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A blended learning teaching strategy strengthens the nursing students' performance and self-reported learning outcome achievement in an anatomy, physiology and biochemistry course – A quasi-experimental study

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ABSTRACT

In nursing, bioscience is regarded as one of the cornerstones of nursing practice. However, bioscience disciplines as anatomy, physiology and biochemistry are considered challenging for students and the failure rate is high. In this study we explore a blended learning teaching strategy in an anatomy, physiology and biochemistry course for first year Bachelor nursing students. In the blended learning teaching strategy, short narrated online digital resources of bioscientific terms and concepts were integrated into the teaching design along with digital meta-cognitive evaluations of learning outcomes. Results show that compared to students receiving traditional face-to-face teaching, the students with a blended learning approach performed better on their national exam with a small to medium effect size (Cohen's d=0.23). Student course evaluations supported the blended learning delivery with small to medium effect sizes. The students reported that the digital resources supported their learning outcome achievement, that they better understood the teacher's expectations and that they were more satisfied with their virtual learning environment. This study adds to the growing literature of blended learning effectiveness in higher education, and suggests the use of digital resources as an enrichment of teaching and enhancement of students' study experience.

1. Introduction

By nature, anatomy and physiology courses are challenging with a high volume of subject specific terms that the students need to understand before they can begin to develop conceptual mastery in these disciplines (Slominski et al., 2019). The knowledge of bioscience (e.g. anatomy, physiology, biochemistry, microbiology and pharmacology) is necessary as a basis for clinical biomedical subjects, such as clinical pathology, clinical microbiology, and pharmacology as well as in nursing theory on basic physiological needs, hence bioscience for nursing is considered one of the cornerstones for nursing practice (Craft et al., 2017). Nurses having expert knowledge and competencies in bioscience have been shown to be more confident and competent practitioners (Montayre et al., 2021; Prowse and Lyne, 2000; Van Wissen and McBride-Henry, 2010), as well as better working in teams (Prowse and Heath, 2005). Nurses need to measure and interpret physiological patient data, and without an understanding of these processes, nurses would lack the insight of the meaning to physiological changes a patient goes through (Smales, 2010).

It is well documented that theoretical concepts in biosciences are an area of knowledge acquisition that nursing students find difficult to understand (Jensen et al., 2018; Jordan et al., 1999; McKee, 2002; Montayre et al., 2019; Smales, 2010) and a source of anxiety amongst students (Craft et al., 2013; Crane and Cox, 2013; Nicoll and Butler, 1996). The Human Anatomy and Physiology Society (HAPS) highlights that there is a need to improve the teaching of and performance in biosciences in nursing where attrition rates are high (Hull et al., 2016). A recent review by Jensen and colleagues (2018) shed light on the bioscience challenge in nurse education. The lectures have high expectations, but the students' attainment is low, and there is a discrepancy between the students' high satisfaction score in the bioscience courses and the relatively poorly examination results. Research also reported

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lack of knowledge of how best to support students' learning in effective ways for biosciences in nurse education. McVicar and colleagues (2015) have identified predictive factors of student outcomes in theoretical bioscience courses in undergraduate nursing programs. They found two levels that influence student performance: students and learning environments. For students, entry level, science self-efficacy and study skills were significant, while for learning environments attributed to the institution, the lecturer's skills and teaching strategies influenced the performance.

It has been shown that the use of contemporary digital strategies in teaching of biosciences that complement the traditional use of lessons, has led to an enrichment of bioscience in nursing programs (Bingen et al., 2019; Johnston et al., 2018; Montayre and Sparks, 2018; Todorovic et al., 2016). In higher education, tablets and mobile phones have been shown to improve learning through better observations, higher motivation, improved feedback from instructors, increased sharing of knowledge and opinions, improved coherence, improved structure, improved preparations, and increased reflection (Mathisen and Bjørndal, 2016).

The teaching strategy where online digital resources are combined with face-to-face teaching is called blended learning (Lothridge et al., 2013). Blended learning deliveries have been found to induce proactive behaviors in learning, rather than an outcome that originates from instruction, that define self-regulated learning (Lynch and Dembo, 2004; Van Laer and Elen, 2017). Self-regulation involves cognitive, i.e. task definition, goal-setting, metacognitive, i.e monitoring of knowledge of cognition and behavior regulation, and motivational aspects, i.e. learning (Van Laer and Elen, 2017; Zimmerman, 2000a). Seven aspects of blended learning have been identified: (1) topic relevance (2) tailored learning environment, (3) learner control, (4) scaffolding, (5) interaction, (6) reflection cues and (7) calibration cues (see Van Laer and Elen, 2017 for description). The interaction of these factors in a blended learning environment initiates and maintains learner behavior that explains better performance.

Within nursing education, blended learning is rapidly becoming the new standard for delivering course content (Leidl et al., 2020). Recently, it has been reported that nursing students prefer a blended learning delivery in bioscience instead of exclusively traditional face-to-face learning (Montayre et al., 2019). However, in order to master bioscience, the importance of interactive on-campus activities for nursing students alongside traditional online activities has been pointed out (Bingen et al., 2020). A recent meta-analysis on blended learning approaches from all domains, found significant effect sizes (Cohen's d = 0.20–0.35) in studies contrasting blended learning with traditional face-to-face instruction (Means et al., 2013). However, only blended learning approaches, and not pure online learning, were significantly better when measured against face-to-face deliveries. They also found that blended learning courses were effective in teaching undergraduate and health care students best. Li and colleagues (2019) through a systematic review of learning in nursing, found that blended learning approaches can effectively improve knowledge and satisfaction of nursing students, but highlight that there is a lack of research on the topic.

Internet sites such as YouTube have become a useful resource for information in bioscience, however, the challenge is to find professionally relevant videos (Azer, 2012). The content of the digital resource and learning outcomes must be consistent, and the development and integration into study programs must be conceptualized within a clear pedagogical approach to ensure a targeted and meaningful learning process (Sowan and Idhail, 2014).

In this study we have produced original online digital resources that were constructed in alignment with the learning outcomes of the course. The learning theory that underpins the development of the digital resources is constructivism, which emphasizes the construction of new knowledge by the learner on the basis of existing knowledge as well as a focus on active learned-centered experience (Ertmer and Newby, 2013). Active learning, a form of self-regulated learning, is shown to increases student performance as described above (Freeman et al., 2014). The aim of this quasi-experimental study was to investigate the effects of a blended learning delivery versus a traditional face-to-face delivery through measuring examination results and self-reported evaluations for nursing students in a bioscience course. We propose, in line with previous research, that students who undergo a blended learning approach will outperform students from a traditional face-to-face approach. They will also report higher satisfaction and learning outcomes achievements.

2. Methods

2.1. Participants

Participants were recruited in the first semester of nursing bachelor studies in Norway two consecutive years. The students of 2016 (N = 172; 88% female) received traditional face-to-face teaching strategies, hereafter named FF-students, while the students of 2017 (N = 216; 85% female) received teaching strategies involving blended learning, hereafter named BL-students. The students in this study were met by identical teachers in the same learning environment with nationally defined learning outcomes. Entrance requirement scores from high school was 44.7 for the FF-students and 46.1 for the BL-students (B+ Grade point average (GPA); Coordinated admission, 2017).

2.2. Design

The anatomy, physiology and biochemistry (APB) course (12 ECTS), which is taught over 16 weeks during the 1st semester, was used as the study object in a quasi-experimental design. The Norwegian center for quality and assurance in higher education (NOKUT) implemented standardized national examinations in anatomy, physiology and biochemistry in 2015. National standardized exams are supposed to enable unbiased comparison of different higher education courses and evaluations.

In total, the APB course consisted of 13 modules where the topics in each module were in accordance with the national subject content in anatomy, physiology and biochemistry. The teaching strategies used in this course are based on the principles of student active learning that have been shown to increase students' learning outcomes (Freeman et al., 2014; Goodman et al., 2018). The lectures were presented in a large class lecture theater in a didactic format including peer learning and kinesthetic activities such as practical exercises and animal organ dissection (heart, lung, trachea, liver and oesophagus from deer, moose and sheep). The seminars were student-led presentations in dialogue with the teacher for 1/4th of the class at a time. The teacher decided the seminar form and tasks in advance of the seminar. Students could access study resources as learning outcomes, seminar assignments and work-sheets for lectures in the University's virtual learning environment (VLE). Digital summary lessons (n = 11) of the different organ systems were delivered via VLE 3 weeks prior to examination.

The blended delivery to the BL-students involved lectures and seminars presented in the same format as for the FF-students with the same lecturers and seminar teachers, however with less student-teacher hours. In total, the FF-students had 97 student-teacher hours, and the BL-students had 81 student-teacher hours. In addition to lectures and seminars, the BL-students were presented for in total 75 online digital resources (DIGIs) in their University's VLE. The BL-students could access 5–10 DIGIs per week to complement the APB topics for the week. The DIGIs would fall into the 3 categories: DIGIdraw; DIGIflow; and DIGImcq. DIGIdraw is a 3–7 min recording of an APB concept drawn and explained using a digital graphics tablet (Wacom Intous, Wacom Co. Ltd., Kazo, Japan). The DIGIflow is a PowerPoint (Microsoft Windows, Washington, USA) recording of a flow-chart that visually displays step by step a physiological process sequentially explained. Both DIGIdraw and DIGIflow were recorded in an educational video platform (TechSmith Relay, Michigan, US), and the recordings were provided by the

bioscientist who gave most of the lectures and was well known to the students. The DIGIdraw and DIGIflow were made according to the recommendation by Guo and colleagues (Guo et al., 2014) and with constructivism as a theoretical foundation (Ertmer and Newby, 2013). The title of the DIGIs were reasonable general with a single line description. In the seminar assignments the BL-students were asked to view, draw along or consecutively explain by turning off the sound of the DIGIs. DIGImcq is an individually digital multiple-choice question test (15–25 questions) from each body system (n = 13) produced in the University's VLE by the teacher. The students get the score immediately after delivery. The DIGImcq were open throughout semester and the student could conduct the tests as many times they wanted. In the beginning of each seminar, the DIGImcq, on individual level, was completed, given a metacognitive digital evaluations of learning outcomes. The teacher used the total score of the students for guidance through the seminar. As an example of the teaching delivery for the two student groups, Fig. 1 represents the course design for the circulatory system module.

Examination grades from each year were used as the dependent variables. Examinations were graded on an A to F scale by two external evaluators (from a total of 80) who were appointed by NOKUT. Examination responses were randomly assigned to one of the 159 pairs of graders. Interrater reliability was moderate to high for all parts of the examination (Cohen's k = 0.45–0.98; Pedersen et al., 2018). For this study, the grades were then converted to numbers (A=5, B=4, C=3, D=2, E = 1, F=0, where F represents failure) for analysis purposes.

Quantitative data was anonymously collected online for student evaluation of the APB course. In the course evaluation survey, a validated questionnaire was used, asking the students eight questions (see Table 3). The answers were recorded on a 5-point Likert scale from 1: 'totally agree' to 5: 'do not agree at all'. The student evaluation survey had good reliability (Cronbach's α = 0.866).

In addition, the BL-students were asked two questions about the DIGIs in a separate online questionnaire. The first question was "How often have you taken the DIGIdraws and DIGIflows in use?", and the answers were recorded as "seen all, seen some, seen none". The second question was "How useful do you think the DIGIs were to achieve your learning outcomes?", and the answers were recorded as "high level, middle level, low level".

2.3. Analysis

Statistical analysis was done with SPSS Version 24 (IBM Corporation, Armonk, NY, USA). All variables were centered and standardized for analysis. Alpha (α) levels for hypothesis testing was set at the.05 level (two-tailed). To test the effects of a blended learning versus a traditional learning approach, a *t*-test for independent samples was used. Delivery (BL vs FF) was used as the independent variable while the dependent variables were grades and course evaluations. Analyses for gender were also carried out to see if there were any gender effects. Group comparisons (independent-sample *t*-test) were conducted for student course evaluations.

2.4. Ethics

The study conformed to institutional guidelines and was eligible for approval by the Norwegian Social Science Data Services' (NSD) ethical guidelines for experimental studies. No further formal applications were

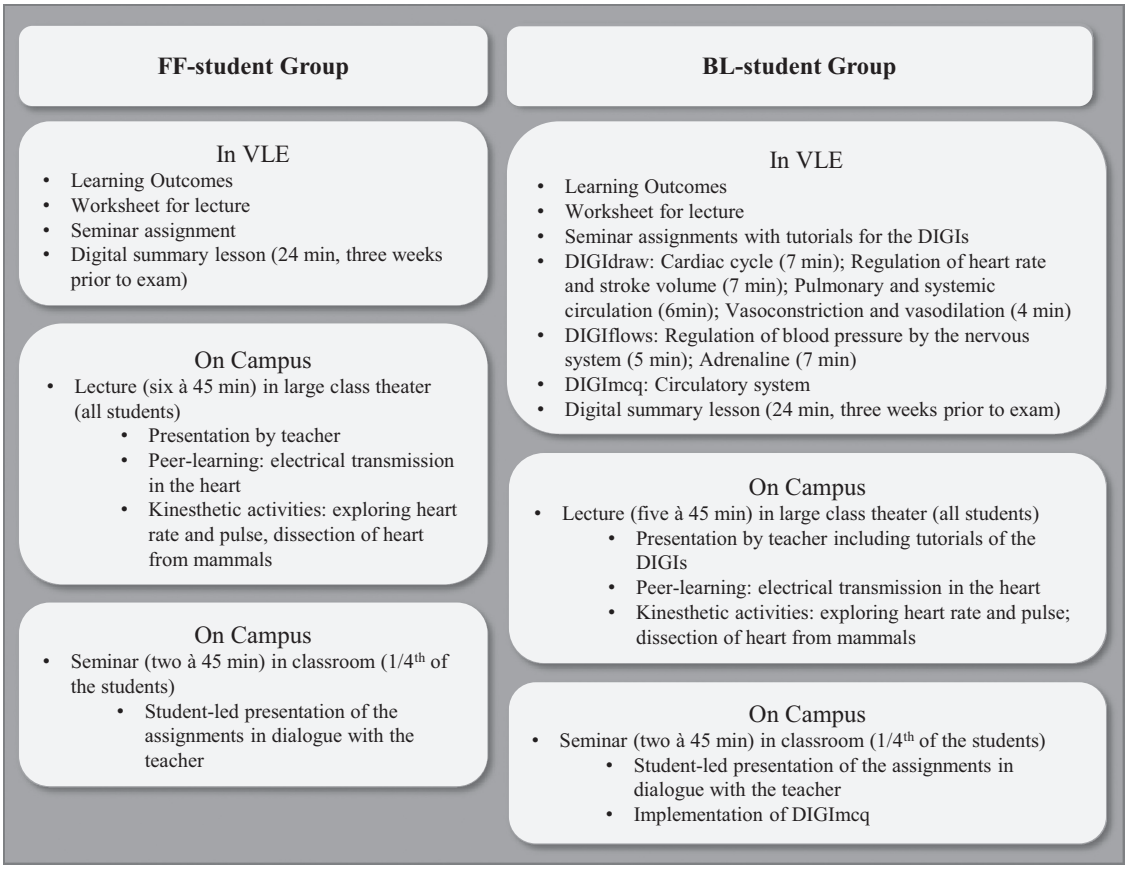

Fig. 1. Course design description of the circulatory system for both student groups. The University's virtual learning environment (VLE) used Fronter (It's learning, Norway) as an online platform for the FF-students, and Canvas (Instructure-com, Utah, US) for the BL-students. DIGIdraw is a video where an APB concept is explain using drawing. DIGIflow is a video where an APB concept is explain using a flow-chart. DIGImcq is a multiple-choice questionnaire. There are in total 13 modules in the APB course.

required after Norwegian law since only anonymized and non-health related data was collected and processed. Answers to questionnaires were considered voluntary participation. There was no participant list, and the results did not include any identifying information.

3. Results

Descriptive statistics for examination scores can be found in Table 1. A blended learning delivery had positive effects on both ends of the grade scale. More students scored higher grades (A: 6.2%; B: 5.2%) and fewer students (6.2%) failed the examination, however the attrition rate was still high for both groups, 23.8% and 17.6% for FF-students and BL-students respectively. To test the hypothesis, an independent sample *t*-test was conducted where teaching design delivery was used as the independent variable and grades were used as the dependent variable. Results show that the BL-students performed better ($t = 2.321$, $df = 387$, $p = .032$, CI [−0.671, −0.030]; see Table 2 for means) with a small to medium effect size (Cohen's d=0.23). Even generally to be considered a 'small' effect, it would produce an increase of almost ½ a grade; a difference that most schools would probably categorize as quite substantial. Nationally, there were no significant difference in average exam grade between the two years (Pedersen et al., 2018).

Gender effects were also tested where both genders showed a change in mean scores. While males given a blended learning delivery scored higher (M=2.31, SD=1.575, $N = 20$) than males given the traditional face-to-face delivery (M=2.05, SD=2.669, $N = 30$), there was no significant difference ($t = 0.572$, df=50, $p = .570$, CI [−1.185,.660], Cohen's d=0.16). However, for females a blended learning delivery had a significant effect ($t = 2.311$, df=334, $p = .021$, CI [−0.77, −0.06], Cohen's d=0.25). The descriptive statistics for BL-students' females were; M= 2.59, SD= 1.63, $N = 152$ and for the FF-students' females; M= 2.19, SD= 1.53, $N = 184$.

There were mixed findings on the course evaluations between the years (Table 3). Significant effects supporting the blended learning delivery were seen in less uncertainty for teacher expectations (Cohens's d=0.39), and the virtual learning platform helped student learning (Cohen's d=0.43). While not significant, difficulty with learning was less reported in the blended learning group (Cohen's $d = 0.29$, $p = .064$).

BL-students reported a high view rate of the DIGIdraws and DIGIflows (80.2% seen all, 15.2% seen some, 4.6% seen non, n = 151) and high self-reported learning outcome achievement by using DIGIs (90% high level, 7.3% middle level, 2.7% low level, n = 151).

4. Discussion

In this study we investigated the effects of a blended learning delivery versus a traditional face-to-face delivery through measuring the examination result in an anatomy, physiology and biochemistry course for first-year students in nursing, as well as their course feedback evaluations. We found that a change in teaching strategies towards blended learning made an improvement of the exam results, although with moderate effect sizes. However, this constitutes approximately an improvement of half a grade. For educational settings, small effect sizes are meaningful. The effect sizes from this study correspond to the effect sizes found in Means and colleagues (2013) meta-analysis of online and blended learning across education domains. The implementation of online digital resources (DIGIdraw, DIGIflow and DIGImcq) conceptualized within the concrete framework of the curriculum structure, supports a constructivist theoretical foundation transforming from teacher-centred to a student-centred approach (Kala et al., 2010). Students were able to integrate the knowledge presented in the digital resources at their own pace, anywhere and anytime and thus build layers upon layers of knowledge (Kala et al., 2010). In line with our findings, flexible, adaptable, self-paced online resources in bioscience have shown to support the academic outcome (Shang and Liu, 2018; Todorovic et al., 2016). However, studies presenting academic performance and effectiveness by use of online digital bioscience resources are limited (Jensen et al., 2018). Gender effects were also found. Females who undertook the blended learning course did significantly better that the females receiving traditional face to face delivery. Males did not show these tendencies. Females have reported better self-regulation in education.

Table 1
Distribution of Exam Grade by Student Group.

Exam Grade	FF-student Group	BL-student Group	Total	*% Change*
A	6	21	27	+6.2
B	34	54	88	+5.23
C	43	48	91	−3.30
D	31	31	62	−3.75
E	17	24	41	+1.22
F	41	38	79	−6.24
Total	172	216	388	

Passing grades (A-E). Abbreviates: FF, face-to-face; BL, blended learning.

Table 2
Group Statistics for Examinations.

Student Group	*N*	*M*	*SD*	*SE Mean*
FF-student Group	172	2.17	1.546	0.118
BL-student Group	216	2.55	1.619	0.110

Abbreviates: FF, face-to-face; BL, blended learning.

The digital resources included a metacognitive evaluation from the students where they judged their knowledge on the topic and if this was low, it was discussed in further detail during seminars. McGarry and colleagues (2015) reported in their integrated review that flexible learning design promotes student's engagement and develops metacognitive learners. Metacognitive instruction has been found to have medium effect sizes (Hedges' g=0.66; Donker et al., 2014). Metacognition has been identified as a strong predictor for learning and achievement in the sciences due to its influence on knowledge and self-regulation development (Schraw et al., 2006).

Being able to practice on digital resources and discussing the difficulties in the classroom settings, helped to knowledge acquisition. Students needed to be active and having a measurement of understanding (the metacognition follow up questions) helped reformulate problems. DIGImcq resources also let students try and fail with the possibility of new chances and support in lectures and seminars. The online platform with its automatic grading is also a powerful tool that allows teacher to apply formative assessment while minimizing the time and the labor required (De Kleijn et al., 2013). Ongoing evaluation helps decipher which concept students find difficult and enable to target the teaching strategies to meet the learning needs of individual students and student cohorts (Evensen et al., 2020; Salvage-Jones et al., 2016). However, for all these factors to have an effect, teacher behaviors and the presentations of the curriculum will mediate the outcome (Forbes et al., 2016; Guo et al., 2014; Ross and Gray, 2006).

In this study, we also investigated the effect of a blended learning delivery on the self-reported course evaluations. Most BL-students took the digital resources in use, and the students evaluated them as valuable in their achievement of knowledge. Several studies demonstrate a high impact on student engagement and motivation to learn bioscience by integrating online resources in the curriculum (Koch et al., 2010; Mikkelsen, 2015; Montayre and Sparks, 2018; O'Flaherty and Laws, 2014; Pickering and Swinnerton, 2019; Todorovic et al., 2016). In the survey the BL-students reported a better understanding of the teacher's expectations and a higher degree of satisfaction with the VLE than the FF-students. In this virtual environment, digital resources were integrated with other learning resources in a structured way. By using a VLE to present digital resources, the result indicates that the students experienced the VLE as more supporting to their learning. Advocates of these

Table 3
Comparisons on Course Evaluations.

	FF-student Group ($N = 98$)		BL-student Group ($N = 66$)					
	M	*SD*	*M*	*SD*	*t*	*p*	*CI [LL;UL]*	Cohen's *d*
General teaching gave a good overview of the subject	1.34	.61	1.33	.90	.05	.958	−0.22;0.23	.01
It was difficult to learn the different themes of the course	3.21	1.25	3.56	1.19	−1.87	.064	−0.73;0.02	−0.29
The course was interesting and exciting	1.42	.65	1.45	.92	−0.30	.767	−0.27;0.20	−0.04
It was meaningful to invest a lot of time in the coursework	1.39	.65	1.50	.88	−0.84	.402	-0.36;0.14	−0.14
I was unsure what the teacher expected of me	3.71	1.13	4.12	.99	−2.47	.015	-0.74; −0.08	−0.39
It was clear which knowledge was expected for the examination	1.65	.78	1.45	.88	1.50	.136	−0.06;0.45	.24
Coursework activity helped with learning outcomes	1.35	.64	1.41	.72	−0.577	.565	−0.28;0.15	-0.09
Using the virtual learning environment supported my learning	1.76	.93	1.39	.78	2.80	.006	.11;0.63	.43

Abbreviates: FF, face-to-face; BL, blended learning.

types of learning environments argue that they could potentially eliminate the barriers to learning by providing increased convenience, flexibility, the currency of material, individualized learning, and feedback over traditional classrooms (Chou and Liu, 2005). Recently, Sáiz-Manzanares and colleagues (2020) showed that blended learning applied in learning management system with hypermedia resources favors greater achievement of effective learning in nursing students.

There were qualitative differences in delivery of the courses that also need to be taken into consideration. Students receiving the blended learning course had a reduction of 14 h of traditional lectures (31%) compared to the previous year. In line with the findings from Lothridge and colleagues (2013) quoting that a blended learning approach is efficient, timely and cost effective, this change in quality might also be a reason for institutions changing their delivery. The students with the blended learning delivery received less teacher facetime and they were forced to use more self-regulated learning strategies (Zimmerman, 2000b) due to the inclusion of digital resources in both lectures and seminars. The importance of self-regulation in an e-learning environment may be related to the fact that students often work in an isolated environment and need to be autonomous learners, especially when the study area is conceptually difficult (Bingen et al., 2019; Greene and Azevedo, 2010). If the students wanted to gain an understanding of the concept of these themes, they had to adopt the online digital resource tools. Button and colleagues (2014) in their review of blended learning in nursing education, stated that some students feel an anxiety when using a computer and a high level of frustration when online programs did not work sufficiently. In this study, we wanted to take this into account and make the DIGIdraws and DIGIflows easy to achieve. The digital resources were mp4-files they could view in the virtual learning environment or download on their computer, and the DIGImcqs were integrated in their virtual learning environment. The BL-students supplemented the face-to-face teaching with more self-regulated learning activities that matched their skills set better as recommended (Huba and Freed, 2000; Margaryan et al., 2011).

There are several limitations for this study. Both the entrance requirements for the students and enrollment increased from 2016 to 2017. The GPA were 1.5 points higher in 2017 than in 2016 and this could influence the results. It has been reported that students with higher GPA's perform better in bioscience (Raynor and Iggulden, 2008). Even though the findings in this study were significant, the average grades were below average (C:3) levels. There was an overall improvement on the top side of the grading scale, but there were negative trends from grades C and below, with the only exception being fewer failing grades. For the students to adapt the digital resources as part of the learning design required both technical skills and motivation for conceptual development. Blended learning, as used here, may be benefiting for students who have higher levels of self-regulated learning and who already perform better. Students with better self-regulation skills typically learn more with less effort and report higher level of academic satisfaction (Zimmerman, 2000a). The mean for the BL-students may be higher due to a shift on the top end of the grading scale instead of a shift from the whole group.

Generational differences may be a factor. The groups are from two cohorts from different years. Using a matched sample from another institution that was not subjected to a blended learning course could have offered more sensitive results. Nationally, however, there were no differences in exam grad distribution in the student groups from 2016 and 2017 (Pedersen et al., 2018).

It must also be noted that the FF-students had a different online platform (VLP; Fronter) than the BL-students (Canvas). The change in VLP may have contributed to the findings. Furthermore, there is also a possibility that differences between the exams of 2016 and 2017 may have influenced the results. However, as there were no significant differences in the national overall results between the two years, this explanation seems less probable (Pedersen et al., 2018).

5. Conclusion

Students in bioscience need to master a huge volume of terms before they can begin to develop conceptual mastery. After integrating short narrated online digital resources of bioscientific terms and metacognitive digital evaluations in a blended learning design, the students scored higher on their national exam in anatomy, physiology and biochemistry. The students reported higher satisfaction with the virtual learning environment and they better understood what the teacher's expectations were. This study adds to the growing literature of blended learning effectiveness and supports blended learning as a teaching strategy in bioscience for nursing education. Future studies should also include a measurement and interventions for metacognitive development within the blended learning delivery, as these may have greater beneficial effects.

Ethics approval and consent to participate

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CRediT authorship contribution statement

Conception and design og study: HK Grønlien, TE Christoffersen, Ø Ringstad. Acquisition of data: HK Grønlien, RG Lugo. Analysis and Interpretation of data: HK Grønlien, RG Lugo. Drafting the manuscript: HK Grønlien, M Andreassen, RG Lugo. Revising the manuscript critically for important intellectual content: HK Grønlien, TE Christoffersen, Ø Ringstad, M Andreassen, RG Lugo.

Conflict of interest

None.

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