessary to continuously create apps that should

be in close contact with the users. In addition, successful intervention is not only related to the design of technology, but also to learning environment culture. A pedagogical environment that encourages reflection, formal feedback, and the adoption of technology into routine practice should be created in clinical settings without interfering with care delivery to patients.

Finally, this feasibility study indicates that although the TSGM intervention is feasible and perceived as desirable by many, it is not yet suitable to transfer to a randomized controlled trial without additional refinements. Its viability is not just in the digital infrastructure available but also the support, training and institutional alignment systems around it. The lessons obtained here can be viewed as a guide to the improvement of the intervention: to enhance a management anchor, to improve training procedures, to consider the problems of time and workload, to establish a culture of engagement among all stakeholders. With these considerations, experimental studies on the intervention could be conducted in the future to test the intervention with optimal conditions to improve its potential in developing critical thinking and improving clinical education outcomes. However, in the end, this paper highlights that technology, together with considerate pedagogy and institutional investment, can serve as an effective facilitator of innovation in nursing education. But success will require identifying and responding to the human, organizational, and contextual conditions under which its application is determined in practice.

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Conflicts of interest

The authors have no conflicts of interest to declare

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