

Article

Comparison of the Effect of Motivation in Medical Students with the Use of Virtual Reality and Non-Immersive Digital Resources

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Abstract: The following article investigates the effect of advanced educational tools—virtual reality (Oculus) and the Sectra virtual anatomy table—on medical students' motivation in learning anatomy. Conducted at the Universidad Autónoma de Guadalajara, the research involved 90 first-semester medical students divided into two groups, each utilizing one of the technologies during anatomy sessions. Motivation was assessed using the Reduced Instructional Materials Motivation Survey (RIMMS). Focus on aspects such as attention, accuracy, confidence, and satisfaction. Of the four variables analyzed in the RIMMS questionnaire (attention, relevance, confidence, and satisfaction), it was noted that the highest p -value of the independent variables is 0.0000, which corresponded to TOTAL SATISFACTION. The findings suggest that immersive technologies like virtual reality can substantially enhance student motivation and learning experiences in medical education.

Keywords: virtual reality; non-immersive tool; student motivation; anatomy



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1. Introduction

1.1. Background of Human Anatomy Education in Medical Training

Human anatomy is defined as the science that studies the human body macroscopically, focusing on its form, topography, location, arrangement, and the relationships between the organs that compose it. Its understanding is fundamental for medical practice, serving as a prerequisite and biological foundation for other disciplines such as histology, embryology, semiotics, and physiology, among others. Consequently, it has been a core part of medical school curricula throughout history worldwide. The systematization of the study of human anatomy began during the European Renaissance in the 14th century with Dr. Andrea Vesalius, who publicly dissected the human body for the first time, redefining anatomical concepts and descriptions, and introducing the method of studying cadavers [1]. For centuries, cadavers remained the only practical method for studying human anatomy.

Since the 1990s, new teaching strategies have emerged to enhance students' learning experiences. There is a growing trend to move beyond traditional teaching methods by using methodologies that actively engage students [2]. This shift has allowed for a reevaluation of the use of cadavers, an investigation into their advantages and disadvantages, and a reflection on practical methods for studying human anatomy [1].

Following the COVID-19 pandemic, obtaining cadavers has become increasingly difficult. With the emergence of more medical schools, the standard method of teaching human anatomy through cadaver dissection has gradually changed [3]. As a result, innovative interactive models have been introduced, focusing on the cross-sectional and three-dimensional visualization of anatomical structures [4].

1.2. Immersive and Non-Immersive Digital Tools

Digital tools are designed to facilitate the significant use of digital technologies in education, science, interaction, and personalization. They allow interaction with various digital devices and applications to understand how communication is transmitted, displayed, and managed and to adapt communication strategies and procedures for users [5]. Digital tools have profoundly transformed the way we learn and teach, offering new opportunities and challenges for the educational process. Therefore, it is vital to adapt to the constant technological innovations and readjust teaching methods to include the latest advancements and contributions of information and communication technologies (ICT) in the educational system [6].

Among these digital tools, we find anatomical models via digital tables and 3D virtual reality glasses, which provide immersive and captivating experiences of the human body [7]. These tools allow for the exploration of the location, size, relationships, and functions of anatomical structures. Specific anatomical segments can be removed, enabling isolated visualization of body systems. This contributes significantly to enhancing students' identification skills and spatial memory [1].

1.2.1. Virtual Reality

Virtual reality is an interactive, computer-generated experience that takes place in a simulated environment. Its primary effect is to immerse the user in this simulated environment through a headset that incorporates a display. The user is provided with a sense of presence in the simulated environment through head tracking, which allows them to experience a sense of immersion while exploring the virtual world around them. This sense of immersion, or the feeling of "being in the virtual world", is created by enveloping the user in dynamically generated visuals, audio, or sensory stimuli that provide an absorbing environment. Virtual reality offers a wide range of advantages in the educational and training fields. Firstly, it provides a safe platform for participating in realistic simulations that may involve risks or be unfeasible in a physical environment [8]. Additionally, its application in training spans various fields, from teaching chemistry to surgery, offering practical and realistic experiences that enhance learning [8,9]. This technology also increases motivation by simulating real-life situations, fostering greater interest in the educational process through technological immersion [10]. Furthermore, it facilitates distance education by democratizing access to high-quality teaching resources [11]. However, these advantages can be limited by certain disadvantages. The high initial cost of the hardware can be prohibitive for many institutions, and time is required for educators to become familiar with and master its use. Additionally, challenges may arise related to software complexity [12]. The greatest challenge lies in student engagement, as the mere use of technology does not guarantee active participation. Therefore, it is crucial for educators to design effective pedagogical strategies to maintain student interest and motivation throughout the course [13].

1.2.2. Sectra Table

The SECTRA[®] digital dissection touch table is a non-immersive virtual reality tool that is networked with the SECTRA[®] IDS 7 database and accesses the VH dissector[®] programs and SECTRA[®] Education Portal [14]. This digital platform provides access to anatomical cases with clinical orientation using critical diagnostic information provided by radiological examinations [14]. Users can visualize anatomical structures as they would in a fresh cadaver. Precise reconstructions of individual structures allow for study and learning with an intuitive and easy-to-use preparation method that involves simply "unanchoring" specific anatomical structures. Each structure is clinically labeled, from the smallest ligaments to nerves and blood vessels. Among the advantages, it eliminates the need to handle chemicals, unpleasant odors, regular facility fees, and regulations and has higher student acceptance rates compared to traditional cadavers. However, disadvantages include the high price of the table, making it inaccessible to some institutions. Additionally, like any device with touch function, it is delicate and requires careful operational care and even software updates [1].

1.3. Motivation

Motivation refers to what people want, what they choose to do, and what they commit to doing [15]. It is a drive inherent in humans that can cause, direct, or organize their behavior. This is related to efforts to fulfill perceived needs, both physical and spiritual [16].

Two types of motivations are described:

- Intrinsic motivation, described as the desire to act due to an internal driving factor (without external driving factors). In other words, the learner pursues their goals simply because they want to achieve them. Intrinsically motivated students perform better in learning than those who are extrinsically motivated [16].
- Extrinsic motivation is defined by motivations that are activated and driven by external stimuli. The main goal of extrinsic motivation is to achieve goals that lie outside the learning activity (such as obtaining good grades or diplomas) [16].

The role of the educator should focus on generating motivation in students to make it more active in their learning. Some things that can be performed to increase student motivation to promote their learning include staying constantly updated on new skills and knowledge related to their field of work; being empathetic with students' experiences, especially those related to academic weaknesses and deficiencies; and providing explanations for topics that are not clear with an understandable attitude and language [16].

The Instructional Measure of Motivation Survey (IMMS) questionnaire was created to assess the four objectives of learning motivation: attention, relevance, confidence, and satisfaction (Figure 1) [15]. Each of the four components can be used and evaluated individually.

- "Attention" refers to the tool's ability to excite perception, activate inquiry, and incorporate a variety of media to meet diverse student needs.
- "Relevance" refers to immediate applicability or future utility (i.e., goal orientation) and reflects the congruence between student needs and the presented tool.
- "Confidence" depends on whether the tool provides guidance and/or feedback based on learning requirements and meaningful learning opportunities.
- "Satisfaction" reflects students' experiences with outcomes (positive), unexpected rewards, and reinforcement/recognition. As a result, it reflects consistent standards that define success, external rewards, and intrinsic reinforcement.

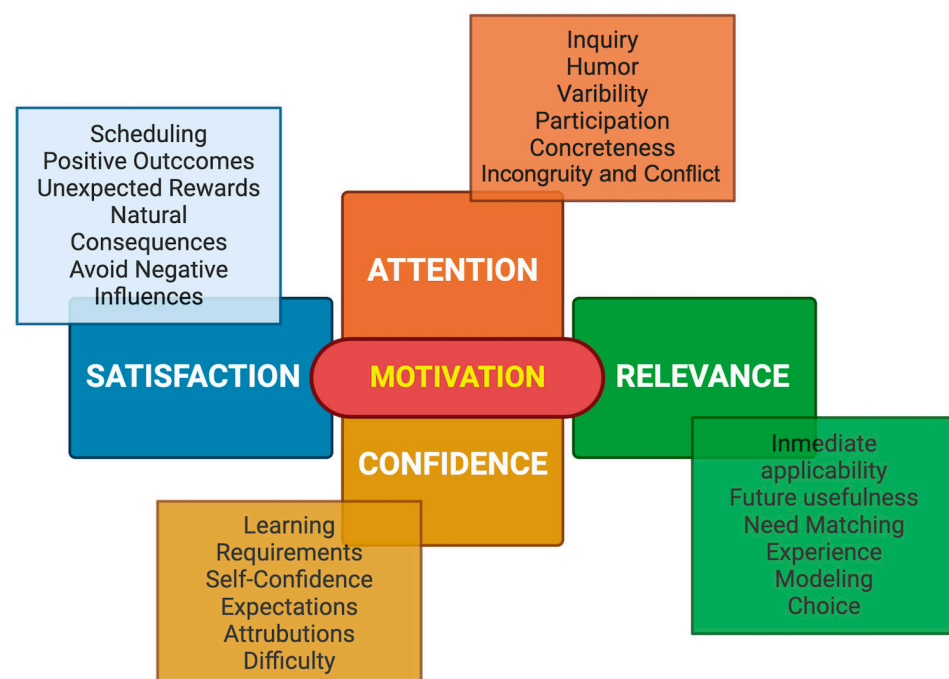


Figure 1. Graph of areas evaluated in the Instructional Measure of Motivation Survey (IMMS) questionnaire.

Increasing Motivation in Teaching

Based on the definition of motivation in student learning processes, motivation is one of the most relevant variables because it can determine the direction, positive or negative, in which the student pursues the course in question. Therefore, it should be considered in the design of the study program for the subject [9], so that students can achieve the expected learning objectives. The more motivated students are, the more likely they are to complete study tasks, study diligently, and achieve their learning goals [17] (pp. 335–342). In summary, motivation plays a crucial role in students' academic success and should be cultivated and fostered in the educational environment.

1.4. Effect of Digital Tools on Motivation

The connection between technology and motivation is becoming increasingly evident as digital innovations offer more interactive, personalized, and engaging learning experiences. Regarding the use of technological tools such as the SECTRA[®] Table and 3D virtual reality glasses for medical education, especially in anatomy, it can make it more interactive, interesting, and appealing for students, increasing their motivation by allowing them to explore the human body in a more immersive and dynamic way.

1.4.1. Effect of Motivation on Students with the Use of Virtual Reality

The incorporation of virtual reality (VR) into student learning has been a recent research topic in recent years, driven by advancements in new technologies and educators' quest to implement new dynamics for teaching their courses. It has been demonstrated that virtual reality has had a positive effect, particularly in increasing students' motivation towards learning [10], as well as being considered a powerful learning tool that meets students' expectations in medical education regarding anatomical structures [18].

1.4.2. Effect of Motivation on Students with the Use of the SECTRA Table

Medical education has witnessed a transformative shift with the integration of advanced technologies, such as the virtual table "Sectra", in anatomy teaching. The adoption of these virtual anatomy platforms holds great promise for enhancing student learning experiences. A virtual table like "Sectra" can motivate medical students to study anatomy by providing an interactive, realistic, and visually appealing learning experience, along with access to additional educational resources mentioned [19].

1.5. Research Question and Hypothesis

- Which tool increases medical students' motivation the most when studying human anatomy: Oculus (immersive digital tool) or MESA SECTRA (non-immersive digital tool), based on the application of the Reduced Instructional Materials Motivation Survey (RIMMS)?
- Hypothesis: There is a positive relationship among students studying human anatomy between motivation and the use of immersive and non-immersive digital tools.

The objective is to understand how these technologies influence students' level of attention, confidence, satisfaction, and relevance towards anatomical learning, with the aim of providing valuable insights to enhance teaching strategies in the field of medicine. By exploring differences in motivation generated by both tools, this study seeks to contribute to the design of more effective and engaging educational programs for future healthcare professionals.

2. Materials and Methods

In Mexico, throughout eight semesters, one year of internship, and one year of social service, the student must develop a series of advanced medical-surgical, clinical, and cognitive skills that he will perform throughout his working life. This training is also focused on complying with a series of general competencies in order to pass a series of knowl-

edge and practical exams that must be accredited due to the high level of competitiveness of the profession.

In this research, the correlation of motivation in medical students in the use of the digital tool Sectra Table with the virtual reality Oculus in anatomy sessions was analyzed. This subject is fundamental for the basis of topographic reasoning of the body and is integrated with the clinic in a patient in any medical context. Its content is distributed in 10 units in which the student undergoes different academic activities such as lectures, teamwork activities, and laboratories in which the use of the Sectra Table and Oculus has been implemented in different samples.

2.1. Sample

The study was carried out at the Universidad Autónoma de Guadalajara, Campus Instituto de Ciencias Biológicas, during the period between 31 July and 1 December 2023. The study population were regular first-semester students of the School of Medicine enrolled in the subject of anatomy.

2.1.1. Design

This was a cross-sectional study with a descriptive multiple regression analysis technique. The sample was selected using a non-probabilistic convenience sampling technique. The inclusion criteria were that they were regular students currently taking the course and that their participation was voluntary; the exclusion criteria were that they were irregular students and refused to participate.

2.1.2. Varieties

The variables were as follows: dependent variable—motivation; independent variables—attention, relevance, confidence, and satisfaction. They were correlated through the shortened version of the Instructional Material Motivational Survey by Keller from 2010, validated by Looibach, Peters, Karreman, and Steehouder in 2015, which consists of 12 questions.

The processes to begin gathering the database started once the project was approved by the Academic Directorate and presented to the corresponding university authorities of the deanship and health sciences directors. Subsequently, it was submitted to the core of educational research and innovation for approval and registration. To avoid bias, an intern was requested from the department head to ensure the collection of reliable information.

2.2. Instruments

This applied questionnaire indicates that for the implementation of a didactic tool to have an effect on student motivation, it must be attractive and interesting, its instructional design must be in accordance with the objectives of the session, it must represent a balance in the student's self-perception, and finally the satisfaction of having completed the activity with positive experiences as a learning reinforcer.

Keller's original 2010 Instructional Material Motivational Survey (IMMS) questionnaire estimates student motivation in the academic context, consisting of 36 questions distributed in four subscales: attention, relevance, confidence, and satisfaction. The IMMS is a self-report measure, so measuring motivation is limited since it evaluates perceived motivation, not the actual amount of effort, which is a more specific measure of motivational behavior since the effort is aimed at the actions to fulfill the activity.

Discovering its potential for studying user motivation in self-directed instructional contexts, specifically in confidence-centered instruction, the IMMS structure was analyzed for application in a self-directed environment focused on learning and performance to measure people's reactions to instructional materials (not their motivational needs prior to motivational strategies). After evaluating its structure and validity, the Reduced Instructional Materials Motivation Survey IMMS (RIMMS) was finalized, which is the abbreviated IMMS questionnaire, which reduces its items to questions that categorize the same four subscales

and is designed to measure reactions to self-directed instructional materials. It has an alpha greater than 0.70 with a statistically significant internal correlation with a p less than 0.05. This abbreviated questionnaire is composed of 12 items with Likert format and offers information for the analysis of motivation in its different dimensions: attention, relevance, confidence, and satisfaction.

A calculation of the validity of the questionnaire was performed with the sample of this research; this procedure executes a factor analysis (Table 1). The purpose of the analysis is to obtain a small number of factors that explain most of the variability in the 12 variables. In this case, the extraction of one factor is recommended since it is the only factor with an eigenvalue greater than or equal to 1.0. It explains 75.1864% of the variability in the original data (Figure 2).

Table 1. Factor analysis.

Factor Number	Eigenvalue	Percentage of Variance	Percentage Accumulated
1	9.02237	75.186	75.186
2	0.63062	5.255	80.442
3	0.515789	4.298	84.740
4	0.415421	3.462	88.202
5	0.361469	3.012	91.214
6	0.297017	2.475	93.689
7	0.214251	1.785	95.474
8	0.166126	1.384	96.859
9	0.128657	1.072	97.931
10	0.119769	0.998	98.929
11	0.0682133	0.568	99.498
12	0.0602986	0.502	100.000

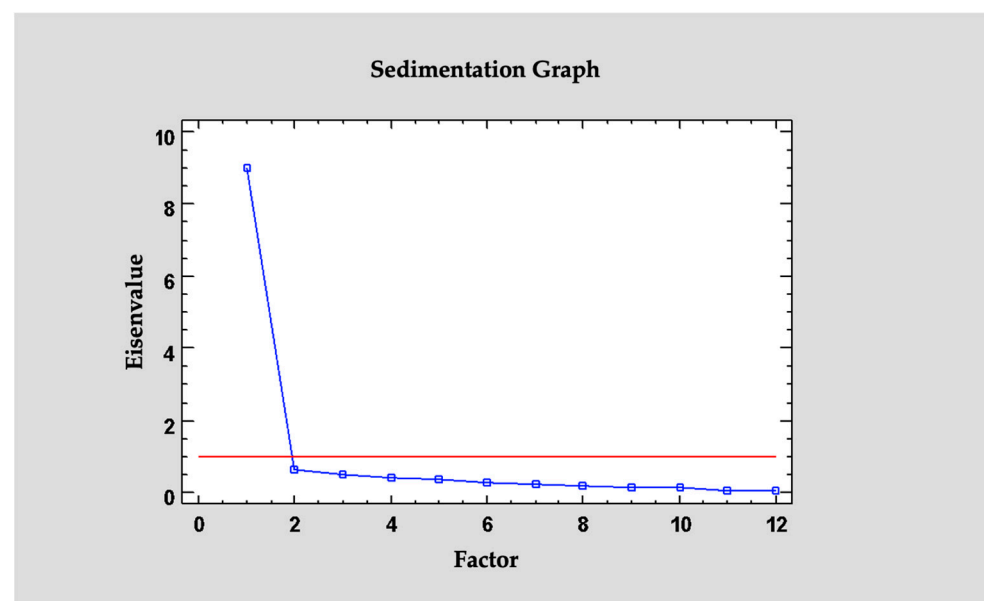


Figure 2. Sedimentation graph of construct validity. Note: The red line refers to the Kaiser criterion for determining the number of factors in the factor analysis. The first factor has a significantly larger eigenvalue than the others, indicating that a single factor may be sufficient to explain a considerable proportion of the variance in the data.

The eigenvalue of the first factor (9.02237) was very high compared to the rest of the factors, suggesting that this factor explains a large part of the variance (75.19%). The following factors are much lower. The data may be predominantly unidimensional. This does not imply that the construct lacks validity but that it is dominated by this underlying factor as the main one given that it refers to the relationship of the quality of immersive and non-immersive activities with the maintenance of attention.

2.3. Procedure

Usually, medical students study with the digital tool “Mesa Sectra”. The university acquired the immersive tool “Oculus”, so it trained a selected sample of university teachers of the subject of anatomy; therefore, two groups of the same trained teacher were selected to apply each didactic resource with one of their groups.

A sample of 90 male and female students was selected and divided into two groups, each implementing a different ICT. The first group consisted of 45 students who analyzed musculoskeletal system topics of the anatomy course using the digital tool “Mesa Sectra”, which features a mobile screen the size of a rectangular touch table connected to an inter-university education portal and includes an interactive full-body human atlas, software with more than 2000 3D anatomical structures and multiplanar views, clinical cases, examinations, and images collected from CT and MRI scans. The second group, consisting of 45 students, analyzed the same topics using the virtual reality “Oculus Quest 2”, which is a high-end helmet presented in standalone virtual reality glasses, weighing approximately 503 g, with an LCD panel and a resolution of 1920×1832 per eye, has a Snapdragon XR2 processor, connects by Wifi 6 or Bluetooth 5.1, with a USB type C port, and has a storage of 64/256GB with a 3D sound. It contains a viewer, $2 \times$ controllers, $2 \times$ AA batteries, $1 \times$ USB Type-C cable, $1 \times$ charger, and $1 \times$ glasses adapter; it is played with an institutional human anatomy application.

At the end of the academic sessions, the “Reduced Instructional Materials Motivation Survey IMMS” was implemented to answer the objective of this research. The analysis technique used was descriptive multiple regression; a $p \leq 0.05$ was considered statistical significance. The statistical analysis was performed in the Statgraphics 18 statistical package.

3. Results

The analysis was performed using the Statgraphics Centurion program by means of a multiple linear regression model, cross-tabulation, and comparison of two samples. The RIMMS questionnaire compiles, in its four dimensions: attention, relevance, confidence, and satisfaction, the final result, which is the motivation of the student in his academic context. Therefore, the results presented below are the independent variables most related to motivation.

To analyze the dimensions attention, relevance, confidence, and satisfaction, scales were established for each one, and they were classified into low, medium, and high levels according to the score obtained in each dimension of the inventory. They were classified as follows: the low scale with a score between 3 and 7, the medium level with a score between 8 and 11, and the high level with a score between 12 and 15 points. To examine motivation, the RIMMS level was taken and classified into scales as follows: the low scale with a score between 12 and 28, the medium level with a score between 29 and 44, and the high level with a score between 45 and 60 points.

A forward stepwise regression model was performed, which showed the results after fitting a multiple linear regression model to describe the relationship between motivation level and four independent variables.

The fitted model equation is as follows:

$$\text{LEVEL (LVL) RIMMS} = 0.756651 + 0.154954 \times \text{TOTAL SATISFACTION}.$$

Since the p -value in the ANOVA table was less than 0.05, there was a statistically significant relationship between the variables with a confidence level of 95.0%. The R-Squared

statistic indicated that the model thus adjusted explains 82.7223% of the variability in LVL RIMMS. The adjusted R-Squared statistic, which is more appropriate for comparing models with different numbers of independent variables, was 82.5259%. The standard error of the estimate showed that the standard deviation of the residuals was 0.237058. The mean absolute error (MAE) of 0.172609 was the average value of the residuals. The Durbin–Watson (DW) statistic examines the residuals to determine if there was any significant correlation based on the order in which they are presented in the data file. Since the p -value is greater than 0.05, there was no indication of serial autocorrelation in the residuals at the 95.0% confidence level. To determine whether the model could be simplified, it was observed that the highest p -value of the independent variables is less than 0.00010, which corresponded to TOTAL SATISFACTION. Since the p -value was less than 0.05, that term was statistically significant at the 95.0% confidence level.

The satisfaction subscale is composed of three items:

“I enjoyed the class with MESA SECTRA/OCULUS so much that I would like to know more about it.”

“I enjoyed the class using MESA SECTRA/OCULUS.”

“It has been a pleasure to work in such a well-designed class (with SECTRA/OCULUS TABLE).”

The total satisfaction score is obtained by adding the responses to these three items with a maximum of 15 points. Scales were made to obtain the classification of satisfaction levels; in the low level are students with values between 3 and 7, medium between 8 and 11, and high between 12 and 15 (Figure 3).

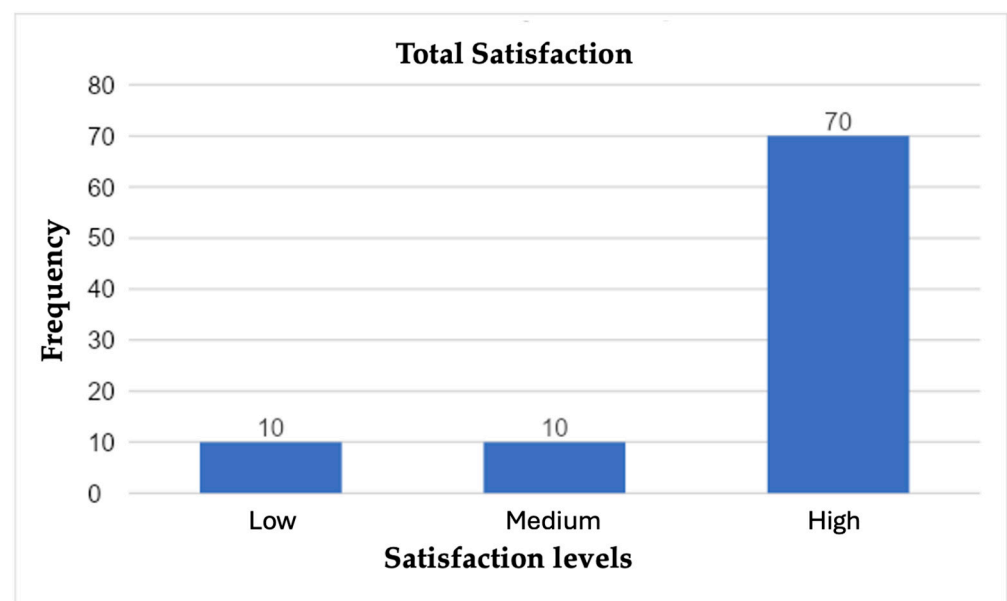


Figure 3. Graph of total satisfaction.

The questions asked through the RIMMS questionnaire will be broken down below, with graphs corresponding to the most significant results for each answered question.

For the attention variable, three questions were asked: Question 1: The quality of the activities with immersive (IM) and non-immersive (NIM) tools helps me to maintain attention; Question 2: The way of organizing the information using these IM and NIM tools helps me to maintain attention; and Question 3: The variety of activities helps to maintain my attention in class (Figure 4).

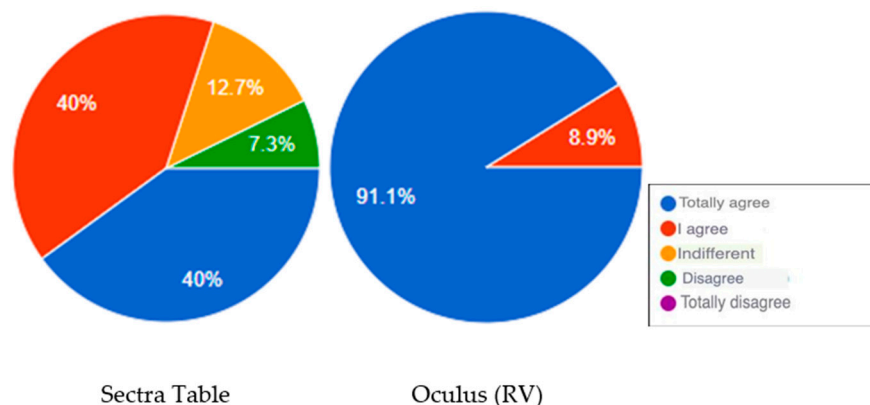


Figure 4. Graph of Question 3: The variety of activities helps me to maintain my attention in class.

In Question 3, the greatest difference in the attention variable was found between the Sectra Table and the Oculus. By looking at the previous graph, we can analyze that for the attention variable, the students preferred the use of the IM, which in this case would be the Oculus as virtual reality, reaching a difference of between 40 and 50% in the totally agreed option, more in comparison to the non-immersive tool.

In the case of the second variable, which is the relevance to measure motivation, it was performed by means of three questions, which were as follows: Question 4: For me, it is clear how this class supported with IM and NIM is related to things I already knew; Question 5: The contents and activities with IM and NIM convey the impression that it is worth knowing the contents of the lesson, and Question 6: the content of this class is useful for me (Figure 5).

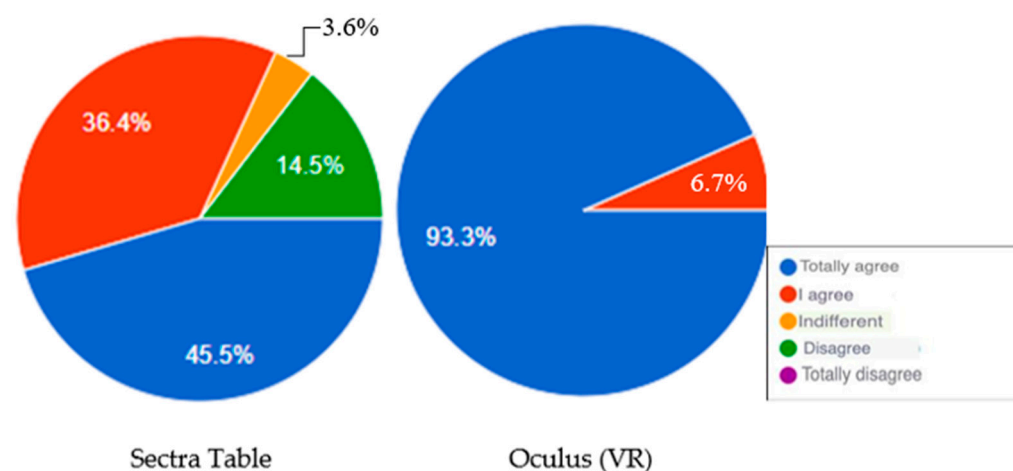


Figure 5. Graph of Question 6: The content of this class is useful to me.

In Question 6, we found the biggest difference in the relevance variable between Sectra Table and Oculus. In this relevance variable, the use of the IM by means of Oculus with virtual reality continues to be more predominant. It is also worth mentioning as an important detail that students considered indispensable in Question 5 to have previous knowledge before using the Oculus as IM, which may lead us to believe that it requires more concentration for them to be more experiential and to massify the significant learning experience.

As the third variable was confidence, three other questions were asked: Question 7: While working in this class with the IM and NIM, I am sure that I will learn the contents; Question 8: After working in this class, I feel confident that I would be able to pass an exam on the subject (Figure 6); and Question 9: The good organization of the class with the IM and NIM helps me to be sure that I will learn the contents (Figure 7).

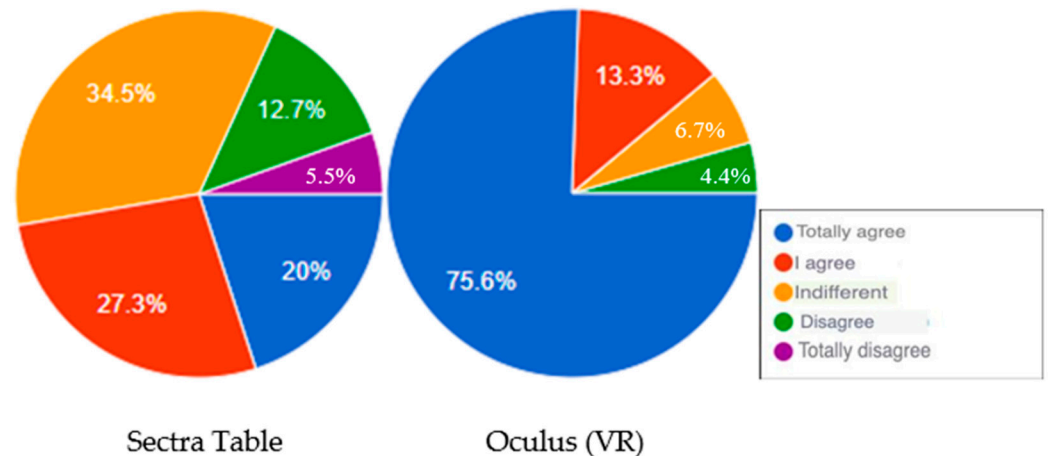


Figure 6. Graph of Question 8: After working in class, I feel confident that I would be able to pass an exam on the subject.

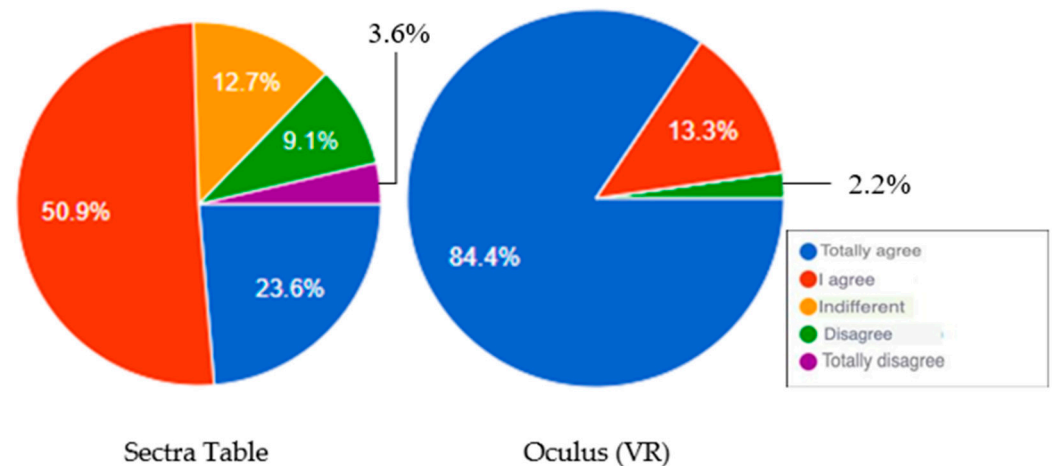


Figure 7. Graph of Question 9: The good organization of the class with the IM and NIM helps me to be sure that I will learn the contents.

In Question 9, the greatest difference in the confidence variable was found between Sectra Table and Oculus. It can be analyzed that IM gives them much more confidence than NIM, which, despite being digital, is not experiential. Question 8 is striking, where 88.9% of the students commented favorably that after using the Oculus they could pass an exam, compared to 47.3% for Sectra Table, which leads us to think that being an immersive experience generates greater retention of knowledge in the students.

The last variable taken into consideration for motivation is satisfaction, so 3 other questions were asked to be able to make a measurement, thus completing the 12 questions of the proposed questionnaire. Question 10: I have enjoyed so much in class with IM and NIM that I would like to know more about this topic. Question 11: I enjoyed this class with IM and NIM (Figure 8). Question 12: It has been a pleasure to work in such a well-designed class.

In Question 11, we found the greatest difference in the satisfaction variable between Sectra and Oculus. The results for the satisfaction variable show that 100% of the students had a positive response to the use of the IM, but 16.4% had a negative response to the use of the NIM.

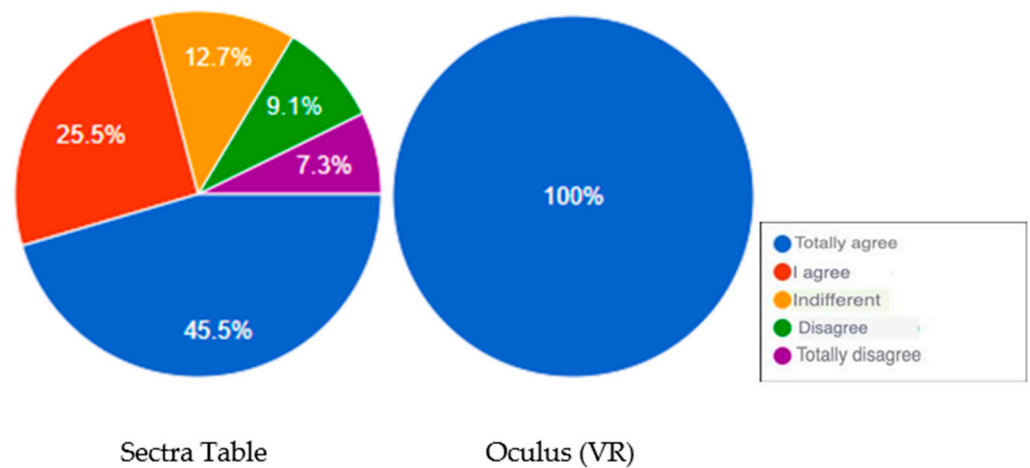


Figure 8. Graph of Question 11: I liked the class using the IM or NIM.

A cross-tabulation was performed for LVL RIMMS and LVL SATISFACTION. This procedure constructed a two-way table showing the frequency of occurrence of the unique pairs of values of LVL RIMMS and LVL SATISFACTION. It constructed a 3 by 3 contingency table for the data and displayed the results in different forms. Table 2 shows how frequently the 3 values of LVL RIMMS occur together with each of the 3 values of LVL SATISFACTION. The first number in each cell in the table is the count or frequency. The second number shows the percentage of the entire table that the cell represents.

Table 2. Frequencies for LVL RIMMS by LVL SATISFACTION.

	1	2	3	Total per Row LVL RIMMS
1	6	0	0	6
	6.67%	0.00%	0.00%	6.67%
2	4	6	0	10
	4.44%	6.67%	0.00%	11.11%
3	0	4	70	74
	0.00%	4.44%	77.78%	82.22%
Total per column LVL SATISFACTION	10	10	70	90
	11.11%	11.11%	77.78%	100.00%

Note: There were 6 times when LVL RIMMS equals 1 and LVL SATISFACTION equals 1. This represents 6.66667% of the total 90 observations.

Figure 9 shows the relationship between the frequency of the level of satisfaction and the levels of motivation in the total sample analyzed.

A comparison of the two samples was made: sample 1 implements ICT 1, which was Sectra Table; sample 2 implements ICT 2, which was Oculus. Sample 1 has 45 values in the range of 20.0 to 60.0, and sample 2 has 45 values in the range of 48.0 to 60.0. This procedure is designed to compare two samples of data, calculate several statistics and graphs for each sample, and run several tests to determine if there were statistically significant differences between the two samples.

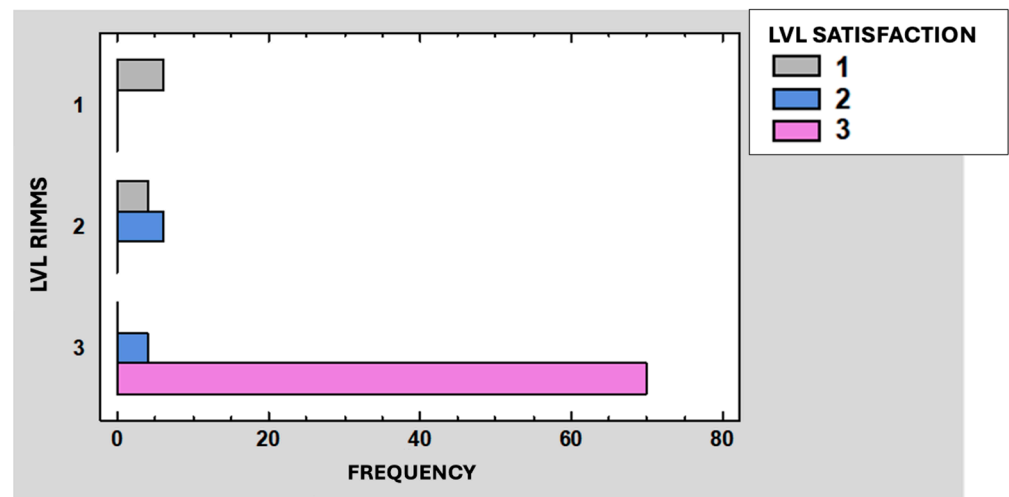


Figure 9. Bar chart for LVL RIMMS according to LVL SATISFACTION.

Table 3 shows the statistical summary for the two data samples. Of particular interest are the standardized skewness and kurtosis, which can be used to compare if the samples come from normal distributions. Values of these statistics outside the range of -2 to $+2$ indicate significant deviations from normality, which would tend to invalidate tests comparing the standard deviations. In this case, ICT = 2 has a standardized skewness value outside the normal range. ICT = 2 also has a standardized Kurtosis value outside the normal range.

Table 3. Statistical summary for TOTAL RIMM.

	ICT = 1	ICT = 2
Count	45	45
Average	45.3333	58.1333
Standard deviation	11.2452	3.04213
Coefficient of variation	24.8056%	5.23302%
Minimum	20.0	48.0
Maximum	60.0	60.0
Range	40.0	12.0
Standardized bias	−1.8395	−5.18013
Standardized Curtosis	−1.09493	4.29686

A *t*-test was run to compare the means of the two samples; of particular interest is the confidence interval for the difference between the means, which ranged from -16.2511 to -9.34888 . Since the interval does not contain the value 0, there was a statistically significant difference between the means of the two samples, with a confidence level of 95.0%. The *t*-test was also used to evaluate specific hypotheses about the difference between the means of the populations from which the two samples come. In this case, the test was constructed to determine whether the difference between the two means was equal to 0.0 versus the alternate hypothesis that the difference is not equal to 0.0. Since the calculated *p*-value was less than 0.05, the null hypothesis can be rejected in favor of the alternate hypothesis (Figure 10).

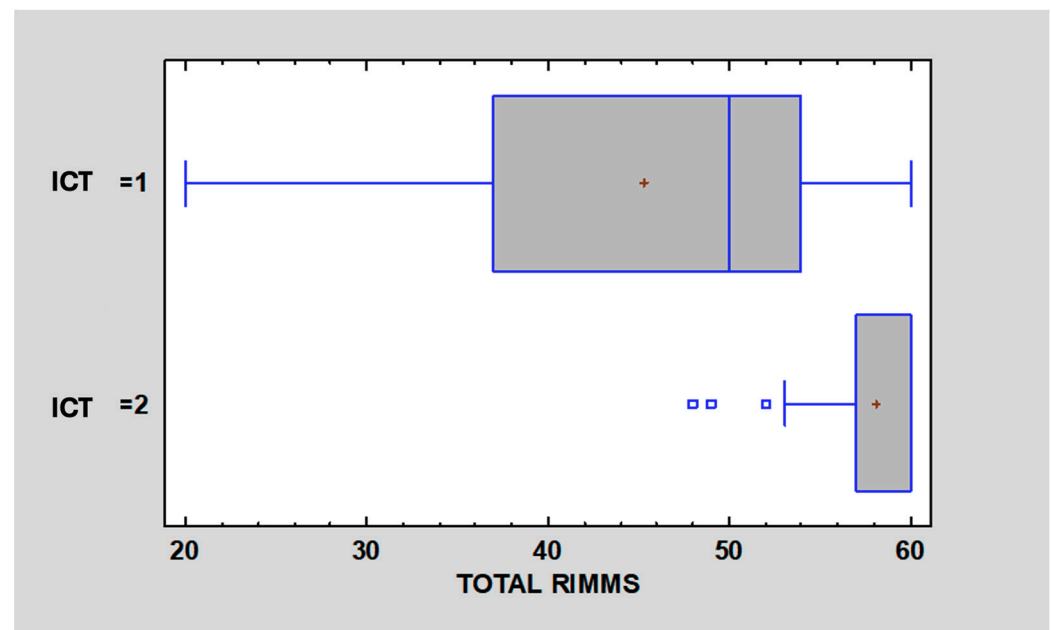


Figure 10. Graph of comparison statistics between two samples. Note. The red cross represents the mean, while the line inside the box indicates the median. The results of the F-test to compare the standard deviations suggest that there may be significant differences between them.

Since the distribution was not normal, nonparametric statistics were adopted. A comparison of medians was performed with the Mann–Whitney (Wilcoxon). The Mann–Whitney (Wilcoxon) W test was performed to compare medians with the following data:

Null Hypothesis: median1 = median2.

Alt. Hypothesis: median1 $\neq$ median2

Sample mean rank 1: 27.1667

Sample mean rank 2: 63.8333

W = 1837.5

p-value = 1.48097×10^{-11}

The null hypothesis was rejected for alpha = 0.05; there was a significant statistic between the medians at a confidence level of 95.0%. Therefore, it can be said that the group in which the immersive tool “Oculus” was implemented presented higher levels of motivation than the group that implemented the use of the digital tool “Mesa Sectra”.

4. Discussion

When analyzing our results, we observed the responses of the 90 surveyed students, divided into two groups of 45 each. Each group used a different educational digital tool. Upon comparing the results, we found much more positive responses with the use of virtual reality through Oculus, which was used as an immersive tool, compared to the use of the Sectra table as a non-immersive digital tool. This aligns with the findings of Santos Garduño, et al. [9], who applied the same questionnaire to evaluate the motivation of their classes using virtual reality with Oculus for science subjects in high school. They used this immersive tool because they believed it allowed for better understanding and visualization of information, which aligns with the study conducted by Ekstrand, et al. [20] in which they compared virtual reality with a paper-based group in the learning of neuroanatomy and suggest that virtual reality is an effective tool for understanding complex spatial relations between different structures of the brain. This has been shown because virtual reality maximizes their learning experience in anatomy by introducing them inside the human body and allowing them to dissect and manipulate anatomical structures while being fully immersed and creating real-life situations in control environments [1,10]. It is very important to consider that motivation is a key piece for success in the acquisition

of meaningful learning for students, as mentioned by Wardani, et al. [16], who state that student motivation helps them become aware of their role in acquiring their own learning and the importance of the knowledge retention process and its effect on their daily lives, just as is mentioned in the introduction, this by fostering their enthusiasm for learning, the habit of daily study, and the effect of all this on their employability after finishing their studies. Therefore, it is important to create conditions that guide them in this process. However, we know that achieving student motivation to study eagerly is not an easy task; it requires time and the active participation of a creative teacher who can implement didactic activities, sometimes accompanied by digital tools. This is where our study takes relevance by demonstrating that increased motivation is key in the learning process, because it is not only important the use of digital tools, but the type of tool we implement, because being immersive, as was the oculus in this study, generated more student acceptance. Thus, the teacher must also play a role as a motivator, being responsible for applying innovative educational systems for this process to occur. Therefore, success will depend on the teacher's efforts to motivate students to learn.

In our study, among the dependent variables analyzed, the satisfaction variable had the highest positive response, followed by the relevance variable. Comparing our findings with the study conducted by Santos Garduño et al. [9], where they found that the variable with the highest positive response was attention, followed by the satisfaction variable, we observed similarities in the favorable responses towards the immersive tool and its connection to increased student motivation. Among the findings in both studies, it is worth noting the positive response to the satisfaction variable, which can reinforce intrinsic motivation in students through the use of immersive digital tools. As described previously in the text, the intrinsic motivation is the act due to an internal driving factor; seeing a positive effect in the intrinsic motivation will guarantee that students will continue learning even when there's no exam or test to complete a course.

In other articles in the field, the effectiveness of virtual reality in anatomy education has been examined versus other digital technological tools such as video classes with PowerPoint presentations with 2D images. Zhao et al. conducted a meta-analysis of 15 randomized controlled trials involving 816 students from Xijing University. The findings indicate that virtual reality significantly improves medical students' exam scores compared to 2D technological methods. Furthermore, in this study, students showed higher levels of satisfaction with VR education (SMD = 0.77 points). This is consistent with what is presented in this article [21].

For this, 21st-century teachers use digital tools as motivational means while teaching a digitized generation. However, in this study, we can analyze that it is not just about using technology because the Sectra table is also a digital tool, but being non-immersive, its effect on motivation was lower, similar to what was reported by Zhao et al. [21], who analyzed various studies and found that virtual reality has greater potential to transform the teaching of anatomical content compared to traditional methods or even those that support technology in 2D or anatomical models. Perhaps this is due to the complexity of the subject itself, as mentioned by Moro et al. [22], who described that understanding this subject requires significant intellectual effort since students must learn to identify both the internal organization of structures and their relationship with other systems under study. Immersive tools allow showing complex body structures in a three-dimensional form by immersing students in the study of structures, enabling them to increase their spatial understanding of the organ.

Considering the above, we can see that there are several publications where some advantages of using virtual reality in anatomy teaching are found, as mentioned by Marín et al. [23], who in their research found a positive effect with the use of virtual reality in the understanding and application of anatomical content. The students' perception was that this tool supported their study of laryngeal biochemistry since such content involves anatomo-physiological content. This could be explained by Saab et al. [24], who indicate that the characteristics that enhance this tool are due to students considering it as a novel,

easy, and pleasant learning method, which enhances knowledge retention and skill acquisition. Therefore, it can be useful as a complement in the teaching-learning process, being a support tool for the teacher, especially in the area of health academic training.

Other authors, such as Espinar et al. (2020) and Thompson et al. (2020) [25,26], mention other characteristics of using virtual reality as an immersive educational tool, being innovative, and promoting experiential learning by consolidating the skills and abilities of both students and teachers, which increases the participation and cooperation of the two fundamental pillars mentioned earlier in the teaching-learning process.

Analyzing all the above, we can consider that creating immersive learning experiences can help us face one of the current challenges for teachers, which is creating personalized learning for our students. We can consider what Villón-Briones et al. [27] mentioned, stating that in educational terms, these immersive tools create virtual environments that foster experiential and personalized learning experiences that transcend the physical limits of a conventional classroom. This is because students have the possibility to explore complex concepts visually and practically, promoting the development of communication and teamwork skills, which are essential for success in today's society. It becomes indispensable to have close collaboration between educational institutions, technology developers, policy-makers, and even society to create an inclusive, safe, and efficient environment for digital learning in the contemporary era to continue transforming education as we know it today.

Additionally, it should be considered fundamental to train teachers since these immersive tools promote experiential, reflective, and situational learning. It is necessary to have the ability to identify and implement predominant instructional designs in ADDIE (Analysis, Design, Development, Implementation, and Evaluation) or ACRS (Attention, Confidence, Relevance, and Satisfaction).

5. Conclusions

The study highlights the significant relationship between student motivation and several dimensions of learning, namely attention, relevance, confidence, and satisfaction, as measured by the RIMMS questionnaire. The results indicate that higher total satisfaction is associated with higher levels of motivation. In addition, the use of immersive technologies, such as Oculus, improves relevance and satisfaction in learning, suggesting that these tools are key to increasing student engagement and motivation. We can conclude that it is essential to integrate advanced technological tools and train educators in their effective use to create personalized and engaging learning environments that meet the demands of contemporary medical education.

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