

Title: NURSING STUDENTS' COLLABORATIVE LEARNING IN DIGITAL LEARNING ENVIRONMENTS: A SYSTEMATIC REVIEW

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Title: DIGITAL COLLABORATIVE LEARNING IN NURSING EDUCATION: A SYSTEMATIC REVIEW

Abstract

Objectives: The aim of this systematic review was to evaluate the effectiveness of educational interventions in digital collaborative learning implemented in nursing education.

Design: A systematic literature review of randomized controlled trials (RCTs) was carried out in accordance with Joanna Briggs Institute (JBI) and Centre for Reviews and Dissemination guidelines and the PRISMA statement.

Data sources: Cinahl (EBSCO), Eric, Medline (Ovid) and Scopus databases were used to identify original peer-reviewed RCT studies published between 2003 and 2018.

Review method: The ‘hits’ were systematically screened by title, abstract and full-text by two authors acting independently. The quality of the selected original studies was evaluated using the quality assessment criteria of the JBI and Cochrane collaboration’s tool for assessing risk of bias in randomized trials. The studies were analyzed by narrative synthesis.

Results: Five peer-reviewed RCT studies were included in the review. All participants in these studies (647 in total) were nursing students exposed to educational interventions in various nursing program courses. The reviewed studies indicated that digital collaborative learning increased students’ knowledge and nursing skills. The results show that collaborative learning in digital learning environments enhanced nursing students’ interaction and collaborative skills, problem-solving skills, satisfaction and motivation for learning.

Conclusion: Collaborative learning in digital learning environments has encouraging effects in enhancing nursing students’ knowledge, competence, satisfaction and problem-solving skills. Moreover, evidence-based digital collaborative learning is becoming increasingly effective in nursing education, as available tools and teachers’ abilities to use them are improving and providing new learning activities to boost students’ learning outcomes in higher education. Thus, its systematic use in digital collaborative learning environments in various nursing courses is recommended.

Keywords: educational intervention, digital collaborative learning, digital learning environment, nursing education, nursing student, randomized control trial

INTRODUCTION

The continuous increase and ease of accessibility of information, together with rapid changes in working and everyday life, pose new challenges to nursing education. To prepare for working life in the 21st century, students will need to develop greater skills of various kinds, including innovative thinking (creativity, critical thinking and problem-solving), effective working (via communication and cooperation), and digital tools management (requiring information literacy, i.e. competence in handling relevant information and communication technology). Development of these skills requires exposure to strong collaborative-based problem-solving, critical thinking environments and work in complex new patient-centered situations that directly exploit existing knowledge (1, 2, 3).

Hence, there has been increasing interest in both the development of digital learning environments and collaborative learning (4, 5, 6), which have become increasingly popular in higher education (7). Collaborative learning is not a unified theory of learning, but diverse theoretical frameworks (often inter-disciplinary) can be used in its development, analysis and evaluation (8). A major element of such theoretical frameworks is socio-constructivism (9, 10, 11), which holds that social processes guide individuals' learning (12). According to social constructivism-based theory, learning is seen as a process where individuals' knowledge and understanding develop through supportive interaction with peers in a learning community, building of common group understanding, and guidance of (or collaboration with) others (8, 12). *It has been viewed as a learning theory, which is effectively considered a mode to improve instruction (13). Construction of one's learning begins with engaging learners in the meaning-making process and ends with enabling them to handle real world problems. However, educators play a vital role in assessing students' self-directive skills prior to the implementation of the socio-constructivist paradigm (14). Socio-constructivism is a student-centered educational paradigm that releases students' autonomy and freedom using collaborative learning approaches (15). It signifies students' involvement in knowledge construction, which is seen as a natural tendency in the learning of individuals (16). The socio-constructivist approach considers that learning is the result of disagreement between two points of view in social interaction, when such a socio-cognitive conflict leads to the coordination of the two points of view, resulting in an enhanced understanding at the individual level. Verbal interactions activate several cognitive processes, including perception, comprehension, information processing, representation and anticipation among others (7,8).*

In this systematic review, digital collaborative learning is regarded as a goal-oriented activity of a group of students committed to achieving a common goal and interactively creating new knowledge in digital learning environments (17, 18, 19). This involves sharing, arguing about, and jointly processing ideas (20). Similarly, collaborative learning environments are regarded as settings where co-operative knowledge building and shared problem-solving support the development of future working life skills, with group-level regulation processes (18).

Studies of digital collaborative learning have shown that digital environments promote nursing students' reflection on experiences and thinking together with peers, leading to deeper understanding of both relevant knowledge and skills (14, 21). In addition to the pedagogical tools, various technological solutions can promote beneficial interactions and collaborative work (14, 21). The interactive features of technologies, like scaffolding, prompts and sociability tools, afford opportunities for students to develop deep understanding of key content and interactive activities (15, 22).

However, previous educational studies have shown that students have difficulties effectively planning, monitoring and adapting to collaborative efforts (23, 24). Recent studies have also shown that students' own socioemotional processes together with interactive self-, co- and shared-regulation play important roles in successful collaboration (25), and that both 'scripting' and 'group awareness tools' can facilitate collaboration (26). Interaction during collaborative learning has both cognitive and emotional aspects. It also enables teachers to cater for variations in students' learning styles and ages by using various sorts of learning materials, like links, pictures, videos and versatile discussion methods (27, 28). However, to support collaborative learning, learning environments should have a student-centered design, taking into account factors that prevent and promote collaborative learning (29). These include socioemotional aspects of interaction that may either promote or hinder productive collaborative efforts (30).

Factors that can have negative effects on collaborative learning include unequal participation of students in joint work, insufficient coordination, inappropriate division of labor and technical problems (31). Careful planning and further investigation are needed to address such obstacles and optimize collaborative learning approaches, which are increasingly important in education (30). Collaborative learning in digital learning environments can be promoted by appropriately designing interventions and guiding student interaction (18, 33). However, there is no definitive proof that collaboration in digital learning environments promotes learning more effectively than collaborative

practices in classroom situations without digitalization (34). Moreover, digital collaborative learning has received more attention in general education science research than in nursing education research. This may be significant, because nursing education involves integration of theoretical knowledge into authentic work-related training with inter-professional teams taking essential decisions in patient care. Digital collaborative learning could potentially facilitate students' preparation for future professional settings by helping them to develop self-directive and cognitively flexible competence to deliver patient-centered care in effective collaborative environments. However, to develop such environments, more knowledge is needed to identify effective education interventions for enhancing nursing students' collaborative learning in digital learning environments. Thus, the aim of this systematic review was to evaluate the effectiveness of educational interventions involving digital collaborative learning in nursing education.

The research questions were:

1. What types of educational interventions involving digital collaborative learning have been developed in nursing education?
2. What effects of these interventions had on nursing students' learning outcomes?

METHODS

The systematic review was conducted based on Center of Reviews and Dissemination (35) and Johanna Bridge Institute (36) guidelines and the PRISMA statement (37).

Search strategy

The CINAHL (EBSCOhost), ERIC, MEDLINE (Ovid) and SCOPUS electronic databases were searched for relevant studies to review. The inclusion criteria and keywords were formulated using the PICOS approach, i.e., defining Participants (or populations), Interventions (educational), Comparators, Outcomes, and Study type (35). The participants had to be nursing students. Studies that addressed other groups were excluded. The educational interventions had to include digital collaborative learning in a virtual nursing education environment. Studies on use of social media in teaching, collaborative learning in clinical environments and/or simulations were excluded. The comparator had to be a control group that did not use a digital collaborative learning environment, and/or were exposed to classroom teaching and/or whose teaching did not include collaboration-based

pedagogy. Reported outcomes had to include descriptions of digital collaborative learning interventions and their effects on students' learning outcomes. The study type encompassed peer-reviewed original studies involving randomized controlled trials (RCTs) published between 2003 and 2018. All other studies, including quasi-experimental, observational and qualitative studies were excluded from the review. The languages included in the review were English, Finnish and Swedish. The keywords and search queries were selected with the help of a library information specialist according to the requirements of each database. The English keywords were combined with the Boolean operators AND and OR (see Table 1). In addition a reference list of selected original studies was manually searched.

Search outcomes

The search strategy and selection process is presented in the PRISMA flow diagram in Figure 1 (37). Through the database searches, in total 1326 original studies were found. After duplications (n=408) were removed, the studies were screened by title (n=918), abstract (n=314) and full text (n=133) by two researchers (MM, MK) individually. Consensus was reached for each decision in the screening process (35). In total, six articles were included in the quality assessment. The systematic selection process was carried out in four steps to minimize the choice and bias and to find all the studies that were relevant to the research questions and met all the inclusion criteria. In order to ensure the repeatability of the study, the data selection process was saved in the web-based commercial reference management software package RefWorks (35).

Quality appraisal and risk of bias assessment

Six of the original studies were screened for quality assessment by two researchers (MM, MK) independently using the 13-item Joanna Briggs Institute (JBI) Critical Appraisal Checklist for RCTs (38). All disagreements regarding the methodological quality of the research were discussed and resolved when the researchers agreed about the quality of the studies. The cut-off for inclusion criterion was $\geq 50\%$ of a total of 13 possible points to ensure the included studies had sufficient quality and minimize excessive bias and errors (39, 40) (see Table 2). One study was assigned only five points and excluded (41). The Cochrane Risk of Bias Tool (42) was used to assess risk of bias of the remaining five original studies by two researchers (MM, KM) (Table 3).

The quality of the studies included in this systematic review was also evaluated using the JBI Critical Appraisal Checklist for RCTs. The total quality score ranged from 9 to 11 out of the total 13 possible points (Table 2). The Cochrane Risk of Bias Tool (42) was used to assess the sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incompleteness of outcome data, selective outcome reporting and other bias (Table 3). Risk of bias scores were high for most of the studies, due either to lack of methodological rigor in the RCTs or insufficient clarity in the reporting (42). The random sequence generation process was clearly described in four studies (43, 44, 45, 46). The randomization methods were adequate in all five studies. Allocation concealment was described clearly and validly in three studies (43, 44, 45). Blinding the participants and personnel was only described in the study by Lu et al. (44). The blinding of outcome assessment was not discussed in any of the chosen studies. Bloomfield et al. (43) and Gagnon et al. (44) described causes of missing data. In all of the studies, the significance of differences in outcomes between interventional and control groups were examined and reported.

Data extraction and synthesis

The authors, year and country of publication, participants, setting, teaching and learning theory, instruments, intervention, and key outcomes of each study were extracted (Table 2). The studies included in the systematic review were then analyzed by narrative synthesis to acquire better understanding of the complexity of the interventions, and various relationship and interdependences within the interventions. (35) . **The defining characteristic of narrative synthesis is the adoption of a textual approach that provides an analysis of the relationships within and between studies and an overall assessment of the robustness of the evidence. The initial stage in this synthesis was to become familiar with the results of the included studies. This meant assessing systematically and comprehensively the results of each study, highlighting important characteristics of the studies where relevant, such as important similarities or differences. This narrative synthesis included an investigation of the similarities and differences between the findings of the studies, as well as an exploration of patterns in the data. This involved examining associations between study outcomes and any other factors related to the study design and conduct. This synthesis considered the results of studies with different forms of intervention implementation. Reasons for both similarities and differences in the findings was explored systematically, with explanations for the pattern of results considered in a logical way for each of the included studies. (35)** The outcomes of each study were evaluated in terms of Cohen's d indicator of the educational interventions' effect sizes. The Cohen's

d values were classified as large ($d > 0.8$), medium ($d > 0.5$), small ($d > 0.2$) or trivial ($d < 0.02$) (47, 48). No meta-analysis of the results was performed as some studies had heterogeneous outcomes or lacked sufficient statistical information, for example, Bloomfield et al. (43) did not report standard deviations of their mean values. Indicated measures of variance in the following text are all standard deviations.

RESULTS

Study characteristics

Studies included in the systematic review were conducted in England (43), Canada (44), Thailand (49), Taiwan (46) and Spain (45). The reported educational interventions were implemented in different courses of nursing degree programs. All participants ($n=647$, sample size range 73-231) were nursing students participating in educational interventions or members of control groups.

Educational interventions in digital collaborative learning

All of the studies compared educational interventions involving digital collaborative learning with face-to-face traditional teaching in different courses of nursing programs. In all cases, a digital learning environment was planned and implemented for use without set time limits or location. The interventions included multimedia, virtual tools, videos, pictures, and animations to facilitate learning (43, 45, 46). A virtual chat room, bulletin board and email were used in one intervention (46). The intervention reported by Morente et al. (45) involved use of a tool developed for web-based learning to evaluate and treat pressure ulcers. **The control group received a traditional on-campus class on the same topic.**

In four studies, the intervention was related to a practical competence course: hand washing (43), delivery of nursing (49), intramuscular injection (46), and treatment of pressure ulcers (45). In the other study, Gagnon et al. (44) developed and applied an educational intervention on research methodology. **Students in the intervention group had blended instruction with internet-based tutorials and in-class sessions, and students in the control group had conventional, face-to-face classroom teaching. In the study of Bloomfield et al. (43) the intervention group used an interactive, multimedia, self-directed computer-assisted learning module, and the control group was taught by an experienced**

lecturer in a clinical skills room. Gerdprasert et al. (49) reported that the control group received traditional teaching, while the experimental group was supplemented with a web-based learning unit on intrapartum nursing care. In the study of Lu et al. (46) the experimental group interacted using a web-based course and the control group received the classroom lectures and skill demonstration only. Learning theories applied in the RCTs were reportedly blended-learning (44) and constructivism (49). The collaborative learning in all interventions was reported narratively by describing its key aspects, such as students' interaction with other students and/or teachers, (43, 46, 49), self-direction (43, 44, 49), motivation and satisfaction (44), critical thinking and problem-solving skills (45, 46, 49). The role of the teacher in the digital collaborative learning was also reported narratively.

The studies confirmed that collaborative learning is based on successful interaction. Gerdprasert et al. (49) and Lu et al. (46) described digital collaborative learning as having positive effects on students' interactions and collaborative skills. Lu et al. (46) reported that digital collaborative learning encouraged students to discuss and ask about topics, increased reciprocal sharing of information and promoted students' co-operation skills, **unlike with classroom lectures, where students just listened to the lecturer and did not discuss with each other at all.** Gerdprasert et al. (49) found that digital collaborative learning enabled students to share information and create new knowledge by interaction with other students. Integration of the digital learning model allowed students to review their prior knowledge and construct their related new knowledge naturally as arose from the problem situation. **This did not occur in traditional lecture settings. That means that a well designed e-learning unit with good academic content and integrated tests motivates learning and yields outcomes that are better than those of the traditional method.**

Another general finding was that digital collaborative learning enhanced students' self-direction and meaningfulness of study. It reportedly gave students the opportunity to influence their studies by studying at their own pace and repeating engagement with difficult learning contents, for example by watching online videos several times (43). Lu et al. (46) reported that digital collaborative learning enhanced self-direction because the peer pressure stimulated others to study and do online tasks more efficiently and on time. Gagnon et al. (44) also found that students at entry level significantly improved their self-direction in the online learning environment. **In the control groups students were not self-directed because they did not have to do learning tasks or other activities during lectures in the classroom (43, 44, 46).**

Four of the five intervention studies (43, 45, 46, 49) detected correlations between students' motivation during the course and digital collaborative learning. Gagnon et al. (44) found that motivation had a significant positive effect on students' satisfaction, and the intervention clearly increased the motivation of unmotivated students during the course. **Among less motivated students, those in the intervention group performed better than those who received traditional training, and motivation was positively associated with satisfaction in both groups.** Gerdprasert et al. (49) reported that online familiarization with the focal topic in advance increased the students' satisfaction and reduced stress **when compared to those of the control group.** In three interventions, students' satisfaction and motivation increased with significant development of knowledge and practical nursing skills while studying in the digital learning environment **compared to traditional face-to-face classroom teaching** (43, 44, 49). Gerdprasert et al. (49) also noted that the interactive tools they used (such as video clips) enhanced the students' satisfaction and attitude towards learning. **The students showed a much more positive attitude compared to students learning in classroom settings.**

In the intervention by Gerdprasert et al. (49) and Morente et al. (45) digital collaborative learning enabled students' better problem-solving skills with interaction. Gerdprasert et al. (49) also found that working together in groups improved students' evaluation of their nursing skills and knowledge by enabling them to find more information and providing support for decision-making in problem-solving situations. **The mean score of the conceptual knowledge test of the experimental group was significantly higher than that of the control group.**

Another general finding was that teachers' activities influence processes and outcomes of digital collaborative learning. Gerdprasert et al. (49) and Lu et al. (46) found that the teachers' communication on the platforms they provided and immediate digital feedback encouraged students to refine their learning outcomes and enhanced their nursing competences. **In digital learning environment, unlike within classroom settings, students did not have to wait for the next class to obtain feedback. In traditional lecturing students are not used to asking questions in the classroom due to fear of authority, large class size, and fear of making mistakes in public** (46). Bloomfield et al. (43) also found that the teachers' feedback streamlined online interaction between students and teachers. Moreover, the ability to ask and receive answers from their teachers reduced students' stress and anxiety when starting their practical training (ibid.). In contrast, lack of teacher monitoring and feedback hindered the digital collaborative learning according to Gerdprasert et al. (49) and Lu et al. (46). They concluded that teachers' engagement in the digital learning environment strongly influenced collaborative learning, and it is important for learning environments to be easy to use, with

clear instructions, that provide sufficient information. However, lack of students' technical incompetence and know-how in online work inhibited learning (46, 49), and unmotivated students needed motivation and encouragement from teachers to study (46).

Effects of the interventions on nursing students' learning outcomes

In all of the reviewed studies, the outcomes were quantitatively evaluated using a test or exam designed to measure students' knowledge, skills and/or competence. Bloomfield et al. (43) measured their handwashing knowledge and skills using a multiple-choice test and skills performance checklist immediately before and after the intervention, as well as in 2-week and 8-week follow-ups.

Gagnon et al. (45) also used a multiple-choice test and collected measurements at the mid-point and end of the course. Gerdprasert et al. (49) used a conceptual knowledge test, performance checklist, occupational stress indicator and questionnaire designed to probe students' attitudes, but did not report the data collection timing. Lu et al. (46) used a knowledge assessment scale immediately before and after the course, and an intramuscular injection skills performance checklist to assess outcomes at the end of the course. Morente et al. (45) used a test consisting of a series of questions grouped into various categories designed to measure students' competence in pressure ulcer care.

In all of the RCTs, the digital collaborative learning environment reportedly affected the development of students' knowledge, skills and/or competence. However, not all of the outcomes were statistically significant. In the study reported by Bloomfield et al. (43), handwashing skills of the interventional group of students were found to be significantly better ($p < 0.02$) than those of the control group in the 8-week follow-up test (mean scores: 23 and 22, respectively), but the effect size (Cohen's d) could not be calculated because standard deviations were not presented. Gagnon et al. (44) detected a significant ($p < 0.03$) difference in development of research knowledge between interventional and control groups (mean scores: 19.6 ± 1.9 and 19.0 ± 2.7 , respectively, $d = 0.25$) at the mid-point. However, the outcomes at the end of the course did not differ significantly between the groups (mean scores: 13.3 ± 2.2 and 13.6 ± 2.2 , respectively, $p = 0.68$). The interventional group exposed to the interactive web-based learning unit developed by Gerdprasert et al. (49), to facilitate and improve students' intrapartum nursing care, had significantly higher scores than the control group in conceptual knowledge (11.4 ± 2.1 and 8.88 ± 3.17 , respectively; $p < 0.05$, $d = 1.28$) and performance skills (3.17 ± 0.29 and 3.33 ± 0.28 , respectively; $p < 0.01$, $d = 0.56$).

Lu et al. (46) tested the effectiveness of supplementing traditional classroom teaching with a web-based course for teaching intramuscular injection nursing skills, and the interventional obtained higher scores than the control group (81.67 ± 8.49 and 76.40 ± 11.91 , respectively; $p < 0.01$, $d = 0.52$). Morente et al. (45) detected no significant differences between interventional and control groups in competence in pressure ulcer care treatment (scores: 15.83 ± 2.52 and 11.6 ± 2.39 , respectively; $p = 1.14$). However, the educational intervention based on use of the *ePULab* tool yielded significantly better learning outcomes than traditional face-to-face classes.

DISCUSSION

Previous preliminary evidence suggests that collaborative e-learning approaches are more effective than traditional interventions (22). The systematic literature review presented here provided new evidence on its efficacy and influential factors in nursing education. However, we only identified five relevant RCT studies that met the rigorous applied inclusion criteria, although digital learning is being widely discussed and promoted in educational communities (50, 51, 52). It should be noted that various aspects of the phenomenon have been reported in studies that did not include RCT educational interventions (e.g. 53), which were not covered in this review.

The results of all included studies show that collaborative learning in digital learning environments enhanced nursing students' knowledge, skills and/or competence, and that flexible use of the digital learning environments enabled by interactive tools was beneficial. These results corroborate findings of various previous studies (e.g. 54, 55, 56, 57, 58) and is rooted in the socio-constructivist learning theory (7). Thus, this review indicates that digital collaborative learning is an effective teaching method in nursing education. This is also consistent with findings by Abdelaziz et al. (34) that an e-learning group obtained significantly higher posttest scores (indicating higher levels of cognitive knowledge) than a control group.

Our review suggests that digital collaborative learning may be more effective than traditional face-to-face teaching in nursing education in terms of developing knowledge and nursing skills, as well as satisfaction and self-direction. In terms of nursing knowledge, in all five included studies it yielded superior, or at least the same, outcomes as face-to-face teaching methods. Most of the reported interventions were also more effective for competence development. Similarly, in an overview of systematic reviews, McCall et al. (59) found that digital education interventions are at least equal to

traditional methods in this respect. Regarding participants' satisfaction, most of the included studies narratively reported that students' satisfaction with digital collaborative learning methods was comparable to, or greater than, the satisfaction of control groups in terms of perceived motivation and development of problem-solving skills. **These findings are consistent with socio-constructivism, which also emphasizes those dimensions in learning (7).** McMullan et al. (60) also found that satisfaction scores were higher for participants in a web-based distance learning group than for a control group. Fernandez Aleman et al. (61) recorded that students preferred to work at home using a computer-assisted learning module, and in a study by Chiu et al. (62) scores for 12 of 16 items of a satisfaction scale were higher for the interventional group than for the control group, although the difference was only significant for one of the items. In addition, in a study by Smeekens et al. (63) the experimental group self-reported a higher self-direction score than the control group. In summary, evidence-based pedagogical design of digital collaborative learning interventions is becoming increasingly possible, especially if teachers strengthen learning activities by monitoring students' learning objectives for their knowledge acquisition and development of nursing competence **according to the socio-constructivist learning theory.**

Previous studies have found that most students like digital collaborative learning because of its time efficacy and flexibility in terms of scheduling, independence and performance (43, 64). Digital learning is widely perceived as beneficial for students in offering flexible and self-paced studying as well as facilitating students' independence and self-direction (65, 66, 67). Additionally, digital collaborative learning allows students to use diverse learning materials and tools, such as videos, multimedia and texts, which can arouse their interest and help them to understand complex information (46, 68). Furthermore, the use of interactive tools like email, bulletin boards and chat rooms can facilitate communication between students and teachers (46, 60, 63). Finally, collaborative digital learning platforms provide students with more information via various web-links. They also provide safe environments where students can discuss, share information, pass on new knowledge and express their opinions in an open atmosphere (46, 68, 69). **Based on socio-constructivism, effective digital collaborative learning requires an environment that promotes positive interdependence and facilitates each students' contribution. The teacher enhances collaborative learning by providing structure for students' interaction through giving appropriate tasks. The purpose of this is to provide opportunities to share learning materials and edit them collaboratively, engaging ingroup discussions and giving and receiving peer feedback on the collaborative learning progress (70). The results of this study were consistent with previous studies**

and clearly indicated that digital collaborative learning eases interaction (71), knowledge construction (72), and awareness of both social and cognitive learning activities (73).

The findings also showed digital collaboration a beneficial for learning including knowledge construction (74), building on each other's reasoning and interaction (75). Also the identification of shared knowledge the establishment of common ground, mutual modelling of the collaborative partner's knowledge state and coordinating joint efforts are benefits of collaborative learning based on socio-constructivism. When students study in digital collaborative learning environment, they create solution to the tasks and successful process, when individual knowledge is expected to be enhanced (76, 77).

A key finding is that teachers play crucial roles in digital collaborative learning, in guidance, finding suitable and effective pedagogical solutions, providing appropriate tools and intervening at appropriate times (46, 49, 78). However, designing suitable environments is time-consuming and the teachers must have sufficient information technology competence to play these roles.

Inadequate digital technology competence of students may also cause difficulties in use of digital learning environments for discussions and group collaboration, so they may need substantial support to use them effectively. These important issues should be considered when designing digital collaborative learning platforms (49, 78).

Limitations

This systematic review has several limitations. First, the RCT studies included in the review did not measure collaborative learning in digital learning environments as a primary outcome of educational interventions. No such studies were implemented in nursing education. Second, the complex educational interventions were diverse and heterogeneous in content and had high risk of bias in their methodology. Third, the collaborative learning in digital learning environment was reported narratively in each included study, so some reported outcomes were not objectively measured.

CONCLUSION

Collaborative learning in digital learning environments requires several kinds of competence. Social competence is needed to promote positive social interaction, provide effective socioemotional

support, and establish appropriate groups. Administrative competence is needed to formulate learning tasks (and guidance for them) as well as online discussion structures. Technological competence is needed for management and implementation of the digital learning environment and other applications, and pedagogical competence for answering questions, summarizing discussions, and providing source material. Generally, compared with traditional teaching methods, digital collaborative learning has corresponding or even better impacts in enhancing students' knowledge and competence. It enhances self-direction, problem-solving skills and motivation. **In traditional classroom teaching setting one should plan for more occasions where students could discuss, share their opinion and use their previous knowledge to construct new information. They would also need more immediate feedback from the teacher. The results showed positive effects both on knowledge and skills within the subject when participants studied in a digital collaborative learning environment compared to classroom lectures.** These results suggest that to design effective digital collaborative learning environments teachers should ensure that they are easy to use, have clear instructions, appropriate levels of interactivity and communication, and provide feedback throughout the course. We also argue that greater rigor in educational interventional study designs could improve descriptions and understanding of factors that affect learning outcomes of students in digital collaborative learning environments.

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Table 1. Search terms

Search Terms

Search keywords group 1: (collaborative learning)

AND

Search keywords group 2: (digital learning) OR (e-learning) OR (online learning) OR (computer supported learning) OR (technology-based learning) OR (technology enhanced learning) OR (web-based learning)

AND

Search keywords group 3: (nursing education) OR (nursing student*) OR (student nurse)

Table 2. Data extracted from the five original studies chosen for the systematic review. IG and CG refer to interventional and control group, respectively.

Author, year of publication, country	Participants (nursing students)	Educational Intervention	Teaching methods used in educational intervention	Instruments (scale)	Measurement	Outcomes Mean (standard deviation)	p-value	Quality assessment score
Bloomfield et al. 2010, United Kingdom	Total: 231 IG: 118 CG: 113	The theory and skill of handwashing Web-based: An interactive, multimedia, self-directed computer-assisted learning (CAL) module.	IG: Web-based interactive learning methods by integrating of animated multimedia, photographs, links to websites, videos. CG: Lecturer teaching in clinical skills room	Multiple-choice test, 20 items, scale: 0-20 Data collected at baseline, and immediate, 2-week and 8-week follow ups Skill performance checklist, 17 items: 0-25 Data collected at 2-week and 8-week follow-ups	Handwashing knowledge Handwashing skills	Time 0 IG 9 CG 9 Time 1 IG 14 CG 14 Time2 IG 13 CG 13 Time 3 IG 13 CG 13 Time1 IG 23 CG 22 Time2 IG 23 CG 22	p=0.75 p=0.58 p=0.15 p=0.20 p=0.42 p=0.02	10
Gagnon et al. 2013, Canada	Total: 112 IG: 56 CG: 56	Introduction to the Research Process Web-based: An interactive, computer web-based modules for self-study combined with 5 traditional	IG: Web-based interactive learning CG: Face-to-face classroom teaching	Multiple-choice test, few open-ended questions Data collected at mid-point and end of the course	Research knowledge Satisfaction in learning	Time1 IG 19.6 (1.9) CG 19.0 (2.7) Time2 IG 13.3 (2.2) CG 13.6 (2.2.) Time1	p=0.03 p=0.68 p=0.68	11

		classroom sessions				IG 78.3 (11.9) CG 79.5 (12.2)		
					Self-directed learning – Low	Time 1 IG 1.91 CG 3.53	p=0.01	
					Self-directed learning-Medium	IG 2.99 CG 3.81	p=0.02	
					Self-directed learning- High	IG 4.79 CG 4.28	p=0.02	
Gerdprasert et al. 2011, Thailand	Total: 84 IG: 42 CG: 42	Intrapartum nursing care Web-based: The computer web-based learning unit	IG: Web-based interactive collaborative learning methods including interactive graphics, animation of the key topics, video clips CG: Traditional classroom teaching	Conceptual knowledge test Scale: 0-15 Performance checklist, 15 items Scale:1-4 Occupational Stress Indicator (OSI), 40 items Scale: 1-6 Students' attitudes questionnaire, 20 items Scale: 1-5 Likert Data collection timing not reported	Conceptual knowledge Performance skills	Time1 IG 11.4 (2.1) CG 8.88 (1.35) Time1 IG 3.17 (0.29) CG 3.33 (0.28)	p<0.05 p<0.01	10
Lu et al. 2009, Taiwan	Total: 147 IG: 79 CG: 68	Fundamental nursing skill course:	IG: Web-based including videos, discussion by	Knowledge: Intramuscular Injection Knowledge Assessment Scale	Intramuscular injection knowledge	Time0 IG 6.66 (1.40)	p<0.01	9

		intramuscular injection skill	e-mail, a bulletin board, interactive chatroom CG: Traditional classroom lectures and skill demonstration	Scale: 0-9 Data collected at baseline and end of the course Skills: Intramuscular Injection Skill Performance checklist Scale: 0-100 Data collected at end of the course	Intramuscular injection skills	CG 6.97 (1.02) Time1 IG 7.84 (1.15) CG 8.01 (1.54) Time1 IG 81.67 (8.49) CG 76.40 (11.91)	p<0.01 p<0.01	
Morente et al. 2013, Spain	Total: 73 IG: 30 CG: 43	Nursing for Adult I: pressure ulcer evaluation web-based course	IG: Web-based including using adaptive self-learning e-learning tool (ePULab) by computer CG: Traditional on-campus class	Test consisted of a series of questions grouped into different categories of items on PrU evaluation Total scale: 0-22 Data collected at baseline and end of the course	Competence in pressure ulcer care	Time0 IG 8.27 (1.39) CG 8.23 (1.23) Time1 IG 15.83 (2.52) CG 11.6 (2.39)	p=not significant p=1.14	11

Table 3. Risk of bias assessment of the five included studies according to the Cochrane Risk of Bias Tool (Higgins et al., 2011)

Studies	Sequence generation	Allocation concealment	Blinding of participants & personnel	Blinding of outcome assessment	Incomplete outcome data	Selective outcome reporting	Other bias
Bloomfield et al. 2010	Low	Low	High	Unclear	High	High	Low
Gagnon et al. 2013	Low	Low	High	Unclear	High	High	High
Gerdprasert et al. 2011	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	High
Lu et al. 2009	Low	Unclear	Low	Unclear	Unclear	High	High
Morente et al. 2013	Low	Low	Unclear	Unclear	Unclear	Low	High

<http://handbook-5-1.cochrane.org/>

Higgins, J.P.T., Altman, D.G., Sterne, J.A.C., 2011. Chapter 8: Assessing risk of bias in included studies, in: Higgins, J.P.T., Green, S., (Eds.), Cochrane handbook for systematic reviews of interventions. Version 5.1.0 [updated March 2011]. The Cochrane Collaboration. Available at www.handbook.cochrane.org (accessed 24 June 2018).

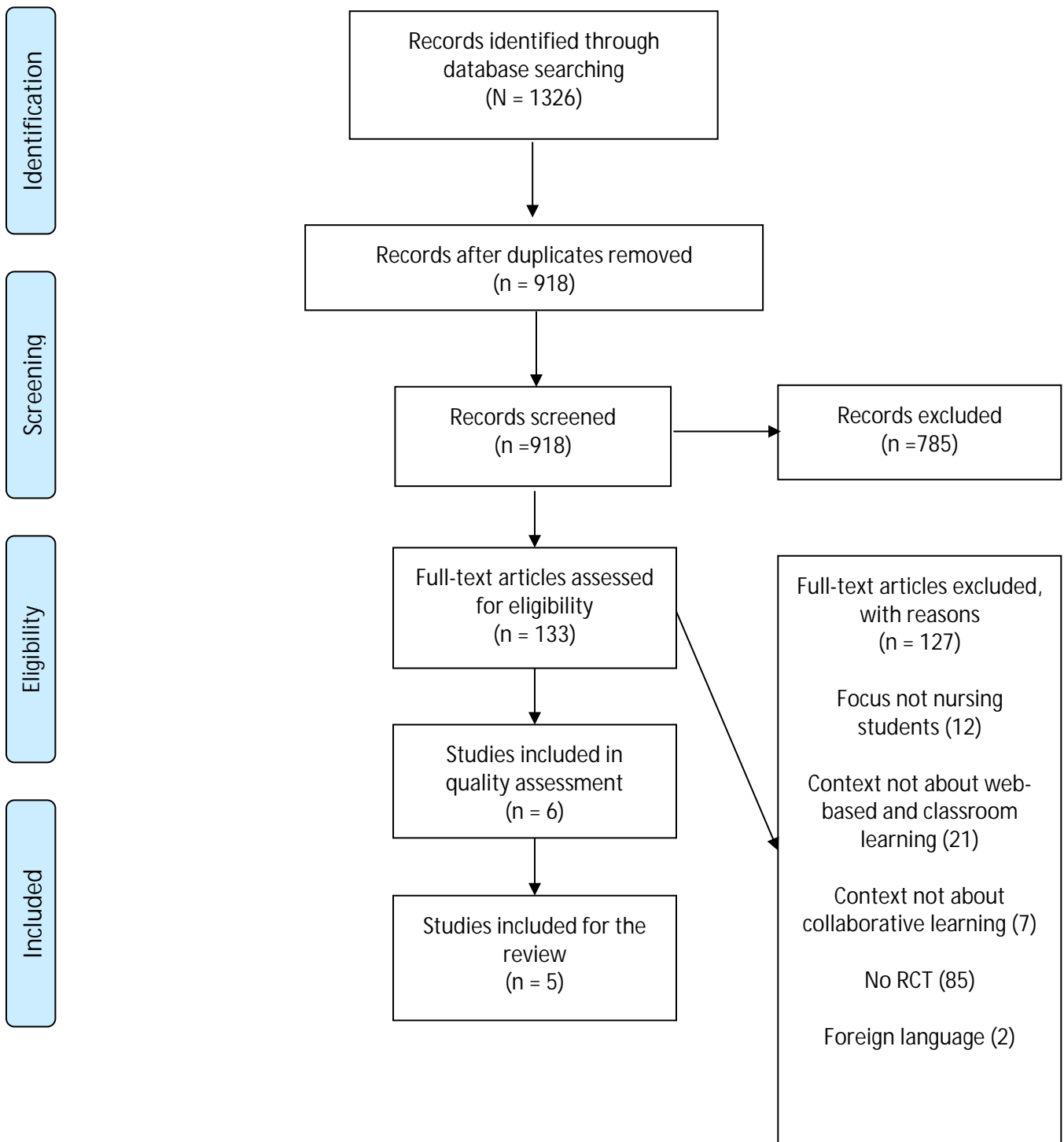


Figure 1. Flow diagram of study selection process.