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REVIEW ARTICLE

Nursing diagnostic reasoning learning of students through educational technologies: an integrative review

Aprendizagem do raciocínio diagnóstico de enfermagem de estudantes por meio de tecnologias educacionais: revisão integrativa

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ABSTRACT

Objective: To analyze the skills and experiences developed from the use of educational technologies in the nursing diagnostic reasoning of undergraduate students. **Method:** Integrative literature review performed in April 2020 through online access to seven databases without establishing a time frame. Search terms such as "nursing students", "educational technology" and "nursing diagnosis" were incorporated into the search strategies. **Results:** From a universe of 332 consulted titles and abstracts, 21 articles that fully answered the research question were selected. Thirteen face-to-face and 8 virtual educational technologies that provided metacognitive, cognitive and practical skills and affective and motivational experiences to nursing students were identified. **Conclusion:** Most face-to-face technologies impacted directly on the diagnostic reasoning of students, while virtual technologies contributed indirectly to its development.

Descriptors: Students, Nursing; Educational Technology; Nursing Diagnosis; Learning.

RESUMO

Objetivo: Analisar as habilidades e experiências desenvolvidas a partir do uso de tecnologias educacionais no raciocínio diagnóstico de enfermagem de estudantes de graduação. **Método:** Revisão integrativa da literatura realizada em abril de 2020, por meio do acesso *on-line* a sete bases de dados, não sendo estabelecido um recorte temporal. Termos de busca como "estudantes de enfermagem", "tecnologia educacional" e "diagnóstico de enfermagem" foram incorporados nas estratégias de busca. **Resultados:** Em um universo de 332 títulos e resumos consultados, foram selecionados 21 artigos que respondiam de forma integral à pergunta de pesquisa. Foram identificadas 13 tecnologias educacionais presenciais e 8 virtuais que forneceram habilidades metacognitivas, cognitivas,

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práticas e experiências do tipo afetivas e motivacionais aos acadêmicos de enfermagem. **Conclusão:** A maioria das tecnologias presenciais impactaram diretamente no raciocínio diagnóstico dos estudantes, enquanto as tecnologias virtuais contribuíram indiretamente para seu desenvolvimento.

Descritores: Estudantes de Enfermagem; Tecnologia Educacional; Diagnóstico de Enfermagem; Aprendizagem.

INTRODUCTION

The reduction of diagnostic errors and a better diagnostic performance are goals desired by professional nurses. In the field of health education, achieving these goals involves emphasizing education and training strategies for clinical reasoning skills. However, the growing complexity of the area requires the development of curricular changes in professional education, and the incorporation and proper use of technologies[1].

In addition, reinventing the teaching-learning routine becomes important at certain times, as occurred due to the COVID-19 pandemic declared by the World Health Organization in March 2020. Given the high transmissibility of the virus and the attempt to contain the rapid pandemic evolution of the disease, social isolation measures such as social distancing were adopted and schools and higher education institutions were closed[2].

Considering the broadness of educational technologies, they have the potential to be used as processes and resources that can act as strategies for the development of clinical-diagnostic reasoning, contribute to an evidence-based practice and the training of qualified nurses and above all, increase the health status of the population[3]. The debate on the use of educational technology is placed in a context of growing complexity of the health area and pedagogical improvement. It is conceptualized as a field of study that encompasses both the educational applications of technologies and the examination of educational aspects that depend on the use of technologies[4]. The health field has a demand for educational processes with the same innovation needs as those imposed by globalization on all other sectors[5].

Educational technologies can have different natures and produce different results and applications in the diagnostic process and therapeutic decision-making. Alternatives include: the traditional nursing process that uses an analytical approach; clinical instructions in direct patient care under the direct supervision of a teacher or preceptor; and analyzes of clinical cases completed in the classroom and, more recently, in human patient simulation laboratories[6]. In terms of specific purposes, they can help students develop nursing diagnoses by accurately identifying patient data[7], support diagnostic reasoning through the use of forms that explore clinical cases[8] and explore the analytical and heuristic dimensions of nursing diagnostic reasoning through simulated scenarios[9], among other applications.

The development of alternative active methodologies is emphasized, especially those centered on students as co-responsible for the teaching-learning process, whether virtual or non-virtual[10]. However, given the panorama experienced by the new coronavirus pandemic, Ordinance No. 343 was published, which provided for the replacement of in-person classes by emergency remote teaching in order to authorize the continuation of the school year in digital media for as long as the COVID-19 pandemic situation lasts[11]. Therefore, the remodeling of the way of teaching has become a great challenge for managers of educational institutions, teachers and students. They had to go abruptly from face-to-face teaching to the remote teaching model and adapt to the use of active methodologies and digital platforms and technologies for pedagogical purposes. Within this context, interest in virtual reality processes gained ground and continues to receive growing interest.

The theory of generations is also an important factor to be considered when thinking about the use of technologies in the educational environment. Students between 18 and 35 years are the totality in undergraduate education in the health field. This audience is formed by students from Generation Y (born between 1983 and 1997) and Generation Z (born between 1998 and 2009). As these generations are formed by the "sons of technology", they follow technological changes quickly and require constant innovations to establish learning. It is important that teachers search educational instruments that introduce dynamism and quality in the transmission of knowledge at the same time, since the practice of lectures alone cannot keep students continuously interested. However, technological resources must be mediated to guide students and not characterize their mere existence as the exclusion of the physical space for learning and the teacher as a conductor[12].

As a general recommendation, educators and students should explore the use of educational methods that guide the establishment of a diagnosis, and develop, test and adapt appropriate educational technologies, especially considering the multiplicity of human responses presented in nursing diagnoses. The defense for the usefulness of technologies remains a position subject to consensus. A deeper knowledge about the influence of educational technologies applied in training on nursing diagnostic reasoning is essential. Therefore, the development of the present investigation was considered opportune. The objective is to analyze the skills and experiences developed with the use of educational technologies in the nursing diagnostic reasoning of undergraduate students.

This study is justified because it contextualizes valuable issues for this area of health, such as the use of educational

technologies in the teaching-learning process for the development of nursing diagnostic reasoning and the training of qualified professionals, directly impacting in care planning and consequently, in the quality of services offered to the population. Generations Y and Z, the predominant audience in undergraduate courses, also corroborate the justification for the study, since the identification of methodologies that encompass the largest number of students is the educator's responsibility. In addition, the study is justified as a way to register and highlight themes that emerged in a historical moment of great importance for nursing teaching worldwide.

METHOD

Integrative review carried out in six steps: identification of the theme and development of the research question; literature search of primary studies; extraction of data from primary studies; evaluation of primary studies included in the review; analysis and synthesis of the review results; and presentation of the integrative review[13]. The integrative literature review is a type of study that allows combining data from theoretical literature with data from primary studies. It can serve different purposes, such as defining concepts, examining theories, reviewing evidence and analyzing methodological issues on a particular topic[13,14].

The purpose of this review was to identify the educational technologies used in the development of nursing diagnostic reasoning. To meet this purpose, the PEO strategy (Population, Exposure and Outcome)[15] was used to construct the research question: the letter "P" corresponded to Nursing Undergraduate Students, the letter "E" corresponded to Educational Technologies and the letter "O" corresponded to the Teaching-Learning of Nursing Diagnostic Reasoning. Thus, the following research question emerged: What are the outcomes in diagnostic reasoning learning of Nursing Undergraduate students resulting from the use of educational technologies?

The search for studies was performed in August 2021 through online access in the following databases: Nursing Database (*Base de Dados de Enfermagem* — BDENF) — via VHL; Index to Nursing and Allied Health Literature (CINAHL) — via EBSCOhost; Spanish Bibliographic Index of Health Sciences (IBECS) — via VHL; Latin American and Caribbean Health Sciences Literature (LILACS) — via VHL; Medical Literature Analysis and Retrieval System Online (MEDLINE) — via PubMed; Scopus and Web of Science. The choice of databases ensured national and global coverage, with publications from Latin American countries, guaranteed access to specific databases in nursing and the health area in the world, as well as science from several other areas, such as the Health Sciences and Human and Social Sciences, for example Education.

Search terms, including descriptors and keywords, were combined in different ways to enable a comprehensive search of primary studies (Chart 1). The inclusion criteria defined for the retrieval of studies were: original articles; addressing the significant elements of the research question; works published in English or Portuguese; without time frame in order to cover as many studies as possible. Exclusion criteria were: literature reviews; experience reports; and theoretical essays.

The process of search and selection of studies was conducted in five steps: search in databases; removal of duplicates; application of eligibility criteria based on the reading of titles and abstracts; preliminary application of eligibility criteria from reading the full texts; and, application of eligibility criteria based on the reading of full texts performed by peers.

Data were organized from the development of an instrument containing a code given to the article, the country where it was conducted, year of publication, the educational technology used for the development of diagnostic reasoning, the main findings of the study, reasons for excluding the documents and the DOI or URL of documents. The sample was analyzed through exploratory reading and critical analysis of titles, abstracts and results on the type of technology chosen, the way it was used and its impact on nursing diagnostic reasoning.

The documents were identified with alphanumeric codes in descending order according to year of publication. The analysis and synthesis of results of the integrative review were performed descriptively and presented in two steps. In the first step, identification data of the sample documents were analyzed by applying descriptive statistics operations, such as absolute and relative frequency. In the second step, the findings of studies were analyzed by means of content analysis.

RESULTS

Study characteristics

The 21 documents selected for analysis met the inclusion criteria and were published in scientific journals between 1988 and 2021. The search and selection process of documents is represented in the form of a flowchart in Figure 1.

As for the place of publication, the articles came from eight different countries: United States (n=7; 33.3%), Brazil (n=6; 28.6%), South Africa (n=2; 9.5%), Iran (n=2; 9.5%), Canada (n=1; 4.8%), Indonesia (n=1; 4.8%), Italy (n=1; 4.8%), Taiwan (n=1; 4.8%. All authors were researchers of the nursing field.

Regarding the distribution by year of publication, two (9.5%) were published until 1999, six (28.6%) between 2000 and 2009, 12 (57.1%) between 2010 and 2019, and one (4.8%) in 2020.

Chart 1. Search strategies for primary studies in selected databases. Rio de Janeiro, RJ, Brazil, 2021.

BDENF / IBECS / LILACS	CINAHL
1. mh:("Estudantes de Enfermagem" OR "Bacharelado em Enfermagem" OR "Educação em Enfermagem") 2. tw:("estudantes de enfermagem" OR "estudante de enfermagem" OR "alunos de enfermagem" OR "aluno de enfermagem" OR "alunas de enfermagem" OR "aluna de enfermagem" OR "bacharelado em enfermagem" OR "faculdades de enfermagem" OR "faculdade de enfermagem" OR "escola de enfermagem" OR "escolas de enfermagem" OR "graduação em enfermagem" OR "curso de enfermagem" OR "cursos de enfermagem" OR "ensino de enfermagem") 3. OR/1-2 4. mh:("Tecnologia Educacional" OR "Aprendizagem") 5. tw:("tecnologia educacional" OR "tecnologias educacionais" OR "tecnologia instrucional" OR "tecnologias instrucionais" OR "recurso educacional" OR "recursos educacionais" OR "recurso didático" OR "recursos didáticos" OR aprendizagem OR aprendizado) 6. OR/4-5 7. mh:("Diagnóstico de Enfermagem") 8. tw:("diagnóstico de enfermagem" OR "diagnósticos de enfermagem" OR "julgamento diagnóstico" OR "julgamentos diagnósticos" OR "decisão diagnóstica" OR "decisões diagnósticas" OR "raciocínio diagnóstico" OR "raciocínios diagnósticos") 9. OR/7-8 10. la:("pt" OR "en") 11. 3 AND 6 AND 9 AND 10	S1.MH ("Students, Nursing, Baccalaureate" OR "Students, Nursing") S2. AB ("nursing students" OR "nursing student" OR "undergraduate nursing" OR "baccalaureate nursing" OR "nursing baccalaureate" OR "nursing school" OR "nursing schools" OR "school of nursing" OR "schools of nursing" OR "nursing college" OR "nursing colleges" OR "college of nursing" OR "colleges of nursing" OR "nursing education") S3. OR/1-2 S4. MH ("Educational Technology" OR "Learning") S5. AB ("educational technology" OR "educational technologies" OR "instructional technology" OR "instructional technologies" OR "educational resource" OR "educational resources" OR "didactic resource" OR "didactic resources" OR learning) S6. OR/4-5 S7. MH ("Nursing Diagnosis") S8. AB ("nursing diagnosis" OR "nursing diagnoses" OR "diagnostic decision" OR "diagnostic decisions" OR "diagnostic reasoning") S9. OR/7-8 S10. 3 AND 6 AND 9
MEDLINE	**SCOPUS**
1. "Students, Nursing"/ 2. "Education, Nursing, Baccalaureate"/ 3. "Education, Nursing"/ 4. "nursingstudents" 5. "nursingstudent" 6. "undergraduatenursing" 7. "baccalaureatenursing" 8. "nursingbaccalaureate" 9. "nursingschool" 10. "nursingschools" 11. "schoolofnursing" 12. "schoolsofnursing" 13. "nursingcollege" 14. "nursingcolleges" 15. "collegeofnursing" 16. "collegesofnursing"	1. INDEXTERMS("Students, Nursing" OR " Education, Nursing, Baccalaureate" OR " Education, Nursing") 2. TITLE-ABS("nursing students" OR "nursing student" OR "undergraduate nursing" OR "baccalaureate nursing" OR "nursing baccalaureate" OR "nursing school" OR "nursing schools" OR "school of nursing" OR "schools of nursing" OR "nursing college" OR "nursing colleges" OR "college of nursing" OR "colleges of nursing" OR "nursing education") 3. OR/1-2 4. INDEXTERMS("EducationalTechnology" OR "Learning") 5. TITLE-ABS("educational technologies" OR "instructional technology" OR "instructional technologies" OR "educational resource" OR "educational resources" OR "didactic resource" OR "didactic resources" OR learning) 6. OR/4-5 7. INDEXTERMS("Nursing Diagnosis")

Continue...

Chart 1. Continuation.

MEDLINE	SCOPUS
17. "nursingeducation" 18. OR/1-17 19. "Educational Technology"/ 20. "Learning"/ 21. "educationaltechnology" 22. "educationaltechnologies" 23. "instructionaltechnology" 24. "instructionaltechnologies" 25. "educationalresource" 26. "educationalresources" 27. "didacticresource" 28. "didacticresources" 29. learning 30. OR/19-29 31. "NursingDiagnosis"/ 32. "nursingdiagnosis" 33. "nursing diagnoses" 34. "diagnosticdecision" 35. "diagnosticdecisions" 36. "diagnosticreasoning" 37. OR/31-46 38. Portuguese[lang] 39. English[lang] 40. OR/48-49 41. 18 AND 30 AND 47 AND 50	8. TITLE-ABS("nursing diagnosis" OR "nursing diagnoses" OR "diagnostic decision" OR "diagnostic decisions" OR "diagnostic reasoning") 9. OR/7-8
WEB OF SCIENCE	
#1 TS=("Students, Nursing" OR "Education, Nursing, Baccalaureate" OR "Education, Nursing" OR "nursing students" OR "nursing student" OR "undergraduate nursing" OR "baccalaureate nursing" OR "nursing baccalaureate" OR "nursing school" OR "nursing schools" OR "school of nursing" OR "schools of nursing" OR "nursing college" OR "nursing colleges" OR "college of nursing" OR "colleges of nursing" OR "nursing education") #2 TS=("Educational Technology" OR "Learning" OR "educational technologies" OR "instructional technology" OR "instructional technologies" OR "educational resource" OR "educational resources" OR "didactic resource" OR "didactic resources" OR learning) #3 TS=("Nursing Diagnosis" OR "nursing diagnoses" OR "diagnostic decision" OR "diagnostic decisions" OR "diagnostic reasoning") #4 #3 AND #2 AND #1	

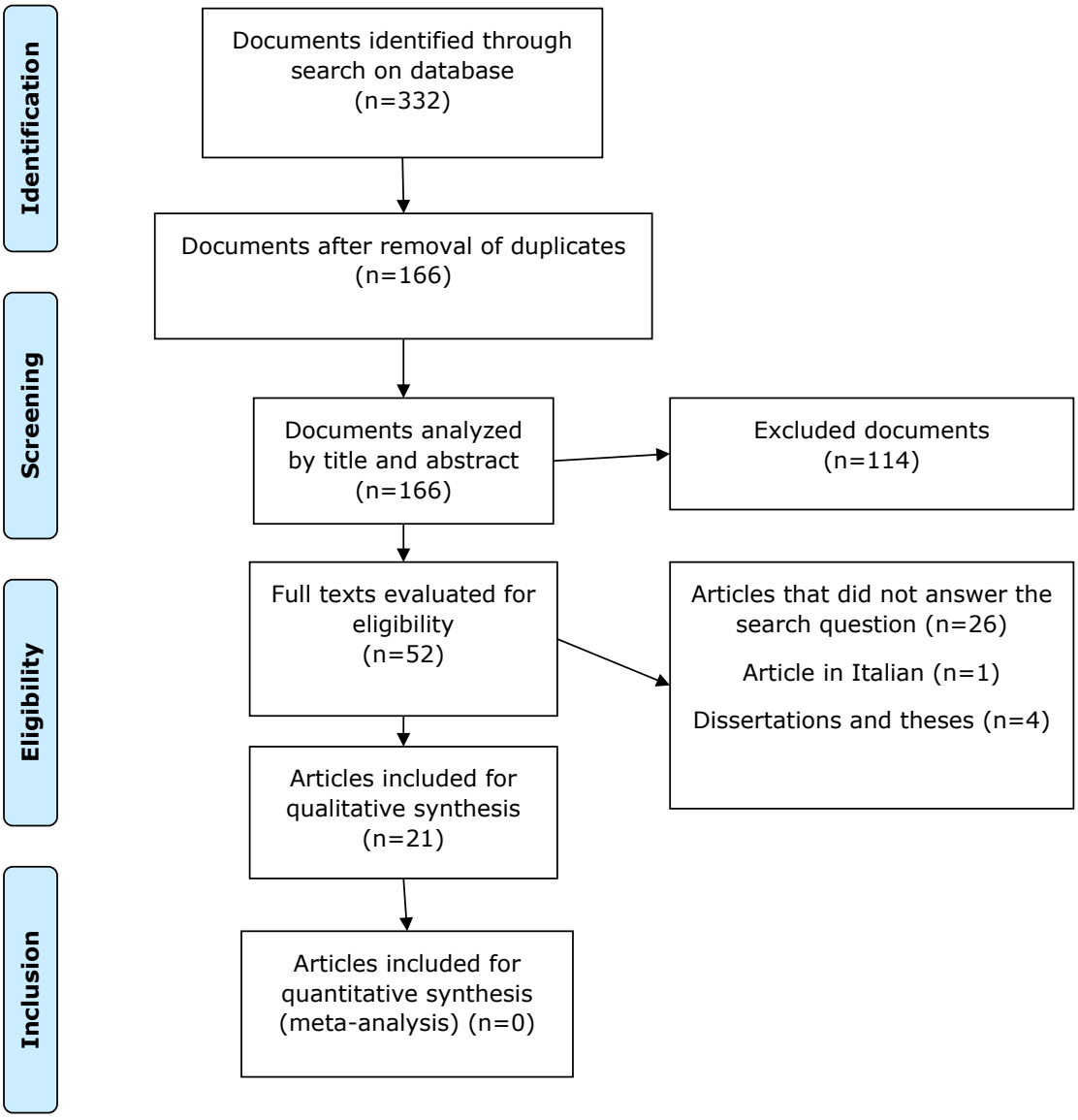
BDENF: *Base de Dados de Enfermagem* (Nursing Database); IBECS: *Índice Bibliográfico Espanhol de Ciências de Saúde* (Spanish Bibliographic Index in Health Sciences); LILACS: Latin American and Caribbean Health Sciences Literature; CINAHL: Index to Nursing and Allied Health Literature; MEDLINE: Medical Literature Analysis and Retrieval System Online; mh e MH: Medical Heading; tw: Title word; AB: Abstract; TS: Topic.

Characteristics of educational technologies

Educational technologies used both in face-to-face environments (n=13; 61.9%) and in virtual environments (n=8; 38.1%) were identified. Among the studies developed in the virtual environment, the implementation of software (n=8; 100.0%) with different educational applications was addressed, as shown in Figure 2.

Diagnostic reasoning learning outcomes

The educational technologies used for the development of diagnostic reasoning in nursing students provided learning outcomes focused on modifying skills and experiences, namely metacognitive, cognitive and practical skills and affective and motivational experiences (Chart 2). The results also showed educational technologies that did not interfere



Source: Research database.
Prepared by the authors.

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analysis flow diagram of studies identified and selected for inclusion in the integrative review.

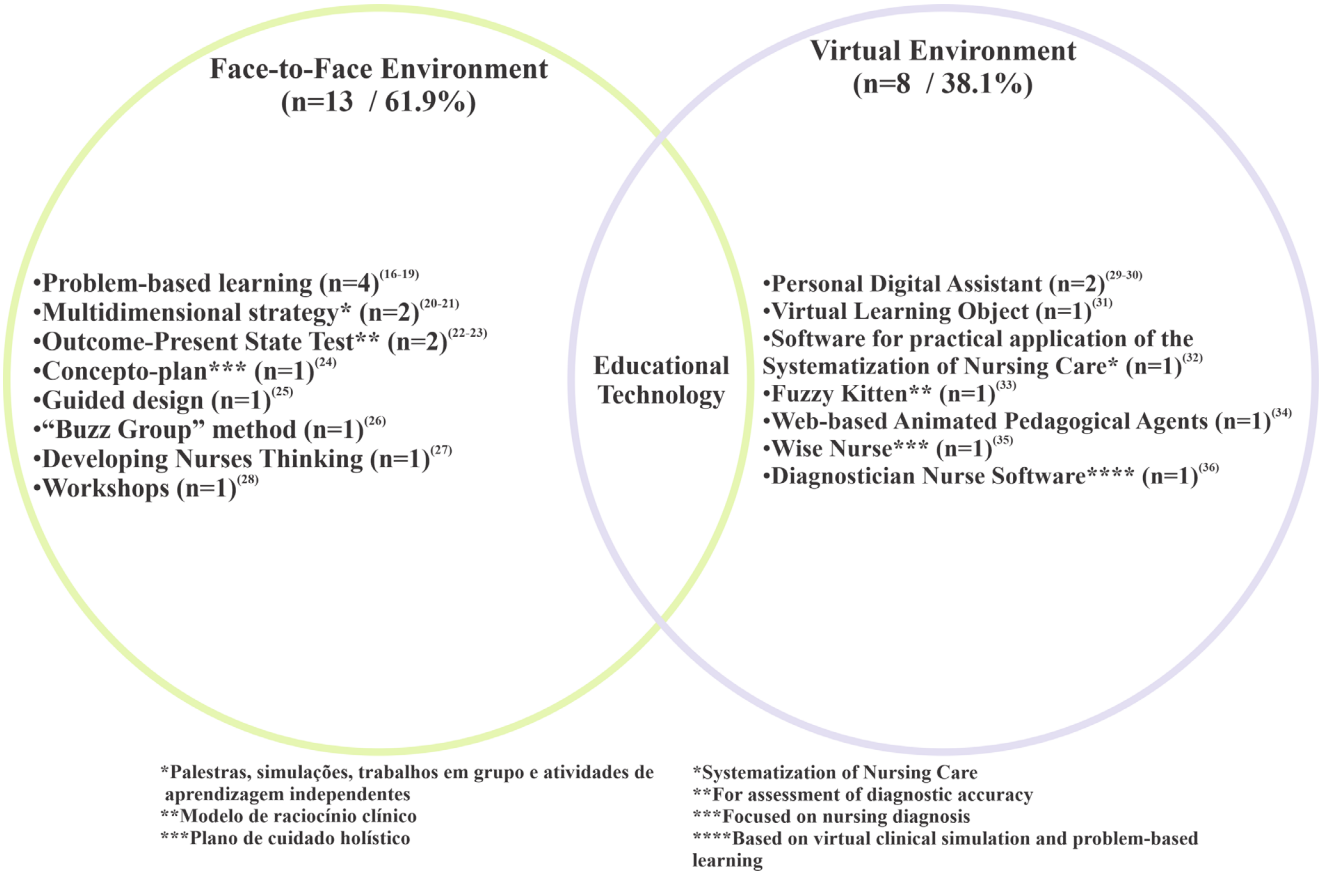
with the aforementioned skills and experiences of diagnostic reasoning (indicated as NA in Chart 2) and modified other dimensions of learning.

There was an impact on cognitive ability when the following were detected after the use of different educational technologies: an increase in diagnostic accuracy; improvement in ability to group data; development of skills of clinical reasoning and problem formulation; and improvement in students' clinical logic capacity.

Likewise, there was an impact on metacognitive ability when identifying an improvement in clinical reflective reasoning ability and a reflection on self-performance and self-directed learning.

It can also be said that practical skills were impacted when an improvement in nursing research, data collection and computer use skills were detected, as well as the possibility of exercising the recording of the nursing process.

Regarding affective and motivational experiences, the indicators of higher sense of competence and satisfaction, greater motivation and pleasure during learning, and higher self-confidence in using the computer corroborate the impact of educational technologies. As shown in Table 1,



Source: Research database.
Prepared by the authors.

Figure 2. Distribution of scientific production according to the main environments and educational technologies used in the development of diagnostic reasoning in databases.

Chart 2. Main outcomes related to educational technology for each primary study, and skills and experiences developed by nursing students. Rio de Janeiro, RJ, Brazil, 2021.

Code	Primary study; year	Main outcomes related to educational technology	Skills and experiences developed
A1	26; 2017	Through education via the Buzz Group method, students were able to identify nursing diagnoses more accurately. There was a 36% increase in the level of assertiveness of the nursing diagnosis among students, although the study does not identify what changes occurred in reasoning.	- Cognitive skills
A2	20; 1988	The multidimensional strategy was considered beneficial by students. The ability to apply all steps of the nursing process increased, thereby obtaining an average score of 5.16 out of a 6.0-point total. The results that specifically demonstrate the changes in skills for making the diagnosis were not presented.	- NA
A3	22; 2008	The Outcome-Present State Test (OPT) improved clinical reasoning skills. However, the authors indicated the need for further research to assess the influences on clinical reasoning skills.	- Metacognitive skills

Continue...

Chart 2. Continuation.

Code	Primary study; year	Main outcomes related to educational technology	Skills and experiences developed
A4	16; 2011	The experimental group identified a greater number of nursing diagnoses, related factors and risk factors in the post-test. Therefore, the problem-based learning strategy (PBL) contributed to students' diagnostic reasoning and judgment, as there was an improvement in the ability to group data.	- Cognitive skills
A5	17; 2009	The PBL strategy helped students understand the importance of making nursing diagnoses and priority diagnoses. It also collaborated with the skills to plan nursing interventions. Students began to feel more competent in the nursing process and in nursing diagnosis.	- Affective and motivational experiences
A6	31; 2015	The Virtual Learning Object (VLO) helped with computer skills, provided autonomy, motivation and pleasure during learning. However, the purpose of the study was to measure the teaching of diagnostic reasoning and it was not measured. The study pointed out that this strategy can be potentially effective as a support for the teaching of diagnostic reasoning.	- Practical skills - Affective and motivational experiences
A7	32; 2010	According to students' evaluation, the software prototype allowed the exercise of recording the Nursing Process, thereby facilitating the teaching-learning process, although they identified the need for some improvements.	- Practical skills
A8	33; 2012	Students who used Fuzzy Kitten assessed the software as positive for learning nursing diagnoses, especially in identifying nursing diagnoses in clinical cases and in the reasoning process of identifying the diagnosis (path to formulation). However, students understood the need to discuss errors in the classroom. This strategy allowed the teacher to assess students' diagnostic accuracy and it stimulated students' metacognition activity, as there is a reflection on their performance, compared to that of experts.	- Metacognitive skills
A9	28; 2011	The workshop provided deeper learning and satisfaction among students. Students' grades regarding the implementation of the nursing process after the activity improved significantly (p=0.0001), a result of the positive effect of the workshop on the level of understanding. It stimulated the sense of competition and excellence among students, increasing their concentration, interest and enthusiasm.	- Affective and motivational experiences
A10	29; 2010	The Personal Digital Assistant has demonstrated that it can help with the organization, and quality of work. It also promoted self-confidence in using the computer and clinical reasoning skills. However, further investigation is needed to assess metacognition and determine the impact on learning in nursing practice.	- Affective and motivational experiences - Cognitive skills
A11	30; 2008	The results indicated that students' scores on clinical reasoning webs and Optimized Production Technology revealed few differences in clinical reasoning between those who used the Personal Digital Assistant and those who did not by applying standard clinical teaching-learning strategies. The Personal Digital Assistant could be used without any negative effect on clinical decision making. It was not possible to affirm that the use of this resource improves diagnostic reasoning and reduces errors.	- NA

Continue...

Chart 2. Continuation.

Code	Primary study; year	Main outcomes related to educational technology	Skills and experiences developed
A12	18; 2009	The study concluded that adding the Nine-Step Problem Solving Process revealed improvements in students' performance on problem solving items, notably: data collection, a final assessment; problem identification; provisional formulation of the problem; nursing intervention; self-assessment; revised formulation of the problem. Data suggest that students who had the experience were better than controls in skills related to the nursing diagnosis: provisional formulation of the problem and revised formulation of the problem. In addition, students seemed better able to formulate nursing interventions based on their nursing diagnoses. The study concluded that the intervention was moderately effective.	- Practical skills - Metacognitive skills - Cognitive skills
A13	24; 2018	Students experienced engagement with mind mapping and Concepto-Plan with the patient and improvement in the collegiate relationship with the faculty. The authors estimate improvements in critical thinking, clinical reasoning, creative thinking and pleasure of learning, student self-confidence through professional reflection, assessing patient responses to care.	- NA
A14	34; 2012	The results were not able to demonstrate that the web-based Animated Pedagogical Agents technology was able to facilitate critical thinking in nursing. The findings were contradictory from participant to participant, as critical thinking is a multifaceted concept and difficult to be tested in a single standardized test. However, the authors assume that technology can have cognitive and social effects that may support critical thinking in nursing students.	- NA
A15	25; 1990	There was no significant difference between the mean values of results related to knowledge about the nursing process in the guided design group, with which a simulation was performed with small groups and lecture groups ($p<0.29$). The guided design group had significantly higher average scores than the lecture group in relation to the accuracy of the nursing care plan as a whole ($p<0.0001$), and of nursing diagnoses ($p<0.0001$).	- Cognitive skills
A16	21; 2008	Students who did not develop the intensive tutorial strategy in laboratories showed worse performance compared to the control group, since in the laboratory they are confronted with reality and seem to reflect more. In addition, there is the presence of the tutor, who encourages before and after reflection (debriefing). The conclusion was that the intensive tutorial strategy can be considered positive to improve critical thinking.	- Cognitive skills - Metacognitive skills
A17	35; 2016	The intervention group used the Wise Nurse software and did not have a significantly higher average post-test score ($p=0.542$) than the average post-test score of the compare group, which answered the same questions written on paper. An increase in post-test scores was observed for both groups, which was attributed to the teaching provided to the intervention and control groups. Performance can also be different depending on the diagnosis used, with better performance in clinical cases belonging to the nutrition and perception/cognition domains. The benefits of computational use were especially attributed to peripheral issues to diagnostic reasoning: time efficiency, portability, student's higher confidence in use, and economic advantages.	- Affective and motivational experiences

Continue...

Chart 2. Continuation.

Code	Primary study; year	Main outcomes related to educational technology	Skills and experiences developed
A18	27; 2012	The Developing Nurses' Thinking educational model helped students integrate four constructs: patient safety, knowledge, critical thinking, and repeated practice. It aimed to evaluate clinical reasoning and the results showed greater diagnostic accuracy.	- Cognitive skills
A19	19; 2002	After the three stages in which problem-solving strategies were applied in professional nursing concepts course, there was a significant increase in the average scores for nursing assessment ($p<0.001$), nursing diagnoses ($p<0.001$), nursing evaluation ($p<0.01$) and problem solving ($p<0.001$). Nursing diagnosis was considered "to identify a patient's health problem, evaluating and validating related factors and signs and symptoms presented in a given patient" (p.115).	- Practical skills - Cognitive skills
A20	23; 2017	The OPT model was seen as more effective in increasing clinical logic compared to the conventional strategy. It improved students' clinical logic skills; promoted self-directed learning; encouraged collaborative learning; fostered the terminology of NANDA, NIC and NOC. Thus, it facilitated data analysis, the determination of nursing diagnoses and identification of fundamental problems in the decision-making process.	- Cognitive skills - Metacognitive skills
A21	36; 2021	The effectiveness of the educational intervention was observed in the ability to prioritize the diagnosis, in the identification of diagnostic indicators, as well as in the diagnostic inference. The results showed that the tool is effective in improving clinical reasoning skills. Furthermore, the educational intervention developed was attractive and improved students' motivation for the teaching-learning process.	- Cognitive skills - Affective and motivational experiences

NA: not applicable; NANDA: NANDA International Inc.; NIC: Nursing Interventions Classification; NOC: Nursing Outcomes Classification.

Table 1. Distribution of skills and experiences developed as a result of diagnostic reasoning learning, based on studies that used face-to-face and virtual educational technologies. Rio de Janeiro, RJ, Brazil, 2021.

Diagnostic reasoning learning outcome	Face-to face technologies (n=13)	Virtual technologies (n=8)
Cognitive skills	(n=8; 61.5%)	(n=2; 25.0%)
Metacognitive skills	(n=4; 30.8%)	(n=1; 12.5%)
Practical skills	(n=2; 15.4%)	(n=2; 25.0%)
Affective and motivational and experiences	(n=2; 15.4%)	(n=4; 50.0%)
No skills or experience	(n=2; 15.4%)	(n = 2; 25.0%)

Source: Research database.
Prepared by the authors.

with regard to face-to-face technologies, 61.5% of studies showed the development of students' cognitive skills; 30.8% of metacognitive skills; 15.4% of practical skills; 15.4% of affective and motivational experiences; and 15.4% of the studies did not indicate the development of skills or experience for students. With virtual technologies, 50.0% of studies indicated the development of affective and motivational experiences; 25.0% of cognitive and practical skills; 12.5% of metacognitive skills; and 25.0% did not indicate the development of skills or experience for students.

DISCUSSION

From the interpretation of the characteristics of studies, the authors emphasize that the predominance of articles from the United States of America and Brazil seems to replicate the worldwide bibliometric trend in the field of nursing. Research conducted in the WoS database collection identified that the United States of America occupies the first position in the total number of nursing articles and Brazil ranks fourth worldwide[37,38].

The increasing publication curve for decades follows the rise of publication in the field of nursing[38]. However, the magnitude of growth between decades may indicate a progression of interest in the subject of nursing diagnostic reasoning learning.

The predominance of studies using face-to-face technologies compared to virtual ones may have an explanation related to the very nature of the professional practice. Since the institution of a professional training model by Nightingale, practical teaching has traditionally incorporated technologies in technical laboratories, application of manikins and other simulation modalities in face-to-face scenarios with a fidelity that can minimally meet the requirements of professional education. This type of teaching-learning strategy allows the student to be trained through an approximation with the real scenario. Concomitantly, it contributes to the development of critical thinking, priority setting, higher capacity for assessment, reasoning, clinical decision-making and correction of errors without harm to patients, thereby favoring good care practices[39-41].

A North American study[24], found that the use of mind mapping and Concepto-Plan, a type of face-to-face educational technology, enabled real contact and promoted learning through dialogue, which provided significant learning with a holistic approach to care. This was possible due to the experience of relationship and connection that mirrored the patient/nursing student relationship. In line with these results, an Italian study[21] used the multidimensional strategy and managed to provide undergraduate students with the development of diagnostic reasoning while they were in laboratory sessions and intensive clinical tutorials that reported reality. The development of clinical reasoning for an accurate practice will be intrinsically related to the use of different teaching strategies[42].

On the other hand, the virtualization process allows classrooms to transcend the physical environment, providing flexibility and diversification of the multiple possibilities of proposed activities and involvement of students in the learning process. Thus, it becomes possible to expand access in the desired time and place[43], which can be characterized as an agent that strengthens the teaching-learning process.

According to a Brazilian study[44], there are advances in the development of systems to support digital technologies, making them more interactive and realistic, with a positive impact on the teaching-learning process. On the other hand, some of the studies detected the need for improvements in the software used, as no significant differences in learning were found between the students who used it and those who did not[35].

Knowing the impact caused by educational technologies on student education when these are chosen to develop diagnostic reasoning is relevant, since each learner is unique and uses different analysis and synthesis models. The reliability of previous studies allows this orientation[42].

Data from the present study demonstrate that both face-to-face technology and virtual technology generated results in the learning of nursing diagnostic reasoning, thus interfering in metacognitive, cognitive and practical skills and in metacognitive experiences (affective and motivational). These categories are directly related to the teaching-learning methodology[45].

This research provides interesting evidence regarding the way of reporting the results related to skills and experiences developed with the use of educational technologies in the nursing diagnostic reasoning of undergraduate students. In face-to-face technologies, the results focused on indicating cognitive and metacognitive skills. In studies of virtual technologies, the emphasis was on reporting findings related to affective and motivational experiences, practical skills or not reporting any developed skill. We assume that such evidence is related to widespread beliefs in the innovative character and possible inherent limitations of virtual technologies that involved two innovation conditions: the technology itself and the use of the (virtual) environment. This naturally may have motivated researchers to investigate criteria more in line with theories and models of technology acceptance, such as attitudes towards technology, social and emotional factors and perceptions of use[46].

The cognitive skills that predominated in face-to-face technologies were related to analysis, assessment of clinical situations based on the literature, judgment of priority nursing diagnoses, inference, interpretation, and transformation of knowledge. The presence of these skills indicates the existence and/or development of diagnostic reasoning[47,48]. This category of skills showed a significant higher level of students' correct answers in the nursing diagnosis[26]. Another study[16] indicated the positive impact on diagnostic judgment and reasoning by improving the ability to group data.

Metacognitive skills, also more identified in studies with face-to-face technologies, are identified as essential for self-regulated learning[49], as they constitute the metacognition

control function[50]. The OPT strategy or model[22,23] was considered important for the development of metacognitive skills, as it improves reflective clinical reasoning and promotes self-directed learning. Clinical reasoning requires the use of reflection and higher order skills. Thus, metacognition, by functioning as a second-level (higher order) discourse[51], monitors and controls the essential cognitive actions for performing the task.

The regulation and monitoring of nursing students' thoughts, feelings and behaviors is very important, since the consequence of their deregulation can have deleterious effects on the patient care process[52].

Also in relation to metacognition, the recovery of metacognitive experiences formed in previous encounters with the same or similar tasks is activated by the task and/or its situational context. These affective memories create an intrinsic context based on the quality of metacognitive experiences when involved in similar tasks to those of the past[52]. Thus, in one of the reviewed studies[17], after using the educational strategy, students began to feel more competent in the nursing process and in nursing diagnosis, which expands the understanding of the value of metacognition.

In turn, affective and motivational experiences, more commonly explored by virtual technologies, involve emotions — multifaceted states that incorporate cognitive, affective, physiological, motivational and expressive components[53]. Affects and motivations can also approach metacognitive feelings in the manifestations of cognition monitoring, as the person is faced with a task and processes the information related to it[54]. Studies show that motivation is essential to the learning process, in addition to being a precursor for reflection and the ability to criticize the issues addressed as an essential aspect of clinical reasoning[55,56].

Motivation and personal satisfaction can be associated with the reward of tasks performed successfully, in which students report an improvement in these feelings when inserted in educational environments that use active methodologies as a teaching-learning strategy[57]. Another reward of the personal satisfaction experienced by students is the higher probability of transporting positive affective states to the professional sphere, as the factors more closely related to academic satisfaction are those that provide incentives and opportunities for students experiencing in practice what was taught in classes[58].

Practical skills are focused on experiences acquired in professional practice[47,48]. In the present study, the interference in these skills was observed when the results of another study[31] indicated that the VLO helped in the ability to use the computer. Research[32] identified that the software for a practical application of the systematization of nursing care allowed an effective documentation of the nursing process.

Two limitations of this study can be mentioned. The first refers to the scarcity of studies, which hinders the aggregation of findings that indicate a more sustained trend. However, the rigor in the search strategy, selection and analysis of the material gives some assurance that the authors obtained an appropriate perspective of the state of knowledge on the subject. The second limitation refers to the difficulty in classifying the results of articles in the categories of skills and experiences, especially given the possible overlap of cognitive, metacognitive, affective and motivational constructs present in some studies. However, the authors sought to increase the reliability by incorporating more judges in the decision for classification.

Both the results obtained and the limitations faced motivate future research on the development of skills and experiences in diagnostic reasoning learning with use of educational technologies.

CONCLUSION

Educational technologies could be categorized into face-to-face or virtual, and held responsible for the impact on the development of clinical reasoning through interference in cognitive, metacognitive and practical skills, as well as in metacognitive experiences, such as affective and motivational.

Most face-to-face technologies had a direct impact on the diagnostic reasoning of students, while virtual technologies had a more indirect contribution to its development. On the other hand, virtual technologies have significantly contributed to affective and motivational experiences, as well as to practical skills, which are essential characteristics of the teaching-learning process. These data point to the need for more in-depth studies aimed at measuring cognitive skills in virtual learning environments.

Thus, we believe the use of face-to-face educational technologies will increase diagnostic accuracy, which may impact the quality of care provided to patients cared for by these future professionals.

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