Evaluation of Human Dissection in Anatomy Teaching using an Interactive Simulator

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Abstract: The anatomy study is required in Life Science related courses. Nowadays, there are no instruments to replace the real human bodies. Therefore, it was noticed the need of the development of a learning tool to assist the anatomic study in laboratory which was able to dissect the organs for human anatomy study. Thus, the ultra-high interactive simulator for human dissection (Visible Human Table – VHT) was created as a computational tool for human anatomy study in classrooms. The main characteristic of the simulator is the fact that it is not an anatomic atlas, but a dissection table based on real body models. That is what makes it stand out from most same-purpose anatomic simulators and atlases. This article presents the results of a VHT evaluation assessed by higher education learners in the health sector. The simulator promising potential becomes evident through the answers obtained from the questionnaire, showing the significant contribution in the anatomy teaching-learning process.

1 INTRODUCTION

The technological development has enabled a lot of digital image processing advancements which allowed for innovations and improvements in a wide range of sectors. In relation to the health sector, projects are developed to increase resources to help both skilled professionals and learners during qualification. The acquisition and image processing permit the computational environment development in favor of training, medical diagnosis and treatment as well as, the anatomy teaching helps students and teachers in the teaching-learning process (Beveridge et al., 2013).

The study of anatomy is crucial in many courses related to health. There is no book or computational tool to replace the study of the real human body. The corpse is the most similar to a living human being the student can have as a study object. However, educational institutions have been having difficulties in obtaining bodies for this purpose due to the lack of data from the population about the possibility of corpse donation (Bassete, 2009) and legal procedures involved.

A possible solution is the digital visualization of this information; however, because of the complexity of organic structures, the process of digital visualization in high definition and the segmentation of organs and human body systems is a complex task and requires high computational capacity. From an anatomic point of view, the division or separation of systems is needed for the perfect understanding of its parts. In the health sector, it is also important that computational tools exhibit realistic models of human body. Even though there are anatomy tools that allow human dissection available, they present synthetic artifacts of the body that do not express the real color and texture.

Based on this scenario, it was noticed the necessity of developing a learning tool to serve the anatomic study needs in laboratory through the visualization of artifacts in high resolution and with realistic colors and textures. They would perform procedures such as the dissection of the body to assist

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students in their learning process.

This article presents the virtual dissection evaluation in an ultra-high-definition simulator for human anatomy teaching in the classroom. The simulator consists of hardware and software developed for this purpose (Brongel. et al., 2019). The device seeks to respond the requirements of representation of high-quality models, visual acuity, color, texture, depth perception and touch interactivity.

This article is structured as follows. The related works are described in Section 2. Section 3 presents how VHT was implemented based on the data used in it and the use of a tool in active methodologies for anatomy teaching. The method used to evaluate is described in Section 4. Section 5 shows the results of this evaluation which was carried out by students from degree courses using the simulator. Section 6 reports the conclusions.

2 RELATED WORKS

The project known as The Voxel-Man, uses the low-resolution database developed by the Hamburg University. It was known as The Segmented Inner Organs (SIO) (Voxel-Man, 2019). This image database is synthetic and was created by computational addition and corrections from Visible Human Database. Synthetic images result in some problems for anatomic study such as, quality reduction in representation because of the manual corrections which do not represent the real organic structures.

Another example is the Anatomage Table. It is in the seventh version and it has some colored bases including the VHP base (Anatomage Inc., 2018). So, as the models are rendered, they are committed to the quality resulting in more artificial appearance of the structures. A comparative study was carried, to evaluate the qualitative efficiency and experience of the learning of pelvis and perineum and skeletal muscle system general anatomy by cadaveric dissection. The purpose of this study was to learn these same anatomic parts using Anatomage Table whose results showed that students were more motivated and noticed greater learning (Baratz et al., 2019). Other study about this table highlighted that there is a reduction in the use of the cadaver in teaching and it revealed the importance of the cutting tool (Fyfe et al., 2013).

Other environment developed for teaching through stereoscopy is presented by (Olsen. et al., 2018), in which the acquisition of the images is done by means of Full Frame Semi-spherical Scanner (F2S2). And the learning objects can be used in different knowledge fields promoting an educational environment with interaction and dynamism. An evaluation of the learning impact of the F2S2 was carried, and the results showed that the interactive material is an alternative which can motivate teachers and students because they consider the visualization represents the real object properly and it can help in teaching-learning process (Silva et al., 2019).

3 MATERIAL

For the simulator development was need acquisition and segmentation of color images, a hardware which attended on the requirements of usability and performance which enabled to accommodate the totality of the bases of The Visible Human Project, besides an interactive software which made feasible significant learning providing the teacher an active teaching tool.

3.1 Database

The database used in the simulator comes from The Visible Human Project made available on November 28, 1994 for the male body and one year later, the female body images (Ackerman, 1998) and (Spitzer et al., 1996). The base is composed of Magnetic Resonance Imaging (MRI), Computed Tomography (CT) and color images. For the male body, the MRI images were acquired in 6 subsets: head in the axial form and chest, abdomen, pelvis, thighs and foot in the coronal form. The images were acquired in three different modalities, T1, T2 and proton density images, shown in Figure 1 (a,b,c) with resolution of 256x256 pixels at 4-mm-intervals (Ackerman, 1998).

Figure 1 shows a CT with a resolution of 512x512 at 1-mm-intervals in the axial plane, and Figure 1 (e) displays a color axial image in 2048x1216 pixels (2k). Each high-definition image takes 7.5 megabytes with 1871 color images, all available to be used in research. The whole process of image acquisition and body preparation to generate the database is described in (Spitzer et al., 1996).

The female data set presents a larger amount of images than the male ones with 5189 images, due to the 0,33-mm-intervals with a resolution of 2048x1216 pixels (2k) and 4096x3061 pixels (4k). Figure 2 shows the images that illustrate the male and female bodies reconstituted in the coronal plane. The process of freezing the cadavers was performed by blocks and they did not exceed 51 cm in length. So, it is observed that the images presented are not continuous (U.S. National Library of Medicine, 2019).

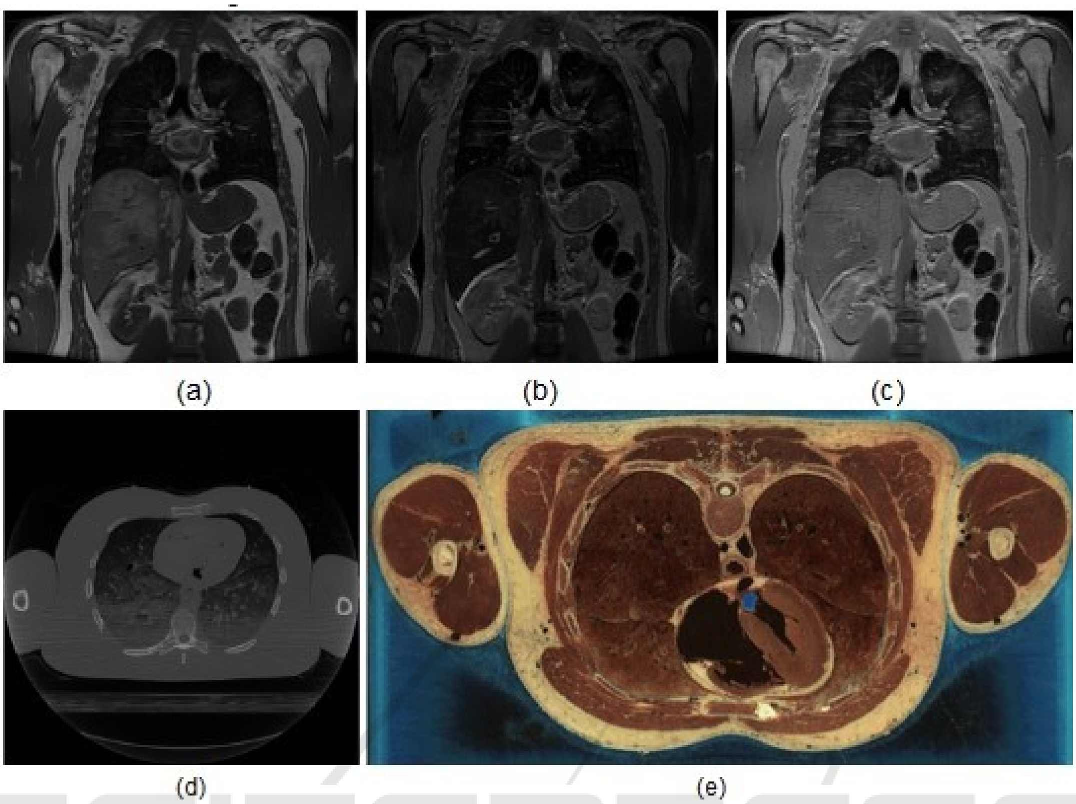

Figure 1: Images available on the website of The Visible Human Project: (a) MRI T1-; (b)MRI T2-; (c) proton density images; (d) CT; (e) color axial image (U.S. National Library of Medicine, 2019).

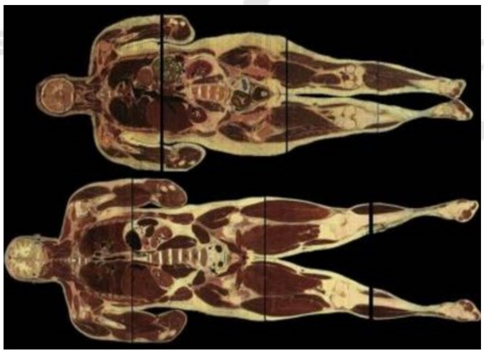

Figure 2: Reconstruction of male and female bodies of The Visible Human Project (Ackerman, 1998).

3.2 Interactive Simulator

The interactive dissection simulator for anatomy study is consisted of two parts, hardware and software. The hardware is formed by a computer with selected components with the purpose of executing the work satisfactorily. To attend the requirements of usability in anatomy classes, it is presented dynamically and it has a user-friendly interface. It also has an interactive screen that supports resolutions of up to 4k and about 1.70-m-human body, as shown in Figure 3.

Concerning the software, it is an application with support for input by multiple touches on the screen, enabling the dynamism and interactivity desired in a computational application. The system has two main areas, shown in Figure 4. In the first one the human body is visualized in a volumetric way and in the second one the image in ultra-high definition of the anatomical plane is selected by the user.

The interface between the user and the application is made, mainly, with a dynamic dial, shown in Figure 5. It operates as a virtual mouse and can be positioned anywhere on the screen to enable the mobility around the high-resolution table.

The dial includes several tools. They allow the exchange of the visualization plane, manipulation and selection of the volumetric model. Also the creation of notes by means of a digital chart and content upload to the study environment of the institution through Internet.

Also in Figure 5, it is possible to observe that the interaction with the images in an ultra-high-definition is made through buttons and colored lines. They can be dragged to apply anatomical cuts in the volumetric model and to determine the cut displayed in the main frame.

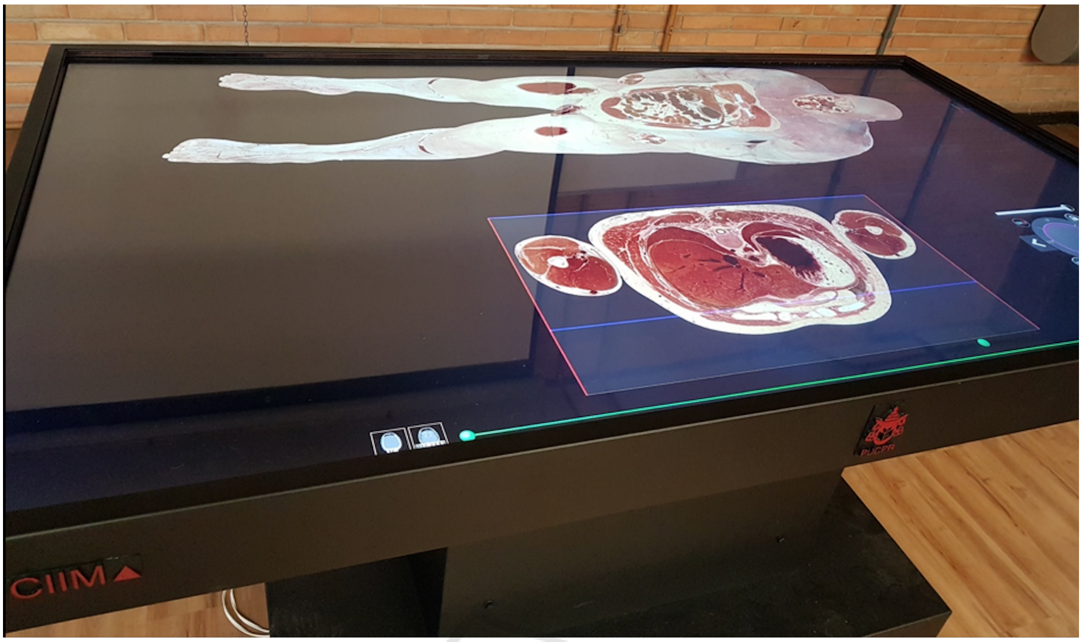

Figure 3: Visible Human Table.

For each anatomic plane, there are indexed windows of MRI and CT scans which can be maximized and positioned at any point on the screen creating the desired corresponding association with the color images.

3.3 Active Learning

The Educational field is going through major changes especially, concerning conceptions and teaching techniques. So, new teaching-learning process understanding and alternative teaching operationalization proposals have been elaborated. It is considered they must admit an ethic, critic, reflexive and transforming pedagogic practices, transposing merely technical training limits to reach the man education as a historic being (Mitre et al., 2008) and (Paiva et al., 2016).

Students must read, write, ask, discuss or engage on problems solving and projects development in order to make the active learning process happen. They are encouraged to build the knowledge instead of receiving it from the teacher in a passive way. Thus, the active learning strategies can be described as activities which keep students occupied in doing something and, at the same time, help students think about what is being done (Bonwell and Eison, 1991) and (Silberman, 1996). In an active learning environment, the teacher acts as mentor, supervisor, learning process facilitator and not just as the single source of information and knowledge.

The active methodologies, serving to this educational revision, consist of alternatives to teaching-learning process with benefits and challenges. Flipped Classroom, Blended Learning, Peer Instruction, PBL (Problem Based Learning), GTD (Getting Things Done), Think-pair-share, Just-in-time teaching this is called “Customized Teaching” by (Elmôr Filho et al., 2019). They are some of the active methodologies application possibilities. They aim to put students in the middle of the learning process in order to develop their own autonomy.

An active learning environment should create the possibility to apply activities which will develop critical reflections through discussions to promote the construction of meanings to an enduring learning. Thus, students can understand the skills and competences acquisition needed to deal with professional challenges of their training area. Apprenticeship learning is built in action whose spontaneity is enhanced when it has meaning and it is noticed as necessary (Piaget and Caixeiro, 1983). In the face of these conditions, it is possible to raise questions to provoke reflections because knowledge is built when students appropriate of their thoughts.

In this respect, the interactive simulator fits perfectly because it allows the exploratory study of a real human body anatomy. It is possible to visualize image details with visual acuity, organs scale compliance, texture, color and depth perception that are not obtained at anatomy laboratories. Consequently, students are stimulated to build knowledge instead of receiving it from the teacher passively. The simulator enables the teacher organize exploratory activities

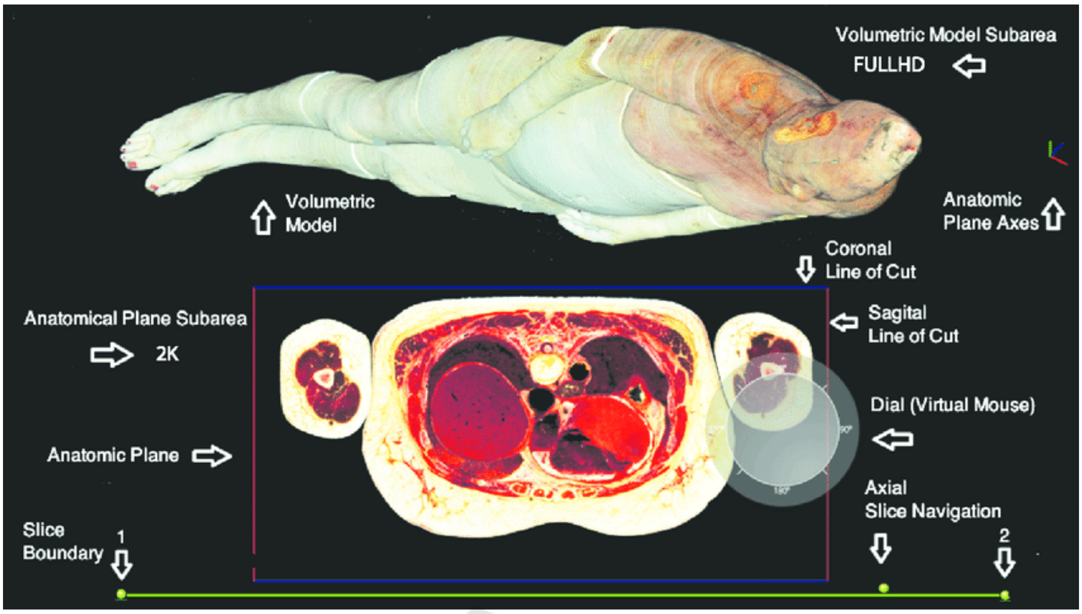

Figure 4: Interface of the Visible Human Table (Brongel. et al., 2019).

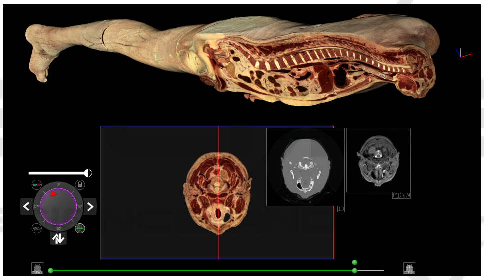

Figure 5: Dial visualization, volumetric section, and MRI and CT exams.

into anatomy studies or problem resolution through organs or human body systems observation whose results come from discussions involving all students.

Among many options which can also be considered in future works with the simulator usage, the flipped classroom approach was chosen for this work. Its application process is divided in three stages: pre-assignment activities, pre-activities and post-activities. These stages are applied to the proposed experiment using the simulator. First, students did previous research of anatomy contents. Second, students had contact with the simulator under teacher supervision, whereby it was possible to identify characteristic such as color, depth, texture and anatomic arrangement of previously studied organs. Third, they were inquired about their perception of the simulator's contribution to the learning process. The experiment's results are presented in the following section.

4 METHOD

The simulator was evaluated during the anatomy classes by students from different courses, such as Biological Sciences, Dentistry, Physical Education, Physiotherapy, Nursing and Nutrition. The flipped classroom approach was chosen and the three stages were carried out with teacher supervision. In the first stage previously mentioned, students carried out studies on anatomy contents to recognize the organs, their characteristics and spatial location in the human body using a cadaver. On the stage, students explored the resources of VHT visualizing images in the several ways the environment allows. They applied cuts all organs, checked colors and textures during the class. The final stage, after all simulator functionalities were presented to students, they were supposed to answer an online questionnaire evaluating their experience with the anatomy learning tool usage as after class activity. Figure 6 shows in which course each student respondent was.

The questionnaire above was composed by 7 close-ended questions and a five-point Likert scale (Likert, 1932) with the following choices: I totally agree (TA), partially agree (PA), indifferent (IN), partially disagree (PD) and totally disagree (TD). The questionnaire was applied through Google Forms in order to obtain the degree of satisfaction and learning from students. According to (Wainerman, 1976), the measurement instrument proposed by Likert aims to verify the agreement level of the subject with sev-

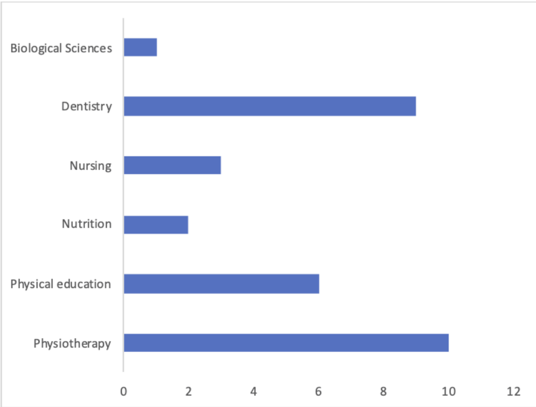

Figure 6: Distribution of students by course.

eral statements which express something favorable or unfavorable in relation to an object. The questions elaborated for the applied questionnaire were:

1. Would you use the digital table for further study outside of school hours?
2. Do you consider that the corpses available on the digital table contribute towards the proper assimilation of organ positioning in the human body and understanding of their structures, scale, color and texture?
3. Do you believe that the possibility of visualizing various axial, sagittal and coronal views using the digital table contributes to your learning in your anatomy studies?
4. Do you believe that the increased visual magnitude provided by the digital table provides a better understanding of the structural details of an organ and its relationship to others?
5. Do anatomical studies using only the digital table meet your learning expectations?
6. Does the anatomy class using the digital table combined with other resources available in the anatomy lab contribute positively to your learning?
7. Does the use of manipulable volumetric digital models of real bodies, such as the digital table contribute positively to your learning?

Data collection was carried out on June, 2019 and the online questions were answered by students voluntarily.

5 EVALUATION AND RESULTS

Table 1 shows the number of answers counted in each proposition. The sum of the values should result in the total of the participants.

Table 1: Survey Data.

Question	T.A.	P.A.	I.N.	P.D.	T.D.
1	24	7	0	0	0
2	21	7	1	2	0
3	30	0	1	0	0
4	23	8	0	0	0
5	9	9	0	9	4
6	27	3	1	0	0
7	27	2	1	1	0

The result of the first question showed that the virtual table is considered a very useful resource for complementary studies outside of class hours by the students. The answers highlighted an index of 77% approval of the table use in this sense.

The results related to the second question indicated that 67% of students totally agree that the bodies available on the table contribute to the assimilation of the structure, scale, color and texture of the human body organs.

Third question showed that the visualization in the axial, sagittal and coronal planes available in the tool contributes to the learning in the anatomy studies with 96% of respondents totally agreeing with the affirmation.

The possibility of increasing the visual magnitude provided by the digital table is understood as another benefit for learning. With this functionality it is easier to visualize small structures. In this respect 74% of the students completely approved this feature..

Students were asked if their learning expectations of human anatomy would be met only when they used the digital table. It was observed that 29% of them partially disagree and 13% totally disagree, indicating how important the simulator is to complement the anatomy learning. It was noticed that the real human body is still needed and the table is not intended to replace its usage. Although, it was also observed that 97% of all answers were in favor of using the table as a complement. So, for students, the combined usages of the table with the anatomy laboratories make the learning more efficient, they also highlighted the interactive simulator usage importance to the learning process.

Finally, the results of question 7 attest that the manipulable volumetric models of the table assist in the assimilation of the contents with 87% of the respondents fully agreed. Figure 7 shows the percentages of each answer per questions answered.

The answers indicated with TC and PC, that is total and partial agreement, when they were compared to the other options, in general, demonstrate that the data showed low disagreement in relation to the use of the simulator, in other words most students agree

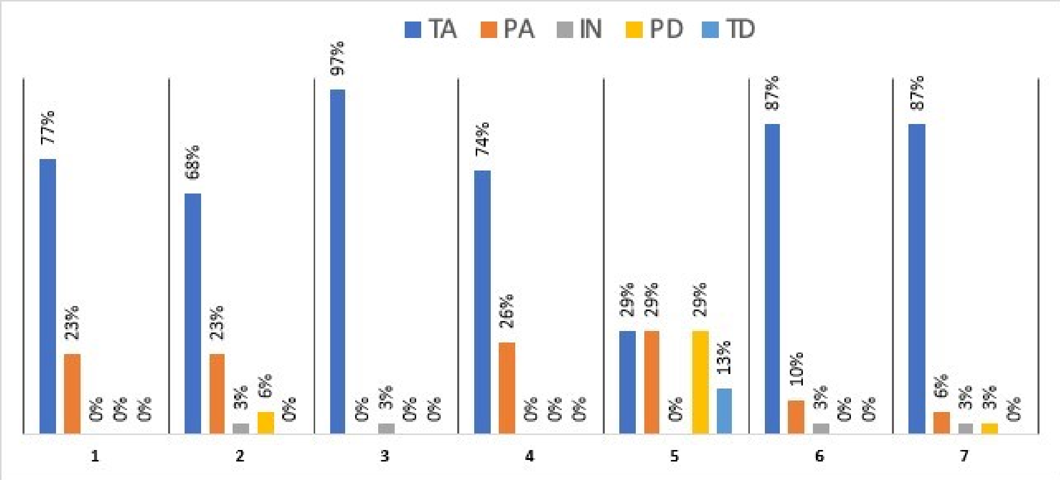

Figure 7: Percentages of each answer per question answered.

that the computer tool presented to them, the VHT is promising for the learning process in human anatomy studies.

6 CONCLUSIONS

This article presented the evaluation of an ultra-high-definition simulator called VHT. Its purpose is for dissection and teaching anatomy in classroom. The difference from other anatomical tools and atlases is the use of ultra-high-definition images and the use of real human body images which provides visual acuity, scale conformity with real human organs, texture, color and depth perception.

The simulator complies with the precepts used in the study of anatomy, that is, it presents the anatomical planes of cut, visualization in the dissection process. Another essential element of this learning tool is the availability of imaging exams associated with anatomical slices of images, the connectivity with other online tools and the active blackboard.

The research also reported an experience with undergraduate students which have the anatomy studies as a regular discipline. The flipped classroom approach was used in order to evaluate the simulator usage on the learning process. The results were achieved through close-ended-questions analysis based on the Likert scale. The questionnaire was answered by students at the third stage of the methodology application.

The Flipped classroom use with the simulator resource in anatomy studies has created an appropriate environment for knowledge construction in which students identified organs studied in previous activities and raised questions, discussed and discovered organs that were near each other on their own as it was expected. It was possible just because it is a real human body in size, shape, color and anatomical arrangement like a living body. And, because of the easy usage of the table provided by the interface generated by the dial whose usage was extremely simple e intuitive. The magnetic resonance and computerized tomography images integration were also elements that draw attention due to the easy access to perform anatomy studies.

The research has indicated the simulator is a promising tool in active teaching-learning methodologies. It was also observed the tool is not supposed to replace the human body dissection, but to complement anatomic studies. It was also considered this resource can be extra-class used, outside of school hours. It allows students to explore the human body and do research. The answers received from the questionnaire show that with the simulator usage in a Flipped classroom, there was a contribution in the anatomy teaching-learning process.

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