CHAPTER
187

Virtual reality

https://doi.org/10.56238/alookdevelopv1-187

Kauane L Costa Ferreira
Human anatomy training.
E-mail: klysien@gmail.com

Andrea Teresa Riccio Barbosa
Human anatomy training.

ABSTRACT
Research Objective: To develop a Virtual Reality (VR) application for the practice of human anatomy. Context: The search for innovation in education is a global problem, the need for new ways to achieve it has created concern around the world. Problem: Develop appropriate technologies as a way of supporting practical teaching with the impossibility of face-to-face practical classes. Proposed solution: Develop a work with the aim of creating, at low cost, a virtual laboratory of human anatomy, which allows the simulation of practical classes. Method: empirical research, to define characteristics for the development of a virtual anatomy laboratory in the health area; descriptive to delimit the pertinent content in a virtual laboratory of human anatomy of the locomotor system. The data were used for the development of the laboratory where Blender 3D and JavaScript software were used, both free licenses. Summary of results: economic and infrastructure in public universities, from the implementation of a VR laboratory for teaching anatomy. Contributions: As a scientific contribution, the developed application will make the information accessible to a greater number of users, facilitating practical work. The financial contribution will lead to a reduction in expenses with the purchase of corpses for practice laboratories and with a reduction of physical facilities in public educational institutions. Impact in the IS area: In the educational area, where the student of the health area will know advantages and potentialities that the use of VR in teaching can offer in the practical learning process.

Keywords: Virtual reality, human anatomy, virtual lab, locomotor system.

1 INTRODUCTION

1.1 BACKGROUND

The search for innovation in education is a global problem, especially in a pandemic context. Today the goal is for information to reach the largest number of people, in the shortest possible time, and to all this is added the desire to eliminate limitations such as distance and time.

The need to generate and communicate new information around the world, as well as the desire to be always up to date, produces the need to create, master and innovate technological tools and instruments that assist in the process of practical training, especially for health professionals (PELARGOS et al.; 2017).

It is noted that although globalization has allowed greater access to information, the need for new ways to achieve it has created concern around the world, especially in Higher Education Institutions (HEIs).

What is aimed, mainly, is to break barriers and limitations that separate the search for information and communication between teachers and students. In response to this problem, Virtual Reality (VR) has advanced, providing quick solutions in relation to the practical teaching of professionals in health laboratories. Pelargos, et al. (2017) defined VR as a real or simulated environment in which an observer experiences telepresence.

" With different levels of immersion, and even a telephone conversation can also be considered a RÁ, as long as there is a virtual space created by a telephone handset that is shared by two or more participants.

For Aspera and Hernandez (2011) "virtual reality is a computer system used to create an artificial world in which the user has the impression of being, of being and having the ability to navigate and manipulate objects in it".

One can define RÁ as a platform that provides an artificial environment where the user can perceive the simulations created by the system and take them as if they were real.

In this process of searching for better learning tools, some areas of knowledge that are suitable for implementation emerge.

It was verified, for example, that in the process of learning human anatomy from the Hippocratic era until today, it has always been carried out with corpses and its study was the basis of knowledge about the human body.

This is because this represented one of the most appropriate means available to obtain information about the structure of the living body (TESTUT, 2017). That is why the corpse continues even in the present day to be the means of learning.

Therefore, it is a method that contributes effectively to the understanding of form and space, as well as the relationships between anatomical structures or elements and the possible variations in the different regions of the human body.

The learning of human anatomy, however, has evolved since the corpse and/or anatomical parts of visual quality are not always present.

Thus, this reflects on the development of classes with the implementation of didactic models (software, videos, atlases and synthetic models) to supply the lack of the corpse, also constituting effective methods in the teaching-learning process, as these methods support the visual construction of the form (TESTUT, 2017).

The scientific-technological development of the biomedical sciences in the learning of anatomy, therefore, have evolved over time with the use of supporting didactic resources such as: multimedia, X-rays, software computerized, self-study modules, including anatomical models, among others (TESTUT, 2017). These resources can enable support for practical activities in the learning process.

Given the above, the research problem is the need to develop more appropriate technologies, such as immersive VR, as a way to support the practical teaching of disciplines in the health area.

Especially in an environment with the impossibility of in-person classes, as is the case with a pandemic, such as COVID.

In this context, the motivation arose to elaborate a work with the intention of creating, at low cost, a "virtual laboratory of human anatomy", which allows students to simulate practical classes.

1.2 GENERAL OBJECTIVE

Develop a non-immersive VR application for the practice of anatomy of the human locomotor system.

1.3 SPECIFIC OBJECTIVES

The specific objectives of this work can be cited:

- map the necessary characteristics of a virtual laboratory of human anatomy in health courses;
- model the application of the human locomotion system to be used in the development of the virtual laboratory;
- design a prototype of the laboratory;

1.4 JUSTIFICATION

VR is widely used in various fields of knowledge, being in education one of the most relevant. Its rapid technological advancement enhances the need for constant training of teachers and students on the subject, in order to ensure its use, in addition to enabling a more efficient and cutting-edge access to information.

The positive impacts that this research provides are numerous. The most significant is found in the educational area, where the student of the health area will know advantages and potentialities that the use of VR in the teaching of anatomy can offer in the process of practical learning, in addition to the limitations and difficulties.

And also, it will be a tool that can assist in non-in-person teaching in cases of public calamity, such as the COVID-19 pandemic.

As a social contribution of the work, it can be affirmed that it will make efficient the dissemination of complex scientific, cultural and technological knowledge, through the experiences that will be offered to the user in a fun and attractive way.

The use of VR will facilitate the educational process by allowing the dissemination of content on a larger scale, with fewer tools and involving the creativity of the user.

With regard to scientific contribution, the developed application can make quality information accessible to a greater number of users, facilitating presentations, conferences, exhibitions and practical work in the classroom.

The proposal is to offer immersion to students, teachers and academic institutions, because with fewer resources it will be possible to obtain innovative and quality results. It can simplify the teaching-learning process, bringing the academic content closer to the users, in order to arouse their interest, especially in practical activities.

With regard to the financial contribution, it is perceived that it may lead to a decrease in expenses with the purchase of cadavers for practice laboratories and with a reduction of physical facilities in public educational institutions, which suffer constant cuts in funds, often making it impossible to perform their activities with excellence.

This research may, therefore, promote a possible reduction of costs by reducing the need for investment in health laboratories by educational institutions, replacing it with the use of VR laboratories.

As a personal contribution, the development of a virtual laboratory will enable the improvement of knowledge acquired throughout undergraduate and graduate studies. It will also allow a professional growth in the area of study, being an opportunity to hone soft skills that are interesting for the job market.

Regarding the other contributions, reference can be made to the place of development and application of the work, since there is little research on the subject and the information obtained will be useful to disseminate others.

Not only in the anatomy laboratory of the IES, but possibly at the local and national level, since local production is what motivates the production of research or meta-analysis at national or international level. Likewise, the proposals and recommendations provided will be useful to properly apply VR in the anatomy laboratories of other universities.

2 THEORETICAL BACKGROUNDS

In the training of health professionals in this twenty-first century, student-centered teaching is required, in which, in addition to high scientific and technological standards, other domains such as communication, professionalism, teamwork, among others, are included.

Healthcare education should be, as far as possible, based on the recognition and management of real-life patients. However, health practice has an ethical and legal obligation to provide the ideal treatment and provide safety to patients, fully respecting their autonomy and that of their family (MARAN and GALVIN, 2003)

The point of balance between these needs: to teach, to "heal" and not to cause harm, sometimes faces ethical, administrative, legal, religious dilemmas, which usually limit direct contact with the patient. Therefore, they leave to the student's imagination the resolution of the event (ZIV et al., 2003). From an ethical point of view, the use of Simulation as an educational tool should be based on:

1. Seek better standards of care for patients
2. Give a better training to the student
3. Allow a more objective evaluation of teachers
4. Direct and find the mistakes in practice
5. Respect and preserve patients' autonomy
6. Respect and preserve professional autonomy in the health sciences (ZIV et al., 2003).

The simulation, considered as an educational tool that must obey the rigor of the scientific method, has become an excellent practice to understand and seek the logical relationship between knowing, doing and being, with which it is possible to be better teachers and students, with the final benefit for the patient and his environment.

Through simulation, combined with teaching based on problem solving through objective and structured clinical assessments, greater objectivity, control and satisfaction of the teacher and the student are allowed when looking together determines the degree of competence (CHAPMAN, 1985).

The most important value of simulation as an educational tool are the elements suitable for practical evaluation of a specific case, such as spaces (offices, rooms, operating rooms, etc.), built on a real scale and equipped with virtual elements, scenarios and every day and trivial situations can be generated in sophisticated and complex ways when necessary and in the context and level that is required; Thus, the teacher and the student will be able to repeat, correct and perfect their practice.

3 RELATED WORKS

A consultation of related works was carried out during the period from March to June 2021, and the date of publication of the analyzed works was not fixed.

We opted for articles from the databases of the Portal de Periódicos da Capes that are accessible within the university and allows the search of articles in related databases, such as Elsevier, Springer, Ebsco, IEEE, among others.

We found on the platform of the Portal de Periódicos da Capes 20 articles related to the theme. After a first analysis, 11 papers were selected for a more detailed reading.

It was observed that in the platform better results are retrieved through the search with wordskeys in the English language. The search for journal databases was limited by selecting the seguintes: Scopus (Elsevier), Web of Science, Gale, Directory of Open Access Journals (DOAJ), Springer, Science Direct, Wiley Online Library e Taylor & Francis Online.

The keywords used in these researches were:

- Virtual reality;
- Virtual lab;
- Laboratory practices;
- Laboratories of teaching centers;
- Virtual reality in teaching anatomy;
- Implementation of a virtual laboratory.

Chart 1 presents the summary of the related works selected for a careful and detailed reading.

Table 1- Summary of related works

Authors	**Points addressed**
Bacarea *et al.* (2019)	They developed a 3D virtual laboratory for anatomical dissection at the *University of Medicine, Pharmacy, Science and Technology Târgu Mureş*
Guerrero *et al.* (2008)	They presented the *design* and construction of a low-cost prototype of a two-screen virtual immersion system.
Kharki *et al.* (2021)	They stated that laboratory experimentation plays a vital role in science education. They presented the use of computer simulation combined with the JavaScript programming language for the development of a low-cost virtual laboratory integrated into an interactive learning environment based on the *Moodle platform*.
Cardenas *et al.* (2015)	They described the design and development of a computational tool for the chemistry laboratory, specifically the distillation process.
Heather *et al.* (2019)	They made an evaluation about the application of

	VR in the teaching process of the discipline of anatomy and affirmed that there is a demand for new and efficient tools for the teaching of anatomical sciences.
Abdullah *et al.* (2018)	They observed that VR education is a computer interface with specific characteristics, which transforms an immersive and interactive experience into an educational evolution. The authors examined different approaches to study the emergence of the application of VR in classroom teaching and learning.
Zhao *et al.* (2020)	VR is an innovation that allows the individual to discover and operate within a three-dimensional (3D) environment to gain practical understanding. This research examined the overall efficiency of VR in teaching medical anatomy. They ran a meta-analysis of randomized controlled trials of anatomy education performance in VR.
Fairen *et al.* (2017)	They conducted an experiment designed to give students a specific VR session where they can directly inspect and evaluate 3D models of various human organs using VR systems.
Alfalah *et al.* (2019)	They conducted a comparative study between a VR cardiac anatomy system and traditional medical education modalities.
Wang (2018)	This research objective was the teaching of virtual experiment at a distance by computer, through methods of investigation, summarization and

	analysis of cases, based on the analysis of distance learning by computer, VR technology, teaching of virtual experiment and other related technological theories.
Sattar *et al.* (2019)	They explored the effects of text, video and immersive VR learning methodologies for participants' learning at public and private medical colleges and universities in Pakistan.

Source: Prepared by the author

Bacarea et al. (2019) They developed a 3D virtual laboratory for anatomical dissection at the University of Medicine, Pharmacy, Science and Technology Târgu Mureş

Guerrero et al. (2008) They presented the design and construction of a low-cost prototype of a two-screen virtual immersion system.

Guerrero et al. (2008) They presented the design and construction of a low-cost prototype of a two-screen virtual immersion system.

Kharki et al. (2021) They stated that laboratory experimentation plays a vital role in science education. They presented the use of computer simulation combined with the JavaScript programming language for the development of a low-cost virtual laboratory integrated into an interactive learning environment based on the Moodle platform.

Cardenas et al. (2015)They described the design and development of a computational tool for the chemistry laboratory, specifically the distillation process.

Heather et al. (2019) They made an evaluation about the application of VR in the teaching process of the discipline of anatomy and affirmed that there is a demand for new and efficient tools for the teaching of anatomical sciences.

Abdullah et al. (2018)They observed that VR education is a computer interface with specific characteristics, which transforms an immersive and interactive experience into an educational evolution. The authors examined different approaches to study the emergence of the application of VR in classroom teaching and learning.

Zhao et al. (2020) VR is an innovation that allows the individual to discover and operate within a three-dimensional (3D) environment to gain practical understanding. This research examined the overall efficiency of VR in teaching medical anatomy. They ran a meta-analysis of randomized controlled trials of anatomy education performance in VR.

VR is an innovation that allows the individual to discover and operate within a three-dimensional (3D) environment to gain practical understanding. This research examined the overall efficiency of VR in teaching medical anatomy. They ran a meta-analysis of randomized controlled trials of anatomy education performance in VR.

They conducted an experiment designed to give students a specific VR session where they can directly inspect and evaluate 3D models of various human organs using VR systems.

They conducted a comparative study between a VR cardiac anatomy system and traditional medical education modalities.

This research objective was the teaching of virtual experiment at a distance by computer, through methods of investigation, summarization and analysis of cases, based on the analysis of distance learning by computer, VR technology, teaching of virtual experiment and other related technological theories.

They explored the effects of text, video and immersive VR learning methodologies for participants' learning at public and private medical colleges and universities in Pakistan.

4 METHODOLOGIES

The work, as mentioned, aims to create a computerized application to implement a virtual laboratory of human anatomy, to complement the distance classes, of vocational courses, such as university teaching courses. It can also be used by professionals related to the health area, for the exercise of continuous training activities.

The research was defined according to an analysis by Jesus-Lopes et al. (2022), where health sciences were identified as areas of knowledge, with an area of concentration in computational technologies for the health area.

The research has an interdisciplinary epistemological approach with respect to applicability in various disciplines in health.

Regarding the nature of the research, quantitative methods were applied. In relation to the purpose, there is the character of applied research, where a practical solution to concrete problems is sought.

As for the research objectives, there is an exploratory character that has the function of solving the gaps that usually appear in a practical study.

The origin of the data is from the following sources, reading of bibliographies adopted in the discipline of human anatomy, and consultation of scientific articles in the databases of the portal of journals of Capes.

As for the procedures of data collection survey, there are bibliographic and documentary surveys, where the norms of conduct in the human anatomy laboratory are analyzed, books that are used in the anatomy discipline, and also a systematic review of scientific articles is carried out.

As for the data collection instruments, non-participant observation was used, where the researcher enrolled in the discipline of human anatomy and participated in its activities and evaluations and data collection.

The development of the virtual simulation laboratory will be carried out following the steps mentioned below and that will later be described in detail.

- Step 1: define characteristics necessary for the application of a virtual laboratory of human anatomy in health courses;
- Step 2: define the application to be used in the development of the virtual lab;
- Step 3: define the programming language to be used;
- Step 4: define the content for a virtual laboratory of human anatomy of the locomotor system (bones, ligaments and muscles);
- Step 5: Develop the application;
- Step 6: Perform tests on the application.

The details of the Steps follow:

Step 1) define characteristics necessary for the application of a virtual laboratory of human anatomy in the courses of the health area: from an on-site analysis, the survey of the characteristics of a human anatomy laboratory, the necessary equipment and those of individual protection that should be considered mandatory for laboratory practices of students in a university will be carried out;

Step 2) define the application to be used in the development of the virtual lab: For the development of the work will be used the Kodular platform and the JavaScript programming language. The implementation of the work will be done on a Dell computer with Intel® Core™ i3 processor (3.1GHz, 4MB cache) and 4 GB of RAM and Windows 10 Home 64-bit operating system. The JavaScript programming language will be used in the implementation of the Scripts.

Step 3) define the programming language used: the JavaScript programming language will be used in the development of the site;

Step 4) define the content for a virtual laboratory of human anatomy of the locomotor system (bones): from the initial analysis of a laboratory of human anatomy, and also from the bibliography of the discipline, where the delineation of the anatomical pieces necessary for a practice of anatomy of the locomotor system, that is, the bones, which play a crucial role in human locomotion, will be carried out, the nomenclature that should be known to the student in the functional practice, and also, the definition of the dynamics of identification of the pieces by the students in the laboratory, aiming to reflect the real practices in a virtual environment;

Step 5) develop the application: the application will be developed using the Kodular platform that will be integrated into the site with the anatomical pieces and the 3D images were taken from a database called BodyParts3D that has Creative Commons;

Step 6) perform tests on the application: at the end of the development of the laboratory, execution tests will be carried out to analyze whether the application is processing all the functionalities necessary for the practice of the human anatomy laboratory of the locomotor system. The tests with the virtual lab will be carried out on different mobile devices (Smartphones) that have the Android operating system with the evaluation of the application through a questionnaire.

Therefore, following all these steps it will be possible to develop a virtual laboratory of human anatomy of the human locomotor system that can be used for the teaching of anatomy in the courses of the health area and that will assist the student in the process of remote teaching.

This application is useful for memorizing the nomenclatures of anatomical parts and their respective functions. This research can be used in the implementation of other virtual laboratories in higher education institutions.

5 ANALYSES OF THE RESULTS

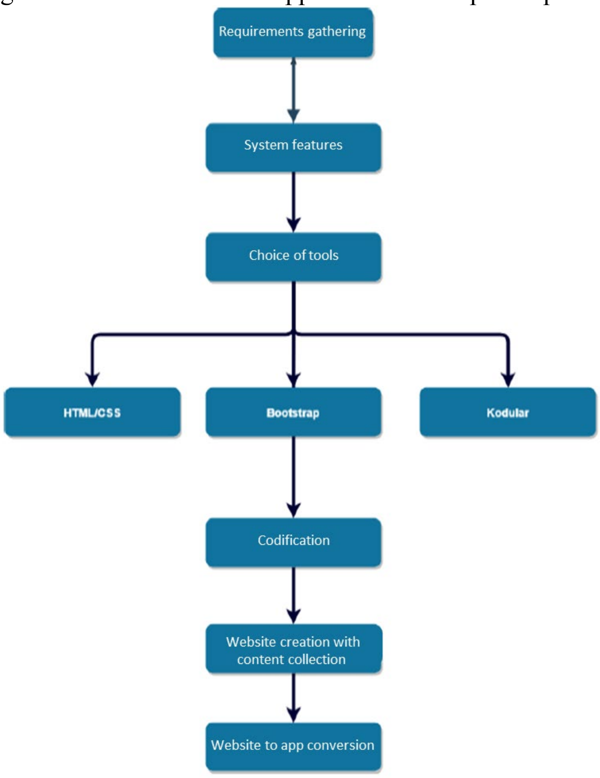
The results will be presented below in subsections, after implementation described in the methodology.

5.1 DESCRIPTION OF VIRTUAL LAB IMPLEMENTATIONS

This section describes what was implemented for the virtual laboratory and the functionalities necessary for learning the human locomotor system. First, the content to be implemented was surveyed, which is the reference for the selection of the parts of the locomotor system.

Then, the development of the back-end of the virtual laboratory in the JavaScript language began with the implementation of the anatomical parts of the locomotor system and their respective nomenclature, starting from the development of a website, which were implemented in separate parts: head, trunk, lower limbs and upper limbs. Figure 1 shows the representation of the processes described.

Figure 1 - Flowchart of the application development process.



Source: Prepared by the author

5.2 APPLICATION MODELING

For modeling of the laboratory virtual the Kodular platform was used. For this, some requirements were defined as: whether the laboratory would be viewed in first person or third person. In this case, we opted for the third-person perspective, in which the user views the information from an outside perspective.

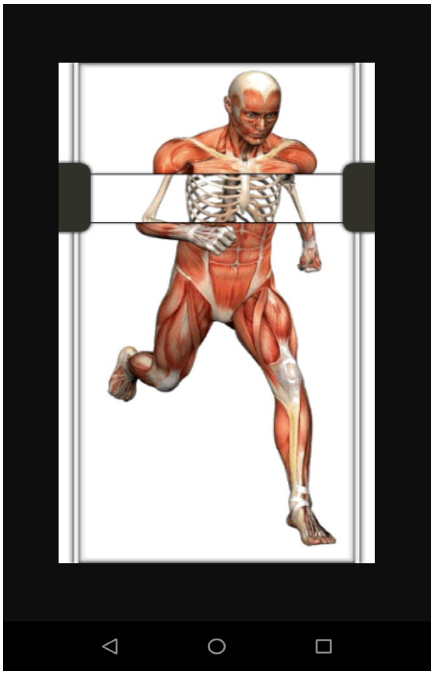
The next requirement was to determine whether or not to use a character (avatar). In this case, it was decided not to use a character because it had to create animations for each iteration with the laboratory and with the anatomical pieces.

That is, if it were used, to have a greater realism, it would be necessary to model the character and add the Bones (bones) so that the character could move realistically.

When the app starts, it presents a screen: default (home screen), which can be seen in the Figure 2.

To proceed to the next screen, the user must wait until the end of the visualization of this initial screen, which in this case, has a scroll bar that passes through the entire body of the individual automatically. Soon after, a new screen will be automatically shown to enter the virtual lab and choose the PPE.

Figure 2 -Application splash screen.



Source: Prepared by the author

Within the virtual lab it is possible to have a view as if you were in the real lab. The anatomical models will only be presented to the user when the "enter the laboratory" option is selected and the PPE is chosen.

In the virtual laboratory, if the student chooses the unsuitable PPE, an error screen will appear informing, and also, what equipment is mandatory for the practice of this laboratory of anatomy of human bones.

Subsequently, it will return to the selection screen of the PPE and when choosing the correct equipment for the practice the student will see a menu to choose the anatomical piece to be studied.

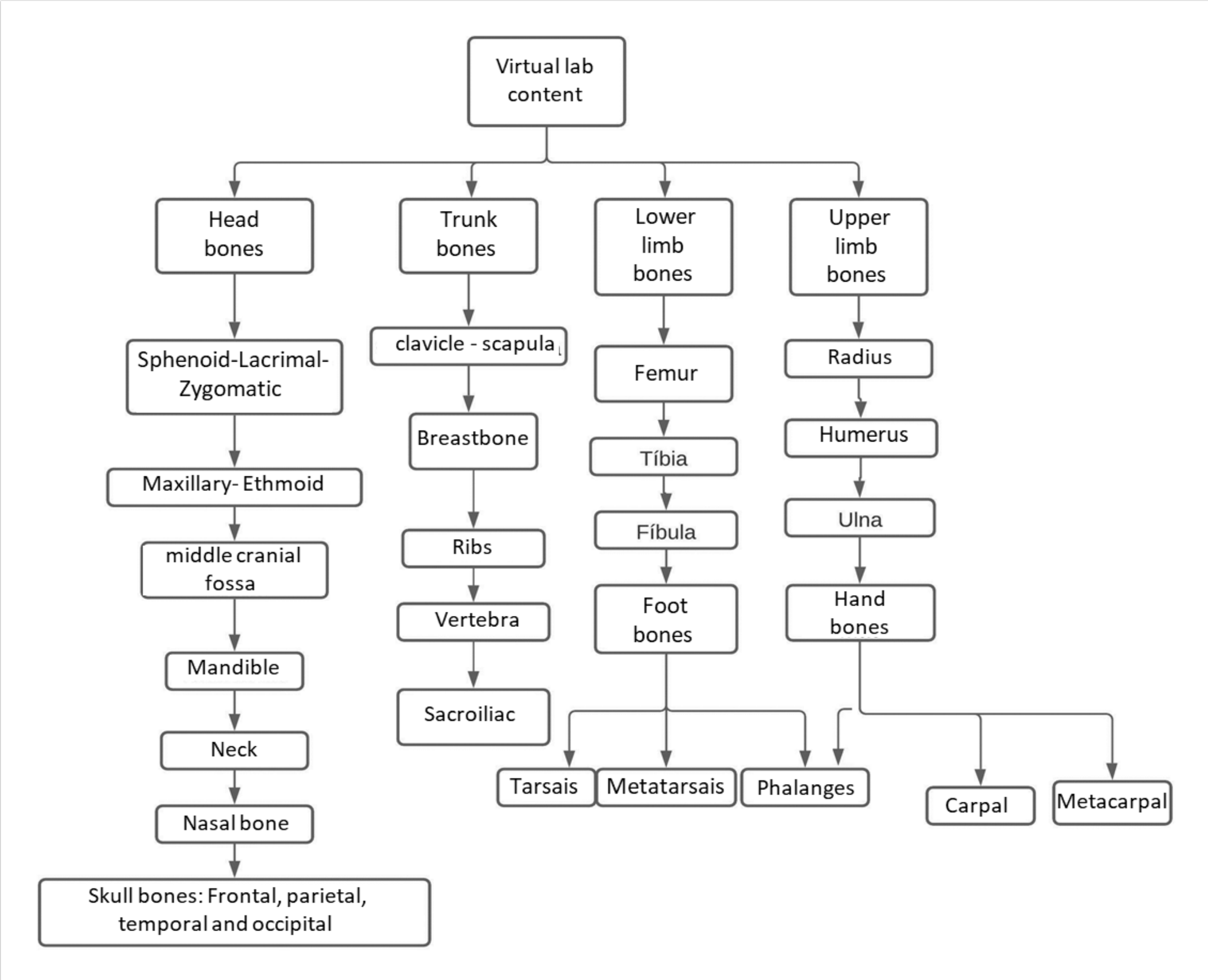
5.3 VIRTUAL LAB CONTENT

In this section the content in the application of the virtual laboratory of the human locomotor system will be described, highlighting the content and its functionalities. Figure 3 shows a flowchart with the content of the virtual laboratory developed.

This content was selected based on the reference book of the discipline of human anatomy in the health area: Atlas of human anatomy (Sobotta, 2000).

But the images were taken from the online database BodyParts3D which has Creative Commons that allow copying and sharing with fewer restrictions.

Figure 3- Virtual lab content flowchart

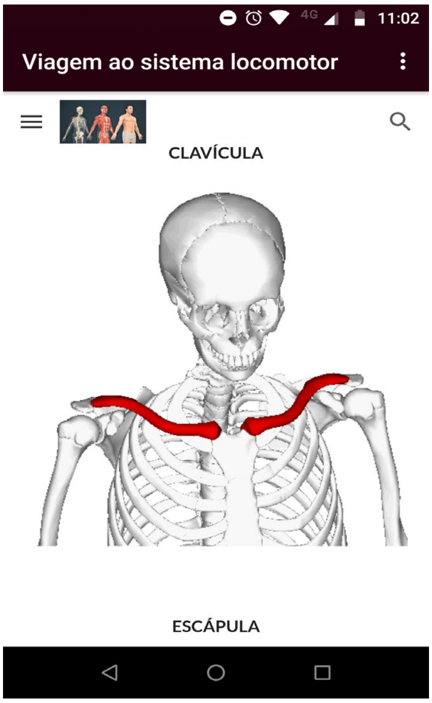


Source: Prepared by the author

In the menu the student must select the bone that is interested in knowing the nomenclature and after choosing will be presented the image and the respective name of the anatomical piece.

To select a specific piece, the student must click with the left mouse button on the desired structure, being illuminated, standing out from the others. Figure 4 shows how the bone is visualized after selection by the student.

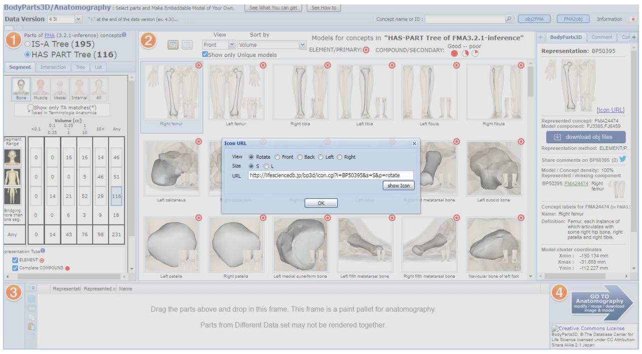
Figure 4-Screen of visualization of the anatomical piece.



Source: BodyParts3D (2022)

To exit the system the user must click on the side menu and select the exit option. The 3D images were inserted into the Locomotomic Website through the URL that the BodyParts 3D database offers, as can be seen in Figure 5.

Figure 5- 3D BodyParts URL



Source: BodyParts 3D (2022)

5.4 TURNING THE WEBSITE INTO AN APPLICATION

So that the web site in application it was necessary to use the Kodular tool. After you created a project in Kodular you had to use the component WebView, which serves to allow the content of the site within the app, with more features than standard browsers.

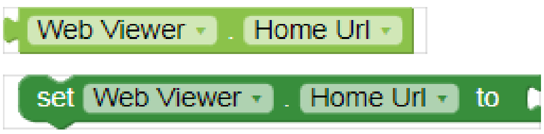
The WebView structure allows you to specify the settings that cause web pages to appear at the appropriate size and scale in all screen configurations. When you added the WebView component, you had to add the home page of the site, so that when you open the application it always starts on the home screen of the website.

5.4.1 Web View

Component for viewing Web pages. An initial URL can be specified in the Designer or the Block Editor. The view can be configured to follow links when they are tapped, and users can fill out web forms. Warning: This is not a full browser. For example, pressing the back key on the phone's hardware will exit the app, rather than going back to the browser history.

You can use the WebViewer.WebViewString property to communicate between your application and the Javascript code running on the Webviewer page. In the application, you get and set WebViewString. In WebViewer, you include Javascript that references the window object. Kodular, using the getWebViewString() and setWebViewString(text) methods.

For example, if WebViewer opens on a page that contains the Javascript document write command ("The response is" + window. Kodular.getWebViewString()); and if you set WebView.WebVewString to "hello", the web page shows the answer is hello. What if the web page contains Javascript that executes the window command. Kodular.setWebViewString (“hello from Javascript"), the value of the WebViewString property will be hello from Javascript. You must set the URL of the page that WebViewer should initially open. Setting this will load the page.



After completing the previous step, the application is ready to be installed on mobile phones. In order to be able to install the application, it was necessary that the project be exported with the APK extension, being the type of extension that mobile devices recognize as an application.

5.5 HUMAN ANATOMY APPLICATION DEVELOPMENT STEP-BY-STEP

The human locomotor system is made up of bones, muscles, joints, and other tissues that work together to allow the body to move.

With the advancement of technology, creating applications that allow users to better visualize and understand this system has become a necessity.

In this section, we will show you step-by-step application development of the human locomotor system using the JavaScript programming language, the Kodular application development platform, and BodyParts3D images. The development of the application followed the following steps:

a) Kodular account creation: To get started, we create an account on the Kodular platform. It is a free platform that allows you to create applications without the need for coding.
b) Importing the BodyParts3D images: Next, we import the BodyParts3D images, which are 3D images of the human locomotor system. These images will be used for viewing in the app.
c) UI creation: We create the UI for the app. We use prefabricated components of the Kodular platform to create buttons, checkboxes, and other interface elements.
d) Adding functionality: After creating the UI, we add functionality to the app. We use JavaScript to add interactions, such as rotating the 3D image at the click of a button.
e) Testing and deployment: Finally, we tested the app to make sure everything was working properly by installing it on a smarthphone running the Android operating system.

Already in relation to the process of entering the information of the site developed for the application in Kodular we add the site to the project on the platform, after the site with the images is ready, we add to the application created. This was done by adding the site as an extension on Kodular.

The process of entering site information into Kodular using extensions was as follows:

a) The site was published: First of all, we publish the site in a place accessible through the Internet. This was done using a web hosting service.
b) We've added a WebViewer extension: To display the site in Kodular, we've added a WebViewer extension. This extension allows you to display web content within an application.
c) We add the code block: After we add the WebViewer extension, we add a code block to the project in Kodular to specify the URL of the site.
d) We customize the look: Finally, we customize the look of the application, including the size and position of the WebViewer.

The WebView component in Kodular is used to display web pages in your application. It works as a kind of "browser within the application". To append a URL to a WebView component, we follow these steps:

a) A WebView component was added to the application canvas: we drag and drop the WebView component from the component library to the project canvas.

b) The properties of the component have been configured: in the properties panel of the WebView component, we configure the options, such as size, position, etc.

c) Added a variable to store the URL: In Kodular, we created a variable to store the URL that we wanted to attach to the WebView component.

d) The URL was assigned to the variable: we assigned the URL to the variable through an action in the "On Click" event.

e) The URL stored in the variable has been assigned to the WebView component: In the properties tab of the WebView component, we use the "URL" option to assign the URL stored in the variable to the WebView component.

f) Ran the application: When we ran the application, the WebView component displayed the web page corresponding to the assigned URL.

Developing a human locomotor system application is a fun and educational way to learn about this complex system. With the Kodular platform and the BodyParts3D images, it was possible to create an application of the human locomotor system.

5.6 INSERTING THE 3D IMAGE INTO THE WEBSITE

Added a ready-made 3D image from a database called BodyParts3D to the site, we loaded the 3D model using a JavaScript library called A-Frame. Figure 20 shows the code developed to insert the image to the site using A-Frame:

Figure 6- Code to Insert 3D Image

```
<html>
  <head>
    <title>Sistema Locomotor Humano</title>
    <script src="https://aframe.io/releases/1.0.4/aframe.min.js"></script>
  </head>
  <body>
    <a-scene>
      <a-entity gltf-model="#human-skeleton" position="0 0 0"></a-entity>
      <a-sky color="#ECECEC"></a-sky>
    </a-scene>
    <script>
      AFRAME.registerComponent('model-opacity', {
        schema: {default: 1.0},
        init: function () {
          this.el.addEventListener('mouseenter', function () {
            this.setAttribute('material', 'opacity', 0.5);
          });
          this.el.addEventListener('mouseleave', function () {
            this.setAttribute('material', 'opacity', 1.0);
          });
        }
      });
    </script>
  </body>
</html>
```

Source: Prepared by the author

In this code, we load the 3D model of a human skeleton bone in glTF format and add it to the scene using the <a-entity> component. In addition, we added a background image (sky) to give context to the 3D image.

We added the 3D scene using the component <a-scene>. Inside the scene, we added a 3D object, the bone of the human skeleton, using the component <a-entity>. The attribute gltf-model indicates that we are loading a 3D model in glTF format. The attribute position is used to position the 3D model in the scene.

We also added a background image (sky) to the scene using the component <a-sky>. The attribute Color Sets the color of the background image.

We also added an interaction to the 3D model. Registering a component called "model-opacity" that allows the user to change the opacity of the 3D model by hovering over it.

The "model-opacity" component defines a data structure (schema) with the default opacity value being 1.0. The method Init is called when the component is started and adds the mouse events "MouseEnter" and "MouseLeave" to the object.

When the mouse enters the object, the opacity is changed to 0.5, and when the mouse exits the object, the opacity is changed back to 1.0.

5.7 TURNING SOME 2D BONE IMAGES INTO 3D ON THE KODULAR PLATFORM

Some images of bones had to be transformed from 2D to 3D on the Kodular platform because they were not available in the previously used database.

The process of transforming a 2D image of a bone into a 3D image in Kodular involved several steps. First, a "Canvas" component and an "Image" component were added to the application layout. The 2D bone image was loaded into the "Image" component and a "Slider" component was added to control the viewing angle of the 3D image.

In the "Canvas" section of the block panel, a "Draw Image" block has been added to draw the 2D bone image on the Canvas. Then more "Draw Image" and "Rotate Canvas" blocks were added to create the illusion of depth and perspective.

The application was tested to see if the 2D image of the bone appeared in a 3D perspective and the parameters were adjusted, if necessary, to get the desired effect.

The process of transforming a 2D image into a 3D image in Kodular is a complex process that requires knowledge in correctly adjusting the parameters to obtain a quality 3D image. The end result will depend on skill and technique to apply the concepts necessary for the transformation of 2D images into 3D, and also, of the image quality.

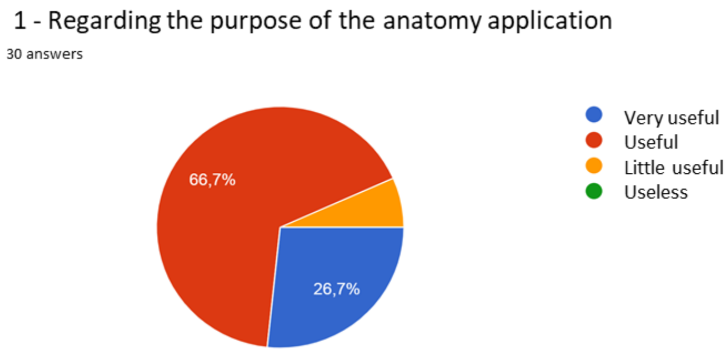
5.8 OPINION POLL RESULTS

The opinion poll was attended by thirty students of the discipline of human anatomy.

A questionnaire was applied that should as a parameter for your development the research of Raphael Naves (2013) who also developed a veterinary anatomy application and used an opinion survey as a way to evaluate the application.

The survey link and the app were shared in a group of WhatsApp where the collaboration of the students of the discipline was requested. The graphs below are in pie format to illustrate the answers to each question.

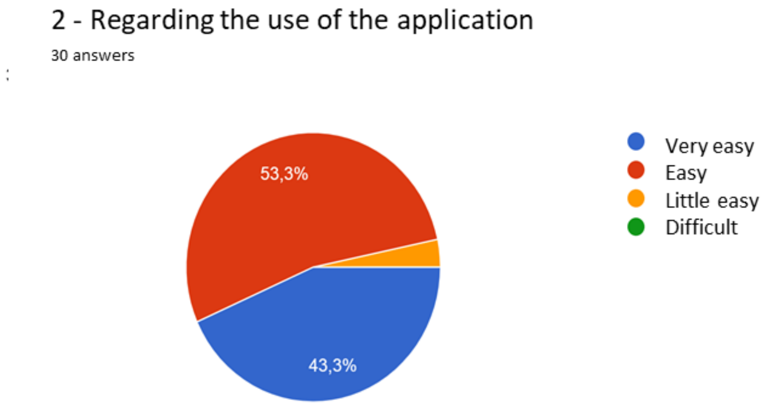
Graph 1- Answer 1 of the questionnaire



Source: Prepared by the author

Based on the data, we can say that most users of the anatomy app find it useful (20 responses) and some even find it very useful (8 responses). However, a small number of users (2 responses) found the app to be of little use. This information suggests that most users of the app are satisfied with its functionality and believe that it meets their needs in relation to its purpose.

Graph 2- Answer 2 of the questionnaire

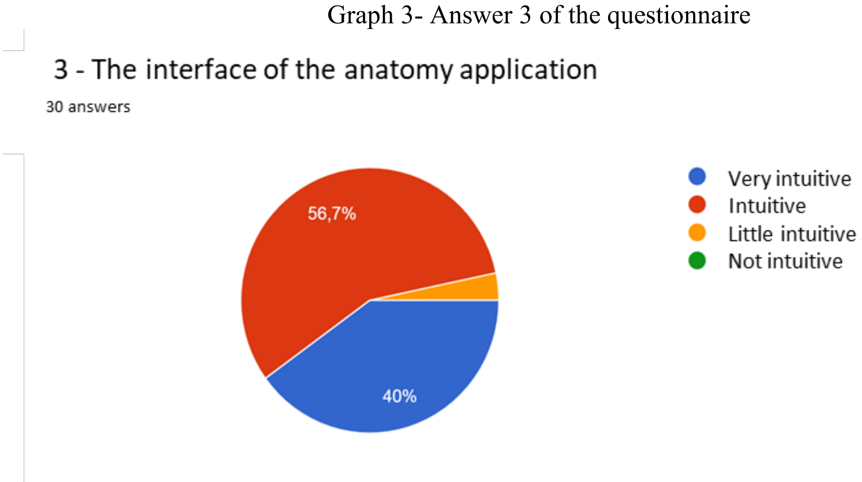


Source: Prepared by the author

Based on the data, we can state that most users of the anatomy app find it to be easy (16 answers) or very easy to use (13 answers), which indicates that the app's interface is intuitive and userfriendly. However, a small number of users (1 response) found the app a bit difficult to use. This information suggests that most users of the app have had no trouble finding and using the app's functionalities effectively.

However, it is important to note that users' opinion is subjective and may vary according to their personal experiences with the app, technological skills and familiarity with mobile devices.

Graph 3- Answer 3 of the questionnaire

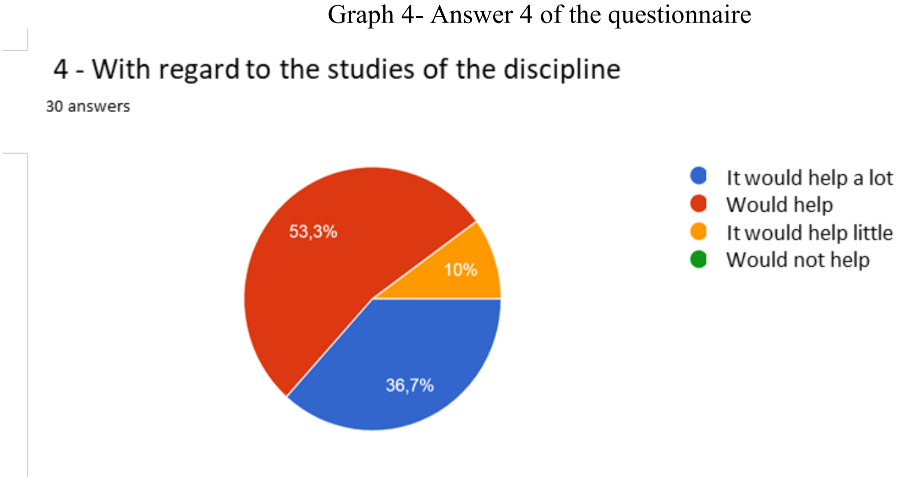


Source: Prepared by the author

According to the data, most users of the anatomy app think the interface is intuitive (17 responses) and some even think it's very intuitive (12 responses). However, a small number of users (1 response) found the interface somewhat intuitive.

Therefore, this information suggests that most users find the app's interface easy to understand and navigate, which is consistent with the answers about the app's ease of use.

Graph 4- Answer 4 of the questionnaire



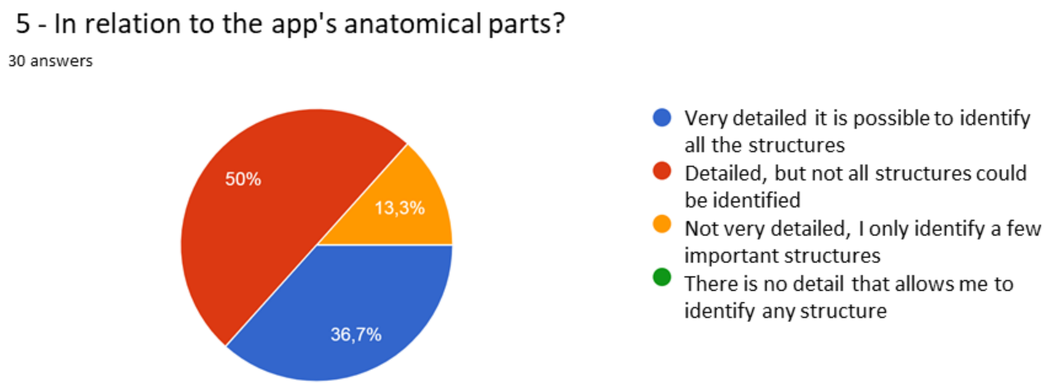
Source: Prepared by the author

According to the data aboveCan affirm that most users believe that the anatomy app will help in their studies of the discipline (16 answers), and some even believe that it will help a lot (11 answers).

However, a small number of users (3 responses) found that the app will help little. This information suggests that most users believe that the app can be useful for their anatomy studies and can help in understanding the concepts and structures of the human body.

Is It being important to note that the opinion of users is subjective and may vary according to their needs and learning objectives. Some users may find the app more useful than others, depending on their level of prior knowledge and learning style.

Graph 5- Answer 5 of the questionnaire



Source: Prepared by the author

As shown in the data above, most users of the anatomy app think that the anatomical parts of the app are detailed, but it was not possible to identify all the structures (15 responses).

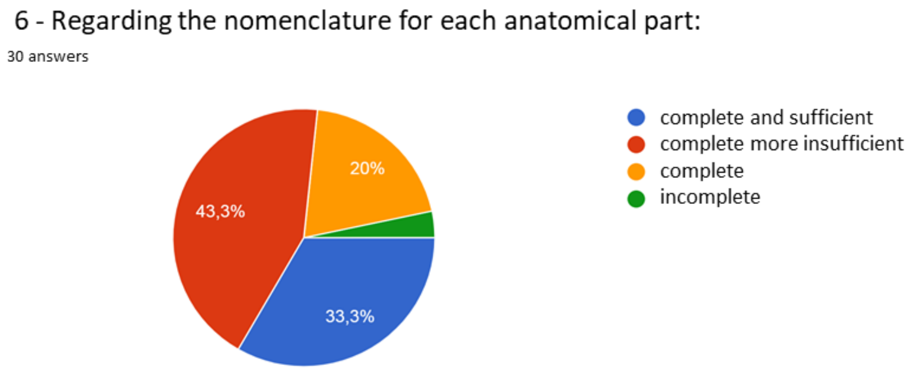
Some users think that the anatomical pieces are too detailed and it is possible to identify all the structures present (11 responses), while others think that they are not very detailed and it is only possible to identify some important structures (4 answers).

This information suggests that users' perception of the anatomical parts of the application is varied, with some users finding all the structures and others finding it difficult to identify all the structures present.

It is important to remember that human anatomy is a complex area and requires in-depth study to understand all anatomical structures and relationships.

Therefore, it can be difficult for an application to present all the structures in a detailed and clear way to all users.

Graph 6- Answer 6 of the questionnaire



Source: Prepared by the author

Based on the data, most users of the anatomy app think that the nomenclature for each anatomical piece is complete but insufficient (13 responses). Some users think the nomenclature is complete and sufficient (10 responses), while others think it is complete (6 responses).

Only one user found the nomenclature incomplete. These data suggest that although most users believe that the nomenclature is complete, there are are detailed, but it was not possible to identify all the structures (15 responses).

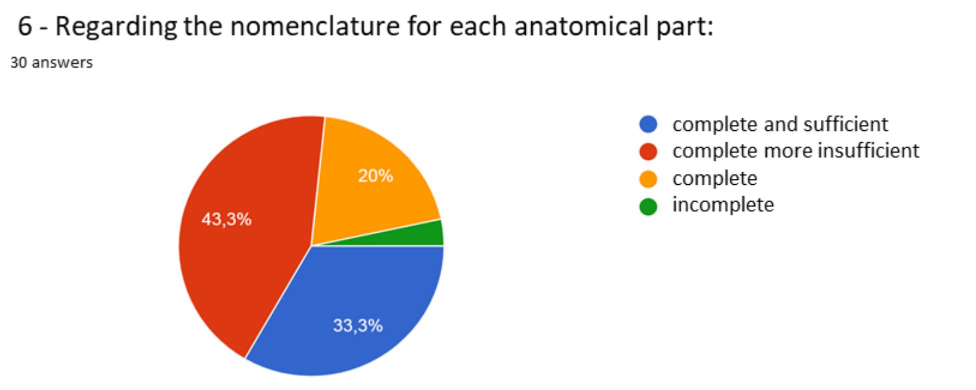
Some users think that the anatomical pieces are too detailed and it is possible to identify all the structures present (11 responses), while others think that they are not very detailed and it is only possible to identify some important structures (4 answers).

This information suggests that users' perception of the anatomical parts of the application is varied, with some users finding all the structures and others finding it difficult to identify all the structures present.

It is important to remember that human anatomy is a complex area and requires in-depth study to understand all anatomical structures and relationships.

Therefore, it can be difficult for an application to present all the structures in a detailed and clear way to all users.

Graph 6- Answer 6 of the questionnaire



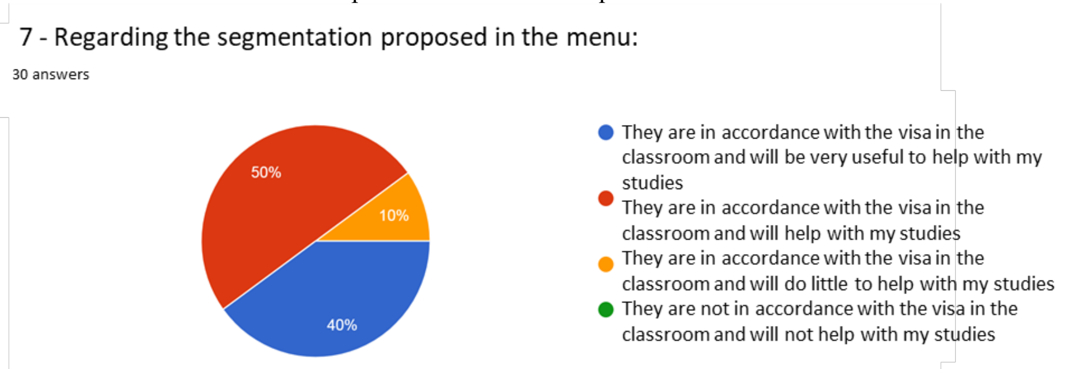
Source: Prepared by the author

Based on the data, most users of the anatomy app think that the nomenclature for each anatomical piece is complete but insufficient (13 responses). Some users think the nomenclature is complete and sufficient (10 responses), while others think it is complete (6 responses).

Only one user found the nomenclature incomplete. These data suggest that although most users believe that the nomenclature is complete, there are some users who feel that it is not sufficient for a complete understanding of anatomical structures.

This may be due to the complexity of anatomical terminology, which can be difficult to understand for those without previous experience in anatomy. However, it is relevant Highlight that the opinion of users is subjective and may vary according to their personal experiences and knowledge in anatomy.

Graph 7- Answer 7 of the questionnaire



Source: Prepared by the author

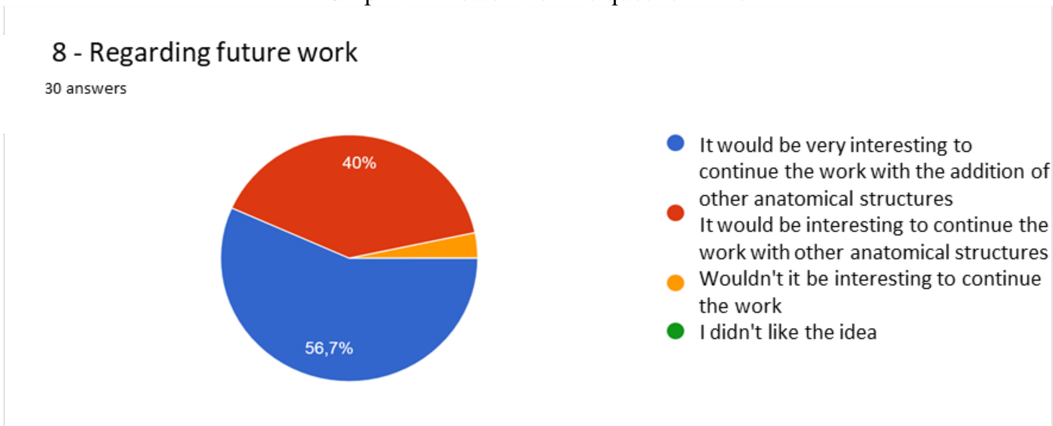
According to the data Presented, most users of the anatomy application think that the segmentation proposed in the menu is in accordance with what is seen in the classroom and will serve to assist their studies (15 answers).

Some users think that the segmentation is in accordance with what is seen in the classroom and will serve a lot to assist their studies (12 answers), while others think that it will serve little to assist their studies (3 answers).

This information suggests that the proposed segmentation in the menu is considered appropriate by users in relation to the content seen in the classroom and can be useful for reinforce their studies.

It is important to note that proper and clear segmentation of content can be a critical factor for the effectiveness of an anatomy application. The organization and structure of content can help users more easily navigate and find the information relevant to their studies.

Graph 8- Answer 8 of the questionnaire



Source: Prepared by the author

Based on the data Raised, most users of the anatomy app Believe that it would be very interesting to continue the work with the addition of other anatomical structures (17 responses).

Some users think it would be interesting to continue the work with the addition of other anatomical structures (12 responses), while only one user does not think it would be interesting to continue the work.

This information suggests that most users are interested in seeing the anatomy app expanded with the addition of more anatomical structures.

Adding more content can make the app more useful for anatomy students and healthcare professionals, allowing them to study and review more anatomical structures and concepts. However, it is important to note that developing new content requires time and resources.

6 FUTURE WORK

As a proposal for future work, we can develop new functionalities for the application, adding quizzes to evaluate the knowledge of students, allow access to the content in an accessible way such as with descriptive audios of the anatomical pieces and explain all the contents present in the discipline of human anatomy.

7 FINAL CONSIDERATIONS

Initially, it is intended that the virtual laboratory can be used as a complement to the classes taught at the School of Health of the Federal University of Ceará (UFC). However, in the near future, it is intended that its use be extended to any user external to UFC who has access to the Internet.

A VR laboratory was implemented in the teaching of human anatomy of the human locomotor system as a viable tool for practical teaching in university and professional centers in the health area, aiming to optimize the teaching-learning process.

The importance of the use of digital technologies is perceived, in particular highlighting the use of interactive virtual environments, developed with the use of VR, in order to contribute positively in assisting students in the health area.

It was observed that the main concepts of anatomical structures in VR environments, which allow students an interactivity with the subjects addressed in the practical classes, can be used to compose a learning tool of great importance and help.

One of the main advantages offered by practical work in the laboratory is its interactivity, as it allows the student to contact the elements, their manipulation and their transformations. By being able to observe what happens in the experiments, the student develops cognitive and practical skills, which facilitate the placement of problems and the application of their knowledge about the world that surrounds them, training in the execution of the scientific method in the real world.

However, despite being an ideal place for experimentation, this space also has disadvantages, among which we can highlight initial cost, maintenance, energy consumption and space restrictions due to the increase in enrollment, typical of the population explosion.

Among the advantages of using virtual laboratories in the teaching-learning process are the methodological variety, flexibility and ease of access to computer applications, attractive presentation of contents, possibility of new environments and problem situations, as well as the optimization of resources and costs.

Since a virtual lab is based on mathematical models that work on computers, its setup and installation are much easier than in real labs. In addition, virtual spaces have a much higher degree of robustness and security, since, because there are no real devices, they cannot cause problems in the environment (CALVO et al., 2008).

Virtual laboratories are developed as a computer system accessible through the Internet and, through a simple browser, one can simulate a process in which experiments are carried out following a procedure similar to that of a conventional laboratory. Among the digital tools designed for educational purposes, virtual labs stand out for their visual impact and animation characteristics, which simulate the environment of a real laboratory.

Therefore, it is perceived the advantages that the virtual laboratory brings to students to study human anatomy which are the following: it improves learning because many students learn anatomy visually; are easy to see because they show 3D graphics and allow rotations on the three three-dimensional axes; there is availability of use anywhere and anytime, because as the application is on a mobile phone or notebook, it can be carried with you at any time, which will allow you to make a review before class or in the comfort of your home, deepening your knowledge in the anatomical pieces; It's a different way of learning because conventional models are left behind and take advantage of new technologies.

REFERENCES

Abdullah, raja nazim; azman, mohamed nor azhari; kamal, mohd firdaus mustaffa; riu, tang jing; yaacob, raja ahmad iskandar raja. Experiential learning: the effective application of virtual reality in teaching and learning. The journal of social sciences research. N. 6, p. 1208-1212, 2018. Issn(e): 2411-9458, issn(p): 2413-6670. Doi: https://doi.org/10.32861/jssr.spi6.1208.1212.

Appgeek. 7 aplicativos que vão ajudá-lo a estudar anatomia no iphone. [2021?]. Disponível em: https://www.appgeek.com.br/anatomia/. Acesso em: 03 nov. 2021.

Alfalah, salsabeel f. M.; falah, jannat f. M.; alfalah, tasneem; elfalah, mutassem; muhaidat, nadia; falah, orwa. A comparative study between a virtual reality heart anatomy system and traditional medical teaching modalities. Virtual reality. N.23, 2019, p. 229–234. Doi: https://doi.org/10.1007/s10055-018-0359-y.

Alves, p.; pires, j. A. A usabilidade em software educativo: princípios e técnicas. In: vi congresso iberoamericano, iv simpósio internacional de informática educativa, vii taller internacional de software educativo, 2002.disponível: https://bibliotecadigital.ipb.pt/bitstream/10198/1950/1/2002_a%20usabilidade%20em %20software%20educativo%20ie.pdf. Acesso em: 12 maio. 2022.

Abnt, associação brasileira de normas técnicas. Nbr iso/iec 9126-1: engenharia de software - qualidade de produto, 2013. Disponível em: https://jkolb.com.br/wp-content/uploads/2014/02/nbr-iso_iec-9126-1.pdf. Acesso em: 12 abr. 2022.

Aspera, a. L. González; hernández, g. Chávez. La realidad virtual inmersiva en ambientes inteligentes de aprendizaje: un caso en la educación superior. Revista icono14. Revista científica de comunicación y tecnologías emergentes, v.9, n.2, 2011, p. 122-137.

Bacarea, v.; maruşteri, m.; brinzaniuc, k. Next generation 3d virtual human anatomy laboratory, using off-the-shelf hardware and software. Applied medical informatics. University of medicine, pharmacy, science and technology târgu mureş . V. 41, suppl. 1, 2019.

Barsuk, j; mcgaghie, w.; cohen, e. Use of simulation-based mastery learning to improve the quality of central venous catheter placement in a medical intensive care unit. J hosp medicine. [s.l], v.4, p. 397-403, 2009.

Bluestacks. O emulador android nº 1 do mundo. [s.l], 2021. Disponível em:www.bluestacks.com. Acesso em: 18 jan. 2021.

Bodyparts3d. Peças anatômicas. [s.l], 2022. Disponível em: http://lifesciencedb.jp/bp3d/?lng=en. Acesso em: 18 de ago. 2022.

Bould, m. D; crabtree, n. A; naik, v. N. Assessment of procedural skills in anaesthesia. Br j anaesth. [s.l], v.103, n.4, p. 472-483, 2009.

Calvo, i.; zulueta, e.; gangoiti, u.; lópez, j.; cartwright, h.; valentine, k. Laboratorios remotos y virtuales en enseñanzas técnicas y científicas. Ikastorratza. E-Revista de didáctica, vol. 3, p. 1-21, 2008.

Cárdenas, sandra m.; sánchez, giovanni; luengas, lely a. New pedagogical tools: virtual laboratory. Visión electrónica. [s.l], 2015.

Chapman, a.; dane, m. Teaching and evaluating clinical reasoning through computer-based patient management simulations learning strategies, computer-based instruction. Brigham young university. [s.l], 1985.

Eis, d. O básico: o que é html? 2011. Disponível em: https://tableless.com.br/o-que-html-basico/. Acesso em: 05 jul. 2022.

Fairén, m.; farrés, m.; moyés, j.; insa, e. Virtual reality to teach anatomy. Eurographics. [s.l], 2017. Doi: 10.2312/eged.20171026

Falah, j., khan, s., alfalah, t., alfalah, s. F., chan, w., harrison, d. K., & charissis, v. Virtual reality medical training system for anatomy education. In: science and information conference (sai), [s.l], 2014, p. 752–758.

González, víctor. Teoría y práctica de los medios de enseñanza. La habana: pueblo y educación, 1990.

Guerrero, christian david quintero; ballén, eduard leonardo sierra; sarmiento, wilson j. Diseño de un prototipo de sistema de realidad virtual inmersivo simplificado. Ciencia e ingeniería neogranadina, bogotá, v. 18, n.1, p. 35-50, 2008. Issn 0124-8170.

Heather, amy; chinnah, tudor; devaraj, vikram. The use of virtual and augmented reality in anatomy teaching. Mededpublish. [s.l], 2019. Doi: https://doi.org/10.15694/mep.2019.000077.1

Houben, k.w; hombergh c. L. Van den; stalmeijer, r.e; scherpbier, a.j; marcus, m.a. new training strategies for anesthesia residents. Curr opin anaesthesiol. [s.l], n.24, v.6, p. 682-686, 2011.

Hughes ch. E.; moshell j. M. Shared virtual worlds for education: the explorenet experiment. Multimedia systems, v. 5, n. 2, p. 145-154, 1997.

Hughes ch. E.; moshell j. M. 2002. Virtual environments as a tool for academic learning. Handbook of virtual environments, 2002, p. 893–910. Disponível em: https://www.taylorfrancis.com/chapters/edit/10.1201/9780585399102-56/virtual-environments-tool-academic-learning-michael-moshell-charles-hughes. Acesso em: 24 maio 2021.

Jesus-lopes, josé carlos de; maciel, wilson ravelli elizeu; casagranda, yasmim gomes. Check-list dos elementos constituintes dos delineamentos das pesquisas científicas.desafio online. [s.l], v.10, n.1, 2022.

Kharki, khadija el; berrada, khalid; burgos, daniel. Design and implementation of a virtual laboratory for physics subjects in moroccan universities. Sustainability. V. 13, n. 37, 2021. Doi: https://doi.org/10.3390/su13073711.

Kodular. Understanding kodular. Disponível em: https://docs.kodular.io/guides/. Acesso em: 10 maio 2022

Lozano, g.; s. Ojeda; b. Valdez (coords.). Tecnología en la uabc. Baja california: universidad autónoma de baja california, 2006.

Make-human. Make-human. [s.l], 2008. Disponível em: http://ww38.dedalo-3d.com/?subid1=20211105-0507-5617-89dd-adf59a3502e6. Acesso em: 09 de ago de 2021.

Maran, n; glavin, r. Low- to high-fidelity simulation - a continuum of medical education? Medical education. [s.l], v.37, n.1, p. 22-28, 2003.

Mazuryk, tomasz; gervautz, michael. Virtual reality-history, applications, technology and future. Viena: institute of computer graphics.1999.

Microsoft. Visual studio code. 2015. Disponível em: https://code.visualstudio.com/. Acesso em: 02 fev. 2022.

Morgan, p.j; tarshis, j., leblanc, v.; cleave-hogg, d.; desousa s.; haley m.f. Efficacy of high-fidelity simulation debriefing on the performance of practicing anaesthetists in simulated scenarios. Br j anaesth. [s.l], v.103, n.4, p. 531-537, 2009. N. 6669, p. 756, 1998.

Naves, raphael. Laboratório virtual de anatomia para medicina veterinária. Lavras: universidade federal de lavras, 2013. Disponível em: http://repositorio.ufla.br/bitstream/1/31288/1/monografia_laboratorio_virtual_de_anatomia_para_medicina_veterinaria.pdf. Acesso em: 29 abr.2021.

Pelargos, p. E. Et al. Utilizing virtual and augmented reality for educational and clinical enhancements in neurosurgery. Journal of clinical neuroscience. V. 35, p. 1–4, 2017.

Shannon, r.e. Systems simulation: the art and science. Englewood cliff: prendice hall, 1975.

Sattar mu, palaniappan s, lokman a, hassan a, shah n, riaz z. Effects of virtual reality training on medical students' learning motivation and competency. Pak j med sci. V.35, n.3, 2019, p. 852-857. Doi: https://doi.org/10.12669/pjms.35.3.44

Silva, m. S. Criando sites com html: sites de alta qualidade com html e css. Novatec editora, 2008.
Silva, m. S. Javascript-guia do programador: guia completo das funcionalidades de linguagem javascript. Novatec editora, 2010.

Sobotta. J. Atlas de anatomia humana. [s.l]: guanabara koogan, 2000.

Song, y.; xiao-ping, f.; zhi-fang, l. A study of the endoscopic surgery simulation training system based on 3d virtual reality. 30th the control conference chinese (ccc). Yantai, 2011.

Stiegler, m.p; neelankavil, j.p; canales, c.; dhillon, a. Cognitive errors detected in anaesthesiology: a literature review and pilot study. Br j anaesth. [s.l], v.108, n. 2, p. 229-235, 2012.

Testut, l.; latarget, a. Trattato di anatomia umana. Toscana: edra, 2017. Isbn: 978-8821445378.

Zhao, jingjie; xu, xinliang; jiang, hualin; ding, yi. The effectiveness of virtual reality-based technology on anatomy teaching: a metaanalysis of randomized controlled studies. Bmc medical education. V. 20, n. 127, 2020. P. 1-10. Doi: https://doi.org/10.1186/s12909-020-1994-z.

Ziv, a; wolpe, p.; small, s.; glick, s. Simulation based medical education: an ethical imperative. Academia medicine. [s.l], v. 78, n. 8, p. 783-786, 2003.

Wang, shwu-huey; cheng, yufang. Applying a 3d virtual learning environment to facilitate student's application ability – the case of marketing. Computers in human behavior. [s.l], n. 27, 2011, p. 576–584.

Wang, fengxu. Computer distance virtual experiment teaching application based on virtual reality technology. Ijet. [s.l], v.13, n. 4, 2018.