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Original research

Evaluation of Swedish nursing students' experience of a web-based platform for drug calculation

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ABSTRACT

Safe drug calculation is important in nursing as insufficient skills pose a risk to patient safety. Therefor solid education in mathematics for undergraduate nursing students must be provided. To support nursing students' skills in drug calculation, a web-based learning platform for drug calculation was created. The aim of this study was to investigate nursing students' experiences of a web-based learning platform for drug calculation in terms of usability and learning support. The study was a cross-sectional comparative study. Ninety-five nursing students participated, out of which 46 students were in semester one and 49 students were in semester six. A questionnaire was used to evaluate the nursing students' experiences of a web-based learning platform for drug calculation in terms of usability and learning support. The findings were informed by statistical and thematic analyses. The majority of the participants evaluated the platform positively. The platform was deemed useful, and it was a support for the nursing students' learning. These findings provide that a web-based learning platform for drug calculation can be used as a complement to traditional lectures. Nevertheless, further research is required focusing teaching strategies facilitating different learning styles and level of computer skills.

1. Introduction

To provide safe drug calculation and administration, healthcare professionals must work in accordance with nine rights that relate to the patient, medicine, ways of administration, timing, dosage, documentation, handling, pharmaceutical form and response. Every step poses a risk, and attention must be given to solve these problems (Elliott and Liu, 2010). In most countries, regulations and national laws help ensure the safety of the patients and outline how to prevent adverse reactions caused by calculation errors. Despite this, errors are a common problem and a patient safety risk (Barker et al., 2002; Harolds, 2015). This is a particularly important task with a high degree of responsibility. Inaccuracies can be caused by several factors, and insufficient skills are one such factor (Barker et al., 2002). Koohestani et al. (2010) found that nursing students would like further education to help decrease inaccuracies. One way to make drug calculation and drug administration safer may be to guarantee access to adequate education at universities. This can be further stressed by findings from previous studies. For example, in high school, many nursing students had received low grades in mathematics (Eastwood et al., 2011; Røykenes et al., 2014), and this may be related to previous negative experience of the subject. Critical events in a student's learning environment such as parents' attitudes, frequent changes of teachers and poor transitioning between school levels can all affect one's future skills and attitudes towards mathematics (Røykenes, 2016). Thus, a solid education in mathematics for both working nurses and undergraduate nursing students must be provided and taken seriously (Sung et al., 2008). In a diagnostic test among first year pre-registered nursing students aimed at identifying their mathematical skills before entering a course, the results showed difficulties in basic maths which were caused by deficient prior education; thus, the higher the level of education in maths the students had achieved, the better the results (Harvey et al., 2010). This correlate with Sulosaari et al.'s (2015) result for which showed that success from previous academic education was strongly related to the nursing students' competence in drug calculation. However, at the end of the nursing program, the performance was related to the students' study motivation and their capacity in self-regulated learning. Students who used allocated time for drug calculation achieved better results than students who did not attend the learning activity. Further, nursing students' from year one through to year three showed inadequate skills in drug calculation competency, not only in regard to basic principles (Bagnasco et al., 2016; Özyazicioglu et al., 2018) but also in regard to performing drug calculations (Bagnasco et al., 2016; Eastwood et al., 2011). Students from a Bachelor of Nursing program in Norway failed both the first and second drug calculation tests; accordingly, the requirement of having no errors was experienced as stressful for the students (Røykenes and Larsen, 2010). Difficulties in performing drug calculations could also be a result of anxiety regarding maths, self-efficacy as well as certain teaching approaches (Williams and Davis, 2016; Thompson et al., 2015), for example traditional face to face lectures that passivate the students and reduce the connection between theory and practice (Weeks et al.,

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2013a,b,c,d). Wright (2013) found that many nursing students and registered nurses failed drug calculation tests and recommended that the development of different teaching methods for drug calculation be highlighted and prioritised. Previous studies have shown that nursing students have difficulty in solving tasks in medicine dosage calculation as they consist only of numbers as they also need the data to be visualized to increase understanding (Eastwood et al., 2011; Weeks et al., 2013a,b,c,d). In a study by Lee and Lin (2013) students suggested methods such as quizzes with options to preview and review e-learning videos which could take place in a less stressful environment than traditional face to face lectures.

In the near future, the design of study activities will change due to the increased use of Information and Communication Technology (ICT). The ongoing development of ICT has the potential to increase learning by prompting the students to reflect on their practice and also create a base for new learning, (Duţă and Martínez-Rivera, 2015; Button et al., 2014). Quizzes are not only an educational tool to promote and enhance learning but also a more effective method for deeper learning. Students who completed these quizzes attained better test results compared with students who had only re-read the content (Messineo et al., 2015). Similar results were found by Nyroos (2016), who also found that quizzes decreased anxiety about tests. This will probably widen the learning space of traditional face to face lectures held in classrooms into new and flexible learning spaces (Beckers et al., 2016). One way to widen the learning space might be the use of blended learning as a pedagogical approach. This is a model that supports different ways of learning were the teachers and students can use different learning environments to interact either synchronous or asynchronous (Rowe et al., 2012). To minimize medical errors caused by novice nurses and nursing students and improve risk management and quality improvement in drug calculation, it is important to educate nurses in a more effective way. One way is to integrate e-learning of drug calculation is by using appropriate software and video instructions (Feizalahzadeh et al., 2016). Nursing students valued the brevity and conciseness of the e-lectures, with the possibility to pause and replay, and stated that it benefited their learning (Hanson, 2016; Button et al., 2014). Using digital recordings based on real-life-experiences combined with face to face activities allows for scenarios which otherwise would be difficult to demonstrate on campus (Hewitt et al., 2015). Nursing students found the digital recordings highly useful, and it is an approach that could lessen the incidence of errors in medication calculation (Hewitt et al., 2015; Weeks et al., 2013a,b,c,d). Although the students considered their skills in basic medical calculation to be adequate before they gained access to the medication administration web course, they measured the web-based medication administration education as important for their learning and felt that their skills had improved after they completed the web-based course. Research findings have highlighted different ways of learning and hence the diverse learning needs of nursing students. Despite this knowledge, many lecturer teach in their own way of thinking and solving problems (Weeks et al., 2013a,b,c,d). In clinical practice, errors in drug calculation and administration happen frequently (Barker et al., 2002; Harolds, 2015; Sheikh et al., 2017), often with serious and even lethal injuries. Markary and Daniel (2016) estimate that death related to medical errors is the third biggest cause of death in the US. Translated into numbers, it means an annual mean rate of 251 454 between year 1999 and 2013 (Makary and Daniel, 2016). In Sweden, between 2013 and 2017, medical errors in clinical practice were estimated to 1, 5% a year in 77 188 reviewed patient journals. Converted to numbers it corresponds to approximately 18 000 cases, out of which 0, 1% of these cause permanent or lethal injuries (Swedish Association of Local Authorities and Regions, 2018). Therefore these findings indicate and identify the need to develop and implement new strategies for drug calculation. To address this challenge a web-based learning platform for drug calculation was developed which contains a visual structure for drug calculations. It combines e-learning videos, exercises and self-regulated quizzes to further develop competency. The current study presents the evaluation of nursing students' experiences of this web-based learning platform for drug calculation in terms of usability and learning support.

2. Methods

2.1. Design

The study is an evaluation study comparing the experiences of the web-based learning platform for drug calculation between nursing students in semesters one and sex.

2.2. Participants

During the autumn of 2016 a new web-based platform for drug calculation was implemented in a Bachelor of Nursing programme at a university in southern Sweden. We used convenience sampling as all students in semester one and six were invited to test the platform and participate in the evaluation. During these semesters students are exposed to drug calculation for the first time and then again right before graduation. A total number of 95 students responded and completed the evaluation, forty-six students volunteered from semester one and 49 students from semester six.

2.3. Setting and the web-based learning platform for drug calculation

When starting the e-learning session a written presentation regarding the platform's content and a guide on how to use it becomes visible. The platform consists of 17 e-learning lectures visually illustrating drug calculation for practicing calculation skills. (Table 1).

Each e-learning lecture ends with an interactive quiz different for every topic. Camtasia Studio 8 software transformed PowerPoint presentations into video clips, with recorded lectures and quizzes relating to the specific topic at the end of the e-learning lectures. The students receive immediate feedback during the exercises and also at the end of every topic via the self-corrected quizzes. This was facilitated by each quiz being connected to a specific topic, in the event of an incorrect answer, the students could go back to that topic, receive instructions and practice again. The platform allows the students to pause and review the instructive content. The e-learning lectures are also accessible as self-directed animated slide shows were students can practice their skills step by step. If students experience difficulties they can activate the animations and receive guidance on how to properly solve the drug calculation and thus correct themselves. The e-learning videos and the exercises can be downloaded and be used offline (Fig. 1).

Table 1
The 17 e-learning lectures.

How to calculate with a triangle	Drops per os, eyes and ears	Percentage
Mathematical laws regarding rounding	Powder to injection, infusion fluid	Dilution
Active ingredient and volume	Inhalations	How much medication is needed?
Time	Body weight and body surface	Two e-learning videos consisting of mixed tasks
Injections, infusions and speed	Oxygen	
Depot court plaster	Transport	

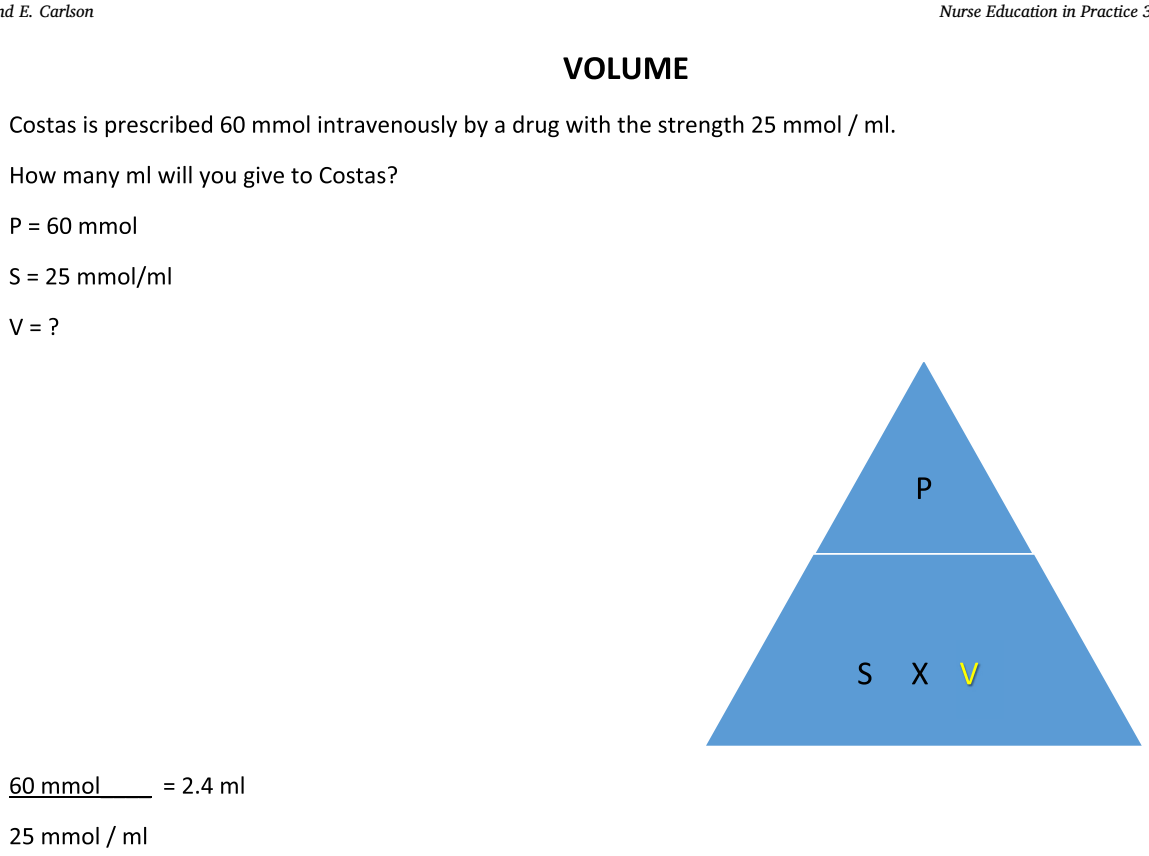

Fig. 1. The content of e-learning lectures and illustration of module "Active ingredient and volume". P = Prescription (amount of active ingredient, S = Strength and V = Volume (dose).

2.4. Data collection

Data was collected in December 2016 by questionnaires created to evaluate the supportive function and usability of the web-based learning platform for drug calculation. It consisted of eight items on a 4-point Likert scale ranging from 1) not at all, 2) to some extent, 3) to a high degree and 4) to a very high degree as well as four open-ended questions (Fig. 2). Furthermore, variables for sex, age and semester of study were added. To test if the questions were clear and understandable, face-validity was performed by sending the questions to academic colleagues and students who were familiar with the web-based learning platform for drug calculation. Cronbach's alpha was calculated for internal consistency and the value $\alpha = 0{,}891$ indicate that the items were interrelated. The questionnaires were distributed and collected manually by the first author.

2.5. Ethical considerations

The study followed local ethical guidelines and the Declaration of Helsinki's (DoH) fundamental ethical principles (World Medical Association, 2013). The participants were assured of confidentiality and all questionnaires were anonymised. The students were informed that they had the right to withdraw without any consequences. Returning the questionnaires was considered as consent to participate. The first author was a teacher to the students, the second author had not taught or otherwise been involved with the participants. The risk for dependence were minimized by collecting the data at the end of the semester after the students had passed their practical and theoretical exams.

2.6. Data analysis

Statistical Package for Social Sciences (SPSS) version 23 was used to analyse the quantitative questions. Descriptive analysis, mean, and median were used to describe the data. The Mann-Whitney *U* test which is a non-parametric test was set to compare if there were any differences in means between students in semesters one and six. The statistical level of significance was set to 5% ($p = 0.05$). The qualitative data was analysed by a manifest structured analysis after Elos et al.'s (2008, 2014)descriptions. To avoid any predetermined interpretations, the open-ended questions were analysed by the first author and were subsequently reviewed and agreed upon by the first and second authors. For the open-ended questions, an inductive approach was used (i.e. data were gathered and generalisations made from the data). Units of meanings were underlined and codes were written in the margins to

- What did you appreciate the most with the web-based platform for drug calculation?
- What did you appreciate the least with the web-based platform for drug-calculation?
- In what way can the web-based platform for drug calculation be developed?
- Other comments:

Fig. 2. Open ended questions.

describe as many meanings as possible. Subsequently, codes from the open-ended questions were grouped in categories. Each category was named after content-characteristic words, and the sentences were sorted in different categories until the categories were as clean as possible.

3. Results

Ninety-five nursing students participated in the study. The participants' ages were between 19 and 53 years old (mean = 27), and the majority was female (n = 76, 80%). The male students represented 10.5% of the participants (n = 10), other gender represented 2.1% (n = 2) and 7.4% of the answers for this were missing (n = 7). The distribution between the two semesters were 78.4% (n = 46) in first semester and 51.6% (n = 49) in semester six.

The majority evaluated the learning platform for drug calculation positively. The mean values (range 1–4) for the dimension of 'Usability' varied between 3.39 for "It was easy to navigate the web-based learning platform for drug calculation" to 3.49 for "The material on the web-based learning platform was easily accessible". For the dimension, 'Learning support', the mean values varied between 3.01 for "To what degree do you perceive that you have received knowledge in drug calculation by using the web-based learning platform for drug calculation as a support to obtain knowledge?" to 3.50 "To what degree do you value that the web-based learning platform for drug calculation is useful as a support for drug calculation?" (Table 2).

A comparison to determine any statistical differences between students in semesters one and six was carried out. Two out of eight questions were statistically significant ($p \leq 0.05$). The items, "The web-based platform for drug calculation was easy to use" ($p \leq 0.040$) and "It was easy to navigate on the web-based platform for drug calculation" ($p \leq 0.050$), received more positive evaluations from students in semester six than in semester one (Table 2).

The result that emerged after the analysis of the open-ended questions are presented under the following categories: "Self-determination", "The opportunity to go back and control" and "Educational support".

3.1. Self-determination

The learning platform for drug calculation gave the students a feeling of self-determination. The main advantage that the students noted in the evaluation was the platform's accessibility and the option to go back and repeat it at any time. The students felt that they had the opportunity to decide when and where to listen to the web-based lectures and do the calculations connected to the platform for drug calculation. "[To] sit quietly and listen on the bus, in the car – the possibility to use it everywhere" (student in semester one). The students experienced that even if the lecturer was not physically present, the platform provided them with information whenever it was needed, and this is reflected in the comment, "[What's good is] being able to listen to it at home anytime and feel like you get a clear explanation" (student in semester six). Even if the majority of the students were positive to the platform, as reflected in the comment, "It is good as it is" (student in semester one), some students had different notions of what they appreciated least with the platform. Some students reported technical problems, such as problems with "pause, rewind and fast forward the e-learning lectures" (student in semester one), but according to another student, these were "solved by using Google Chrome instead of Internet Explorer" (student in semester six).

3.2. The opportunity to go back and control

Students appreciated the opportunity to go back and control their comprehension of how to perform drug calculation. This was also facilitated by the accessibility to use different tools for drug calculation.

Table 2
Item statistics and comparison between students' means in semesters one and six.

	Total population			Semester one		Semester six	P-value[a]
	(n = 95)			(n = 46)		(n = 49)	
	Mean (SD)	Median[b]		Mean (SD)		Mean (SD)	
Usability							
The web-based learning platform for drug calculation was easy to use	3.41 (0.725)	to a very high degree		3.27 (0.751)		3.55 (0.679)	0.040
The material on the web-based learning platform was easily accessible	3.49 (0.684)	to a very high degree		3.39 (0.714)		3.58 (0.647)	0.137
The instructions for the web-based learning platform for drug calculation were clear	3.48 (0.756)	to a very high degree		3.39 (0.802)		3.57 (0.707)	0.208
It was easy to navigate on the web-based learning platform for drug calculation	3.39 (0.776)	to a very high degree		3.26 (0.773)		3.51 (0.767)	0.050
Learning support							
To what degree do you value that the web-based learning platform for drug calculation is useful as a support for drug calculation?	3.50 (0.730)	to a very high degree		3.41 (0.777)		3.58 (0.679)	0.228
How educational did you perceive the content in the web-based learning platform for drug calculation?	3.39 (0.751)	to a very high degree		3.29 (0.843)		3.49 (0.649)	0.302
To what degree do you perceive that you have received knowledge in drug calculation by using the web-based learning platform for drug calculation as a support to obtain knowledge?	3.01 (0.905)	to a high degree		2.89 (0.924)		3.12 (0.881)	0.199
To what degree do you perceive that the web-based learning platform is a useful complement to traditional education in drug calculation?	3.41 (0.694)	to a very high degree		3.27 (0.780)		3.55 (0.580)	0.078

[a] The significance level is 5% of Mann-Whitney U test.
[b] 1 = not at all, 2 = to some extent, 3 = to a high degree and 4 = to a very high degree.

One such example was the PowerPoint presentations consisting of animated slideshows and quizzes. By using the PowerPoint, they could calculate at their own pace, and at the same time, test their skills because the correct answers appear at the end. The students expressed that they wanted more quizzes to be sure that they had the knowledge that was expected of them: One student explained that "In a quiz, you can test yourself and get to know your 'weak points'" (student in semester one). The students appreciated the quizzes at the end of every recorded lecture, but a suggestion was made by some of the students to include quizzes that are not related to any special topics from the e-learning videos. One student expressed, "I want to have the quizzes separate, not only at the end of the e-learning lecturers" (student in semester six).

3.3. Educational support

The possibility to sit quietly and listen to the e-learning videos in peace while solving tasks was mentioned as positive aspects. Some students also noted that they liked the calm voice of the narrator in the e-learning videos. To them, it was a refreshing change because they are not always able to keep up with how fast traditional face to face lecturers sometimes speak: "I think it is at good pace and is very carefully and slowly described, which suited me fine because I think drug calculation is especially difficult. I appreciate having it explained clearly" (student in semester one). It was an alternative to traditional face to face lectures that stimulated their learning process depending on the platforms width and variation. The opportunity to listen to the e-learning videos and have the process of calculations clearly and easily explained step by step at the same time they were doing their drug calculations was another aspect that was mentioned: "Good to have other ways [to learn] than traditional face to face lecturers. Sometimes it can be hard to catch and understand everything during a lecture" (student in semester six). Some students also mentioned the benefit of having alternative supportive teaching approaches such as the platform as a complement to traditional face to face lectures: "Great! Educational and easy to use. Contains several learning options" (student in semester one).

The platform stimulated their learning process, and they reported that it had increased their understanding of drug calculation. The continued development of the platform for drug calculation with more e-learning videos, exercises and quizzes was requested; in addition, a similar approach in several other courses in the education was requested because the platform for drug calculation was perceived to complement the traditional face to face lectures well: "It was a good complement to the learning process. I have increased my understanding of drug calculation" (student in semester one). In contrast, a few students expressed that "the pace was too slow in some of the e-learning videos" (student in semester six) and "sometimes a little too explicit" (student in semester six).

4. Discussion

The majority of the participants were positive about the web-based learning platform for drug calculation, and they also had suggestions for further development such as more e-learning videos, exercises and quizzes. The students evaluated the platform as useful and it was also a support to their learning.

The statistical result consistently shows a more positive evaluation from students in semester six than from students in semester one. This might be because the students in semester six have had more experience with the platform for drug calculation compared to students in semester one as they had used it in semester four to six. Additionally, the semester six students were able to compare the learning platform with traditional face to face lectures without additional support as the only means for learning during semester one to three.t. In comparison, the students in semester one had nothing to compare with given that the platform for drug calculation had been there since they started their education. The statistical item difference between semesters one and six was shown for the dimension, 'Usability': "The web-based learning platform for drug calculation was easy to use" and "It was easy to navigate on the web-based learning platform for drug calculation" might be related to the students' experience of the platform. For the remaining items, no statistical significant differences between the two groups were seen. The mean and median value showed an overall more positive evaluation for semester six, which may possibly be due to students in semester six having identified the need to combine the theoretical preparatory training in drug calculation with practical application at their clinical training. Students in semester one had not yet taken part in any clinical training.

For the quality content analysis, self-determination was something that students clearly highlighted. They appreciated the availability to the platform for drug calculation and the possibility to rewind and repeat the content of the platform at any time of day. This is in line with Hanson's (2016) and Button et al.'s (2014) results, which also reported that e-learning provides learning progress and deeper learning skills. However, technical problems relating to the students use of different browsers' firewalls could affect pausing, rewinding and fast forwarding when using the e-learning videos. Such problems can influence the degree of self-determination; therefore, we recommend that universities have IT-support available and to give the students information, both written and verbally about which browsers are preferred when introducing e-learning lectures. Button et al. (2014) found that problems using web-based lectures were related to students' different skills in ICT. Nevertheless, as student's skills in ICT was not explored in the current study, this is only an assumption. However, we argue that the availability of the platform and the possibility to rewind and repeat together with ICT competence are parts of a whole for the students to perform safe drug calculation. Students highlighted the benefits to be able to go back and control their comprehension via quizzes and PowerPoint presentations. They appreciated the possibility to calculate and test their skills at their own pace and wanted similar exercises to promote and enhance learning. This falls in line with Lee and Lin's (2013) study that found that students appreciated the opportunity to learn in a less stressful environment and preview and review anywhere and anytime during the semester; as a result, the students wanted more quizzes to test their skills (Lee and Lin, 2013). Similar results were reported by Messineo et al. (2015) and Nyroos et al. (2016) who found that quizzes are not only an educational tool to promote and enhance learning but also a more effective way to achieve deeper learning. Nyroos et al. (2016) also found that quizzes not only increase learning but also decrease anxiety about tests. Questions regarding students' anxiety about tests were not asked in this current study, but knowledge of this can be important because of the requirement of 100% correct answers to pass the test in drug calculation. An evaluation to determine if the students had increased their skills in drug calculation was not conducted; nevertheless, some students indicated that they had increased their understanding and were thus carrying out drug calculations more safely. This s in line with the study by Mettiäinen (2014) were the students assessed that their skills in drug calculation had increased after the web-course. With these findings in mind, we argue that giving the nursing students the opportunity to control their own comprehension is an important tool for testing the students' skills and supporting their knowledge in drug calculation; as a result, it may also increase patient safety.

Many students mentioned that the learning platform for drug calculation was a supportive tool for their learning because difficult areas were explained at a good pace; however, in contrast, other students stated that the pace was a bit too slow and over explicit. Because opinions vary about the best pace and what is difficult, it would have been interesting to ask questions about the students' previous education in mathematics; according to Thompson et al. (2015), this, together with demographics, motivation, anxiety about maths and one's family

background, is one of many things that can impact one's performance in drug calculation.

Students mentioned that having access to different educational and learning strategies was positive and supportive to their learning process. This falls in line with a study which found that different available resources allowed the students to work at their own pace and were useful for checking answers and aiding understanding. When students got the wrong answers, they were able to go back and check their understanding (Wright, 2012). The benefit of this falls in line with a study that combined different teaching strategies, such as traditional face to face lectures and e-learning, in drug calculation and drug administration with the aim to reduce medication errors. The findings were that the students' awareness of medication administration and patient safety issues, in which drug calculation is a part, increased (Latimer et al., 2017). A similar result was observed in another study where nursing students used an e-learning program in drug calculation. After using the e-learning program, the ability for them to understand and perform drug calculation was higher in the group that was supported by an e-learning program than with the group that experienced only traditional face to face lectures (Lee and Lin, 2013). Thus, the positive evaluation of the web-based platform for drug calculation may be related to the students' different ways of learning and a result of the students having experienced different educational approaches instead of only traditional face to face lectures. With these results in mind, we claim that a combination of synchronous traditional classroom learning combined with asynchronous digital learning spaces where students can learn at their own pace and with the opportunity to go back and control what and how they have learnt benefit students 'drug calculation competency.

Handing out and collecting the questionnaires in the classroom may be seen as a strength because the response rate probably rose. A weakness is with the number of participants: only a few students from one school of nursing participated; therefore, the result in this study cannot be generalised. However, the results indicate that the students experienced the e-learning platform as useful and able to support their learning process in drug calculation. Credibility was assured by the approach of the analysis with open-ended questions. The first author of this study performed the analysis, and the second author subsequently reviewed and approved the analysis.

5. Conclusions

Drug calculation is an important task in nursing, and to decrease errors attention must be taken during the training of nursing students at the universities. This study shows that a web-based learning platform for drug calculation is useful as it was experienced as supportive and beneficial to students' learning. Nevertheless, further research exploring relations between exposure to web-based learning strategies and advancement in drug calculation competency is needed as drug calculation and administration is a major prerequisite impacting safe practice.

Conflicts of interest

The authors have no conflicts of interest to report.

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Ethical approval details

Not applicable.

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