

Student Motivation Using Virtual Reality in Human Anatomy and Physiology Courses

Anatomie de la réalité virtuelle dans l'enseignement supérieur : Efficacité, motivation d'apprentissage et adoption institutionnelle

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Abstract

This study investigates student motivation using virtual reality (VR) technologies in anatomy and physiology courses. Over a two-year period, 21 college students from nursing, paramedic, and biotechnology-health programs were recruited for this study. The participants were randomly assigned to either a group using immersive VR on Quest 2 headsets or a group using desktop-based VR on personal computers. Both groups utilized VR on the health education platform 3D-Organon. The study compares the intrinsic motivation between these two groups. Four subscales of the *Intrinsic Motivation Inventory* were employed for this study. The immersive VR group was statistically significantly higher on the interest/enjoyment and perceived competence subscales. There was no significant difference between the two groups on the pressure/tension and perceived choice subscales. This study demonstrates VR's potential in boosting student motivation in human anatomy and physiology courses. Due to limited participation in pre- and post-assessment tools, content-based learning gains could not be compared. This highlights challenges in conducting VR studies in postsecondary institutions, including volunteer bias, curriculum integration barriers, student recruitment, and survey fatigue. These insights are critical for administrators and pedagogical designers when evaluating wider VR adoption in health and science education.

Keywords: 3D-Organon, human anatomy and physiology courses, motivation, nursing, technology-enhanced learning, virtual reality

Résumé

Cette étude se penche sur la perception des étudiantes et étudiants sur l'utilisation des technologies de réalité virtuelle (RV) dans des cours d'anatomie et physiologie. 21 étudiantes et étudiants issus de programmes d'études en soins infirmiers, soins paramédicaux et en biotechnologie santé ont été recrutés sur une période de deux ans pour cette étude. Les participantes et participants ont été répartis de manière aléatoire dans deux groupes : l'un utilisant la RV immersive sur des casques Quest 2, l'autre utilisant la RV sur des ordinateurs personnels. Les deux groupes ont utilisé la RV sur la plateforme d'éducation à la santé 3D-Organon. L'étude compare la motivation intrinsèque entre ces deux groupes. Quatre sous-échelles de l'Inventaire de motivation intrinsèque ont été utilisées pour cette étude. Le groupe de VR immersif a obtenu des scores statistiquement significatifs plus élevés sur les sous-échelles intérêt/ plaisir et compétence perçue. Il n'y avait pas de différence significative entre les deux groupes sur les sous-échelles pression/tension et choix perçu. Cette étude démontre le potentiel de la RV pour stimuler la motivation des étudiantes et étudiants dans les cours d'anatomie et physiologie humaines. En raison de la participation limitée en lien avec les outils d'évaluation pré et post-test, les gains d'apprentissage basés sur le contenu n'ont pas pu être comparés. Cela met en évidence les défis liés à la réalisation d'études sur la RV dans les établissements d'enseignement supérieur, notamment le biais des volontaires, les obstacles à l'intégration dans les programmes d'études, le recrutement des étudiantes et étudiants et la fatigue liée aux sondages. Ces informations sont essentielles pour les administratrices et administrateurs et les conceptrices et concepteurs pédagogiques lorsqu'ils évaluent l'adoption de la RV à plus grande échelle dans l'enseignement des sciences et de la santé.

Mots-clés: 3D-Organon, cours d'anatomie et de physiologie humaines, motivation, soins infirmiers, apprentissage assisté par la technologie, réalité virtuelle

Introduction

Virtual reality (VR) tools are revolutionizing education by offering immersive, experiential learning for students and introducing novel teaching methods for faculty. This study explores the two forms of virtual reality. *Immersive* VR uses headsets to create an immersive computer-generated simulation that enables users to engage with and explore a virtual world while disconnecting from physical reality (Lessick & Kraft, 2017). This is distinct from *desktop-based* VR, which uses a flat computer screen to display 3D objects or worlds. Both forms of VR offer students an immersive sense of presence, context, and control over their learning environment. Realistic and engaging virtual environments, such as life sciences labs, allow students to interact with and examine life-sized anatomical models, providing unique and visceral learning experiences. While the experiential learning afforded by VR can be effective, its implementation costs and efforts must be balanced against its educational benefits.

Generally, technology-enhanced learning describes the application of technology to support learning whether on campus or remotely (Sen & Leong, 2020). Technology-enhanced learning tools include learning management systems, artificial intelligence, mobile applications, social networking

applications, information visualizing tools, virtual reality, augmented reality, podcasts, gamification systems, and cloud services (Daniela et al., 2018). In recent years, due to advances in digital quality, device mobility, and the proliferation of devices and applications, immersive technologies have become particularly appealing to higher education institutions (Adnan et al., 2025; García-Robles et al., 2024; Odogwu et al., 2025).

At the participating Canadian college in Central Ontario, the integration of VR has been primarily faculty-driven, though it is now beginning to attract the attention of administrators. This cautious institutional approach reflects widespread hesitancy within large organizations toward adopting new learning modalities like VR, due to administrative reluctance, high deployment costs, and swift obsolescence of devices (Hamilton et al., 2021). Despite these challenges, the appeal of VR use in higher education is growing, attributed to its immersive learning experience, enhanced graphics, falling device costs, and utility in remote education (Angel-Urdinola et al., 2021; Cicek et al., 2021). Currently, this college has implemented VR in approximately 20 programs, focusing on cases where traditional learning experiences would be otherwise dangerous, impossible, counterproductive, or expensive, which is aligned with Bailenson's (2018) D.I.C.E. framework (as cited in Bailenson et al., 2025). The expanding use of VR in educational settings has sparked research interest.

An increasing number of studies document positive benefits of learning with VR, using a wide variation in research methods, participant demographics, subject areas, and study durations, making it difficult to state definitely how and why VR can improve learning (Hamilton et al., 2021). One factor contributing to the difficulty in assessing the impact of VR on learning is the challenge of conducting controlled studies in postsecondary educational settings, as assigning students in the same program to different treatment groups is often not feasible (Hamilton et al., 2021). Consequently, educational VR studies are often voluntary, short-term, single-exposure, and involve participants from diverse educational backgrounds (Adnan et al., 2025; García-Robles et al., 2024; Odogwu et al., 2025) and are further complicated by rapidly evolving VR technologies that can render past studies less useful for comparisons. Studies focusing on specific applications also make it challenging to distinguish between the effects of the application itself and the efficacy of the VR medium (Hamilton et al., 2021). Furthermore, ensuring consistent completion of assessment tools in VR research is difficult, affected by factors such as, lack of incentives and varying priorities of the participants. Measuring long-term knowledge retention is also challenging due to high student turnover and time constraints (Hamilton et al., 2021).

Despite research challenges, studies suggest VR enhances student enjoyment and motivation, leading to positive learning experiences (Abundez Toledo et al., 2024; Makransky & Lilleholt, 2018; Niu et al., 2025). It is important to recognize that these favourable outcomes are specific to the experiences studied and not statistically generalizable. Virtual reality has been shown to be effective for procedural training where learners must perform tasks in a specific sequence, such as in safety training, mechanical assembly, and repair procedures (Allcoat & von Mühlenen, 2018; Blumstein et al., 2020; Hamilton et al., 2021; Rainford et al., 2023). For instance, Blumstein and colleagues (2020) found that students trained in VR correctly performed 63% of fracture nailing surgical steps, compared to 25% for

those taught through a standard guide traditional methods (p. 971). In addition, some studies suggest that VR learning experiences may also increase short-term memory retention (Allcoat & von Mühlenen, 2018; Hamilton et al., 2021; Huang et al., 2019; Krokos et al., 2019). A review of the literature for this study found an absence of longitudinal studies.

Of particular interest to the current study is the fact that VR has proven useful for teaching content where students must comprehend the 3D spatial arrangements of objects (Jensen & Konradsen, 2018), especially when this is difficult to depict in two dimensions. This is highly relevant human anatomy and physiology training (Gloy et al., 2021; Liou & Chang, 2018; Maresky et al., 2019; Odogwu et al., 2025; Reymus et al., 2020; Salimi et al., 2024; Schloss et al., 2021; Zinchenko et al., 2020). Indeed, recent systematic reviews (Adnan et al., 2025; García-Robles et al., 2024; Minouei et al., 2024; Odogwu et al., 2025; Salimi et al., 2024) and empirical studies (Al-Hor et al., 2024; Hammouda et al., 2025) have documented the effectiveness of using VR in anatomy education, particularly for enhancing spatial understanding and engaging learners. For example, Niu et al. (2025) documented an increase in pre-class assessment scores for students assigned to a continuous VR group compared to a control group using traditional learning methods of 2D images and textual descriptions (p. 2). Those students using VR also reported a higher level of satisfaction.

The current study draws from the growing body of evidence supporting the potential of VR for enhancing learning and applies it to the learning of human anatomy and physiology which requires spatial understanding and medical procedural accuracy. Several related studies have investigated students' learning experiences by comparing VR with non-VR instruction in neuroanatomy (Schloss et al., 2021), human anatomy (Gloy et al., 2021), heart anatomy (Zinchenko et al., 2020), physiotherapy (Cikajlo & Potisk, 2019), root canal anatomy (Reymus et al., 2020), and biomedical instruction (Fabris et al., 2019). Previous studies have focused on various metrics, including efficacy, motivation, engagement, content retention, and learning outcomes (Adnan et al., 2025; Odogwu et al., 2025). The context for the current study was higher education instruction of human anatomy and physiology, and set out to explore how VR might enhance the learning. The goal was to compare experiences of students using immersive VR to students using desktop-based VR. The following three hypotheses were generated:

- 1) Students using immersive VR will report a higher level of motivation compared to students using the desktop-based VR.
- 2) Students using immersive VR will demonstrate a higher level of engagement compared to students using the desktop-based VR.
- 3) Students using immersive VR will have increased learning gains compared to students using the desktop-based VR.

Method

Participants

From January 2022 to April 2023, the study recruited 21 students enrolled in the Honours Bachelor of Science Nursing (HBSN) degree, the Primary Care Paramedic (PCP) diploma, or the Biotechnology-Health (BH) diploma programs at the participating Canadian college in Central Ontario. Among the 21 students, 17 (81%) were female and 4 (19%) were male, and their ages ranged from 18 to 44 years. To avoid coercion, students were recruited via in-class announcements from a member of the research team who did not teach in the programs. The college's research ethics board approved the study. None of the participants in the immersive VR group reported motion sickness or other adverse events (e.g., eye strain and fatigue) when returning their VR headsets following its use.

Materials

VR System and Software

The health education platform 3D-Organon VR Anatomy (Medis Media) was used as it offers both an immersive VR-headset version and a desktop-based VR version (which is in 2D). For the immersive VR group, the study software was installed on stand-alone VR headsets, called the Meta Quest 2, and each student assigned to this group took one headset home for the entire semester. Students assigned to the desktop-based VR group installed the software on their personal devices.

Research Instruments

Pre-Assessments and Post-Assessments. Two professors from the HBSN and PCP programs at the college developed a pre-assessment instrument (i.e., diagnostic quiz) focused on anatomy content in their courses. This assessment was conducted in a “Virtual Lab” within the Blackboard learning management system (LMS). These labs provide interactive lessons with instructions, learning activities, resources, and assessment tools, all accessible online. A set of course resources was created containing all research materials, including the study consent form, as well as the anatomy-focused content. The post-assessment instrument was designed to evaluate students based on their respective anatomy and physiology course final exam grades.

Mental Rotation Test. Research shows a positive link between mental rotation skills and success in anatomy learning in non-VR settings (Guillot et al., 2007; Hoyek et al., 2009). Building upon this research, Bogomolova et al. (2020) investigated that link using an interactive model of human anatomy represented in augmented reality. To control for variations in learning anatomy that might be unrelated to the primary variables of the current study (immersive and desktop-based VR formats), an online 3D mental rotation test was developed. This test was designed and hosted using the PsychoJS platform, available on Pavlovia (<https://pavlovia.org/>). The format of the mental rotation test was derived from Ganis and Kievit's (2015) 3D adaptation of the Shepard and Metzler objects and their experimental approach.

Intrinsic Motivation Inventory. The *Intrinsic Motivation Inventory* (IMI) is a multidimensional questionnaire intended to assess self-reported motivation and self-regulation by asking participants to use a 7-point Likert scale to respond to 45 statements, which are divided into 7 subscales (interest/enjoyment, perceived competence, effort/importance, pressure/tension, perceived choice, value/usefulness, and relatedness; Center for Self-Determination Theory [CSDT], n.d.). The Likert scale used ranged in responses from 1 (not true at all) to 7 (very true), with 4 being somewhat true. To fit a research purpose, the IMI can be modified to use a selection of subscales and alter the wording of statements (Choi et al., 2010; CSDT, n.d.; Gibbens, 2019). Various IMI subscales have been used to quantify participants' subjective experience of virtual environments (Du et al., 2020; Lloréns et al., 2015; Rivera-Flor et al., 2019; Sattar et al., 2020).

Four subscales were selected for the current study: interest/enjoyment, perceived competence, pressure/tension, and perceived choice. While the subscales of effort/importance and value/usefulness contribute to students' motivation, one assesses task relevance (i.e., effort/importance) which is not the focus of this study. The other (i.e., value/usefulness) uses fill-in-the-blanks and Likert-scale items and does not follow the same scoring procedure. The developers of the IMI attribute the following uses for these four subscales: the interest/enjoyment subscale is a self-report measure of intrinsic motivation; the subscales perceived competence and perceived choice are considered to be positive predictors of behavioural measures of intrinsic motivation; the pressure/tension subscale is a negative predictor of intrinsic motivation (CSDT, n.d., para. 1).

Students' Thoughts on Virtual Reality Questionnaire (STVRQ). The STVRQ questionnaire was developed to capture students' thoughts and opinions on VR and the implementation of VR technologies in higher education (Cicek et al., 2021). The questionnaire is composed of 27 items scored on a 5-point Likert scale intended to assess three subscales. The Likert scale used ranged in responses from 1 (not true at all) to 5 (very true) with 3 being somewhat true. The first subscale examines students' perceived preference to use VR over a 2D display. The second subscale captures whether students think that VR systems can increase interest in teaching content. The third subscale captures students' opinions regarding the belief that VR in education can improve learning outcomes.

Student Engagement Log. As a measure of engagement, students were asked to complete a journal activity log to track the number of hours they spent using 3D-Organon.

Study Procedure

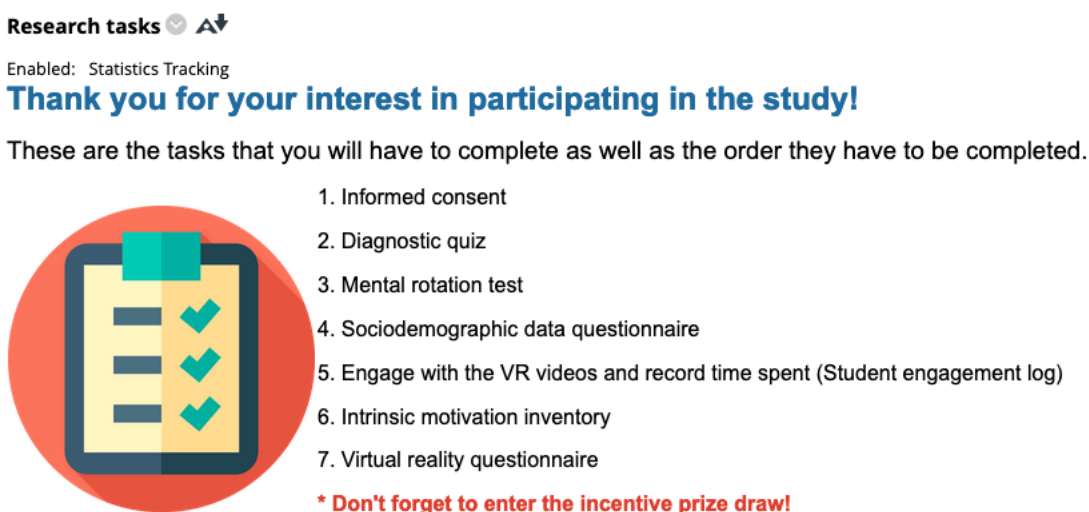
Lacking a true control group, this study employed a quasi-experimental design to compare student perceptions of immersive VR and desktop-based VR using content from 3D-Organon to learn anatomy and physiology. Students were randomly assigned to either the immersive VR or desktop-based VR group using a randomization procedure implemented in Microsoft Excel (using the =RAND() function). Ten students ($n=10$) were assigned to the immersive VR group, and eleven ($n=11$) were assigned to the desktop-based VR group. A Virtual Lab on the Blackboard LMS hosted course content and research instruments, including the consent form, the pre-assessment (i.e., diagnostic quiz), the

mental rotation test, the sociodemographic data questionnaire, the IMI, the STVRQ, and the student engagement log.

Figure 1 shows the ordered tasks that the students were asked to complete. The students were asked to complete the informed consent form, the sociodemographic data questionnaire, pre-assessment (i.e., diagnostic quiz), and the mental rotation test before engaging with 3D-Organon. At their own pace, students accessed the Virtual Lab to explore anatomy modules and then used their assigned format (either immersive or desktop-based VR) via the 3D-Organon platform. Students were asked to track their 3D-Organon usage time as an indicator of engagement. At the end of the study, they were asked to fill out the IMI questionnaire and the STVRQ. As an incentive, participants could enter a draw each semester for a new Meta QUEST 2 headset.

Figure 1

Screenshot of Virtual Lab



Results

Pre-Assessment and Mental Rotation Test

Due to the extremely low participation rates in the pre-assessment quiz (6 of 21), the mental rotation test (0 of 21), and the student engagement log (1 of 21), these three measures were excluded from all subsequent analyses. As a result, it was not possible to test the hypotheses related to engagement (hypothesis 2) and learning gains (hypothesis 3); therefore, the revised hypothesis is: Students using immersive VR will report a higher level of motivation compared to students using the desktop-based VR.

Intrinsic Motivation Inventory

To evaluate differences in motivation between the desktop-based VR and immersive VR groups, the study used Mann-Whitney U tests to analyze four IMI subscales: interest/enjoyment, perceived competence, pressure/tension, and perceived choice. In this test, medians are reported when the distributions for the immersive VR and desktop-based VR groups are similar in shape, whereas the mean rank is reported when the distributions are not similar in shape. The Mann-Whitney U tests were conducted on a final sample of 19 participants, as two participants did not complete the IMI.

Interest/Enjoyment Subscale

The distributions of scores were dissimilar between desktop-based VR and immersive VR groups. A Mann-Whitney U test indicated that interest/enjoyment was significantly higher for participants in the immersive VR group (mean rank = 12.78) than for those in the desktop-based VR group (mean rank = 7.50), with $U = 20$, $z = -2.049$, $p = .043$.

Perceived Competence Subscale

Again, the distributions were dissimilar. Perceived competence was significantly higher for participants in the immersive VR group (mean rank = 13.67) than for those in the desktop-based VR group (mean rank = 6.70), with $U = 12$, $z = -2.704$, $p = .006$.

Pressure/Tension Subscale

The distributions were dissimilar, but no significant difference was observed in IMI scores between immersive VR group (mean rank = 9.83) and desktop-based VR group (mean rank = 10.15), with $U = 46.5$, $z = 0.123$, $p = .905$.

Perceived Choice Subscale

The distributions of scores were similar. No significant difference was found between the median scores between the immersive VR group (mean rank = 5.60) and desktop-based VR group (mean rank = 6.00), with $U = 50.50$, $z = .454$, $p = .661$.

Students' Thoughts on Virtual Reality Questionnaire

To assess for variations in student perceptions of immersive VR and desktop-based VR experiences, the study compared responses using Mann-Whitney U tests across three subscales of student perceptions: preference between immersive VR and desktop-based VR, interest in teacher content, and improved learning outcomes. The Mann-Whitney U tests were conducted on a final sample of 20 participants, since one participant did not complete the questionnaire. Missing responses on a given item were automatically excluded from the analyses. Initially, no statistical differences were found between the immersive and desktop-based VR groups in each of the three subscales.

Subsequent Cronbach alpha reliability tests revealed varying levels of internal consistency. The immersive VR versus desktop-based VR subscale, comprised six statements and showed low internal consistency with a Cronbach's alpha of 0.368. The interest in teacher content subscale consisted of 10 statements and demonstrated good internal consistency with a Cronbach's alpha of 0.777. The improved

learning outcomes subscale used 11 statements, and showed low internal consistency, indicated by a Cronbach's alpha of 0.112.

The findings suggest that while the interest in teacher content subscale was reliable, the other two may require revision for improved consistency in measuring student perceptions.

In response to initial findings, a Categorical Principal Component Analysis (CATPCA) was conducted on the 27-statement questionnaire assessing student thoughts on VR. This process aimed to refine the questionnaire to provide more reliable insights into students' perceptions of VR in education. Pre-analysis checks confirmed CATPCA suitability, with the correlation matrix showing variables having at least one coefficient above 0.3. CATPCA identified four components (i.e., subscales) with eigenvalues over one, explaining 28.05% (subscale 1: immersive learning perceptions), 14.47% (subscale 2: experiential learning), 13.16% (subscale 3: learning environment), and 11.12% (subscale 4: thoughts on learning) of the total variance, cumulatively accounting for 66.8% of the variance.

Subsequently, Cronbach's alpha tests were conducted for the four new subscales: immersive learning perceptions, experiential learning, learning environment, and thoughts on learning. The immersive learning perceptions subscale, consisting of 12 statements, exhibited a high internal consistency (Cronbach's alpha = 0.889). The experiential learning subscale, comprised of five statements, showed a low consistency (Cronbach's alpha = 0.278). The learning environment subscale, initially designed with five statements showing a very low consistency (Cronbach's alpha = -0.377), was revised to be three statements with two statements being removed i.e., statement #4 "The classical evaluation system in education (e.g., exams) does not reflect the real knowledge of the respondents" and statement #9 "Through the learning process, it's necessary to apply theoretical knowledge to practical examples in order to master a new skill". The revised subscale showed a low consistency (Cronbach's alpha = 0.483). The thoughts on learning subscale consisted of five statements and showed a low consistency (Cronbach's alpha = 0.417).

Spearman's correlation was used to validate correlations within each new subscale. This analysis led to the removal of one statement from the experiential learning subscale (statement 20 with $r_s = 0.174$, $p = 0.463$) and two from the thoughts on learning subscale (statement 21 with $r_s = 0.360$, $p = 0.118$; and statement 26 with $r_s = 0.355$, $p = .125$) due to a lack of significant correlation with their respective subscales. Descriptive statistics for each subscale are detailed in Tables 1—4. Each table represents one new subscale and reports the number of responses (n), along with the mode, median, and mean for each statement included in each respective subscale. While the full sample ($N=20$) was included in the CATPCA analysis, individual item-level data had some missing responses, resulting in a range of 19 to 20 responses per statement.

Table 1*Descriptive Statistics of STVRQ Statements that Measured Immersive Learning Perceptions*

No.	Statement	<i>n</i>	Mode	Median	Mean
2	The visual stimuli provided by VR systems are fascinating to the users.	20	5	4	4.28
3	Stimulation of multiple senses leads to a better understanding of educational content (positive stimulation to the senses consequently leads to more impactful experiences and understanding of educational content).	20	4	4	4.13
7	Time passes faster for me while I consume content via VR system compared to consuming content via regular 2D displays.	20	3	3	3.18
8	Introducing VR into the classrooms turns learning into entertainment.	20	5	4	4.08
10	Due to the simulation and experience provided by VR, students will continue to explore and research the educational content.	20	5	4	4.03
11	Virtual reality develops students' creativity.	20	5	4	3.95
17	With VR, I'm not limited to passively consuming information and images displayed on the screen.	20	5	4	4.10
18	Being able to see and experience the various locations around the world within the classroom provided by VR can inspire and intrigue students.	19	5	5	4.47
23	It's difficult for me to understand abstract contents and concepts (e.g., cranial nerves) without a visual representation of the same.	20	5	4.75	4.18
24	Evaluation tailored to the individual, where certain parameters of the respondents are monitored with the help of a VR system, represents a better evaluation system.	20	4	4	3.55
25	I think that my interest in courses and educational content would be higher if interactive content and VR systems were used.	20	5	4	4.05
27	While using VR systems, students can actively learn and participate instead of passively looking at 2D displays.	20	5	4	4.08

Note. Virtual reality (VR). Students' thoughts on virtual reality questionnaire (STVRQ).

Table 2*Descriptive Statistics of STVRQ Statements that Measured Experiential Learning*

No.	Statement	<i>n</i>	Mode	Median	Mean
5	People learn better through interaction.	20	5	5	4.48
12	Unlike VR, which can provide an interactive experience, classical learning boils down to providing facts only.	20	3	3	2.65
16	With the help of VR, a student can learn how to react in certain (unknown, dangerous) situations.	20	3	4	3.80
19	Virtual environment models teach and train with the same efficiency as reality.	20	3	3	3.18

Note. Virtual reality (VR). Students' thoughts on virtual reality questionnaire (STVRQ).

Table 3*Descriptive Statistics of STVRQ Statements that Measured Learning Environment*

No.	Statement	<i>n</i>	Mode	Median	Mean
13*	While I use a VR system, I am always aware that I'm in a virtual world and that none of it is real.	20	1	2	2.05
14	The group's shared experiences in a shared environment are important.	20	4	4	4.08
15	The classical evaluation system in education (e.g., exams) reflects the real knowledge of the respondents.	20	2	3	2.73

Note. *Negatively formulated statement. Values were calculated using inverse data. Virtual reality (VR). Students' thoughts on virtual reality questionnaire (STVRQ).

Table 4*Descriptive Statistics of STVRQ Statements that Measured Students Thoughts on Learning*

No.	Statement	<i>n</i>	Mode	Median	Mean
1*	Interaction with the real people in the real world, whether they are lecturers or students, is necessary.	20	1	1	1.45
6*	Complete immersion in the virtual world frightens me.	20	5	4	3.83

No.	Statement	<i>n</i>	Mode	Median	Mean
22	In the classrooms, there should be mostly interaction between students (the professor only serves as a “guide” to the conversation).	19	3	3	2.53

Note. *Negatively formulated statement. Values were calculated using inverse data. Students’ thoughts on virtual reality questionnaire (STVRQ).

The Mann-Whitney U test was conducted on the four new subscales (engagement, experiential learning, learning environment, thoughts on learning) of the STVRQ statements. Each subscale showed a dissimilar distribution of scores between the immersive VR group and the desktop-based VR group. Because of this, mean ranks were used regardless of the null hypothesis outcome. Differences between the mean ranks were determined using the exact sampling distribution for U as per Dinneen and Blakesley (1973). Each subscale showed no significant difference. The engagement subscale used an immersive VR mean rank of 11.35 and a desktop-based VR mean rank of 9.65 to generate the results $U = 41.5$, $z = -0.644$, $p = 0.529$. The experiential learning scale used an immersive VR mean rank of 10.45 and desktop-based VR mean rank of 10.55 to create results $U = 50.50$, $z = 0.038$, $p = 1.00$. The learning environment subscale used an immersive VR mean rank of 9.85 and a desktop-based VR mean rank of 11.15 to show the results of $U = 56.50$, $z = 0.498$, $p = 0.631$. The thoughts on learning subscale used an immersive VR mean rank of 11.30 and a desktop-based VR mean rank of 9.70 to produce the results of $U = 42.00$, $z = -0.612$, $p = 0.579$. These analyses were conducted on the four subscales tailored for this study using results from 22 of the 27 STVRQ statements documented in Tables 1 through 4. For completeness of reporting on the use of the STVRQ, Table 5 shows the descriptive statistics for the five excluded statements.

Table 5

Descriptive Statistics of STVRQ Statements Excluded From the Four New Subscale Analyses

No.	Statement	<i>n</i>	Mode	Median	Mean
4*	The classical evaluation system in education (e.g., exams) does not reflect the real knowledge of the respondents.	19	3	3	2.63
9	Through the learning process, it’s necessary to apply theoretical knowledge to practical examples in order to master a new skill.	19	3	4	4.05
20	While I use a VR system, I feel like I am present in a virtual world.	20	4	4	3.75
21*	Using a VR system would distract students from the educational content.	20	5	4	4.03

26*	In classrooms, the professor should lead the keynote, i.e., the professor is the main source of information and interaction.	20	2	2	2.45
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Note. Virtual reality (VR). Students' thoughts on virtual reality questionnaire (STVRQ).

Discussion

This study investigated students' perceptions of using VR in human anatomy and physiology education. Based on the varying completion rates of instrument use, the primary focus narrowed from three hypotheses to one hypothesis. This study tested the hypothesis that students using immersive VR will report a higher level of motivation compared to students using desktop-based VR. Students completed the IMI and STVRQ self-reporting instruments. From the results of the IMI there were two subscales of motivation that showed a statistically significant difference between the two study groups. Students in the immersive VR group reported higher levels of motivation as measured by the interest/enjoyment subscale. This result is consistent with findings from studies across various disciplines including neuroanatomy (Schloss et al., 2021), human anatomy (Gloy et al., 2021), heart anatomy (Zinchenko et al., 2020), physiotherapy instruction (Cikajlo & Potisk, 2019), root canal anatomy (Reymus et al., 2020), and biomedical instruction (Fabris et al., 2019). Students in the immersive VR group also reported higher levels of motivation as measured by the perceived competence subscale. This finding aligns with a study by Sattar et al. (2019) that documented a greater increase in both motivation and perceived competence for students in an immersive VR group. We found no significant difference in pressure/tension or perceived choice subscales between students in the immersive VR and desktop-based VR groups, indicating that students in both groups felt in control of their learning activities and did not feel pressured to use the assigned technology. Together, these results suggest that students using immersive VR found more interest and enjoyment in learning and felt more competent in their academic performance than their counterparts using desktop-based VR, which are key behavioural predictors of intrinsic motivation (CSDT, n.d., para. 1). The findings of this study align with previous research on the use of VR in anatomy education, suggesting that VR may be a useful tool to support student learning (Adnan et al., 2025; Gloy et al., 2021; Odogwu et al., 2025; Scholoss et al., 2021).

In contrast to the IMI results, the STVRQ results showed no significant differences between the immersive VR and desktop-based VR groups across its subscales. The psychometric properties of the STVRQ and the general nature of its statements require careful consideration when interpreting these null results. The survey's initial three-subscale structure proved to have a low internal reliability, necessitating a restructuring into four new subscales (engagement, experiential learning, learning environment, and thoughts on learning). While this improved the reliability for the engagement subscale ($\alpha = 0.889$), the other subscales' reliability remained low to moderate (experiential learning, $\alpha = 0.278$; learning environment, $\alpha = 0.483$; thoughts on learning, $\alpha = 0.417$) suggesting that these results should be interpreted with caution.

Additionally, the survey's statements generally asked about students' broad opinions or beliefs about VR in education, rather than the specific experiences in this study of using immersive VR or desktop VR in a human anatomy or physiology course. Given that several students likely have some familiarity with VR from non-educational contexts like gaming, it is perhaps unsurprising that no differences were found between groups based on these general attitude questions. Nevertheless, based on the overall high median scores on many items, the results do show that both groups of students reported favourable beliefs that VR can assist with learning.

Limitations

Several limitations should be considered when interpreting the findings of this study, particularly those related to sample size, data completeness, and the reliability and validity of certain research instruments. Conducting a controlled study with emerging technologies, such as VR, in a live academic setting presents numerous practical and methodological challenges, many of which were encountered in this project.

Volunteer Bias

This study relied on volunteers from demanding health science programs. Students who chose to participate may have already had a keen interest in VR or a positive bias towards new technologies, while non-volunteers during classroom visits cited the additional stress of participation as a deterrent. This self-selection process may skew the sample towards students predisposed to having a positive experience.

Participant Compliance

Ensuring participants completed all study components proved difficult. Most critically, the low completion rate for the pre-assessment, mental rotation, and engagement log instruments prevented any analysis of learning gains or engagement levels, meaning two of the three primary hypotheses could not be evaluated. Efforts to incentivize completion, such as classroom visits and a prize draw for a Meta Quest 2 headset, were only mildly successful.

Instrument Validity

The STVRQ has not been validated prior to this study. This study showed the STVRQ has mixed internal consistency even after modification based on statistical tests. The internal consistency of this instrument undermines the validity of the findings related to student perceptions on VR. Future studies should employ or develop more robustly validated instruments to assess these constructs.

Generalizability

The study is not generalizable because it employed a small sample size. While this is a limitation, it is aligned with previous research exploring the use of VR for learning anatomy (Abundez Toledo et al., 2024; Alturkustani et al., 2025; Kim et al., 2023; Li et al., 2024; Wu et al., 2023) and contributes to the knowledge development in this area.

Technological and Human Factors

This study did not assess potential shortcomings of the 3D-Organon software itself. The specific design, usability, and features of the application could have influenced student motivation and is an aspect that warrants further investigation. Finally, the study did not systematically collect data on the potential negative side effects of VR use, such as cybersickness (e.g., dizziness or nausea), having only been informally asked when returning the VR headsets. Such factors may impact a student's experience and willingness to engage with the technology and represent an important variable for future research to consider.

Conclusion

Prior to this study, VR had been explored independently by faculty at the college, with anecdotal reports of its benefits sparking grassroots adoption and attracting the attention of institutional decision-makers. Our research aimed to rigorously investigate student perceptions of the use of VR in human anatomy and physiology courses within the college's existing semester structure. The study's primary finding is that the immersive VR group reported significantly higher intrinsic motivation, as measured by interest/enjoyment, and perceived competence compared to the desktop-based VR group over a full semester. This motivation suggests that VR has the potential to enhance nursing and paramedicine student learning experiences. These findings contribute to the growing research on implementing immersive VR in postsecondary education and may be valuable in supporting student learning experiences in health and science programs.

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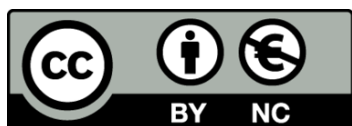
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