Title: EFFECTS OF DIGITAL EDUCATIONAL INTERVENTION ON COLLABORATIVE LEARNING IN NURSING EDUCATION: A QUASI-EXPERIMENTAL STUDY

Authors

First author (corresponding author): Merja Männistö, Doctoral Candidate, Lecturer, MHSc; Research Unit of Nursing Science and Health Management, University of Oulu, Oulu, Finland; Health care and nursing, Oulu University of Applied Sciences, Oulu, Finland
Mailing Address:
Research Unit of Nursing Science and Health Management
Faculty of Medicine
P.O. Box 5000
FI- 90014 University of Oulu
Tel.: +358 50 5437594
Email: merja.mannisto@oamk.fi , merja.mannisto@oulu.fi
Twitter: @merjamannisto
ORCID: https://orcid.org/0000-0002-0017-6343

Second author: Kristina Mikkonen, Researcher, PhD; Research Unit of Nursing Science and Health Management, University of Oulu, Oulu, Finland
Twitter: @Kristinamikkon
ORCID: https://orcid.org/0000-0002-4355-3428

Third author: Essi Vuopala, University Lecturer, PhD, Research Unit for Learning and Educational Technology, University of Oulu, Oulu, Finland

Fourth author: Heli-Maria Kuivila, Lecturer, Doctoral Candidate, MHSc; Research Unit of Nursing Science and Health Management, University of Oulu, Oulu, Finland

Fifth author: Mari Virtanen, Principal Lecturer, PhD; Health Care Diagnostic Services and Service Management, Helsinki Metropolia University of Applied Sciences, Helsinki, Finland

Sixth author: Helvi Kyngäs, Professor, PhD; Research Unit of Nursing Science and Health Management, University of Oulu, Oulu, Finland; Medical Research Center Oulu, Oulu University Hospital and University of Oulu, Oulu, Finland

Seventh author: Maria Kääriäinen, Professor, PhD; Research Unit of Nursing Science and Health Management, University of Oulu, Oulu, Finland; Medical Research Center Oulu, Oulu University Hospital and University of Oulu, Oulu, Finland; The Finnish Centre for Evidence-Based Health Care: A Joanna Briggs Institute Centre of Excellence, Helsinki

Conflict of Interest: No conflict of interest.

Funding Statement: This study has been funded by VTR-funding (Oulu University Hospital).

Acknowledgement: We would like to acknowledge Sees-Editing Ltd (http://www.seesediting.co.uk) service for improving the language and helping us to communicate our findings to readers of the Journal.

Abstract

Collaborative digital learning is becoming increasingly popular in higher education. However, the use of collaborative digital learning does risk placing too big a responsibility on the learner and reducing face-to-face interaction with the educator. The aim of this quasi-experimental study was to evaluate the effects of digital educational intervention on collaborative learning in nursing education. The intervention group (n=87) studied using collaborative digital learning environment and the control group (n=38) studied in the traditional classroom setting. There were no significant differences between the groups in terms of student satisfaction. However, the students' satisfaction of studying decreased in the intervention group after completion of the course. In the intervention group students had higher satisfaction in the area of promoting collaborative group work and received statistically significant higher grades in the final course evaluation. This study emphasizes that collaborative digital learning can be an effective approach in nursing education in terms of learning outcomes. It also shows that more study is needed on the role of the teacher in collaborative digital nursing education.

Keywords: collaborative learning, digital learning environment, intervention, nursing education, student

INTRODUCTION

The working life of a nurse nowadays' requires collaboration, client orientation, service guidance, quick decision making and the ability to use digital technology. Nurses are expected to have competence in problem-solving, fluent interaction with patients and social skills to face the challenges of the rapidly changing healthcare system.[1] In recent years, educators have recognized the need to develop teaching practices that help nurses meet the above-mentioned challenges. In addition, these challenges have emphasized the requirement that graduates from nursing programs have the ability to communicate fluently, think critically and creatively, learn independently and function effectively in collaborative multidisciplinary teams.[2]

One approach has been to explore learning processes that require active participation, social interaction, and the use of computer-supported collaborative learning (digital collaborative learning).[3, 4] Collaborative learning can be defined as goal-oriented group work where learners are committed to joint activities, and where they construct new knowledge through social interaction.[4,5] Collaborative learning is derived from the constructivist approach, which emphasizes the active participation of students in the learning process[6] , and from the socio-constructivist approach more specifically. Socio-constructivism emphasizes the role of social interaction in individuals' learning and knowledge construction.

Digital collaborative learning research focuses on the possibilities for digital technology to enhance collaboration and interaction between learners, group work and sharing expertise.[3,4] Digital collaborative learning in virtual environments, like Moodle, enhance social interaction since collaboration is a desirable working method in these platforms.[7] However, digital collaborative learning is not a spontaneous process, and pedagogical scripting is needed to enhance interaction and productive knowledge co-construction.[8] Scripts guide learners during their shared learning processes by structuring and directing interaction in order to commit learners to collaboration.[3,9] Digital collaborative learning is an innovative teaching strategy and a quickly developing area in education. It is also widely perceived as beneficial by students in offering flexible and self-directed learning regardless of time and place.[10] Several studies have highlighted the relevance of pedagogy in digital collaborative learning. It is important that pedagogical solutions guide students to receive professional competence and to seek common understanding of the subject matter in collaboration with other students.[11, 12] Collaboration promotes the active participation of students in the whole learning process.[6]

This means that the process of learning aims to actively construct knowledge, which interacts with students' existing knowledge, personal experiences, beliefs and perceptions. Accordingly, knowledge is purposefully constructed by students in groups working together in a digital collaborative learning environment, rather than knowledge being passively and individually passed on to students by the teacher. On the contrary, traditional face-to-face teaching is commonly orally presented with an explanation of the subject to all students as a single group in a setting of a classroom where the students passively listen and take notes.[13] It has been suggested that students using digital collaborative learning environments might acquire more and better educational benefits (e.g. critical thinking, group skills) and improved learning outcomes compared to traditional teaching.[14]

In digital collaborative learning, the role of the teacher is a designer, guide, consultant, supporter and facilitator of the learning process.[6] The teacher must create, support and facilitate learning in digital environments in order to achieve desired pedagogical objectives, such as engaging students in collaborative working and encouraging creativity and critical thinking in a digital learning environment. The teacher also needs to maintain the dynamics of group working in order to maximize learning outcomes and successfully implement innovative reform-based study-group teaching methods.[15] Digital collaborative learning can improve students' abilities to develop deep and meaningful learning outcomes, social and collaborative skills in team-based settings, motivation to study, problem-solving, critical thinking and metacognitive skills. It develops students' skills of negotiation and conflict resolution. It can also enhance the ability to become self-directed and a lifelong learner, retention of learning outcomes, attitudes towards the subject matter, and persistence in studying.[16] It has been proposed [17,18] that combinations of different forms of collaborative learning enabled by new technologies might reveal characteristics of learning and participants' competences more profoundly.

In response to the perceived advantages of digital collaborative learning, a digital educational intervention was planned in order to implement and experiment with collaborative learning in the context of nursing education. This intervention was based on previously developed and used in the context of education.[16] According to the results presented in this article, nursing education does lack evidence relating the effectiveness of digital collaborative learning to traditional lecture-based teaching. Collaborative learning and the use of digital technology is also a pedagogical approach that is consistent with current curriculum reform occurring in nursing education in Finland. The aim of this study was to evaluate the effects of digital educational intervention on collaborative learning in

nursing education. The research question was: What are the effects of using digital collaborative learning compared to classroom teaching?

METHODS

Design

The study was conducted with a parallel quasi-experimental non-randomized study design.[19]

Setting and participants

The participants were nursing and paramedic students (*n*=125) following a nursing education curriculum, in the course of Health Promotion (3ECTS). Eligible students were selected using the following inclusion criteria: 1) studying a nursing or paramedic degree program at a higher education institution in Finland, and 2) available to participate in autumn 2016. The intervention group (*n*=87) studied a course forming part of their degree curriculum using the digital collaborative learning environment, while the control group *(n*=38) completed the same course in a traditional classroom environment. Students completed the course at a time that was convenient for them, given their respective study plans. Participants could choose to join either the intervention group or control group. Randomization and blinding was not possible since the course formed part of the students' curriculum and only volunteers could join the intervention group which was exposed to the digital collaborative learning environment. The structure of the study is summarized in Figure 1.

Intervention

The educational intervention provided by the digital learning environment was compared to traditional classroom-based face-to-face teaching for the course in Health Promotion. The content and objectives of the course were identical in both groups and the course was conducted over the same ten weeks. The aim of the course was to learn the multidisciplinary concepts associated with and various methods of health promotion. The teacher of both groups was the same (MM). Both groups received identical learning materials. In the end of the course the students' learning outcomes were measured in the format of a written exam.

In this study, collaborative learning took place in a digital learning environment (Moodle). The educational intervention was developed based on evidence of systematic review[20] and socio-constructivist learning theory.[21] At the beginning of the course, a start-up session was held,

introducing the course objectives, content and implementation, working in study groups, and tasks. During that time, small study groups were formed, which remained the same throughout all collaborative online learning in the course. The students were able to form groups on a voluntary basis. After the start-up session, students continued to use Moodle, where they engaged with weekly assignments, online discussions, commentaries, self- and peer reviews, creation of materials and different kind of tests. During the course students learned by acquiring new knowledge, sharing with others and constructing new knowledge by studying themes of the course. In their study groups they had the benefit of continuous social interaction which helped to develop problem solving and decision-making skills. The students were guided to strive for a common learning through constructing shared knowledge and continuous social interaction. The teaching methods followed collaborative-based pedagogy with constant support provided by the teacher.[22] The collaborative tools used in the course were multimedia, videos, pictures, texts, writing materials and tests of theoretical knowledge.[23]

The traditional classroom face-to-face teaching consisted of 33 hours of lessons where the teacher lectured on the subject matter covered by the course. The lectures were written in the form of PowerPoint presentations. The teacher also made additional material available to students using Moodle. Here, the Moodle environment was used simply as a repository for course materials; no use was made of its collaborative learning features. The lessons also sought to discuss different themes through questions raised by the teacher. No attempt was made in these sessions to dictate which students responded or how they responded. The purpose of these discussions was to stimulate the students to think independently and broaden their understanding of the topic.

Data collection

The data was collected electronically using a Webropol® questionnaire. A link to the questionnaire was provided in Moodle. Pre-test data was collected in the course start-up lecture (*n*=125) in September 2016. During the course, six participants dropped out of the intervention group and four left the control group. The post-test data was collected at the end of the course (*n*=115) in December 2016. In total 21 participants from the two groups did not respond to the pre- or post-test questionnaires and were excluded in the final data analysis.

In total, the questionnaire consisted of 25 items, including 4 background questions and 21 items of two instruments. The background questions included questions on the students' age, gender,

educational background, and current study field. The students' satisfaction instrument (8-items) measured students' satisfaction with the course and its effect upon their learning. The collaborative learning instrument (13-items) measured students' digital collaborative learning relating to promotion of their learning, the role of a teacher and the role of the students. Students' perceptions were measured using a 1-5 Likert scale (5=completely agree, 4=partially agree, 3=neither agree nor disagree, 2=partially disagree, 1=completely disagree). Additionally, in the end of the educational interventions students were evaluated by a written exam on their learning outcomes.

Instruments

The students' satisfaction instrument

The students' satisfaction instrument consisted of two sub-dimensions: 1) satisfaction of studying (6 items), and 2) satisfaction of studying in a digital learning environment (4 items). The first five items of satisfaction of studying were developed by the higher education institution where the educational intervention was conducted. The satisfaction of studying in a digital learning environment was developed and used in the previous study.[24] The content validity of all items was evaluated by an expert panel of educators. The instrument was pilot tested by eight nursing students in order to ensure the questions could be understood and interpreted correctly. No changes were made after measuring content validity and a pilot study.[25] Since we combined items from two different sources to measure students' satisfaction, the instrument was construct validated.

Exploratory factor analysis with principal axis factoring was conducted to test the construct validity of the instrument.[26] The Kaiser-Mayer-Olkin test (0.865) and Barlett's Test for Sphericity (439.057 df=28, p=0.01) were performed and the data showed sample adequacy for exploratory factor analysis. The functionality of the factor model was evaluated by eigenvalue > 1 and communalities of the factors. The eigenvalue indicated how well the factors could explain the dispersion of observed variables. The communalities explained how much of the variance of a single observed variable can be explained by the factors found.[22] Promax rotation was performed by including variables with a communality greater than 0.3.[23] Two-factor model was found to be the most suitable in the construct validity. The first factor (*Satisfaction of studying*) yielded an eigenvalue of 4.38 with total item variance explained by a factor of 54.8%. The second factor (*Satisfaction in digital learning environment*) yielded an eigenvalue of 1.06 and a total item variance explained by a factor of 13.3%. Two items were excluded during the validation process due to a low level of communality. The

reliability of the instrument was tested with Cronbach's alpha, with the first factor showing 0.84 and the second 0.83.[24] The results are summarized in Table 1.

Instrument for collaborative learning

The instrument for collaborative learning in the digital learning environment developed by Vuopala[27] consisted of three sub-dimensions: 1) promoting collaborative group work (6 items), 2) teacher's role in collaborative learning environment (4 items), and 3) the student's own role in the collaborative learning (3 items). [28] The content validity of all items was evaluated by an expert panel of educators. The instrument was pilot tested by eight nursing students in order to ensure the questions could be understood and interpreted correctly. No changes were made after measuring content validity and the pilot study.[26] Exploratory factor analysis with principal axis factoring was conducted to test the construct validity of the instrument. The Kaiser-Meyer-Olkin test (0.835) and Bartlett's Test for Sphericity (974.407, df=78, $p<0.01$) were performed and the data were found fit for factor analysis. The eigenvalue and communality of factors were computed using the same limit values as in the student satisfaction instrument. Promax rotation was performed by including variables with a communality greater than 0.3. A three-factor model was found to be most suitable in the construct validity. The first factor (*Promoting collaborative group work*) had an eigenvalue of 5.58 and total item variance explained by a factor of 43.0%. The second factor (*Teacher's role in collaborative learning*) had an eigenvalue 2.70 and total item variance explained by a factor of 20.8%. The last factor (*Student's own role in collaborative learning*) had an eigenvalue 1.03 and total variance explained by a factor of 7.9%. The reliability of the instrument was tested with Cronbach's alpha, resulting in the first factor showing 0.92, the second 0.83 and the third 0.76. The results are summarized in Table 2.[28,29,30]

Evaluation of students' learning outcomes

After the completion of the course, both groups were evaluated on the level of their knowledge of health promotion, its content, methods, challenges and effects. The knowledge level was graded from 0- fail to 5- excellent. The students completed an exam, the intervention group in an online setting and the control group in a classroom setting by answering essay format questions. The evaluation criteria were presented to both groups in the beginning of the course.

Data analysis

The data was analyzed using IBM SPSS 24.0®. The data were described using frequencies and percentages, means and standard deviations. Normal distribution of the data was assessed via

histograms using the Shapiro-Wilkin test. Due to fragmentation of the data, nonparametric Mann-Whitney's U-test was used for statistical testing of intervention and control group outcomes. The Wilcoxon Signed Rank test was used with pre and post measurements with the intervention and control group. A p-value of less than 0.05 was regarded as being statistically significant.[26] The effect size was counted according to Cohen's d value.[31,32]

Ethical issues

Permission to conduct the study was requested from and approved by the higher educational institution, according to the common practice of research conduct in Finland.[33] Written permission to use the instruments in the study was obtained from the instruments' owners. The students were informed in detail about the study including the course, purpose and volunteer participation. The student's autonomy was respected by providing sufficient information on participation in the research. The students were informed and given the right to suspend their participation at any stage of the study, without giving any reason if they did not want. Suspension did not affect the student's teaching nor the student's evaluation at the end of the course. All students in this study provided written informed consent. No physical or psychological harm was caused to the participants.[34] The data resulting from the study is kept in secure files by the university and will be archived for ten years after completion of the research project by the research group.[35,36]

RESULTS

Socio-demographic data of participants

The groups did not significantly differ in age, gender, previous education or current study area (see Table 3). Approximately three-quarters of the participants were female (74%); the mean age was 28 (*SD* 6.81) in the intervention group and 30 (*SD* 7.91) in the control group. The previous education of most participants was either the matriculation examination in high school (38%) or vocational school (49%). Most of the participants were nursing students (96%).

Effects of educational intervention in digital collaborative learning

After the education intervention there was no significant differences between the intervention group (IG) and control group (CG) in terms of the student's satisfaction of studying (IG mean 4.10, *SD*=0.73 vs. CG mean 4.36, *SD*=0.53; *p*=0.09) and satisfaction of studying in a digital collaborative learning environment (IG mean 4.11, *SD*=0.79 vs. CG mean 4.33, *SD*=0.59; *p*=0.26). The student satisfaction of studying decreased in the intervention group after completion of the course (IG pre-test mean 4.32, *SD*=0.57 vs. IG post-test mean 4.10, *SD*=0.73; *p*=0.05) (see Table 4).

Promoting collaborative group work was evaluated by two groups at pre- and post-test level. The intervention group recorded higher satisfaction in this area than the control group (IG post-test mean 4.30, *SD*=0.73 vs. CG mean 3.90, *SD*=0.96; *p*=0.04, *d*=0.5). The teacher's role in the collaborative learning environment was regarded as less satisfactory by the intervention group when compared with the control group (IG mean 4.04, *SD*=0.81 vs. CG mean 4.44, *SD*=0.53; *p*=0.03, *d*=0.5). The intervention group also scored the teacher's role in the collaborative learning as less satisfactory after the course was completed (IG pre-test mean 4.43, *SD* 0.51 vs. post-test mean 4.04, *SD* 0.81; *p*<0.01).

The student's own role in collaborative learning did not change after the intervention among the two groups and no statistically significant differences were found between the groups. In the evaluation of the course the students in the intervention group reached statistically significant (*p*<0.01) better grades when compared with the control group. Learning outcomes indicated that most students in the intervention group obtained very good scores (4=very good, 56%; 5=excellent, 29%). In the control group most students received good scores (3=good, 55%) and two students (7%) received only a satisfactory score of 2. None of the students failed the course (see Table 5).

DISCUSSION

Digital learning is an innovative teaching strategy and an area that is developing quickly in nursing education. It is also widely perceived by students as being beneficial, in offering flexible and self-directed learning that is independent of time and place. One major aim of higher education is to generate satisfied learners.[37] Digital collaborative learning may be one opportunity to develop that kind of capacity. Although earlier studies e.g. [38,39] have reported that students are satisfied when studying within a digital collaborative learning environment, our study indicated that the satisfaction

of studying in the digital learning environment decreased in comparison to traditional classroom teaching. This could be explained by the fact that students in the intervention group had to work harder and be more engaged with the course in order to achieve the learning outcomes. Collaborative learning requires engagement from the student, which has been previously observed to be challenging in real-world learning situations.[40] In collaborative settings, engagement becomes a more complex phenomenon than in individual learning settings. In collaborative learning, engagement is influenced by a variety of social and contextual factors, especially in the interactions between learners. On the other hand, collaborative learning promotes the purpose of the group's activity, the form of group output, the equal participation of students and a common basis for collaboration.[5,41] Margaryan et al.[42] reported that students showed a moderate preference for traditional teaching methods over digital learning methods. The digital collaborative learning was seen to be more challenging, especially in the situations when there were challenges with group engagement and equal share of the workload.[38]

In this study, better learning outcomes, in terms of grades, were achieved by students in the digital collaborative learning group. Most of the students in this group received excellent to good scores. Earlier studies have found that in collaborative learning situations the process and the outcomes are interrelated: i.e. active participation and high-quality interaction have a positive impact on learning outcomes.[43,44] Our study confirms this finding, even though the students in digital collaborative learning condition were less satisfied than students in the traditional classroom environment. Mackintosh-Franklin[45] reported that indirect connection was found between students' attendance and students receiving a better grade with a higher achievement of learning outcomes. Students' motivation was shown to be the strongest factor in predicting high levels of learning outcomes.

The teacher's role in collaborative learning is more complex than in the traditional classroom setting.[46] In this study, the students rated the teacher's role in the collaborative learning environment as less satisfactory, even though the outcome was rated as satisfactory level in both groups. In a traditional classroom setting, the teacher is often an expert responsible for dispensing knowledge.[47,48] In a digital learning environment, students have to work more independently, which could explain the difference between the evaluation of the teacher's role between the groups.[49] In collaborative learning, the emphasis of the teacher's work is in the planning phase, including task formulation, the design of a pedagogical script and preparation of learning materials. If students' collaboration is proceeding as planned towards completion of a task, the teacher may be invisible during the actual learning process.[50] This might also explain why the students in digital collaborative learning group

were less satisfied with the teacher's behaviour than the students in the traditional classroom group. Furthermore, it has been previously observed that when teachers transfer from traditional classroom teaching towards digital collaborative learning, they found the new setting challenging, leading to insecurities about their role and teaching competence.[51,52]

However, the nursing teacher plays an important part in the professional socialization of students, making the teacher a role model for students.[46] The core competencies for teachers are changing as technology plays an increasingly role in the classroom, making the teacher more of a guide and mentor than instructor.[51,52] New teaching methods are required to facilitate student-centered learning and develop their affective and cognitive skills in digital collaborative learning environments. It also causes a special didactic challenge, which needs further research to study most effective learning methods and process.[46] Teachers need to have multi-dimensional competence in education in order to be able to take such role.[52]

LIMITATIONS

This study has several limitations. First, randomization of participants would have enhanced the validity of the study but this was not possible due to curriculum regulations of the higher institution. Second, the effect size of the outcomes when comparing between intervention and control groups was moderate, which is explained by the inadequate sample size used in the study. Power analysis prior to the study would have predicted what sample size would have been required in order to reach effective outcomes. However, there was no previous studies conducted with the similar phenomena in similar settings. Thirdly, one of the researchers (MM) involved in the study was also the teacher of the course studied by the participants. The objectivity of the study would have been strengthened if the teacher had not been one of the researchers. Research ethical conduct[53] throughout the education intervention was strictly followed by the researchers, also in taking part of teacher's role in intervention. The TREND statement checklist was used in planning and reporting stages of the study.[54]

CONCLUSIONS

New technology offers new possibilities for teaching methods, such as collaborative learning. There is a large amount of digital collaborative learning research in the context of education, but relatively little in the context of nursing education. The pedagogical development of the nursing curriculum in

the context of higher education must make use of new digital technology in order to strengthen working life skills. We suggest that when applying digital technology in nursing education the focus has to be on collaborative learning. Nursing education teachers have also to be trained to design and enhance collaborative learning processes for their students. We believe the results of this study can be applied when developing such digital collaborative learning practices for nursing education.

REFERENCES

1. Yoo MS and Park JH. Effect of case-based learning on the development of graduate nurses' problem-solving ability. *Nurse Education Today* 2014; 34(1): 47-51.

2. Chan AW, Chair S, Wing-Hung Sit JW, et al. Case-based web learning versus face-to-face learning: a mixed-method study on university nursing students. *Journal of Nursing Research* 2016; 24(1): 31-40.

3. Dillenbourg P and Jermann P. Technology for Classroom Orchestration. In: Khine M and Saleh I (eds) *New Science of Learning: Cognition, Computers and Collaboration in Education*. New York: Springer, 2011, pp. 525-552.

4. Arvaja M, Salovaara H, Häkkinen P, et al. Combining individual and group-level perspectives for studying collaborative knowledge construction in context. *Learning and Instruction* 2007; 17(4): 448-459.

5. Scardamalia M and Bereiter C. Knowledge Building and Knowledge Creation: Theory, Pedagogy, and Technology. In: Sawyer RK (ed) *Cambridge handbook of the learning sciences*. 2nd ed. New York: Cambridge University Press, 2014, pp. 397-417.

6. Hmelo-Silver CE and Chinn CA. Collaborative Learning. In Corno L and Anderman EM (eds) *Handbook of Educational Psychology*. New York: Routledge, 2015, pp. 349-363.

7. Stahl G. Meaning making in CSCL: conditions and preconditions for cognitive processes by groups. *CSCL Proceedings* 2007: 651─660.

8. Weinberger A and Fischer F. A framework to analyze argumentative knowledge construction in computer-supported collaborative learning. *Computers & Education* 2006; 46(1): 71-95.

9. King A. Scripting Collaborative Learning Processes: A Cognitive Perspective. In Fischer F, Kollar I, Mandl H, et al. (eds) *Scripting Computer Supported Collaborative Learning. Cognitive, Computational and Educational Perspectives.* New York: Springer, 2007, pp. 13–37.

10. Stover S and Holland C. Student resistance to collaborative learning. *International Journal for the Scholarship of Teaching and Learning* 2018; 12, Article 8.

11. Peterson, A.T., Roseth, C.J., Effects of four CSCL strategies for enhancing online discussion forums: social interdependence, summarizing, scripts, and synchronicity. *International Journal of Education Research* 2016; 76: 147-161

12. Pucer P, Trobec I and Zvanut, B. An information communication technology based approach for the acquisition of critical thinking skills. *Nurse Education Today* 2014; 34: 964-970.

13. Danish JA and Gresalfi M. Cognitive and Sociocultural Perspective on Learning: Tensions and Synergy in the Learning Sciences. In Fischer F, Hmelo-Silver CE, Goldman SR, et al. (eds) *International Handbook of the Learning Sciences*. New York: Routledge, 2018, pp. 34-43.

14. Zhang J and Cui Q. Collaborative learning in higher nursing education: a systematic review. *Journal of Professional Nursing* 2018; 34: 378-388.

15. Kalaian SA and Kasim RM. Effectiveness of various innovative learning methods in health science classrooms: a meta-analysis. *Advanced in Health Scientific Education* 2017; 22: 1151-1167.

16. Järvelä S, Järvenoja H, Malmberg J, et al. Exploring socially shared regulation in the context of collaboration. *Journal of Cognitive Education and Psychology* 2013; 12(3): 267–286.

17. Azevedo R, Taub M, Mudrick N, Farnsworth J and Martin SA. Interdisciplinary research methods used to investigate emotions with advanced learning technologies. *Methodological Advances in Research on Emotion and Education* 2016; 231-243.

18. D'Mello S, Dieterle E and Duckworth A. Advanced, analytic, automated (AAA) measurement of engagement during learning. *Educational Psychologist* 2017; 52: 104-123.

19. Grove SK, Burns N and Gray JR. *The Practice of Nursing Research: Appraisal, Synthesis and Generation of Evidence*. 7th ed. St. Louis, Missouri: Elsevier, 2013.

20. Authors-blinded, 2019.

21. Chan CK and van Aalst J. Knowledge Building: Theory, Design, and Analysis. In Fischer, F, Hmelo-Silver CE, Goldma, SR, et al. (eds) *International Handbook of the Learning Sciences*. New York: Routledge, 2018; pp.295-307.

22. Miyake N and Kirschner PA. The Social and Interactive Dimensions of Collaborative Learning. In Sawyer KR (ed) *The Cambridge Handbook of the Learning Sciences*. New York: Cambridge University Press, 2014, pp. 418–438.

23. Kollar I, Wecker C and Fischer F. Scaffolding and Scripting (Computer-Supported) Collaborative Learning. In Fischer, F, Hmelo-Silver CE, Goldma, SR, et al. (eds) *International Handbook of the Learning Sciences*. New York: Routledge, 2018; pp. 340-350.

24. Authors-blinded, 2017.

25. Ritter LA and Sue VM. Systematic planning for using an online survey. The evaluation marketplace: exploring the evaluation industry. *New Directions for evaluation* 2007; 115: 15-22.

26. Kimberlin CL and Winterstein AG. Validity and reliability of measurement instruments used in research. *American Journal of Health-System Pharmacy* 2008; 65: 2276–2284.

27. Vuopala, E. Requirements for successful collaborative learning in virtual learning spaces. University students' experiences and interactional features. 2013. University of Oulu Graduate School; University of Oulu, Faculty of Education, Finland. Acta Universitatis Ouluensis E 133

28. Williams PB, Seaton P, Sim D, et al. Exploratory factor analysis: a five-step guide for novices. *Australian Journal of Paramedicine* 2014; 8(3): 1-12.

29. Yong AG and Pearce S. A beginner guide to factor analysis: focusing on exploratory factor analysis. *Tutorials in Quantitative Methods for Psychology* 2013; 9(I2): 79-94.

30. Rattray J and Jones MC. Essential elements of questionnaire design and development. *Journal of Clinical Nursing* 2007; 16: 234–243.

31. Cohen J. A power primer. *Quantitative Methods Psychology* 1992; 112(1): 155–159.

32. Lakens D. Calculating and reporting effect sizes to facilitate cumulative science: a practical primer for t-tests and ANOVAs. *Front Psychology* 2013; 4: 863.

33. Medical Research Act 488/1999, 295/2004, 794/2010 Ministry of Social Affairs and Health, Finland.

34. Declaration of Helsinki. Ethical principles for medical research involving human subjects. JAMA 2013; 310(*20*): 2191–2194.

35. GDPR. Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC 2016 (General Data Protection Regulation).

36. Personal Data Act 523/1999. Ministry of Justice. Finland.

37. Nicol DJ and Macfarlane-Dick D. Formative assessment and self-regulated learning: a model and seven principles of good feedback practice. *Studies in Higher Education* 2006; 31(2): 199-218.

38. Järvelä S, Kirschner PA, Hadwin A, et al. Socially shared regulation of learning in CSCL: understanding and prompting individual- and group-level shared regulatory activities. International Journal of Computer Supported Collaborative Learning 2016; 11(3): 263-280.

39. Stover S and Holland C. Student resistance to collaborative learning. *International Journal for the Scholarship of Teaching and Learning* 2018; 12(*2*): 8.

40. Näykki P, Järvelä S, Kirschner P, et al. How relational conflict emerges and how students' interpret a conflict situation – a process-oriented case analysis in collaborative learning. *International Journal of Educational Research* 2014; 68: 1–14.

41. Authors-blinded, 2013.

42. Margaryan A, Littlejohn A and Vojt G. Are digital natives a myth or reality? University students' use of digital technologies. *Computers & Education* 2011; 56(2): 429-440.

43. De Backer L, Van Keer H and Valcke M. Exploring evolutions in reciprocal peer tutoring groups' socially shared metacognitive regulation and identifying its metacognitive correlates. *Learning and Instruction* 2015; 38: 63–78.

44. Molenaar I and Chiu MM. Dissecting sequences of regulation and cognition: statistical discourse analysis of primary school children's collaborative learning. *Metacognition and Learning* 2014; 9: 137–160.

45. Mackintosh-Franklin C. An evaluation into the impact of undergraduate nursing students classroom attendance and engagement with online tasks on overall academic achievement. *Nurse Education Today* 2018; 61: 89-93.

46. Koch LF. The nursing educator's role in e-learning: a literature review. *Nurse Education Today* 2014; 34: 1382-1387.

47. Jenkins S, Goal R and Morrele D. Computer-assisted instruction versus traditional lecture for medical student teaching of dermatology morphology: a randomized control trial. *Journal of the American Academy of Dermatology* 2008; 59(2): 255-259.

48. Reime MH, Harris A, Aksens J, et al. The most successful method in teaching nursing students infection control – e-learning or lecture? *Nursing Education Today* 2008; 28(7): 798-806.

49. Howe C and Zachariou A. Small-group Collaboration and Individual Knowledge Acquisition: The Processes of Growth during Adolescence and Early Adulthood. *Learning and Instruction* 2017.

50. Webb N. The Teacher's role in promoting collaborative dialogue in the classroom. British *Journal of Educational Psychology* 2009; 79: 1-28.

51. Authors-blinded, 2019a.

52. Authors-blinded, 2019b.

53. Stang J. Ethics in action: conducting ethical research involving human subjects: a primer. *Journal Academic Nutrition Diet* 2015; 115(12): 2019–2022.

54. Des Jarlais DC, Lyles C and Crepaz N. Trend Group. Improving the reporting quality of nonrandomized evaluations of behavioral and public health interventions: the TREND statement. *American Journal of Public Health* 2004; 94: 361-366.

Table 1. Exploratory factor analysis[1] of scale in students' satisfaction (n=94)

Items	Factor 1	Factor 2
Factor 1. SATISFACTION OF STUDYING		
1. I believe that the course corresponds to my expectations	0.914	
2. I achieve the objectives of the course	0.754	
3. I learn new contents during the course	0.625	
4. I work actively to achieve the course objectives	0.623	
5. I consider the level of the difficulty of the course appropriate	0.553	
Factor 2. SATISFACTION IN DIGITAL LEARNING ENVIRONMENT		
6. The digital learning environment motivates me to study in this course		0.907
7. I find the digital learning environment useful to me		0.750
8. I consider it important to use the digital learning environment in teaching		0.671
Eigenvalue	4.382	1.064
Percentage of variance	54.8%	13.3%
Total percentage of factor model		68.1%
Cronbach's alpha	.847	.830

[1] Extraction method: Principal Axis Factoring with Promax rotation, presented in Pattern Matrix, only loadings ≥.300 presented in the table

Table 2. Exploratory factor analysis[1] of scale in collaborative learning (n=94)

Items	Factor 1	Factor 2	Factor 3
Factor 1. PROMOTING COLLABORATIVE GROUP WORK			
1. The members of the study group are active and participate equally in the work	0.946		
2. The study group has a positive atmosphere	0.938		
3. The interaction in the study group is fluent and the discussions are profound	0.846		
4. Fellow students promote learning of each other	0.749		
5. The members of the study group have enough background information on the themes of the course	0.654		
6. The study group has a clear common study goal	0.643		
Factor 2. TEACHER'S ROLE IN COLLABORATIVE LEARNING			
7. Feedback from the teacher and the supervisor promotes my learning		0.954	
8. Teachers' activity during the course supports collaborative working		0.891	
9. The course material offers ingredients for versatile group discussion		0.688	
10. The digital learning environment enable flexible study group work		0.360	
Factor 3. STUDENT'S OWN ROLE IN COLLABORATIVE LEARNING			
11. My own learning skills are an important prerequisite for the success of collaborative learning			0.878
12. My own motivation is an important prerequisite for the success of collaborative learning			0.810
13. Formatting of the learning task requires collaborative learning			0.356
Eigenvalue	5.584	2.700	1.032
Percentage of variance	43.0%	20.8%	7.9%
Total percentage of factor model			71.7%
Cronbach's alpha	.921	.835	.764

[1] Extraction method: Principal Axis Factoring with Promax rotation, presented in Pattern Matrix, only loadings ≥.300 presented in the table

Table 3. Socio-demographic data of participants (n=94)

Socio-demographic and background information	Intervention group: Digital learning environment students (n=63)	Control group: Classroom learning environment students (n=31)	*p-value*
Age in years º	28 (6.81)	30 (7.91)	0.18
Gender			
Female	46 (73.0%)	23 (74.2%)	0.90
Male	17 (27.0%)	8 (25.8%)	
Previous education			
Matriculation examination	25 (39.7%)	11 (35.5%)	0.76
Vocational school	29 (46.0%)	16 (51.6%)	
University of applied sciences	8 (12.7%)	2 (6.5%)	
University	0 (0.0%)	1 (3.2%)	
Other	1 (1.6%)	1 (3.2%)	
Current study area			
Registered nurse	60 (95.2%)	30 (96.8%)	0.08
Paramedic	3 (4.8%)	1 (3.2%)	

º *M*: mean (*SD*: standard deviation)
p<0.05 (marked in bold)
Parametric continuous data analyzed using independent samples t-test
Categorical data analyzed using Chi-square test

Table 4. Results of a digital educational intervention in collaborative learning of nursing education (n=94)

Outcomes	Testing	Intervention group (n=63) Mean (SD)	Control group (n=31) Mean (SD)	Mann-Whiney U Test results: *p*-value
General satisfaction of studying	Pre-test	4.32 (0.57)	4.46 (0.53)	*U* = 834.00 *Z* = -1.16 *p* = 0.24
	Post-test	4.10 (0.73)	4.36 (0.53)	*U* = 772.00 *Z* = -1.66 *p* = 0.09
	Wilcoxon Signed Ranks Test results, *p*-value	*Z* = -1.94 ***p* = 0.05**	Z = - 0.77 p = 0.44	
Satisfaction of studying in a digital learning environment	Pre-test	4.29 (0.70)	4.29 (0.77)	*U* = 953.00 *Z* = -0.19 *p* = 0.84
	Post-test	4.11 (0.79)	4.33 (0.59)	*U* = 840.50 *Z* = -1.12 *p* = 0.26
	Wilcoxon Signed Ranks Test results, *p*-value	*Z* = -1.55 *p* = 0.12	Z = -0.19 p = 0.95	
Promoting collaborative group work	Pre-test	4.45 (0.56)	3.86 (0.93)	*U = 608.50* *Z* = -2.98 ***p* = 0.03**
	Post-test	4.30 (0.73)	3.90 (0.96)	*U* = 732.50 *Z* = -1.98 ***p* = 0.04**
	Wilcoxon Signed Ranks Test results, *p*-value	*Z* = -1.79 *p* = 0.07	Z = - 0.19 p = 0.85	
Teacher's role in collaborative learning	Pre-test	4.43 (0.51)	4.47 (0.43)	*U* = 959.50 *Z* = -0.14 *p* = 0.88
	Post-test	4.04 (0.81)	4.44 (0.53)	*U* = 709.00 *Z* = -2.17 ***p* = 0.03**
	Wilcoxon Signed Ranks Test results, *p*-value	*Z* = -3.65 ***p* < 0.01**	Z = -0.26 p = 0.79	
Student's own role in collaborative learning	Pre-test	4.46 (0.49)	4.63 (0.44)	*U = 770.00* *Z* = -1.72 *p* = 0.08
	Post-test	4.43 (0.64)	4.52 (0.56)	*U = 916.00* *Z* = -0.51 *p* = 0.61
	Wilcoxon Signed Ranks Test results, *p*-value	*Z* = 0.00 *p* = 1.00	*Z* = -0.96 *p* = 0.33	

p<0.05 statistically significant marked in bold

Table 5. Final evaluation of students' learning outcomes

Grade	Intervention group: (n=63)	Control group: (n=31)	*p-value*
1	0 (0.0%)	0 (0.0%)	**0.01**
2	0 (0.0%)	2 (6.5%)	
3	10 (15.9%)	17 (54.8%)	
4	35 (55.6%)	10 (32.3%)	
5	18 (28.6%)	2 (6.5%)	

* Grade: Scale 0=fail, 1=poor, 2=satisfactory, 3=good, 4=very good, 5=excellent

CONS

CONSORT 2010 Flow Diagram

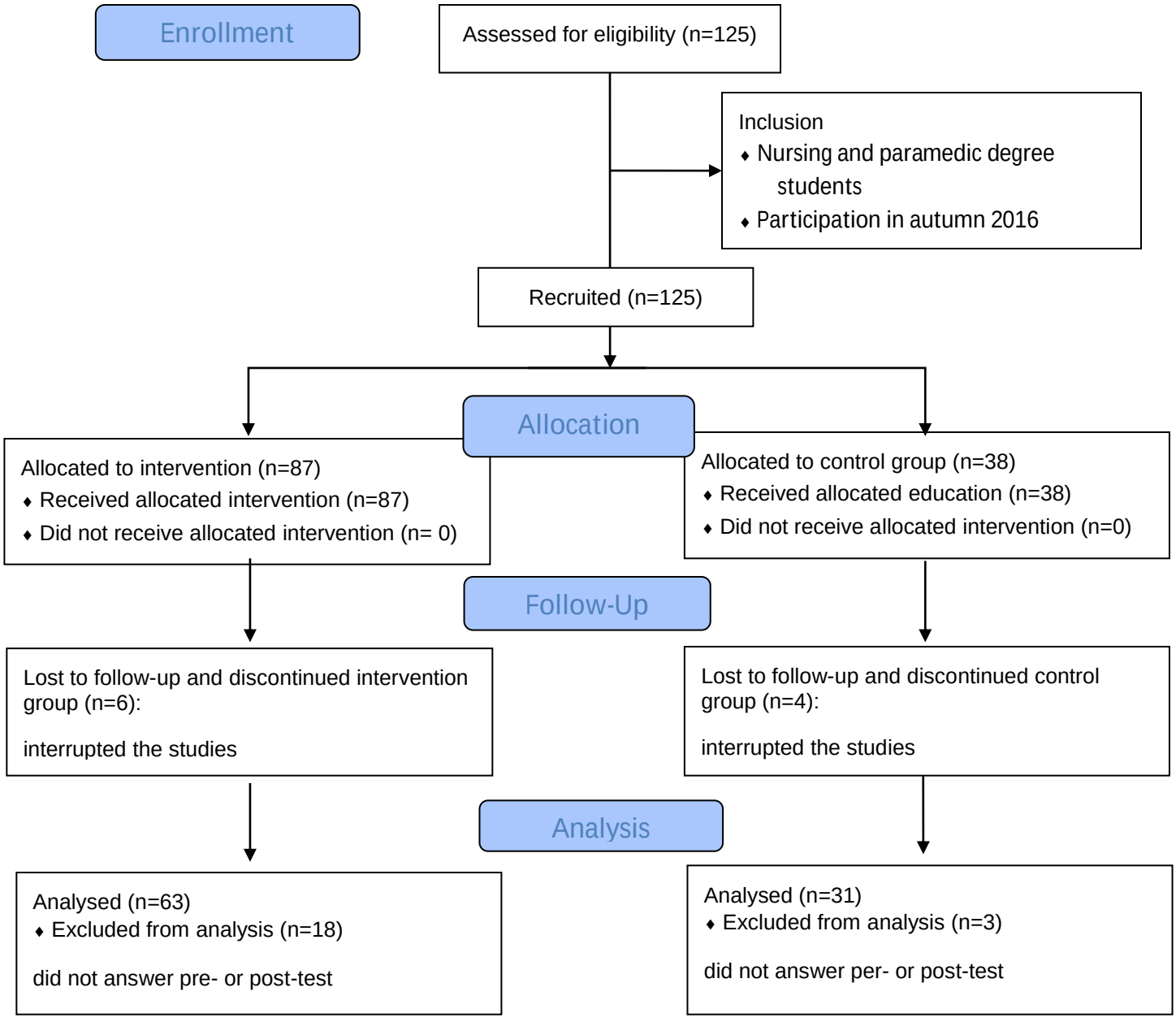

Figure 1. CONSORT 2010 flow diagram of study setting