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Studying physiology within a flipped classroom: The importance of on-campus activities for nursing students' experiences of mastery

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Abstract

Aims and objectives: To explore the on-campus activities of the flipped classroom and their role in nursing students' experiences of mastering physiology.

Background: A nurse must be confident in their knowledge of physiology to feel confident as a nurse. However, many nursing students do not believe in their ability to master physiology. The flipped classroom design could facilitate active learning and promote students' confidence and competence in physiology.

Design: A design-based research design was employed.

Methods: Twenty-three nursing students enrolled in an anatomy and physiology course participated in two focus group interviews and wrote two individual reflective notes. The data were analysed by means of systematic text condensation and activity theory. Reporting was guided by the Consolidated Criteria for Reporting Qualitative Studies (COREQ).

Results: The study findings underscore the importance of careful design of on-campus activities within the flipped classroom to support students' experiences of mastery in physiology. Four themes were identified: (a) preparation which builds a foundation for learning; (b) the use of digital tools; (c) learning through dialogue with peers; and (d) experience of the expected learning outcomes.

Conclusions: On-campus learning activities within a flipped classroom design could support students' experiences of confidence in and mastery of physiology. However, the study participants found learner-centred activities challenging and described feeling doubtful of their ability to master physiology. A didactic framework could take into account the circumstance that students perceive educational technology differently. When designing on-campus activities, emphasis should be placed on collaboration rather than competition to help students develop confidence in their knowledge of physiology.

Relevance to clinical practice: It is important to support nursing students' knowledge acquisition in bioscience and their development of confidence as these skills could enhance their clinical judgment in practice. Comprehension of bioscience is necessary to provide safe patient care and competent nursing.

KEYWORDS
active learning, flipped classroom, mastery, nursing education, physiology

1 | INTRODUCTION

Understanding basic bioscience is fundamental to providing competent and safe nursing (Taylor, Ashelford, Fell, & Goacher, 2015), and an increased focus on bioscience in nursing education may improve patient outcomes (Bakon, Craft, Christensen, & Wirihana, 2016). However, many nurses lack confidence in their bioscience knowledge, and nursing students find bioscience, particularly physiology, challenging; as a result, they attain a limited mastery of the topic (Andrew, McVicar, Zanganeh, & Henderson, 2015).

Active learning could promote nursing students' engagement, knowledge acquisition, competence and confidence (Murray, 2016). In a flipped classroom (FC), the traditional model of classroom-based learning is reversed: the students are introduced to the learning material at home, and during classroom time, they complete assignments (Bishop & Verleger, 2013). Students watch online lectures off campus to gain knowledge which they can understand and retain. On campus, they complete exercises with teacher assistance, such as presentations and discussions, to gain knowledge which they can apply and use for analysis (Bishop & Verleger, 2013; Hwang, Lai, & Wang, 2015; O'Flaherty & Phillips, 2015). Digital tools used on campus such as a student response system (SRS) could facilitate student activity and formative assessments (O'Flaherty & Phillips, 2015), and collaborative activities could promote higher levels of cognitive learning (Hwang et al., 2015). Teaching biosciences in nursing can be particularly challenging in large classes (Bakon et al., 2016; Taylor et al., 2015). However, the use of an FC seems to facilitate active learning in large classes (Santos, Fig ueiredo, & Vieira, 2019) and enhance nursing students' knowledge of the subject matter (Ward, Knowlton, & Laney, 2018).

Research indicates that on-campus activities are crucial to the success of the FC (Foldnes, 2017), yet more knowledge is needed about nursing students' difficulties in studying biosciences, the learning environment's characteristics, the use of technology and students' study skills (Jensen, Knutstad, & Fawcett, 2018). The present paper is part of a larger study exploring nursing students' experiences with the FC within a design-based research frame (Bingen, Steindal, Krumsvik, & Tveit, 2019; Bingen, Tveit, Krumsvik, & Steindal, 2019). The aim of this part of the study was to explore the on-campus activities of the FC and their role in nursing students' experience of mastering physiology.

What findings does this paper contribute to the global clinical community?

- Careful design of on-campus activities can support nursing students' mastery of physiology, which can lead to more confident nurses.
- For nursing students who struggle with confidence in their knowledge of physiology, collaborative activities seem to be better than competitive activities.

2 | BACKGROUND

Research on the on-campus activities in an FC to facilitate the learning of physiology in nursing education is limited. A literature review indicates that, even though nursing students have found on-campus activities to be helpful and the interaction and engagement facilitated learning, many students preferred the traditional classroom approach because of the time required for off-campus preparation (Ward et al., 2018). Off-campus preparation is central to the success of the FC design (Bingen et al., 2019; Mikkelsen, 2015), and students who commit to preparing for and engaging with bioscience lecture content perform better (Jensen et al., 2018). Some students think that it is sufficient to watch online lectures and thus do not participate in on-campus activities, but research indicates that in-class attendance has a positive impact on students' achievement (Foldnes, 2017).

Collaborative on-campus activities can also enhance learning (Foldnes, 2017; Zhang & Cui, 2018), and Santos et al. (2019) found that peer learning could be favourable for learning on campus. Other studies have found that an approach combining collaboration, quizzes and feedback may aid in the retention of physiology knowledge (Vázquez-García, 2018) and that students may perform better in physiology instruction using team-based learning than didactic teaching (Rathner & Byrne, 2014). A collaborative approach may also assist nursing students with low self-efficacy in their ability to learn bioscience and improve their performance (Owens & Moroney, 2015).

The use of digital tools such as an SRS could facilitate nursing students' active learning in large bioscience classes (Efstathiou & Bailey, 2012) and FCs (Bingen et al.,2019). An SRS could promote

students' engagement and interaction with peers and teachers, provide immediate feedback and adapted teaching, and improve learning and understanding (De Gagne, 2011; Nelson, Hartling, Campbell, & Oswald, 2012). Feedback provided through an SRS could have a positive impact on students' self-efficacy and their experiences of the learning environment (Buil, Catalán, & Martínez, 2016).

According to Bandura (1994), self-efficacy is a person's belief in his or her ability to produce specified levels of performance. It is developed by four factors: mastery experiences, vicarious experiences, social persuasion and somatic and emotional states. Mastery experiences are the most effective way to create a strong sense of efficacy. Students' belief in their ability to master academic activities affects their goals, concentration and achievement (Bandura, 1994).

Collaborative learning could promote a more positive self-evaluation of ability than can individualistic or competitive learning (Bandura, 1994). Collaborative learning includes students' communication with peers and teachers. Vygotsky (1978) described the zone of proximal development as the distance between the actual developmental level, a level reached by independent problem-solving, and the potential development level, a level reached through guidance and collaboration. In a student's zone of proximal development (Vygotsky, 1978), they can interact with more capable peers and, through dialogue, achieve a grasp of what those peers understand. That type of collaboration can take place through peer instruction (Mazur, 1997), an activity in which students formulate answers to the teacher's prepared questions, first individually and then in discussion with their peers. Finally, the teacher reviews the answers with the entire class.

Describing humans' activity, Vygotsky (1978) described how tools contribute to a subject's mediated actions. That is the foundation for activity theory, upon which Engeström (2015) expanded with the social aspect of activities. According to Engeström (2015), a learning activity can be understood as an activity system. Introducing new elements to the system could lead to tension, which could cause either conflict or innovative change. Based on the identified tensions, a redesign of the learning activity could be proposed (Engeström, 2000). In the present study, activity theory was used to understand students' experiences with an FC design.

We formulated the following research questions: How do nursing students experience on-campus learning activities in physiology instruction within an FC? How can those learning activities support nursing students' experiences of mastery?

3 | METHOD

Design-based research is a suitable method for the study of learning in real contexts and of educational strategies and tools. It was, therefore, used as the overall research design for the present study (Herrington, McKenney, Reeves, & Oliver, 2007). The teaching design is implemented iteratively and occurs over at least two cycles; in the present study, we examined cycle 2, focussing on on-campus activities and experiences of mastery. Cycle 1 (the pilot) (Bingen et al.,2019) and experiences of off-campus activities in cycle 2 have been previously reported on (Bingen et al., 2019).

Student focus groups and students' reflections were used to explore their reactions to the teaching design. The focus group interviews were used to learn how students experienced and perceived the intervention. More abundant data and spontaneous emotional views can be generated through focus groups than through individual interviews because of the group dynamics (Brinkmann & Kvale, 2015). Students were given the opportunity to describe their experience individually through reflective notes (Garrison & Kanuka, 2004). The reporting of the study was guided by the Consolidated Criteria for Reporting Qualitative Studies (COREQ) (Tong, Sainsbury, & Craig, 2007) (see File S1).

3.1 | Design of the course

The design of the anatomy and physiology course is shown in Figure 1. Based on the findings from cycle 1 (the pilot), we determined that the new design should encourage students to perform group tasks prior to the seminars and help them to generate their own learning materials to guide the seminars and lectures, creating a more learner-centred approach. We continued to use the online lectures and the SRS, and we included additional digital tools, such as Adobe Connect (online conference room), Wordle (to generate "word clouds) and mYouTime (multimedia presentation package for smartphones; Figure 1).

To prepare the students, an introductory programme called "warm-up week" was offered. It was designed as an FC with off-campus activities for students to complete the week before the semester began and on-campus activities the first two days of the semester. The activities focussed on how to study in an FC, familiarisation with the digital tools and the socialisation of the class and their assigned learning groups.

The syllabus was divided into five parts (see Figure 1). Via the learning management system, students could access exercises which focussed on the expected learning outcomes and their solutions. The teachers selected the exercises, including explanations for on-campus group tasks, seminars and lectures. Seminars were guided by two group products completed by the learning groups before seminars: word clouds created with keywords from each group and digital presentations on mYouTime about what they found challenging.

On-campus lectures were guided by the results of quizzes which were taken by students individually on mYouTime after seminars. Students could also participate in SRS polls and respond to questions by voting on various statements formulated by the teachers. The SRS was used twice during each lecture: (a) one question before teaching and one after lecturing, (b) the same question before and after lecturing, or (c) one question answered through peer instruction, with students discussing their thoughts with peers in between two individual voting sessions.

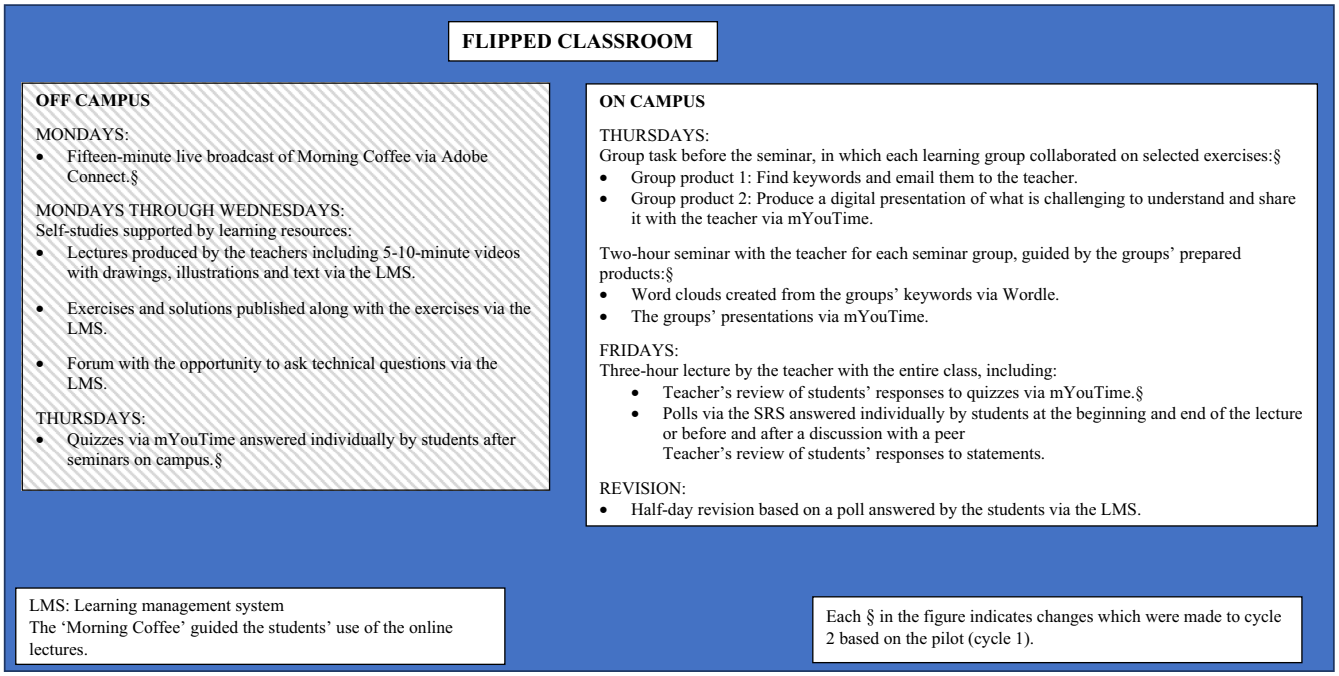

FIGURE 1 Course design description (Bingen et al., 2019) [Colour figure can be viewed at wileyonlinelibrary.com]

3.2 | Participants and data collection

The study was conducted at a university college in south-eastern Norway which offers a bachelor's degree in nursing. In 2015, 192 first-year nursing students were enrolled in the course. The students were divided into four seminar groups with four learning groups in each. The first and last authors invited two learning groups to participate in the study based on purposeful sampling (Maxwell, 2013) using the following criteria: the learning groups had to be from different seminar groups, had to include both male and female students, and had to include both students who had participated in warm-up week and students who had not. The students received invitations to participate via e-mail and agreed to participate in the study before the first focus group interview was conducted. In learning group A, 12 of 13 students agreed to participate, and in learning group B, 11 of 12 agreed. For students in learning groups A and B, the mean ages were 23.1 years (range 19–45 years) and 22.4 years (range 19–35 years), respectively. During the study, one student from each group silently dropped out.

TABLE 1 Illustration of coding and condensation of units of meaning

Unit of meaning	**Step 1**:Preliminary themes were identified after reviewing the material.
From first focus group interview "And then it's easier if you are in a smaller group if you get a question that you can't answer to say that "I don't know, can anyone explain it to me?" than if 30 students sit and watch you."	**Preliminary theme** Dialogues in class/larger groups
From reflective notes "When I feel confident in the subject matter, I feel it's perfectly okay to explain the subject matter, but when I'm not very confident I have felt it has been difficult. So it goes a bit more on myself and how confident I have been on the various topics that have decided whether it has been okay or difficult."	**Preliminary theme** Experiences explaining their understanding to others
From second focus group interview "But it was also very good because I feel that now we are a very good group, I have to boast, I feel that everyone is quite smart, I feel that if I sit with my good neighbour for example, and he has understood about as much as me, if we are just as far in the conversation, then, in a way, it tells me almost more about how well I'm doing than the task does. If I sit there and just, oi this is difficult, and then the neighbour who is approximately on my level and it is easy peasy, then I have missed. But if you don't think it's difficult, then it's fine. I think that it is a very good clue to see how well you are doing it yourself. Those conversations are very good."	**Preliminary theme** Experiences with dialogues during group tasks/ seminars/lectures

The four focus group interviews were conducted in a meeting room on campus. Focus group interviews with each learning group were conducted on the students' second day on campus and two days after their examination in anatomy and physiology. An interview guide based on the findings from cycle 1 was used to initiate dialogue between the participants and guide the discussion (Brinkmann & Kvale, 2015). The first interview guide covered topics related to starting the semester, participating in warm-up week, experiences with and thoughts about using digital tools and having technical discussions with peers when learning physiology. The second interview guide covered topics related to participating in on-campus activities, receiving and giving feedback, and how using digital tools had influenced participation in these activities. It also covered topics such as experiences of the alignment of the activities with the examination and of mastery in physiology. The interviews lasted 60–90 min and were all led by the same moderator (the first author, female). During the first interviews, a secretary (the last author, female) assisted the moderator. After the interviews, the first author wrote notes and debriefed with the last author. The interviews were audio recorded and transcribed by an external transcriber and were not returned to the participants. Between the two interviews, the participants delivered two sets of individually written reflective notes to the first author. The notes were prompted by proposed topics, including students' participation in activities and their experience of explaining knowledge to their peers. Before the analysis, the notes were anonymised.

3.3 | Data analysis

The data were analysed by means of qualitative methods (Brinkmann & Kvale, 2015). NVivo 10 for Windows, supported by tables in Microsoft Word, was used to store and analyse the material. Throughout the coding and condensation of meaning, the transcriptions of the focus group interviews and reflective notes were analysed separately. The process of systematically handling the data included reviewing the data to obtain an impression of the material, identifying the units of meaning as expressed by the participants and restating the themes which dominated the units of meaning (Brinkmann & Kvale, 2015). Malterud's (2012) systematic text condensation method was used to guide the process and to create condensed units of meaning (see Table 1), which were condensed iteratively for further abstraction.

The interpretation of meanings included asking analytical questions (Brinkmann & Kvale, 2015) inspired by activity systems analysis to look for tensions between or within the elements of the students' activity system (Murphy & Rodríguez-Manzanares, 2014).

The analysis was iterative. To facilitate the creation of competing interpretations and understandings, the first author analysed the data while the last author asked critical questions.

3.4 | Ethics

The study was approved by the Norwegian Social Science Data Services (Approval No. 43754). The students in the two groups received information about the study, and its aims the week before they met on campus. The information included an assurance that participation was voluntary and that anonymity and confidentiality would be protected. Signed, informed consent forms were collected before the study began. Anonymity was safeguarded by removing names and other identifying characteristics from the transcriptions and reflective notes.

4 | RESULTS

The analysis identified four themes: preparation which builds a foundation for learning, the use of digital tools, learning through dialogue

Step 2: The units of meaning related to the preliminary negotiated themes were identified and coded to arrange related units of meaning into thematic code groups.	**Step 3**:The units of meaning within each thematic code group were condensed and coded to arrange thematic code groups into subgroups. The units within each subgroup were condensed iteratively for further abstraction of meaning.	
Thematic code group Thoughts on dialogues—small groups—larger groups	**Subgroup** Dialogues—easier in smaller groups; if one cannot answer, ask someone to explain	**Condense** More comfortable to ask for explanations in smaller groups
Thematic code group Experiences of collaboration activities	**Subgroup** Dialogues—lack of confidence if you do not have sufficient understanding	**Condense** A need for technical confidence to explain to a peer
Thematic code group Experiences from dialogues during their first semester	**Subgroup** Dialogues/peer instruction/peers at a similar level/comparing how much you have understood in relation to your peers gives clues of how you are doing	**Condense** Comparison with peers at a similar level of how much you understand and how you are doing

TABLE 2 Overview of the themes and descriptions of the subthemes

Themes	Subthemes
Preparations which build a foundation for learning	Feeling of commitment to meet prepared in small versus large groups. Attitudes about on-campus activities which presuppose preparation and some understanding of the material. Students' responsibility to actively participate and perform group tasks and quizzes to guide the on-campus activities and lectures versus teacher's responsibility to facilitate a common foundation of knowledge in class.
Use of digital tools	Attitudes about the use of digital tools and human contact. Attitudes about how the use of digital tools can facilitate student activity. Facilitating active participation and feedback versus providing a break from listening to the teacher.
Learning through dialogue with peers	Attitudes about subjects such as physiology. Attitudes about collaboration activities; comparison of knowledge levels and perception of peers as partners versus contestants. The influence of the group size on active participation in the entire class versus seminar groups. Having the confidence to interact with peers and perceiving them as capable versus the experience of having nothing to contribute.
Experience of the expected learning outcomes	Attitudes to the alignment of teaching and the examination; activities based on the expected learning outcomes versus teacher's review of previous examination questions. Realising what you have already learned versus being worried about what you still have to learn. Experience of mastery; understanding and confirmation of it through activities based on the expected learning outcomes versus other personal requirements needed to experience a sense of achievement.

with peers and experience of the expected learning outcomes (see Table 2).

4.1 | Preparations which build a foundation for learning

During the semester, students found the on-campus preparations in their learning groups and the group tasks to be completed before seminars to be time-consuming because there were too many students in each group. That made it as one student described "hard to agree and make one common product" such as a presentation. Furthermore, students' commitment level to preparing for meetings was affected by their group size, and they observed that students in smaller groups were more committed.

Students appreciated the chance to direct the content of the seminars through group tasks such as presentations of what they perceived as challenging about the exercises. However, those who felt that they understood everything about the exercises said they had to "invent challenges" to complete the group tasks. Many described experiences of their understanding, confidence and ability to cope during seminars and lectures, which they related to their off-campus preparations and engagement in group tasks. Those preparations resulted in what they called "a foundation," which they felt aided understanding. As one student stated, "On-campus pieces fall into place, and you got explanations." Others felt that the on-campus seminars and lectures should be less learner-centred and more directed by the teachers, who "know what is on the examination and what we need to learn." Those students felt that their out-of-class preparations resulted in what they called "different foundations." They worried that they would not attain the same level of understanding as their peers because they had focussed on different parts of the syllabus. Differences in understanding caused uncertainty, and one student explained that "it would create greater confidence if everyone learned the same things." Another student said that "in class, the teacher should prepare everyone equally to give us all the same foundation and ability to cope." Students also experienced "confusion" when they believed that they had adequately prepared but the activities revealed that they had misunderstood. Additionally, a student who had met unprepared noted that "you got a shock when you didn't understand anything."

4.2 | Use of digital tools

After the on-campus warm-up week, many students were sceptical about digital tools. That scepticism was related to high school experiences in which "technology errors that took the focus from the topic" had been a problem, according to one student. Another student explained that "it isn't enough for [technology] to be fun and innovative; it must be useful, too." Some students thought that there were too many digital tools to remember how to use and that such tools should have been used less. Other students appreciated the use of tools which were more adapted to learning than social media. Other students pointed out the importance of relating to others in their chosen profession. Those students favoured the use of digital tools such as the SRS combined with peer instruction "because [peer instruction] requires you to deal with a peer and, as a nurse, you must relate to other people." Students also stressed the need for human interaction, explaining of experiences that it was "easier to remember if you could connect knowledge to faces" and that they wanted to see other people's faces during the presentation of group answers on mYouTime.

When the entire class met, students found that the SRS facilitated participation when the questions were difficult. Two examples of experiences were that "anonymity created an experience of confidence" and offered "an experience of community with others who also didn't understand." The SRS created pauses during lectures, which "[gave students] a break from listening to the teacher." As one

student explained it, "the use of SRS gives the brain another focus; I relax and remember more than if I am stressed." Others found that using the SRS gave them a chance to participate and receive feedback from the teacher, which they described as "confirmation of being on the right track." They said that questions adapted to their learning process were the most beneficial because "if [the questions] are adapted to what you have already learned, they give you the experience of understanding and coping." Students, therefore, wanted to give the teacher feedback about what they did not understand, and "then [the teacher] can adapt the lecture and explain what most needs to be explained", as one student explained.

4.3 | Learning through dialogue with peers

In the first interview, students expressed a lack of confidence in what they called "subjects with facts, such as physiology" because, as one student elaborated, "you must stick to the facts and can't tell your thoughts and opinions … You expose your ignorance if you don't know the facts." They worried about answering questions and revealing their insufficient knowledge in front of a large class. They also worried about asking questions, and one student expressed concerns about "peers thinking you ask silly questions that are of no use." Students wanted to understand physiology but felt that they needed assistance, which they said they thought peers could provide.

During warm-up week, students socialised within their learning groups and looked forward to participating in activities "where everybody knows each other" because then "you feel confident to show your lack of knowledge and you can ask peers to explain." Dividing the entire class into seminar groups facilitated students' involvement and enhanced their feelings of confidence; as one student wrote in a reflective note, "it's easier to follow lectures and participate in dialogues." Nevertheless, students stated that it was not sufficient to be confident in their peers, either during peer instruction or in their learning and seminar groups. One student explained in the last interview that "you also need technical confidence and a peer on the same level as you, who meets prepared and understands something."

Students had varied experiences of engaging in dialogue with their peers. Some felt that peers could support their learning, and one said, "We explain to each other, reason out and remember together." Others described dialogue with their peers as "rewarding," "social" and "experiences of coping." Still others felt that they or their peers had nothing to contribute to others' understanding. One said, "I was confused when I didn't understand anything during dialogues, even though I met prepared [for the meeting]."

Students compared themselves with others as a form of feedback on their knowledge during peer instruction, but one student stated, "You must accept your learning process and not compare yourself with others." The student described feeling confident throughout their dialogues and noted, "If my peer understood more than I did, I knew I'd study more." That indicated their perceived ability to improve and their use of comparison to encourage increased effort. However, others found that comparison with others lowered their perceived ability and self-confidence, thinking that "others are better than I am."

4.4 | Experience of the expected learning outcomes

Students found physiology to be a complicated subject. During the semester, their motivation to learn physiology changed from being crucial in order to "[become] a good nurse" to wanting to "just pass the examination." Some students found the exercises to be aligned with the examination because both the exercises and the examination corresponded to the description of the expected learning outcomes. That supported their learning process because they knew what was expected, which "[gave them] confidence." However, in order to feel confident about passing the examination, other students wanted to know the possible examination questions and wanted the teachers to review previous examinations.

Students described various mastery experiences related to the acquisition of physiology knowledge, including comprehension, confirmation of knowledge and confidence when participating in on-campus activities. They connected their mastery experiences to their out-of-class preparations and noted the importance of "recognition and understanding during lectures" and "answering questions and quizzes correctly" because "you knew you understood the main points." They also felt that, through dialogue with peers, "you could give explanations of physiology and receive feedback on your knowledge." However, others did not recognise the lecture content and found that they were "lacking a foundation to understand." Some had expectations other than the expected learning outcomes. One student described learning as memorising and felt that mastery experiences were presupposed by memorisation: "I need time to memorise every detail in the textbook to be perfect." Another said that mastery experiences were presupposed by application: "I must use knowledge of physiology in practical situations first." Those who struggled with the material worried about everything they had to learn, failure and performance anxiety, which interfered with their experience of mastery. As one explained, "what you haven't yet learned and you know you must learn obscures what you have already learned. If, in the process, you manage to recognise what you have learned, it motivates you to carry on." Although they emphasised their limited experiences of mastery, after they had reflected on their experience from studying physiology in the last interview, many students realised that they had "never learned so much in such a short time," but the learning had not been obvious to them during the semester.

5 | DISCUSSION

Our aim was to explore the on-campus activities of an FC and its role in nursing students' experiences of the mastery of physiology.

5.1 | On-campus activities which presuppose knowledge and understanding

We found that students managed the presupposed preparations before meetings on campus differently, which influenced their experience of on-campus activities. Students who used the preclass resources and enjoyed learner-centred teaching described an ability to cope with on-campus activities and confidence while participating in them. The out-of-class activities gave them a foundation, representing a scaffolding which supported experiences of confirmation in class and being on the same knowledge level as their peers. This is in line with the findings of other studies (Foldnes, 2017; Ward et al., 2018).

Teaching bioscience to nursing students in large classes can be challenging due to students' lack of confidence (Bakon et al., 2016), their struggles with off-campus preparations and the resulting variation in their level of preparedness, and their preference for a teacher-centred approach (Bingen et al., 2019; Koch et al., 2020; O'Flaherty & Phillips, 2015). Our findings indicated that struggling students could benefit from more in-class lectures to build their foundation of knowledge. Such a foundation could contribute to learning the same content, which may boost their confidence in and ability to cope with group activities. Struggling students also experienced confusion when misunderstandings of the material were revealed and when on-campus learning did not clarify those misunderstandings, which may have been due to an insufficient foundational scaffolding for further learning.

5.2 | Use of tools to facilitate respite, human contact and feedback

Our findings suggest that it is essential to use digital tools alongside pedagogical strategies which aid learning. Students found the use of SRS combined with peer instruction to be a welcome break during class and a facilitator of interaction with their peers. However, the use of digital tools could also reduce human contact, leaving students alone with their digital tools. It was notable that students found it easier to remember information when they could connect it to their peers' faces rather than illustrations when using mYouTime, which underscores the significance of social interactions for learning.

Our study shows that the use of an SRS promoted participation in larger groups when the questions were challenging and that it supported experiences of community, confidence, confirmation and feedback, which is in accordance with the findings of previous research (Bingen et al., 2019; De Gagne, 2011; Nelson et al., 2012). Our students stressed that they appreciated the opportunity to use the SRS to give feedback to the teacher, who could then adapt the teaching to their knowledge level and clarify misconceptions. According to Shute (2008), immediate, directive feedback is suitable for helping students to handle demanding tasks and for supporting knowledge retention, which provides support for the use of SRS. Feedback as a verification of their knowledge is often enough for high-achieving students, while low achievers might need immediate elaboration, feedback and scaffolding (Shute, 2008). Our use of SRS could allow for confirmation and instant feedback, while the teacher could provide scaffolding when reviewing the answers. Furthermore, the SRS allowed students to compare their knowledge with that of peers because it displayed the voting results of the entire class. If the use of SRS is competitive, it may not benefit struggling students as self-referenced feedback is more suitable than normative feedback for low achievers (Shute, 2008). That means that struggling students should compare their progress with what they have previously achieved rather than with that of other students. On the other hand, our students noted that the voting results revealed that their peers did not understand, either, which gave them an experience of community.

5.3 | Peer as the capable other?

Our students attributed their lack of confidence in their knowledge of physiology to its difficulty as a subject and to the large class size. Feeling more confident in small groups was not enough to encourage students to seek assistance from their peers, especially for those whose acquired knowledge was concealed by their lack of technical confidence. Thus, different students experienced peer instruction differently. Some students' descriptions of peers as "being on the same level, meeting prepared and with some understanding [of the material]" resembled what Vygotsky (1978) called "the capable other." It indicated that they had an overlapping zone of proximal development (Vygotsky, 1978) and that their different competencies aided learning through peer instruction. Others did not experience their peers as capable others but thought that more in-class lectures would have led to a similar knowledge level and a more equal zone of proximal development. Furthermore, a common goal and shared knowledge level could be incentives to take responsibility for a group's learning (Owens & Moroney, 2015). Those circumstances could have encouraged our students to make the necessary preparations in their learning groups as they expressed that they felt more committed to smaller groups. In contrast to another study (Versteeg, van Blankenstein, Putter, & Steendijk, 2019) in which students learned during discussions with an incorrect peer, our students felt that discussing physiological concepts with peers who lacked knowledge led to confusion.

Our students compared themselves with the peers with whom they conversed, which may have made peer instruction a competitive rather than a collaborative activity. The students who struggled may, therefore, not have benefitted from peer instruction because comparison with oneself is better than peer comparison to increase perceived ability (Bandura, 1994). When revealing their misunderstanding of the learning material, students with low confidence and low perceived ability felt less knowledgeable, which discouraged them. In contrast, students with high confidence and high perceived ability felt that misunderstandings were part of the learning process and motivated them to study more.

5.4 | Motivation to learn and support to experience mastery

Our students' goals changed during the semester from studying physiology in order to become a good nurse to studying physiology to pass the examination. Limited belief in their ability to gain mastery (Bandura, 1994) may have contributed to this shift in motivation as physiology is a complex subject (Slominski, Grindberg, & Momsen, 2019) and students may choose performance-avoidance goals instead of mastery-approach goals when they doubt their ability (Crane & Cox, 2013). Furthermore, it is possible that students' motivation is influenced by limited time, which could be a challenge in large physiology classes (Taylor et al., 2015). The FC might facilitate deep learning in class, but the constant introduction of new topics could still make it difficult for students to learn the material before moving on to the next topic.

Our students described their experience of mastery through experiences of understanding and recognition and through experiences of feedback gained from the use of digital tools and responses from the teacher and their peers. Yet, their struggle to exhibit what they had learned when studying and participating in activities prevented them from recognising their learning and improvement, which could be related to their low confidence and a lack of foundational scaffolding. Additionally, students' sense of having nothing to contribute to peers' understanding and their confusion during dialogue with peers may have been barriers to their experience of mastery. In contrast to the assumption that seeing others succeed creates a stronger sense of self-efficacy (Bandura, 1994), our students' confidence may have been reduced by peer comparison, and some of them reported that comparison with peers lowered they perceived ability.

Experiencing mastery might be the most effective way to enhance self-efficacy (Bandura, 1994). Students with high self-efficacy probably have more confidence when undertaking bioscience tasks (Andrew et al., 2015). A combination of feedback and goal setting may influence their motivation. Feedback on incorrect answers could motivate students with high self-efficacy because they set goals for themselves and self-dissatisfaction motivates them, while students with low self-efficacy are often demotivated because, without a goal, self-satisfaction motivates them (Bandura & Cervone, 1983). That could explain why our students responded differently to comparing themselves with peers when they answered incorrectly: some perceived that they could do better, while others thought that they did not have the same abilities as their peers.

5.5 | Tension between the design and students' expectations—an adapted teaching design

The tensions between the design of the course and students' expectations revealed by the analysis could inspire the next design of the course (see Table 2). The students' attitudes towards a learner-centred approach seemed to influence tensions for those who struggled as they wanted a more teacher-centred approach. As a supportive environment with scaffolding could improve the belief in the ability to learn bioscience for students with low self-efficacy (Owens & Moroney, 2015), we suggest continuing to offer the warm-up week to foster a welcoming learning environment and students' confidence in their peers.

Because students' attitudes towards subjects like physiology could influence tensions if students believe that it is an especially difficult subject, the next design could include a prescience course, which may improve students' attitudes towards physiology and may influence their goals (Crane & Cox, 2013). We suggest continuing to teach core concepts to build foundational scaffolding on which to continue to learn. As students' preclass knowledge could influence tensions, on-campus micro-lessons could result in shared knowledge levels and the experience of mastery. Emphasis on the connection between expected learning outcomes and exercises could also help students realise the importance of on-campus activities and motivate them to gain knowledge before attending class. We also suggest continuing the use of the SRS before in-class teaching in order to assess students' knowledge. The next design could include more time for students to reflect on what they have learned to facilitate the exhibition of their knowledge.

Our students preferred to collaborate with peers who had a similar knowledge level. However, a previous study found that students who felt uncomfortable during collaboration adopted a surface approach to learning, and mixed-level groups seem to facilitate a more in-depth approach (Beccaria, Kek, Huijser, Rose, & Kimmins, 2014). It seems essential, therefore, to emphasise collaboration over competition. Yet, another study suggests that competition between groups could be beneficial for learning and collective self-efficacy (Chen & Hwang, 2018). Our students' attitudes towards collaborative activities and the use of digital tools appeared to create tension in the design as some students lost their courage when comparing themselves with others and, at the same time, wished for more human contact. In the future, the SRS could be used with a "collective issue-quest approach" (Chen & Hwang, 2018), in which students vote as a group the second time instead of individually. As self-efficacy seemed to relate positively to pride because students attributed their success to their efforts to prepare for the SRS polls (Buil et al., 2016), the continued use of the SRS in the course design to support students' mastery of physiology is supported.

5.6 | Limitations and strengths

The study was based on one urban university college in Norway. The moderator was familiar to the students as the course administrator and as one of their teachers. That familiarity could be a strength as she was familiar with the educational practice, but it could also be a limitation (Mercer, 2007) as it may have influenced what the students were willing to share in the focus groups and reflective notes. We reflected upon our roles to be conscious of how they could influence the study. Participants were informed that what they shared would not affect their grade, and they spoke openly,

voicing both positive and negative experiences with the teaching design. Throughout the interviews, the moderator asked questions to validate instant interpretations. To further enhance the validity of the study, methodological triangulation was used (Maxwell, 2013). The research group consisted of two females and two males. Two researchers were professors: one was an associate professor and one was a PhD candidate. The sample size was evaluated to generate adequate information power (Malterud, Siersma, & Guassora, 2016).

6 | CONCLUSIONS

On-campus learning activities within a flipped classroom design seem to support students' experiences of mastering physiology through experiences of understanding and of giving and receiving explanations and feedback. There appears to be a need to go beyond digital tools and establish a didactical framework which is able to incorporate the notion that students perceive educational technology differently. When facilitating learner-centred on-campus activities for an FC, teachers must be aware of students who struggle to perform off-campus preparations. Students who lack a foundational scaffolding, which, if provided, could improve their confidence in their ability to learn physiology and their disclosure of their improvements for themselves when studying and participating in activities. Different levels of preparedness for activities which presuppose prior knowledge may result in some students experiencing feelings of failure during SRS polls and dialogues with peers if they compare themselves with peers, and they may use those feelings of failure in feedback on their own knowledge level. For large physiology classes, we recommend assigning collaborative activities to small groups in combination with the use of an SRS to facilitate students' experiences of confidence and mastery. During such activities, emphasis should be placed on collaboration rather than competition.

7 | RELEVANCE TO CLINICAL PRACTICE

An understanding of bioscience is necessary for competent nursing, so supporting students' acquisition of physiology knowledge could enhance their bioscience competence in clinical practice. A teaching design which facilitates experiences of mastery might strengthen students' goals of becoming competent nurses rather than just passing examinations. Developing confidence in their mastery of physiology could improve their ability to make clinical judgements in practice and provide safe patient care. Confidence in their abilities could also encourage nursing students to discuss and share their experiences of making clinical judgements with their tutors, peers and future colleagues.

CONFLICT OF INTERESTS

No conflict of interest has been declared by the authors.

AUTHOR CONTRIBUTIONS

Study design: HMB with the assistance of BT and RJK; data collection: HMB with the assistance of BT; data analysis: HMB with assistance from BT and SAS. All authors participated in manuscript preparation and agreed on the final version.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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