Chapter # 40

ACTIVE LEARNING METHODS IN ANATOMY TEACHING FOR OPERATING ROOM NURSING

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ABSTRACT
Several studies have shown the benefit of drawing when learning anatomy. Virtual Reality (VR) also appears to be useful when learning about anatomical structures. This study aimed to describe how students in a master study programme in operating room (OR) nursing perceived the combination of drawing and the use of VR in the learning of anatomy. Constructivism and a sociocultural view of learning constitute a foundation for applying these active learning methods. The two methods were combined in a class of 29 students. The students were provided half-finished drawings of anatomical structures that they were to complete with guidance from the teacher. They also were to find various anatomical structures by using VR technology. A paper questionnaire was applied to evaluate the teaching programme. Data were analysed statistically (check-off questions) and descriptively (open-ended questions and comments field). Twenty-eight students (96.6%) completed the questionnaire. The students highly appreciated both learning methods. They reported that drawing made them work more actively during lectures and increased learning outcomes. They also perceived that the use of VR technology increased their understanding of the location of anatomical structures. The combination of drawing and VR technology appears to offer significant benefits to OR nursing students when learning anatomy, by both increasing student engagement and enhancing their understanding of anatomical structures.

Keywords: operating room nursing, anatomy education, immersive virtual reality, learning by drawing.

1. INTRODUCTION

An operating room (OR) nurse has an independent responsibility for the patient in surgery. When the patient is positioned for surgery, knowledge and skills related to anatomy are essential. For the patient to be optimally exposed during surgery, the patient may be positioned in many different and sometimes unnatural body positions. To be able to do this safely, the OR nurse must be familiar with anatomical structures and how they work (Devlin & Nanavati, 2023). Devlin and Nanavati (2023) claim that, for positioning the patient, OR nurses need to know the cardiovascular system, respiratory system, skin and underlying tissue, musculoskeletal system, and nervous system.

An OR nurse works as part of the surgical team. When assisting in the sterile field, the OR nurse needs knowledge about the various organs, where they are located, and how to treat them. Different instruments and equipment are used on the different organs, and incorrect use of instruments can damage the organs (Rothrock, McEwen, & Van Wicklin, 2023). Thus, knowing anatomy is crucial for students who want to become OR nurses, as it involves positioning the patient correctly for surgery and assisting during operations.

Master's students in OR nursing have a bachelor's degree in nursing before starting the programme. This means they have basic knowledge of anatomy. However, the curriculum of the OR nursing programme states that students should have in-depth knowledge of the anatomy of organ systems and be able to apply this knowledge when the patient is being treated. This understanding must be demonstrated both as learning outcomes and in practical skills within the surgical team (Western Norway University of Applied Sciences, 2024).

2. BACKGROUND

Learning anatomy and other bioscience subjects can be challenging (McVicar, Andrew, & Kemble, 2015), and it has been argued that the use of traditional passive and teacher-centred learning approaches could be one of the reasons for this (Thwin, 2017). Although students learn in various ways, many students seem to prefer active and varied learning methods rather than traditional lectures when studying anatomy and other bioscience subjects (Johnston et al., 2015; Joseph, Roach, Natarajan, Karkada, & Cayaban, 2021).

The term 'active learning' may be understood in different ways. Freeman et al. (2014) collected written definitions of active learning from 338 participants in a seminar on active learning. After coding of the elements that emerged in the definitions, a consensus definition was formulated. The main elements in this definition are that active learning involves learning through classroom activities and discussions, and group work is often part of the active learning process. The importance of emphasising higher order thinking is also highlighted in their definition (Freeman et al., 2014).

Learning through discussion and group work and applying higher order thinking aligns with social constructivism, as described by Vygotsky (Botha, 2020). This implies that new understanding is achieved by connecting new information with previously acquired knowledge, and that interpersonal interaction is perceived as central to the learning process. Student participation, collaboration and discussion are central elements in the classroom (Prakash Chand, 2023). Constructivism and a sociocultural view of learning therefore constitute a theoretical foundation for the application of active learning methods.

A combination of various active learning methods seems to be beneficial in the learning of anatomy (Sørø, Aglen, & Haugan, 2021). Thwin et al. suggested various approaches for achieving effective and efficient anatomy teaching. This includes the use of active learning strategies both during lectures and in small group teaching (Thwin, 2017) in accordance with the definition formulated by Freeman et al (2014).

One of the learning methods suggested is colouring diagrams in workbooks (Thwin, 2017). Several studies have shown the benefit of drawing when learning anatomy. It has been argued that drawing may support students' understanding and visualisation of anatomical structures and thus facilitate their knowledge retention (Adkins, Barrett, D'Amato, Maxwell, & Kindig, 2023; Borrelli, Leung, Morgan, Saxena, & Hunter, 2018). It has also been proposed that drawing may have an impact on a memory trace by combining elaborative, motoric and pictorial elements (Fernandes, Wammes, & Meade, 2018). Students' drawing skills are probably not essential for their learning, as the aim is to draw anatomical key points rather than to create perfect drawings of anatomical structures (Borrelli et al., 2018).

Drawing as a pedagogical tool may be used in different ways. Noorafshan et al. (2014) applied an interactive model where students were to draw simple anatomical sketches simultaneously with the teacher. This made the students participate more actively during lectures, and most of them found that this facilitated their learning of anatomy. In a study regarding obstetric and gynaecological clerkship sessions for medical students, the students were required to draw anatomical structures and subsequently explain their drawings for

fellow students. Most of the students found this interactive session helpful for their understanding of anatomical structures (Adkins et al., 2023).

Virtual Reality (VR) technology is another learning method that has gained significant attention in higher education and training across various disciplines in recent years. It allows the user to explore and manipulate computer-generated real or artificial three-dimensional multimedia sensory environments in real time (Kyaw et al., 2019). *Immersive virtual reality* (IVR) creates an environment that surrounds viewers, enhancing their sense of presence. By adopting a first-person perspective, users can interact with the virtual environment in real time, resulting in a heightened and realistic experience (Slater & Sanchez-Vives, 2016).

Several systematic reviews have consistently demonstrated that students who engage with VR achieve higher learning outcomes and retain information better compared to control groups using different media (Di Natale, Repetto, Riva, & Villani, 2020; Kyaw et al., 2019; Radianti, Majchrzak, Fromm, & Wohlgenannt, 2020). Di Natale et al. (2020), in their systematic review, looked at the use of IVR in higher education through the lens of Dalgarno and Lee's (2009) framework of affordances for 3D virtual learning environments. They suggested that these affordances (characteristics that enable certain types of learning behaviour) may also be applied to IVR. These affordances are:

1. Spatial knowledge – IVR provides spatial knowledge representation and, therefore, allows for a better understanding of spatial relationships.
2. Experiential learning – IVR allows students to perform tasks that would be impossible or impractical to perform in the real world.
3. Intrinsic motivation and engagement – IVR improves the motivational appeal of instructional material, promoting increased student interest and perceived learning outcomes.
4. Transfer of knowledge – IVR improves the transfer of knowledge by supporting situated learning.

(Dalgarno & Lee, 2009; Di Natale et al., 2020).

Like drawing, interacting with a 3D model in VR includes motoric elements as the students use hand controls. By physically engaging and interacting with the learning materials through body movements, students activate sensorimotor areas within their brain, and it has been hypothesized that this promotes both faster and deeper learning (Johnson-Glenberg, 2018).

When it comes to the learning of anatomy, a study among nursing students showed that a VR-based programme significantly improved students' learning of anatomy compared to traditional learning methods (Wang et al., 2023). A systematic review, a meta-analysis covering 15 studies regarding the effectiveness of VR, also concluded that VR can potentially improve the teaching of anatomy. However, there was some uncertainty about the results, partly due to the heterogeneity of the studies, and further research on how VR can be integrated into the teaching of anatomy was encouraged (Zhao, Xu, Jiang, & Ding, 2020).

In the present study, we combined drawing and VR in the anatomy teaching for OR nursing. The aim of this study was to describe how students in a master study programme in OR nursing perceived the benefit of the combination of two active learning methods – drawing and the use of VR – in the learning of anatomy. To our knowledge, this is the first article describing the combination of these two learning methods in the learning of anatomy in health education.

3. METHODS

3.1. Design and Participants

This pilot study had a cross-sectional design. The manuscript was drafted against the SQUIRE-EDU (Standards for Quality Improvement Reporting Excellence in Education): Publication Guidelines for Educational Improvement (Ogrinc, Armstrong, Dolansky, Singh, & Davies, 2019).

We developed a new teaching programme in anatomy for students in the master study programme in OR nursing at a university college by combining learning by drawing and using VR technology. The sample chosen for this study was a class of students in the master's programme in OR nursing that started their master's education in autumn 2023. All the students in the class participated in the teaching programme, and all were invited to participate in the evaluation of the programme by completing a questionnaire. Altogether, 29 students, spread across three different campuses, participated in the programme, and 28 of them participated in the evaluation. The new teaching programme consisted of:

1. A gathering at one of the campuses with:
   - A two-hour session of interactive lectures where students had to draw and name various anatomical structures, guided by the teacher.
   - A two-hour session where students were to find different anatomical structures using VR sets and '3D Organon' – a VR application about human anatomy.
   - Demonstration of positioning of patients on the operating table.

2. Three two-hour sessions with the drawing of anatomical structures, guided by the teacher. These sessions were conducted in person at one of the campuses with digital transmission to students at the two other campuses. Students on these campuses were able to communicate with the teacher via microphones in the classrooms.

For the drawing lessons, the students were provided two drawing pads, covering topics from the respiratory system, circulatory system, nervous system, musculoskeletal system, organs in the abdomen and organs in the pelvis. Thirty-eight of the drawings were half-finished drawings that the teacher had made of various anatomical structures. The drawing pads were made available to the students electronically, so they could print them out and bring them to class. During the lessons, the students had to complete the half-finished drawings by drawing in different anatomical structures and adding names to the drawings while being guided by the teacher. Simultaneously, the teacher showed the same drawings on a screen in the classroom using a document camera and drew and wrote together with the students. When the students participated digitally from other campuses, what was shown on the screen was also transmitted digitally. Drawing and naming of anatomical structures were done in dialogue with the students, as they were encouraged to suggest names to be written on the drawings, for example.

For the VR session, we applied the Pico Neo3 model of portable and cableless head mounted display (HMD) devices. These VR sets consist of "goggles" that cover the entire field of view of the user and provide stereoscopic vision and a sense of depth, and two controllers held in hands that help navigate the virtual environment and interact with the objects in it. Portable HMD devices offer the benefit of providing fully immersive VR.

3D Organon, the application we used, enabled students to engage with 3D models of various human anatomy systems. Through 3D Organon, students could examine the systems both together and individually, navigate around the models and turn them along both horizontal and vertical axes. They could also magnify the model, disassemble it and explore its components individually.

The topics chosen for the VR session were skeleton, muscles, arteries, and nerves in the upper and lower limbs. These were also the topics of the preceding teaching with drawing on the same day. The subsequent demonstration on the operating table also focused on how patients must be positioned to prevent damage to the anatomical structures in the upper and lower limbs.

At the beginning of the VR session, we gave short instructions on the use of the software-relevant buttons. We also provided written instruction regarding the anatomical structures the students were to find and what 3D models in the anatomy programme they had to explore to find these structures.

During the two-hour VR session, students worked in small groups, two or three students together. One of the students in each group wore HMD. What was shown in VR was transmitted to a PC screen, and in that way, it was made available for the other student(s) in the group. The students took turns wearing HMDs and looking at the computer screen, and so everyone was able to explore the 3D models and anatomical structures in VR. This also meant that each student did not have to wear HMD all the time. This may be an advantage, as dizziness and other discomfort symptoms are reported when using HMDs (Oh & Son, 2022; Wang et al., 2023).

The students evaluated the teaching programme using a paper questionnaire, which was made by the teachers. It consisted of 17 check-off questions and five open-ended questions, including one field where they could write other comments. Two of the check-off questions were about whether the students attended the gathering at one of the campuses and how many of the subsequent teaching sessions they participated in. The rest of the questionnaire consisted of two panels of questions, one for the drawing part and one for the VR part. Six of the check-off questions in the drawing part and five of the check-off questions in the VR part were scored on a 5-point scale from 1: totally agree to 5: totally disagree. A sum score was calculated for these questions in each of the two parts. Lower scores indicated better use. The questionnaire and students' responses were written in Norwegian; translations to English are by the authors.

3.2. Statistical Methods

Descriptive statistical analysis was performed for ordinal variables using frequencies and percentages. To test positive relationship between two ordinal variables, we used the chi-squared test for linear-by-linear association with exact one-sided p-value. Cronbach's alpha was estimated to quantify internal consistency of the drawing and VR scale, respectively. All the data from the evaluation forms were analysed in SPSS.

3.3. Analysis of Open-Ended Questions and Comments Field

The total word count of comments (quotes) provided in the comments field and as answers to open-ended questions was small at approximately 800. Therefore, we chose to analyse the comments descriptively by using some elements from summative content analysis (Hsieh & Shannon, 2005). We read through the comments searching for occurrences of central words (e.g., 'organs' and 'nerves'). These words formed the basis for various categories of meaning. Each comment (quote) represented a meaning unit (or sometimes several meaning units). The meaning units were sorted into the different categories. In doing

this, we included words with similar meanings. As an example, the comment "More heart and lung anatomy" was sorted in the category 'Thoracic and/or abdominal organs', although this comment did not contain the word 'organ' (Table 1). We then summarised the number of comments with similar meanings as inspired by summative content analysis (Hsieh & Shannon, 2005).

Table 1.
Example of the sorting of comments (meaning units). The table shows the categorisation of some of the comments regarding what topics the respondents would have liked to include in the virtual reality (VR) exercise other than the topics chosen.

Comment (quote)	Category
Would rather have organs in the abdomen	Thoracic and/or abdominal organs
Abdominal organs	
Abdominal organs, digestive organs	
More heart and lung anatomy	
Abdominal and thoracic organs	
Other organs and structures	Unspecified organs
Larger organs	
Also the larger organs	
Internal organs	
All organ systems	

3.4. Ethical Considerations

Written information was provided on the questionnaire that participation in the evaluation was voluntary and that names should not be written on the evaluation form. Subsequently, we also contacted the Norwegian Agency for Shared Services in Education and Research (SIKT) to assess whether the project was notifiable to them. Their assessment was that if the submitted questionnaires did not contain information that could enable a person who did not know the participants to identify individuals, the project was not notifiable. Information that could identify individuals among the participants did not appear in the submitted questionnaires.

4. RESULTS

Twenty-eight out of the 29 students (96.6%) completed the questionnaire used to evaluate the teaching programme. All 28 respondents had participated in person at the gathering at one of the campuses. 27 respondents participated in all three of the subsequent 2-hour sessions (either in person or digitally), while one respondent had participated in two of these sessions.

Sixteen of the respondents (57.1%) thought the distribution of 2 hours of exercise with VR and 8 hours of lessons with drawing was appropriate. Six respondents (21.4%) preferred to have more VR exercise and less teaching with drawing, while five respondents (17.9%) preferred to have less VR exercise and more teaching with drawing. Some respondents also commented that they would have liked to have more of both.

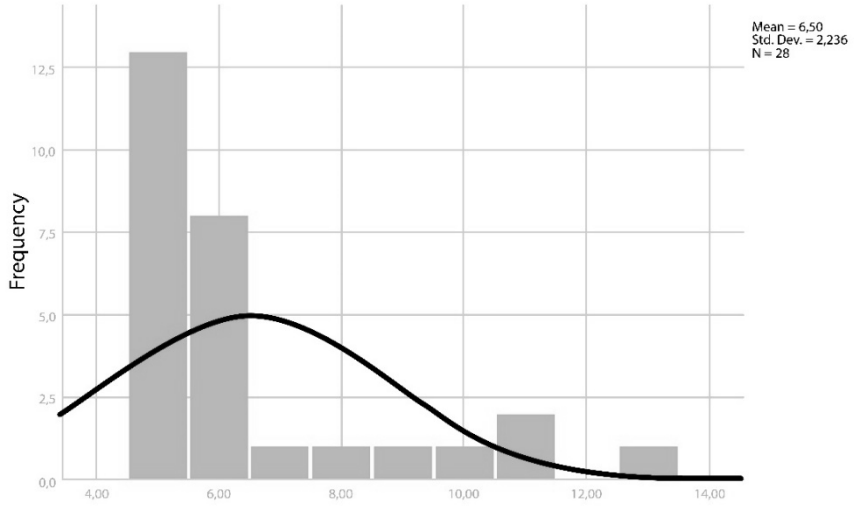
The students were asked to indicate the extent to which they agreed or disagreed with various statements regarding the interactive lectures with drawing. These results are shown in Table 2.

Table 2.
The extent to which 28 respondents disagreed/agreed with six statements related to the use of drawing in the teaching of anatomy in the master study programme in operating room nursing at a university college in Norway, autumn semester of 2023.

Statement	Extent to which the respondents agree, n (%)					Total
	Totally agree	Partly agree	Not sure	Partly disagree	Totally disagree	
The drawing pads made me more active in class	27 (96.4)	1 (3.6)	0 (0.0)	0 (0.0)	0 (0.0)	28 (100)
The drawing pads made it easier to understand the subject matter	25 (89.3)	3 (10.7)	0 (0.0)	0 (0.0)	0 (0.0)	28 (100)
The use of drawing pads increased learning outcomes in lessons	27 (96.4)	1 (3.6)	0 (0.0)	0 (0.0)	0 (0.0)	28 (100)
I would have preferred to use PowerPoint rather than drawing in the lessons	2 (7.1)	1 (3.6)	1 (3.6)	3 (10.7)	21 (75.0)	28 (100)
I have also benefitted from the drawing pads when I have worked on subject matter outside of class	23 (82.1)	1 (3.6)	2 (7.1)	2 (7.1)	0 (0.0)	28 (100)
The drawing pads have contributed to me also using drawing myself in my work with the subject matter outside of class	15 (53.3)	7 (25.0)	0 (0.0)	5 (17.9)	1 (3.6)	28 (100)

The mean sum score for the drawing part (all six items shown in Table 2) was 8.1 and Cronbach's alpha was 0.47. The statement comparing drawing with PowerPoint had a very low correlation with the total scale, and after this was removed from the scale, the mean was 6.5 (Figure 1) and Cronbach's alpha increased to 0.59.

Figure 1.
Sum score (x-axis) of five statements regarding the use of drawing, each ranked from 1: totally agree to 5: totally disagree (thus, the possible range for the sum score is 5–25, where 5 represents answering 'totally agree' with all five statements, and 25 represents answering 'totally disagree' with all five statements). Frequency (y-axis) shows the number of respondents represented in each column. Vertex of graph (curved line) shows the mean score (6.5) for respondents that scored all five statements (28 respondents).



When we used the linear-by-linear chi-squared test, there was no significant relation between the students' experience of teaching with drawing and the fact that they themselves used drawing to work with the subject matter (Table 3).

Table 3.
Associations between students' opinion on the drawing sessions and their use of drawing when working with the subject matter themselves (n = 28) in the master study programme in operating room nursing at a university college in Norway, autumn semester of 2023.

Statement	**p-value[a)]**
The drawing pads made me more active in class	0.214
The drawing pads made it easier to understand the subject matter	0.370
The use of drawing pads increased learning outcomes in lessons	0.214
I would have preferred to use PowerPoint rather than drawing in the lessons	0.464

a) Exact 1-sided p-value from chi-squared test for linear-by-linear positive association between ordinal variables with 5 levels

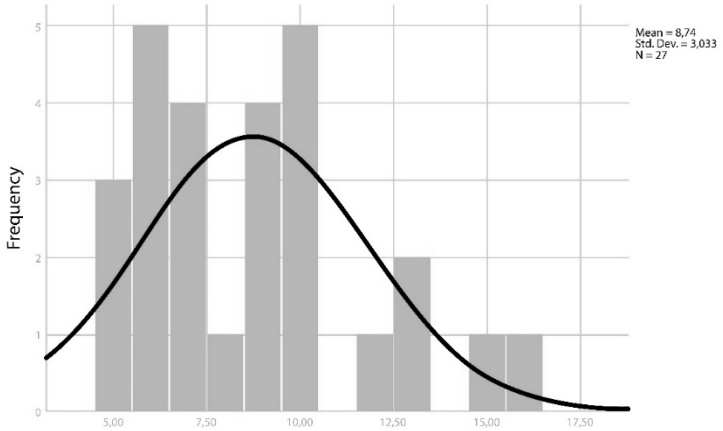
The students were also asked to indicate the extent to which they agreed or disagreed with various statements regarding the exercise in VR. These results are shown in Table 4. For the VR part, the mean sum score for all five items shown in Table 4 was 8.7 (Figure 2), and Cronbach's alpha was estimated to be 0.86.

Table 4.
The extent to which 28[a)] respondents disagreed/agreed with five statements related to the use of VR in the master study programme in operating room nursing at a university college in Norway, autumn semester of 2023.

Statement	Extent to which the respondents agree, n (%)					Total
	Totally agree	Partly agree	Not sure[b)]	Partly disagree	Totally disagree	
It was easy to use the anatomy programme used in the exercise with VR	9 (32.1)	14 (50.0)	3 (10.7)	2 (7.1)	0 (0.0)	28 (100)
It was easy to find the anatomical structures we were to find on the models	6 (21.4)	15 (53.6)	5 (17.9)	2 (7.1)	0 (0.0)	28 (100)
The use of VR made it easier to understand the subject matter	14 (50.0)	10 (35.7)	4 (14.3)	0 (0.0)	0 (0.0)	28 (100)
The use of VR gave me a better understanding of the location of anatomical structures	20 (71.4)	7 (25.0)	1 (3.6)	0 (0.0)	0 (0.0)	28 (100)
The use of VR provided a great learning outcome	11 (40.7)	12 (44.4)	4 (14.8)	0 (0.0)	0 (0.0)	27 (100)

a) 27 respondents on the fifth statement; b) For the first two statements, the category in this column was the Norwegian expression 'både/og' which means something in between 'agree' and 'disagree'

Figure 2.
Sum score (x-axis) of five statements regarding the use of VR, each ranked from 1: totally agree to 5: totally disagree (thus, the possible range for the sum score is 5–25, where 5 represents answering 'totally agree' with all five statements, and 25 represents answering 'totally disagree' with all five statements). Frequency (y-axis) shows the number of respondents represented in each column. The vertex of the graph (curved line) shows the mean score (8.7) for respondents that scored all five statements (27 respondents).



When it comes to the respondents' previous experience with VR, 23 of the 28 respondents had no previous experience, four participants had tried VR 1 or 2 times before, and one respondent 3 to 5 times before. Previous use of VR may have given a slight advantage when students were to find anatomical structures on the 3D models, but numbers are small, and this finding is statistically uncertain (p = 0.045). Previous experience with VR did not significantly affect students' ability to use the anatomy programme itself, their understanding of the subject matter or their learning outcome when using VR (Table 5).

Table 5.

Associations between the students' previous experience with VR and their ability to use the anatomy programme and their perceived benefit of using VR in 28[a)] respondents in the master study programme in operating room nursing at a university college in Norway, autumn semester of 2023.

Statements regarding the use of and the benefit of VR in the learning of anatomy	**p-value[b)]**
It was easy to use the anatomy programme used in the exercise with VR	0.191
It was easy to find the anatomical structures we were to find on the models	0.045
The use of VR made it easier to understand the subject matter	0.199
The use of VR gave me a better understanding of the location of anatomical structures	0.138
The use of VR provided a great learning outcome	0.053

Abbreviation: VR = Virtual Reality

a) 27 respondents in the fifth statement; b) Exact 1-sided p-value from chi-squared test for linear-by-linear positive association between ordinal variables with 5 levels

We also investigated how students' responses to questions regarding the learning outcome and improved understanding related to how they managed to use the anatomy programme in VR (Table 6). As the table shows, there was a significant positive association between students' perceived learning outcome and how they managed to use the programme and find anatomical structures. Students who largely perceived that the anatomy programme was easy to use and the anatomical structures were easy to find, also reported to a greater extent that the use of VR made it easier to understand the subject matter. This was statistically significant, as shown in the table. However, as the table shows, there was no significant association between students' improved understanding of the location of anatomical structures and their perceived ability to use the anatomy programme or to find anatomical structures on the models.

Table 6.
Associations between the students' learning outcome and improved understanding and how they managed to use the anatomy programme and find the different anatomical structures in 28 respondents in the master study programme in operating room nursing at a university college in Norway, autumn semester of 2023.

Statements regarding the learning outcome and improved understanding	**Statements regarding the use of the anatomy programme**	**p-value[a)]**
The use of VR made it easier to understand the subject matter	It was easy to find the anatomical structures we were to find on the models	0.003
The use of VR made it easier to understand the subject matter	It was easy to use the anatomy programme used in the exercise with VR	0.020
The use of VR gave me a better understanding of the location of anatomical structures	It was easy to find the anatomical structures we were to find on the models	0.074
The use of VR gave me a better understanding of the location of anatomical structures	It was easy to use the anatomy programme used in the exercise with VR	0.053
The use of VR provided a great learning outcome	It was easy to find the anatomical structures we were to find on the models	0.001
The use of VR provided a great learning outcome	It was easy to use the anatomy programme used in the exercise with VR	0.005

Abbreviation: VR = Virtual Reality
a) Exact 1-sided p-value from chi-square test for linear-by-linear positive association between ordinal variables with 5 levels

Twenty-six of the respondents provided at least one text comment in the questionnaire. When it comes to the text comments regarding the drawing lessons, 17 of the students expressed in different ways that they appreciated this learning method. Six of these explicitly expressed that they learned a lot, and three highlighted the active learning. Two of the respondents specifically expressed the advantage of this form of teaching over PowerPoint. Two respondents expressed that the drawing pads could have been better organised, and one student recommended using PowerPoint in addition to drawing to show anatomical figures. This student also mentioned that, in retrospect, the VR teaching provided a more comprehensive understanding of anatomy that might otherwise have been lacking.

When it comes to the open-ended questions regarding the VR exercise, the students were asked whether topics should have been added or omitted in this exercise. Seventeen students expressed in different ways that they would have liked to include other topics. Of these, seven mentioned organs in the abdomen and/or thorax. In addition, eight respondents mentioned organs without specifying name or exact location. (Examples are shown in table 1). However, several of these provided answers such as 'internal organs' or 'larger organs', probably also indicating thoracic or abdominal organs. Five respondents mentioned the nerves as something that could have been omitted from the exercise, and it was commented

that these were difficult to grasp in VR due to their small size. Five respondents answered explicitly 'no' to the question of whether some topics could have been omitted.

When it comes to comments regarding the teaching programme as a whole, six respondents expressed a lack of time in various ways. This was related to the size of the course, the time given to prepare for the exam or the schedule of the gathering at one of the campuses.

5. DISCUSSION

The aim of the study was to describe how students in a master study programme in OR nursing perceived the benefit of active learning methods, including drawing and the use of VR technology.

The results show that a great majority of the students appreciated the use of both learning methods. This is supported by the sum score for the drawing part and the VR part of the questionnaire, respectively, and by the analysis of responses to open-ended questions and comments field in the questionnaire. The combination of drawing and VR in learning, is, as far as we have found, scarcely studied. In art education, combining VR and painting has been used (Guan, Wang, Wang, Zhu, & Hwang, 2024), but we have not found any research articles describing the combination of drawing and VR in health education. Nevertheless, combining various approaches to active learning is recommended in anatomy teaching (Sørø et al., 2021; Thwin, 2017).

At the gathering at one of the campuses, we focused on anatomical structures in the upper and lower limbs both in the drawing lessons, the VR exercise, and the demonstration of positioning the patient on the operating table. In this way, the learning was integrated by allowing the students to encounter the same topic in three different arenas, the last of which was close to practice. The combination of various active approaches and integrating them in nursing have proved to be successful factors when teaching anatomy to bachelor nursing students (Sørø et al., 2021). This aligns with social constructivism, where student participation and collaboration are central in the learning process (Prakash Chand, 2023). It seems likely that this combination may also be a useful approach when teaching anatomy for OR nursing students, as these students need even deeper knowledge in anatomy for several reasons (Devlin & Nanavati, 2023; Rothrock et al., 2023). This is also in line with what one of our respondents expressed, which was that VR in addition to drawing provided a more comprehensive understanding than drawing alone.

When it comes to drawing, the benefit of this learning method in anatomy is also supported by other studies (Adkins et al., 2023; Borrelli et al., 2018; Noorafshan et al., 2014). When respondents in our study clearly reported that the drawing pads made them more active in class, it is in accordance with the definition of active learning given by Freeman et al., wherein activities and discussion in class are emphasised (Freeman et al., 2014). The students also reported that drawing made it easier to understand the subject matter and improved their learning outcome, similarly to what Noorafshan et al. (2014) found in their study. One reason for this may be that the activity of drawing forces students to pay attention to what they are doing, as they have to concentrate on what they draw, and thus cannot be passive listeners (Ainsworth & Scheiter, 2021). In addition to the effect of the activity itself, the pace of the teaching may have contributed to improved learning outcomes. When drawing together with the students, the teacher is forced to slow down, as drawing takes time. This means that the amount of information the students must deal with during a lecture is reduced, which can prevent cognitive overload. This may contribute to facilitating knowledge retention, as argued by Borrelli et al. (2018) and Adkins et al. (2023).

Most of the respondents benefitted from the drawing pads outside of organised teaching, and for many of them, the pads also contributed to them using drawing when working with the subject outside of class. However, we did not find statistical correlations between the students' opinion on the drawing lessons and their use of drawing outside of class. The size of the data material and the small spread in the students' responses may be contributing factors to this, making it difficult to obtain statistical significance. However, students' different learning styles may also be a reason (learning-styles-online.com, n.d.). It is possible that whether students choose drawing as a learning method when working on their own depends more on their learning style than the use of drawing during lectures.

When it comes to VR, most of the respondents totally or partially agreed that the use of this learning method provided a great learning outcome and better understanding. This is in accordance with previous research that shows that VR has a generally positive effect on students' learning outcomes when compared to other teaching methods (Di Natale et al., 2020; García-Robles et al., 2024; Kyaw et al., 2019; Radianti et al., 2020). In the background section of the article, we mentioned the theory of affordances given by Dalgarno and Lee (2009), which was applied to VR by Di Natale et al. (2020). Our results indicate that at least the first three of these affordances may have contributed to the respondents' great perceived learning outcome and improved understanding of the subject matter in our project.

Our results also indicate that the students' previous experience of using VR did not seem to have a large impact on their ability to use the anatomy programme or on their perceived benefit of using VR. One possible explanation may be that using VR equipment combined with the 3D Organon application is sufficiently intuitive to make it equally easy to use both for individuals already familiar with the technology and for those completely new to it. This is in accordance with an integrative review that revealed that users' experiences with various kinds of VR technologies were mostly positive, although a few VR systems were difficult to use (Mäkinen, Haavisto, Havola, & Koivisto, 2020). On the other hand, previous experiences from using HMDs and the same anatomy programme as we used in our project showed that students' and teachers' experience with the technology is of importance (Aasekjær, Gjesdal, Rosenberg, & Bovim, 2023).

Another explanation as to why students' previous experience of using VR did not seem to be having a large impact may be that the short instructions on the use of the software-relevant buttons that we gave at the beginning of the VR session combined with the written instructions provided regarding the anatomical structures they were to find played a significant role for first-time users in familiarising them with the technology and the use of the anatomy programme. Lack of instruction may cause uncertainty when students use VR in learning (Aasekjær et al., 2023). An additional comparative study could provide insights into whether the implementation of a deliberately designed introduction plays a role in bridging the gap between first-time users and experienced individuals.

The respondents were a bit divided regarding their opinions on the use of the programme itself and about finding the anatomical structures on the 3D models. The perceived learning outcome and understanding of the subject matter correlated to how easy the students perceived finding the anatomical structures. Although not significant, earlier experience with VR seemed to give a slight advantage when students were to find anatomical structures, in accordance with previous experiences showing that it is of importance that students are familiar with the VR technology (Aasekjær et al., 2023). As mentioned above, for the VR exercise, we chose anatomical structures in the limbs to link this exercise to the preceding drawing lesson and the subsequent demonstration on the operating table the same day. This also meant that the students had to find various nerves in the limbs. As several of the respondents commented, nerves are small and can be difficult to grasp in VR. Many

students also expressed that they would have preferred to explore organs in the thorax and abdomen during the VR exercise. As these organs are larger, they are easier to find in the anatomy programme. In retrospect, we see that we could have chosen larger organs and focused only on the nerves most vulnerable to pressure injury during operations.

Although the students appreciated the use of active learning methods, there are challenges associated with this kind of learning. These challenges include, amongst other things, engaging students, building students' relations and developing teaching strategies that promote learning (Aga, 2023). A literature review revealed that time constraints may be a major challenge for students (Rahman, Sahid, & Mohamad Nasri, 2022). This was also a challenge in our study, as several students in various ways commented on not having enough time. The lack of time may in turn lead to cognitive overload, which may reduce students' motivation (Takase, Niitani, Imai, & Okada, 2019). As teachers we therefore must ask ourselves what is most important to prioritise in various kinds of active learning sessions. It also is important that the curriculum is organised in a way that gives students time to work sufficiently on the subjects outside of organised learning activities. To address this challenge, it may be necessary to take a more overarching view of the curriculum and how the teaching is organised (Novais, Silva, & Muniz Jr., 2017).

6. STRENGTHS AND LIMITATIONS

One limitation is the size of the study, as only 29 students attended the master study programme in OR nursing. However, the response rate was high (96.4%), indicating that the answers are representative for the opinions of the students attending.

Another limitation is that the questionnaire was not validated. For this study, we used a self-made questionnaire. The estimated internal consistency for the check-off questions regarding the use of drawing was lower than 0.70, thereby limiting the generalisation of the answers to these questions. The estimated internal consistency for the check-off questions regarding the use of VR, however, was higher than 0.70 (0.86).

A limitation in the performing of the statistical analysis is that the respondents provided rather similar answers to several of the check-off questions in the questionnaire. This made it more difficult to calculate the statistical correlations between the different statements that the students had to consider.

Having a control group would also have been an advantage for comparing the effect of the teaching programme investigated.

7. CONCLUSION AND FUTURE RESEARCH DIRECTIONS

The combination of drawing and VR technology appears to offer significant benefits to OR nursing students learning anatomy, by both increasing student engagement and enhancing their understanding of anatomical structures. The students in this study reported a high level of appreciation for the anatomy lectures, where they were guided in completing drawings, as well as for the VR session that allowed them to explore 3D models of anatomical structures. The majority of respondents indicated that drawing actively engaged them during lectures and contributed to better learning outcomes. Similarly, most students found the VR sessions helpful in improving their understanding of the spatial relationships between anatomical structures.

However, while students' perceived learning outcomes from the VR session were positively related to how effectively they could use the VR programme, it is important to note that a lack of previous experience with VR had little or no impact on the perceived

benefits of the use of the technology. This suggests that the threshold for integrating VR into anatomy education is relatively low, making it accessible to students with varying levels of technological familiarity.

Despite the promising results, there are areas that could benefit from further investigation. For instance, including larger groups of students or those from different educational backgrounds, to explore whether the combination of drawing and VR is equally effective across different cohorts. Dividing students into a control group and a test group could also improve the credibility of the results. Additionally, investigating the impact of these methods on student performance in practical settings, such as clinical placements or surgical simulations, would be interesting to assess whether the improvements in spatial understanding translate into better practical skills.

Finally, future research could examine the potential of integrating other emerging technologies, such as augmented reality (AR) or interactive digital platforms, to further enhance anatomy education. Additionally, comparing the effectiveness of the combined methods to traditional teaching approaches could provide more insight into their relative benefits and limitations.

In summary, this study highlights the potential of combining drawing and VR to enhance anatomy learning for OR nursing students. Future investigations should focus on refining these methods, exploring their long-time impact, and expanding their application to other areas of health education to determine their broader utility.

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