ORIGINAL RESEARCH

Preparing nursing students for technology-driven healthcare: A workshop-based educational intervention

Sally Schauman*[1], Mette Skriver[1], Frederik L. Kuipers[1], Mette Elisabeth Nielsen[1], Martha Krogh Topperzer[2]

[1] *Team for Education in Clinical Nursing, Heart Centre, Rigshospitalet, Copenhagen University Hospital, Copenhagen, Denmark*
[2] *Department of Education, Rigshospitalet, Copenhagen University Hospital, Copenhagen, Denmark*

Received: January 12, 2026 **Accepted:** March 3, 2026 **Online Published:** April 17, 2026
DOI: 10.63564/jnep.v16n4p24 **URL:** https://doi.org/10.63564/jnep.v16n4p24

ABSTRACT

Background and objectives: Technology literacy is emerging as a competence to support clinical decision-making, documentation, and communication. However, while curricula for nursing students emphasize technological competencies, clinical education fails to support nursing students' understanding of technology in clinical practice. To address this gap, we developed a workshop for nursing students in clinical placement. The objective of this study was to evaluate of a workshop-based educational intervention designed to strengthen nursing students' technology literacy and clinical decision-making.

Methods: ***Design:*** A single group, post-intervention, descriptive design was applied to evaluate nursing students' learning outcomes. The workshop was structured in two parts. Part one focused on everyday technologies in nursing care guided by the TEKU model. Part two focused on future technologies such as AI and remote monitoring, using cases supported by The Pedagogical Reflection model or "The House" in clinical decision-making. To evaluate learning outcomes, a post-workshop questionnaire was completed.

Results: Of 112 respondents, 77% (n = 86) had previously attended teaching in technology literacy during their studies, 20% (n = 22) had not, and 4% (n = 4) were unsure. As for self-reported technology literacy post-workshop (n = 82), 62% (n = 51) reported a high or very high understanding, 37% (n = 30) reported moderate, and 1% (n = 1) reported low understanding. Furthermore, 89% (n = 97) reported improved clinical decision-making when encountering new technologies to a moderate 54% (n = 59), high 29% (n = 32), or a very high degree of 6% (n = 6), and 11% reported low (n = 10) or very low (n = 2). Open-ended responses highlighted that reflection and case-based group work were valuable in supporting critical thinking in assessing technology.

Discussion and conclusions: The results indicate that authentic and case-based learning activities are effective to support nursing students' technology literacy and critical thinking and may address the gap between curricular requirements and clinical practice. However, a single group design might limit generalizability. A practice-oriented workshop approach is effective to strengthen nursing students' technology literacy and support clinical decisions.

Key Words: Acute and critical care, Clinical decision-making, Clinical practice, Educational intervention, Nursing education, Technostress, Technology literacy

1. INTRODUCTION

This article presents an educational development initiative through a workshop-based intervention to evaluate nursing students' technology literacy, and clinical decision-making skills. Hasse, 2015 defines technology literacy as "the continuous ability to learn, assess and analyze new technology,

*Correspondence: Sally Schauman; Email: sally.schauman@regionh.dk; Address: Team for Education in Clinical Nursing, Heart Centre, Rigshospitalet, Copenhagen University Hospital, Copenhagen, Denmark.

technology in situated practice, the complex pathways of technologies, and the influence of technologies on the professions and the interplay between these".[1] The definition provides the conceptual framework for the workshop, which was designed to support the development of professional competencies through a dialogical, reflective, and practice-oriented approach.

The article is structured as follows: First, the article presents technology literacy in nursing education supplemented with international and national perspectives. Thereafter, the purpose of developing the workshop is outlined, methods to evaluate the results, and nursing students' self-reported learning outcome. Finally, the article presents a discussion, implications, and conclusion.

1.1 Background

Technologies are no longer just a tool to support nursing care. Technologies are increasingly being integrated into clinical decision-making, documentation, and communication through electronic patient records, telecare, monitoring devices, artificial intelligence, and predictive analysis.[2] Technology literacy becomes a core competence that requires nurses not only to have technical skills but also to have critical reflection on how the use of technologies affects the nurse role, the interprofessional relations and the nurse-patient relationship.[3,4]

According to the Danish Curriculum for Nursing Education 2025, after completing their education, nursing students must be able to act professionally, competently, and develop into critical reflective and authoritative health professionals capable of navigating in a changing health system through clinical decision-making, clinical leadership, patient involvement and technology literacy.[5]

To address curricular learning objectives in clinical practice, we developed an educational intervention designed as a workshop targeted at nurse students in their 5th semester of clinical practice, focusing on acute and critical care. This theme emphasizes that the student must acquire competencies in:[6]

"Using selected information, communication and welfare technology in acute and critical care and treatment and making qualified clinical decisions".

The importance of technology literacy must be understood in a broader perspective facing the challenges in healthcare both globally and nationally. Demographic challenges, with an aging population combined with nursing shortage, have changed the way healthcare is delivered.[7] The World Health Organization (WHO) and The International Council of Nurses (ICN) describe the need for redefining the way care is delivered to ensure equality, quality, and sustainability in future healthcare. Globally, there is a tendency to increase the usage of digital and technological solutions to meet the increased need for care and healthcare worker shortage.[8]

The growing use of technological solutions has intensified significantly and is seen as a solution to the healthcare sector's structural challenges.[7] The Danish Resilience Commission (2023) addresses better prioritization and smarter task solving through technological and digital solutions, which place new demands on the competencies of healthcare professionals, where technology literacy is a central element in the Commission's recommendations.[9]

Taken together, the national curriculum highlights the importance of technology literacy in nursing education. The clinical teaching during nursing student's clinical placement has, until now, not addressed this domain. The integration of technology literacy in clinical education becomes essential to prepare students for future healthcare practices. If technology literacy is to be implemented in clinical education, dissemination of knowledge cannot rely on the individual student alone. Train-The-Trainer structure could provide a sustainable approach for clinical educators/facilitators to build capacity and then transfer technology literacy in facilitating learning activities.[10]

1.2 Purpose

Given the importance of technology literacy in nursing education, this intervention was developed to strengthen students' understanding of technology and their ability to make clinical decisions in a technology-driven healthcare sector. The aim was to enhance nursing students' understanding of both everyday and emerging technologies, as AI-monitoring tools, are shaping nursing practice in acute and critical care as well as in homecare settings. The workshop-intervention applied an application-oriented format, in which technologies from the students' own clinical practice form the basis for reflective learning.[11]

2. METHOD

2.1 Design

This article employs a single group, post-intervention, and descriptive design. The evaluation of nursing students self-reported learning outcome included both closed and open-ended questionnaire items and have the characteristics of descriptive mixed-method.[12]

2.2 Participants and setting

The participants were 5th-semester nursing students in 6-week clinical placement at Rigshospitalet University Hospital, Capital Region. The students were distributed across the

hospitals in five centers: The Heart Center, The Centre of Cancer and Organ disease, The Neuro Center, The Juliane Marie Center and The Head of Orthopedic Center representing a broad range of specialties. The workshop was held in six sessions, each lasting three hours.

No demographic data such as age or gender were collected. As 5th semester nursing students in a 3.5-year bachelor program (seven semesters of six months each), all participants had completed 2.5 years of their nursing education, including clinical placement in every previous semester.

2.3 Involvement of clinical educators

Alongside nursing students, six clinical educators from the respective centers participated. The first author invited clinical educators based on the train-the-trainer structure to disseminate knowledge about technology literacy, to familiarize them with the workshop format, and to give them the opportunity to work with the concept in a local context.[10]

2.4 Workshop format and content

The workshop was structured in two parts to strengthen nursing student's technology literacy in acute and critical perspectives in clinical practice. First, the workshop began with aligning expectations supported by a dialogue paper, where students in groups discuss their expectations about the workshop, their experiences with using technologies, and the narratives on understanding technology in practice.

Part one focused on technologies in nursing, with an emphasis on familiar technologies from the student's daily practice. The technologies were categorized into six types: simple tools, instruments, equipment, machines, automated devices, and virtual/digital programs.[13] As a next step, technostress was addressed as a potential challenge for healthcare professionals, followed by examples from clinical practice. Technology literacy was nuanced to prevent technostress through a podcast about technology in nursing,[14] accompanied by an individual listening guide developed by the first author. As a last step in Part one, students worked in groups to analyze everyday technologies, using the TEKU model (Technology, Engagement, Complexity, Development),[1] reflecting on their impact on clinical practice, nursing profession, and the nurse-patient relationship.

Part two focused on future nursing, including health data and advanced monitoring technologies based on AI. WHO's six principles of Ethics and Governance of AI for Health were presented as a framework for reflection, covering themes such as ethics, bias, responsibility, accountability and inequality.[15] Thereafter, cases involving monitoring technologies from WARD Clinical Support System (WARD CSS) were presented.[16] Part two concluded with case-based group work using the Pedagogical Reflection Model (PRM)[17] or "The House"[18] developed with inspiration from The Situated Clinical Decision-making Framework by Gillespie & Paterson,[19] where students engaged in clinical decision-making based on a practice-oriented scenario involving a discharged multimorbid patient monitored with WARD CSS technology.

The first author facilitated all six workshops and used the same materials, sequence, cases, and exercises. A pilot version of the workshop was concluded earlier in the year to refine the materials and content before offering the workshop across centers. The TEKU worksheets used in Part one was developed by the first author, and the listening guide for the podcast was developed specifically for this workshop. The PRM model applied in Part two was an established tool already used in clinical decision-making in the local context.

2.5 Didactical approach

The workshop on technology literacy was grounded in a set of didactical and pedagogical principles, aimed to apply a practice-oriented approach with a focus on participation involvement, and active learning to support nursing students' development of technology literacy in nursing practice. These include Barrows & Tamblyn (1980) approach to problem-based learning, and Illeris (2014) theory on learning.[12]

2.6 Problem-based learning

Barrows & Tamblyn (1980) describe PBL as learning that results from the process of working toward the understanding or resolution of a problem.[20] In the workshop, nursing students were presented with brief theoretical input, followed by case-based group work and peer learning. Within PBL, the type of the problem, and the nature of the problem depends on the purpose of the teaching and the intended learning outcome. In line with Ulriksen (2021) nursing students work with learning issues, meaning their assignment wasn't to find a solution to an actual problem but to engage with and understand the underlying theory and practice-oriented complexities.[21] To support this, authentic and practice-oriented cases were included in the workshop.

2.7 A comprehensive and holistic understanding of learning

Our conception of learning is based on Illeris' holistic learning theory.[22] According to Illeris, all learning takes place through two closely integrated, but distinct different processes: on the one hand, an interaction process between the learner and the social and material environment, and on the other hand, an internal psychological process of acquisition and processing, in which impressions from the interaction

process are integrated into frameworks of prior learning. Furthermore, learning also includes three dimensions: (1) a cognitive or content dimension, which concerns what is to be learned with focus on knowledge, skills, and understanding; (2) a psychological or motivational dimension, where feelings, motivation, and will serve as the driving force in learning; and (3) a social or interaction dimension, where social interactions with surroundings, relations, and the context influence learning. In Illeris' view, no learning takes place if these processes are not active, and a full understanding of learning cannot be achieved if they are not related to the three dimensions.

2.8 Data collection

Data was collected through a questionnaire in Survey-Xact. The questionnaire was developed with a combination of closed and open-ended questions to evaluate nursing students self-reported learning outcome. The questionnaire included four closed Likert-scale questions focusing on perceived technology literacy, perceived understanding of technology's role in nursing, perceived improvement in clinical decision-making, and the relevance of the workshop for future practice. For the open-ended questions, the participants were asked to describe (1) which part of the workshop they found most valuable, and (2) how they expect to apply their learning outcome in practice. Furthermore, nursing students were able to give feedback on the workshop. The questionnaire was developed with the purpose to evaluate the workshop's content and perceived learning outcomes and was not intended as a validated measurement tool for technology literacy. The questionnaire was completed post-workshop intervention. The participation in the questionnaire was optional, and responses across the questions varied (n = 82-112).

2.9 Data analysis

The quantitative data were exported directly from Survey-Xact, which provided the descriptive statistics in percentage and frequencies for each question. The results are presented in tables to illustrate the responses across the categories in the questionnaire.

The qualitative data from the open-ended questions were analyzed through an inductive thematic analysis described by Polit & Beck (2018). Based on the inductive process, four themes emerged based on the nursing students' reflections and self-reported learning outcome.

2.10 Ethical considerations

The participation in the evaluation of the workshop was voluntary, and students provided informed consents by completing the questionnaire. The questionnaire was anonymous, and no personal data was collected. All data were stored securely in Survey-Xact and in compliance with GDPR and institutional regulations. According to Danish regulations, educational activities that do not involve patient data are not subject to ethical approvals. In addition, the anonymized data were made available to the participating clinical educators, who observed the workshop and had a professional interest in nursing students self-reported learning outcome solely for the purpose of improving clinical education and development of a workshop in a local context.

3. Results

Of 112 respondents, 77% (n = 86) had previously attended teaching in technology literacy during their studies, 20% (n = 22) had not, and 4% (n = 4) were unsure.

Figure 1 presents nursing students (n = 82) self-evaluation of technology literacy post workshops. Most students reported a high 50% or moderate 37% technology literacy, while a few students reported a very high understanding of 12%, and one student 1% indicated a low understanding.

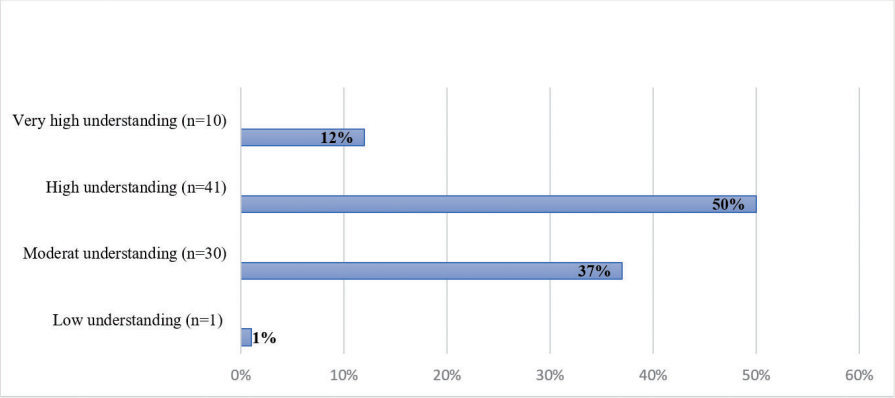

Figure 1. How do you evaluate your technology literacy after the workshop?

Figure 2 presents the extent of nursing students (n = 112) understanding of the role of technology in nursing practice. 75% experienced moderate to great improvement, while 12% experienced an extreme improvement. A small group 9% only experienced a slight improvement while 4% did not.

Figure 3 presents nursing students (n = 109) readiness towards making clinical decisions when encountering new technologies. The majority, 54%, expressed readiness, 29% reported readiness to a high degree while 6% expressed readiness to a very high degree. 9% reported a low degree of readiness while a few 2% indicated a very low degree of readiness.

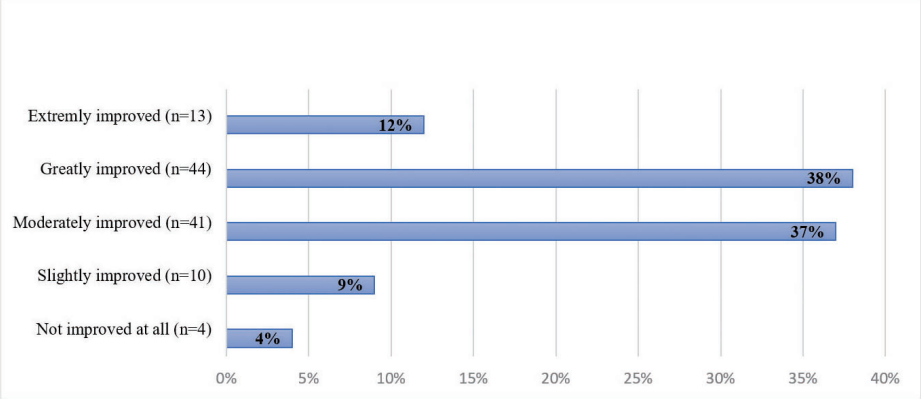

Figure 2. To what extent has the workshop improved your understanding of the role of technologies in nursing

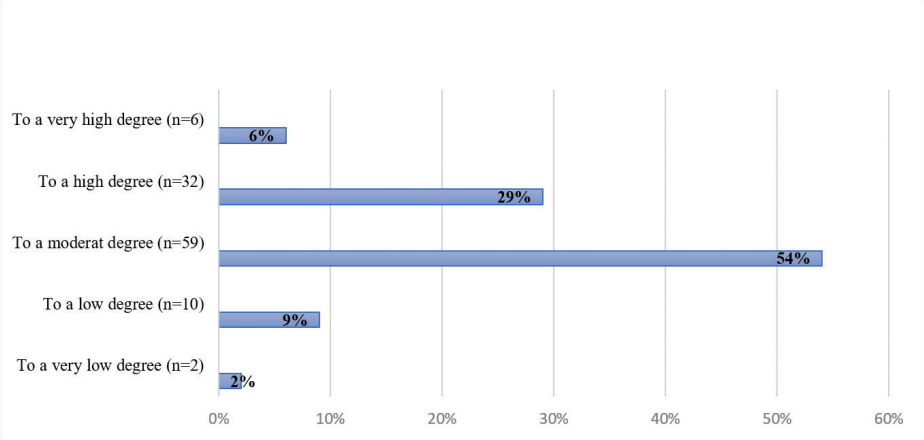

Figure 3. To what extent do you feel better prepared to make clinical decisions when encountering new technologies after the workshop?

Overall, the results indicate a positive effect on nursing students understanding of technology literacy and on the role, technologies have in nursing practice and their readiness to make clinical decisions. Furthermore, the majority reported a moderate to a high degree which indicates that the workshop is a valuable learning activity to strengthen technology literacy.

3.1 Qualitative results

Qualitative responses were analyzed inductively to identify the themes related to nursing students self-reported learning outcome (see Table 1). Following Polit & Beck's (2018) framework of inductive qualitative analysis, the open-ended responses were grouped into themes and presented narratively supported by quotations. Four themes were identified: (1) practice-based learning and collaborative reflection; (2) critical reflection and clinical judgement with technology; (3) awareness of the nurse-patient relationship; and (4) future nursing practice. The themes show that nursing students value practice-oriented cases and collaborative reflection to understand the role of technology in nursing. The importance of maintaining a clinical and critical judgement on the nurse-patient relationship is also highlighted and preparing for a future healthcare with involvement of AI in nursing care.

Table 1. Themes identified from the qualitative responses

Theme	Description	Quotes
Practice-based Learning and collaborative reflection	Nursing students highlighted authentic, practice-oriented cases, group discussions, groupwork and shared reflections discussions as valuable learning activities,	*"Working with real-life cases made it easier to connect theory to practice."* *"The case about Ivan helped me relate the topic to everyday nursing situations."* *"The TEKU case work really helped me understand how technology is implemented in practice."*
Critical reflection and clinical judgment with technology	Nursing students expressed that technology should support, not replace, the nurse's critical thinking.	*"I will remember to use my clinical judgement and not rely solely on technology."* *"Reflect on what could be done alternatively if the technology fails or things do not work optimally"* *"Technology can never stand alone, and it is still important/most important to have clinical perspective"*
Awareness of the nurse-patient relationship	Nursing students reflect how technology can create closeness or distance in care.	*"I will reflect on whether technology brings me closer to or further away from the patient."* *"Remember the patient and not only look at values" (data)* *"Reflect on the distance to the patient (is information conveyed through technology or directly from the patient)"* *"Combination of technology and personal care (remember good communication / patient guidance)"*
Future nursing practice	Nursing students reflects the importance of knowing about the future healthcare sector driven by AI, and potential challenges in implementation of new technologies.	*"The teaching on AI was very interesting – how to work with AI in clinical practice"* *"Learning about AI and different types of technology. Knowledge about WHO and the 6 ethical guidelines for AI as a tool"* *"Think more about the invisible extra work and technostress"*

Overall, the qualitative responses illustrate that technologies cannot replace clinical judgement and highlight the importance of critical reflection in each patient scenario. Reflection with peers and the educator was meaningful for connecting theory with practice. Students emphasize awareness on how technologies can affect the nurse-patient relationship, as well as the need to prepare for the future healthcare context involving AI-based technologies. Ethical consideration in AI technologies was also highlighted.

The teaching is structured to incorporate the students' perspectives on experiences with technology, with attention to practice and the students' individual learning processes, where the degree of previously learned frameworks varies. In group work and workshops, students engage with the content of the teaching in interaction with peers, analyzing the subject in a nursing professional nursing context with a focus on technological understanding. The learning outcomes are influenced by individual interests and motivation, as well as the group's social interaction.

3.2 Additional qualitative feedback on the workshop

Overall, students responded positively, emphasizing engaging facilitation, a good variety of content, and a balance between group work and presentation. Some students described the need for more time dedicated to groupwork, while others suggested scheduling the workshop earlier in the day. One student reported a negative experience. The workshop was intense, and few responses indicated that it was a bit compressing.

4. Discussion

The workshop was developed to strengthen nursing students' technology literacy and the ability to make clinical decisions in a technology-driven healthcare sector. The results show that the majority of nursing students reported a moderate to high technology literacy 87% (n = 71) post workshop, and a moderate to a high degree of readiness towards making clinical decisions when encountering new technologies 83% (n = 91). These results indicate that the workshop had a positive impact on central learning outcomes. The results are consistent with previous research in undergraduate nursing which shows that problem-based learning improves critical thinking particularly in analysis and evaluation compared with traditional teaching methods.[23] Similarly, a Nordic study reports that case-based learning ensures that students can connect theory with practice and exercise judgement in small group work aligned with our qualitative themes of practice-based learning, collaborative reflection and critical

judgement.[24]

Illeris' three learning dimensions: content, motivation and social interaction reflects the design of the workshop.[22] The content dimension supports knowledge and understanding about technology and AI, while the motivational dimension enhanced nursing student's engagement through authentic cases. The social dimension became apparent when interacting in groups and collaborative reflection. These dimensions reflect the principles of problem-based learning and explain nursing students' improvements in critical thinking and judgement with technology and readiness towards making clinical decisions on complex technologies.[20,21]

The qualitative data provides more nuances to the quantitative measurements. The theme Practice-based Learning and collaborative reflection indicates that nursing students value authentic cases, reflection and group work to connect theory with practice:" Working with real-life cases made it easier to connect theory to practice". This suggests that practice-oriented learning activities enhance nursing students understanding. The qualitative themes explain why the quantitative outcomes were moderate to high: nursing students describe authentic cases, peer dialogue and structured reflection that likely support their learning outcomes.

Technology literacy and clinical decision making is not only about technical skills but also critical reflection over how technology affects the relation to the patient, workflow and interprofessional cooperation. Critical thinking remains as a core element in nursing practice and requires continuous interventions. To enhance critical thinking in future learning activities, educators should incorporate Illeris learning dimensions and Barrows & Tamblyn approach to problem-based learning to support learning on AI, ethics and development of technology literacy.

4.1 Strength and limitations

The evaluation highlights relevant insights, but several methodological limitations must be acknowledged. The workshop includes a broad representation of students, ensuring diversity in nursing students' perspectives and experience. By combining quantitative measurements and qualitative perspectives, a deeper understanding of nursing students self-reported learning outcomes was obtained. Furthermore, a practice-oriented workshop creates better conditions for active applications in a clinical context. The didactical approach with integration of learning tools such as TEKU, PRM, The House, authentic cases open for reflection, collaboration, and a problem-oriented focus.

Certain limitations are identified as the design employs a single group with no control group. Therefore, the results are not generalizable, and it is not possible to draw a causal conclusion. Furthermore, the questionnaire was answered immediately post workshop, and nursing students have not applied their understanding actively in practice and in clinical decision making and do not capture the long-term effect of the workshop. Participation was voluntary, resulting in fewer responses to some questions (n = 82-112) which have influenced different forms of bias. Evaluation fatigue, a well-known phenomenon in nursing education, where nursing students often are asked to evaluate, may have contributed to nonresponse bias. Social desirability bias can't be ruled out due to the facilitator's presence during the evaluation. Six responses were partial, which explains the variation in some responses across the questions. Furthermore, some students may have experienced technical challenges with internet connection in the auditorium. As the evaluation was based on self-reported perceptions, the results reflect nursing students experienced learning outcomes rather than objective measurements.

4.2 Implications

The results indicate several implications for clinical practice. Critical reflection remains as a core element in nursing practice as technologies should support and not replace clinical judgement. To strengthen this, clinical education must integrate technology literacy into teaching activities across semesters, ensuring nursing students gradually develop technology literacy competencies. Establishing simulation facilities provides nursing students to practice clinical decision making and apply technology literacy in a safe and realistic learning environment. Furthermore, development of technology literacy competencies for clinical facilitator through train-the-trainer can be a resourceful and a sustainable way to deliver educational concepts by training peers and preparing them to support nursing students' technology literacy and critical thinking.[11] Furthermore, the workshop can easily be transferred to teaching activities across other healthcare professions and semesters.

5. Conclusion

The purpose of the workshop was to strengthen nursing students' technology literacy and clinical decision making, and to increase their understanding of technology in clinical practice.

The results showed that the workshop intervention contributed to these aims. Nursing students reported improved technology literacy and felt more prepared to make clinical decisions when encountering new technologies. The qualitative quotes illustrate that practice-oriented groupwork using cases, reflections models such as TEKU, PRM, The House,

and facilitated dialogue were valuable activities to support critical reflection. Implementing such learning activities might close the gap between educational requirements and clinical practice.

ACKNOWLEDGEMENTS

The first author would like to thank the WARD 24/7 project team for providing access to anonymized clinical cases from WARD CSS that were used in the workshop to enhance the understanding of future nursing care. Gratitude is also extended to Ulla Gars, Lecturer, Academic Coordinator with a focus on Technology and Digitalization, Copenhagen University College, for allowing observation of her facilitation on technology literacy. Special thanks are further extended to the Leaders of Clinical Education at Rigshospitalet for supporting the project, and to the clinical educators for their interest in and active participation in the workshop, engaging with the same content and analyses as the nursing students.

AUTHORS CONTRIBUTIONS

Sally Schauman contributed to all aspects of the manuscript, including conceptualization of the workshop, data analysis, interpretation of results, and writing.
Mette Skriver wrote the didactical approach, contributed to the discussion on didactics, and provided didactical feedback and guidance during the workshop process.
Fredrik L. Kuipers contributed with guidance on interpretation of results.
Mette Elisabeth Nielsen reviewed the manuscript.
Martha Krogh Topperzer supervised and provided guidance throughout the process and review.
All authors approved the final manuscript.

FUNDING

Not applicable.

CONFLICTS OF INTEREST DISCLOSURE

The authors declare that there is no conflict of interest.

INFORMED CONSENT

Obtained.

ETHICS APPROVAL

The Publication Ethics Committee of the Association for Health Sciences and Education. The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

PROVENANCE AND PEER REVIEW

Not commissioned; externally double-blind peer reviewed.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

DATA SHARING STATEMENT

No additional data are available.

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