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Digital Technology in the Training of Future Kinesiotherapists

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Abstract: *Digital technology has permeated all fields of activity, therefore it is absolutely necessary to use it in the education system as well. Today`s students should benefit from the conveniences offered by the digital world; the information activity must thus be permanently adapted to the digital evolution, so that the future specialists can face the demands of society. Kinesiotherapy and Special Motricity students, future kinesiotherapists, need solid knowledge of human anatomy, this knowledge being a support for their whole activity. Digital technology can supplement the traditional way of learning human anatomy. Various apps have been designed for learning human anatomy, among them Complete Anatomy. Created in 2009 by 3D4Medical, now part of Elsevier, Complete Anatomy is an application that offers an alternative to physical anatomical models, through interactive anatomical models; the application can be installed on various devices: laptop, tablet, smartphone and can be accessed anytime and anywhere the student is, both during class/lab and outside them, for individual study. Using the Complete Anatomy app, muscle actions can be visualized; movement analysis being important in the training of future kinesiotherapists. In addition to detailed 3D anatomical models, the app also provides anatomical information and a video library. For the research, the group of subjects was made up of first-year students from the Faculty of Physical Education, Sport and Kinesiotherapy, specialization in Kinesiotherapy and Special Motricity, Romanian-American University of Bucharest. Following the use of a questionnaire, it was found that, regardless of the experience of previous use or not of some applications in learning, students are eager to use digital technology for learning human anatomy through the Complete Anatomy application.*

Keywords: *digital technology; students; Complete Anatomy.*

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Introduction

Digital technology has permeated all fields of activity, therefore it is absolutely necessary to use it in the education system as well. Today`s students should benefit from the conveniences offered by the digital world; the information activity must thus be permanently adapted to the digital evolution, so that the future specialists can face the demands of society.

Students from the Kinesiotherapy and Special Motricity specialization, future kinesiotherapists, need solid knowledge of human anatomy, this knowledge being a support for their entire activity. Digital technology can supplement the traditional way of learning human anatomy. Adams (2013) mentions, following a study carried out with students from the field of kinesiotherapy, that they preferred the hybrid way of conducting courses (traditional and digital) over the traditional teaching method; the use of a hybrid model is recommended for the kinesiotherapy degree program because it provides a high level of satisfaction.

Conceptual aspects

During the restrictions imposed by the 2019 coronavirus pandemic, the method of teaching had to be changed, with courses taking place online. It was then that many teachers looked for ways to conduct classes, ways to maintain and stimulate students` interest in studying. Thus, for learning anatomy, the orientation has been directed towards the use of applications such as *Complete Anatomy* (3D4Medical, Elsevier), contributing to digital anatomy education (Lin et al., 2022).

Created in 2009 by 3D4Medical, now part of Elsevier, *Complete Anatomy* is an application that offers an alternative to physical anatomical models, through interactive anatomical models; the application can be installed on various devices: laptop, tablet, smartphone, being available for macOS, Windows 10, iPad, iPhone, Android and can be accessed anytime and anywhere the student is, both during class/laboratory and outside them, for individual study. (Motsinger, 2020; Thintharua & Dharmasaroja, 2021; Wallenbeck, 2022; 3D4Medical (n.d.). https://3d4medical.com/)

To get started with the *Complete Anatomy* application, the guides on the application website can be consulted online (3D4Medical From Elsevier (n.d). *Getting Started*).

In the *Complete Anatomy* application, muscle actions can be visualized, movement analysis being important in the training of future kinesiotherapists. In addition to detailed 3D anatomical models, the

application also provides anatomical information and a video library (Havens et al., 2020; Wallenbeck, 2022).

Using the *Complete Anatomy* application, the systems of the human body can be visualized both individually and interdependently: skeletal, connective tissue, muscular, vascular (arterial and venous), lymphatic, nervous, respiratory, digestive, endocrine, urogenital, integumentary. Using the plus (+) and minus (-) buttons that appear above the selected system allows navigation through the layers of that system. The *Complete Anatomy* application includes two categories of models: the male model and the female model. Users can isolate body segments, bone landmarks, see muscle action, how the heart beats, trace the pathways for arteries and nerves, view muscle innervation. The anatomical model is easy to manipulate and rotate with fingers on the smartphone or tablet or with mouse on the computer (Motsinger, 2020).

Complete Anatomy also provides users with radiological images located alongside the anatomical model, for comparison views of these 2D images with the 3D model (Wallenbeck, 2022).

Learning anatomy through the use of digital technology has led to the emergence of software capable of displaying three-dimensional digital images of anatomical features of the human body (Silén et al., 2022). Several studies have confirmed the utility of 3D images for teaching human anatomy (Tam et al., 2009; Yammine & Violato, 2015; Hackett & Proctor, 2016; Azer & Azer, 2016; Navid et al., 2017; Clunie et al., 2018; Ardila et al., 2023).

Azer and Azer (2016) undertook a review of studies on the use of 3D anatomy models, reporting their impact on learning. The authors defined the 3D anatomy models as: "Three-dimensional (3D) anatomy models comprise digital, and non-digital (physical) models that can be moved into different positions/planes to enable learner to learn the relationship between different anatomical structures in space and mentally manipulate objectives in three dimensions" (Azer & Azer, 2016, 81). This review showed that digital and non-digital 3D anatomy models are preferred by students, over 2D illustrations; 3D models can be used to support the curriculum and improve students` skills in spatial visualization of the relationships between anatomical structures. The authors also note that research is needed to investigate the factors that influence student learning while using 3D anatomy models. The main factors are related to the educational design of the 3D model, how it is presented, depending on the student`s learning style, and the relationships between the curriculum and the learning environment (Azer & Azer, 2016; Triepels et al., 2019; Silén et al., 2022).

Recently, mobile technologies are increasingly being used in anatomy laboratories, and over time, their use has evolved (MacKenzie, 2022). As mobile technologies have become more powerful, developers including 3D4Medical have increased the flexibility of teaching and learning using 3D tools, allowing students to visualize and manipulate complex anatomical structures (Lewis et al., 2013).

There are studies that have highlighted students` engagement with pleasure and positive perception in learning anatomy when mobile technology is used in laboratory classes (Morris et al., 2016; Chakraborty & Cooperstein, 2017; Scibora et al., 2018). It was also found that students who used mobile technology in learning human anatomy gained as much or even better knowledge than students who did not use mobile technology as a learning tool (Morris et al., 2016; Chakraborty & Cooperstein, 2017; Scibora et al., 2018).

Digital lectures can be used as material for teaching human anatomy, increasing the flexibility of knowledge acquisition, increasing motivation for study, thus leading to better learning results (Singh & Min, 2017). Learning human anatomy involves some challenges, for example appreciating the three-dimensional relationships between differrent anatomical structures. By understanding the processes by which students learn anatomical structures in 3D, teachers will know how to provide support in the learning process. The study of anatomy should be organized in such a way as to allow students to decide for themselves how and at what pace to learn using visualizations, allowing time for a deep approach to learning. Students` learning activities should be first facilitated and then directed. The student`s own discoveries become ways he finds out how to make it easier for him to learn anatomy using visualizations (Pettersson et al., 2023).

From a tablet or smartphone, the users of *Complete Anatomy* application can view the anatomical model, in the classroom or laboratory, using Augmented Reality (AR), as if interacting with the model (Wallenbeck, 2022). "Augmented reality has strong potential to provide both powerful contextual, *in situ* learning experiences and serendipitous exploration and discovery of the connected nature of information in the real world." (Johnson et al., 2010, 22).

Augmented reality is a technology that integrates computer-generated objects or virtual content into the real world, thereby enhancing the perception of reality (Hugues et al., 2011). Connecting the virtual content to the real world requires a device (computer/tablet/smartphone) that provides a window (display) through which the physical world can be seen. To make virtual components visible in this window, a software

application is required on this device (Kamphuis et al., 2014; Dunleavy & Dede, 2013).

Augmented reality provides students with powerful, contextual learning experiences, helping to explore the complex interconnections that exists in the real world. Augmented reality helps the student understand spatial concepts and relationships, acquire knowledge and skills, strengthen cognitive and psychomotor skills, thus shortening the acquisition time and prolonging learning retention. Augmented reality has great potential for promoting learning, especially in the healthcare field (Zhu et al., 2014).

There have been other studies that have highlighted the importance of using augmented reality in learning human anatomy (Kurniawan et al., 2018; Nuanmeesri et al., 2019).

With the students, using the *Complete Anatomy* application, a session between the kinesiotherapist and the patient can be simulated, with the patient visually understanding the injury suffered and the treatment to follow.

For example, a rotator cuff injury can be analyzed.

The following steps are taken:

- for a good visualization, the image on the screen, representing the skeleton, is enlarged (Figure 1);



Figure 1. Skeleton in *Complete Anatomy*
(Complete Anatomy,)

- clicking on the plus button (+) above the icon representing the muscular system, muscles are added to the skeleton (Figure 2);

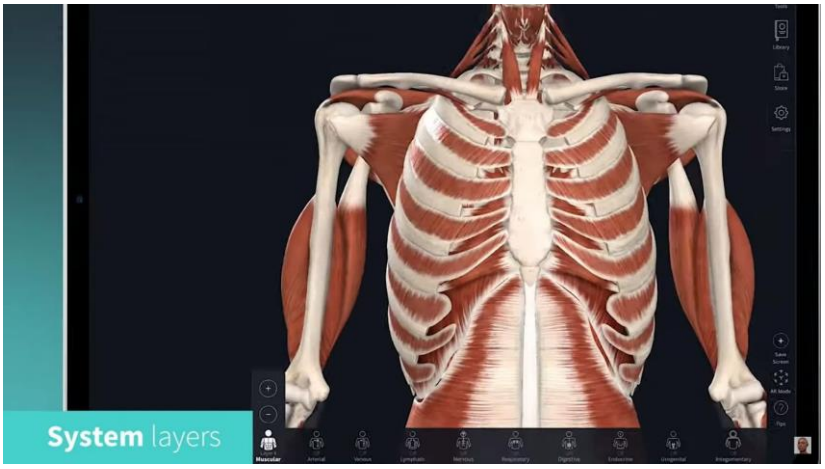


Figure 2. Muscles on the Skeleton in *Complete Anatomy*
(Complete Anatomy, 19th of June 2019)

- the structures that are not involved in the case study (muscles and bones) are selected and hidden, until the desired configuration is obtained – the model of the shoulder joint with the four muscles that make up the rotator cuff: supraspinatus, infraspinatus, teres minor, and subscapular muscles (Figure 3);



Figure 3. Shoulder joint model with the muscles that make up the rotator cuff in *Complete Anatomy* application
(Complete Anatomy, 19th of June 2019)

- the image is saved in the *Library* with the title: Rotator Cuff (Figure 4), so that it can be accessed whenever desired;

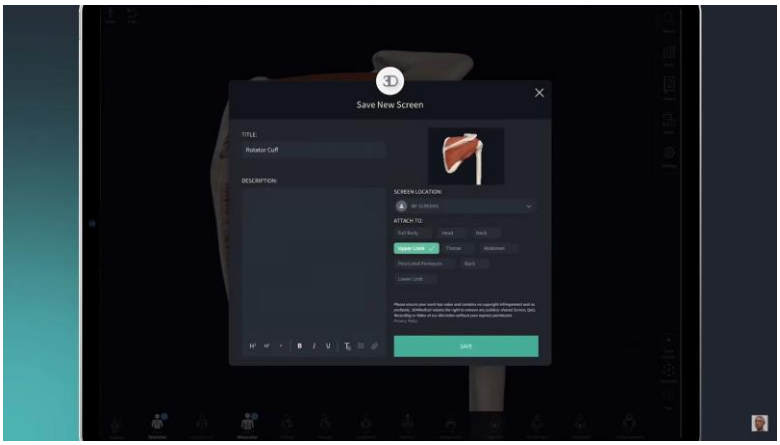


Figure 4. Saving the Rotator Cuff image to the *Complete Anatomy* application Library (Complete Anatomy, 19th of June 2019)

- having set up the model, the kinesiotherapist will explain to the patient the anatomy of the affected area;
- by clicking, one by one, on each of the four muscles, the name of the muscle appears on the screen, in the upper left part, and vertically, under *Info*, different information about the respective muscle appears: origin, insertion, action, innervation, blood vessels passing through the area, anatomical relationships, tests that can be performed, clinical problems that can occur in that region (Figure 5);

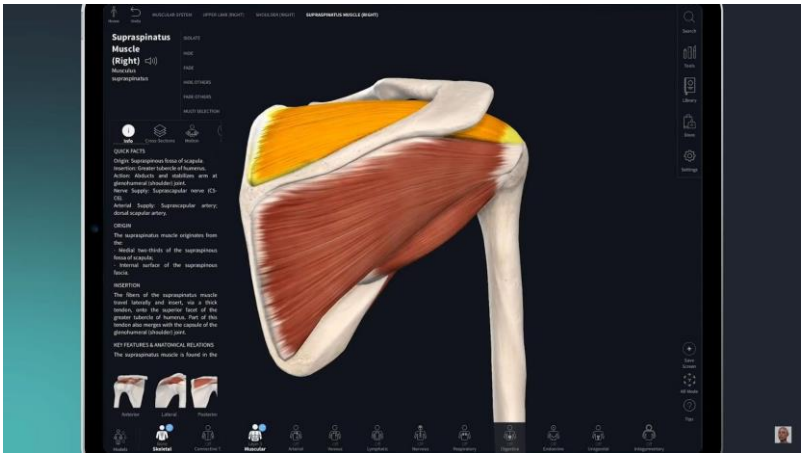


Figure 5. Information about the selected muscle (supraspinatus muscle) from the *Complete Anatomy* application (Complete Anatomy, 19th of June 2019)

- using the *Pen* from *Tools*, the area where the injury occurred is highlighted (Figure 6);

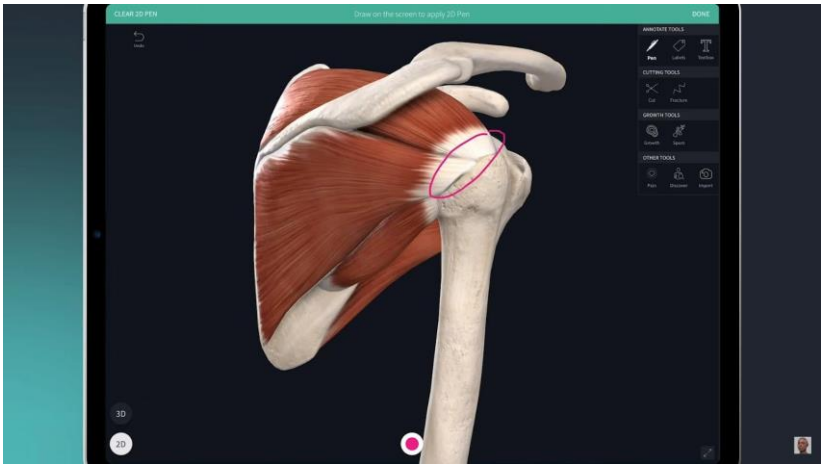


Figure 6. Marking the location of the injury installed at the shoulder in *Complete Anatomy* application
(3D4Medical From Elsevier. https://www.youtube.com/watch?v=YEL55O4El_w)

- the action of the muscle, how the injury was caused and what actions cause pain are demonstrated;
- a muscle is selected from the four muscles that make up the rotator cuff, for example the supraspinatus muscle, and by clicking on the *Motion* icon, on the left of the screen (Figure 7), the abduction movement of the shoulder can be visualized (Figure 8);
- the patient can be shown how repetitive motion and impact trauma can cause injury or tear of the rotator cuff: using the *Fracture* tool, a tear to the tendon of the supraspinatus muscle can be demonstrated (Figure 9);

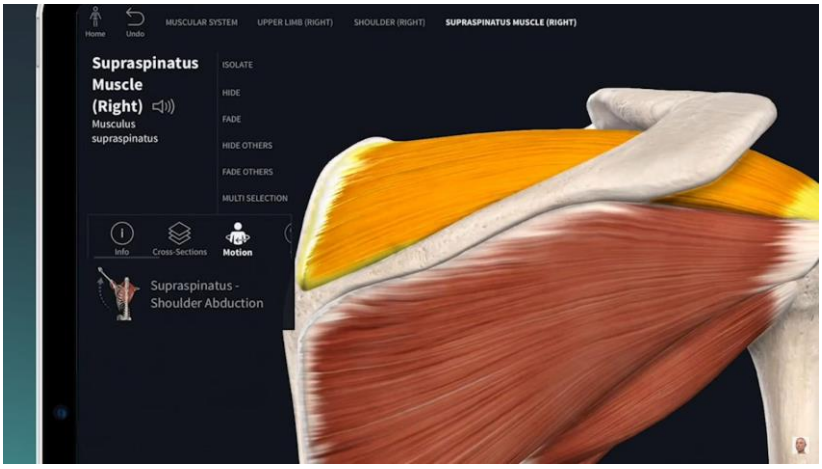


Figure 7. Selecting the Motion icon in *Complete Anatomy* (3D4Medical From Elsevier. https://www.youtube.com/watch?v=YEL55O4El_w)



Figure 8. Visualization of the abduction movement in *Complete Anatomy* (3D4Medical From Elsevier. https://www.youtube.com/watch?v=YEL55O4El_w)

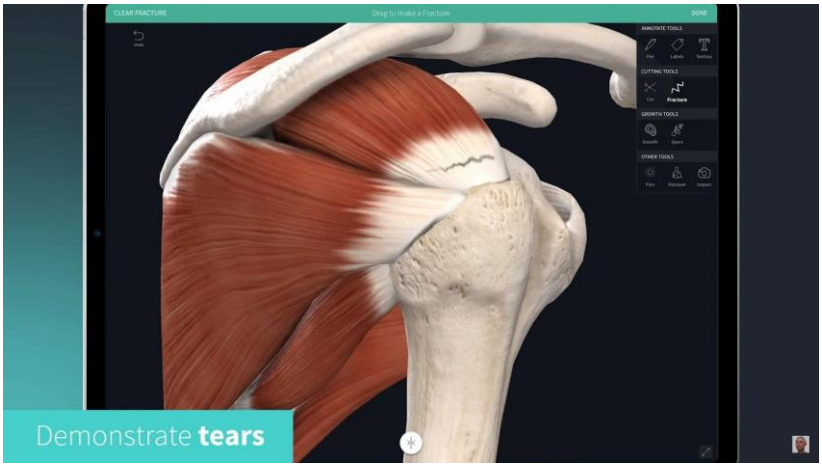


Figure 9. Highlighting a supraspinatus tendon tear using the Fracture tool in *Complete Anatomy* application
(3D4Medical From Elsevier. https://www.youtube.com/watch?v=YEL55O4El_w)

- after explaining the occurence of the injury, the kinesiotherapeutic treatment plan is presented to the patient: exercises included in the platform *Library*, for example for external rotation in the shoulder joint (Figure 10);

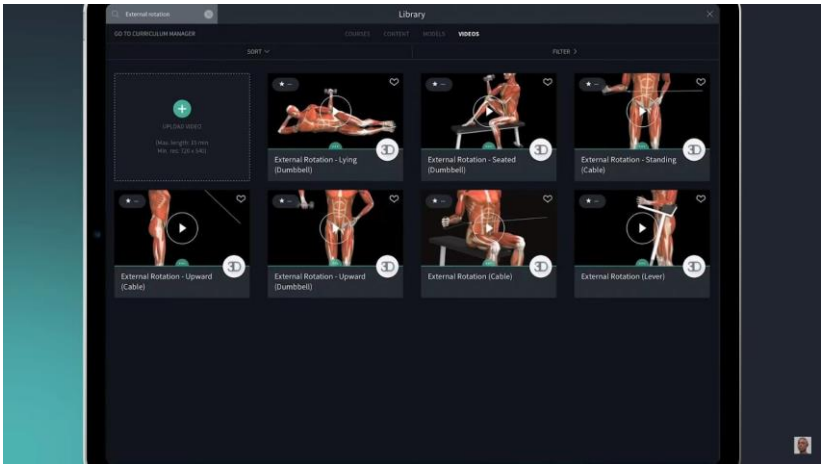


Figure 10. Shoulder External Rotation exercise videos from the *Complete Anatomy* application Library
(Complete Anatomy, 19th of June 2019)

Understanding through a visual presentation the injury and the treatment plan, the patient will be more confident in the actions within the

kinesiotherapeutic treatment, facilitating the cooperation between the patient and the kinesiotherapist (3D4Medical Community Blog, n.d).

The *Complete Anatomy* application is beneficial in training future kinesiotherapists both in terms of anatomy knowledge and work with patient, a simulation exercise of the type described above, carried out during faculty, can be of particular support for real clinical case situations.

Methodology

The hypothesis of the research

If digital technology is used more and more often in professional activities in many fields, then also future kinesiotherapists must benefit from the facilities offered by the digital world, the training for this starting from university studies, with the learning activity, when applications can be used that supplement the traditional way of learning, for example studying human anatomy using the *Complete Anatomy* application.

The purpose of the research

The research aimed to find out the students` opinion regarding the use of digital technology in the learning activity, in general, and, in particular, for the study of human anatomy through the *Complete Anatomy* application.

The period and place of the research

The research was carried out at the beginning of the second semester, between February 20 and March 20, 2023, at the Romanian - American University of Bucharest. In the first phase, the opinion questionnaire was applied, after which the answers were analyzed.

The subjects of the research

For the research, the group of subjects was made up of first-year students from the Faculty of Physical Education, Sport and Kinesiotherapy, specialization in Kinesiotherapy and Special Motricity, Romanian – American University of Bucharest.

Ethical principles were respected: the students were informed from the beginning that this questionnaire would be utilized only as a study, that their participation in this study is voluntary, anonymity is ensured, and they do not have to sign the questionnaire. Non-participation or withdrawal from the completing the questionnaire will have no consequences on their status.

The inclusion criteria were:

- first-year students from the Faculty of Physical Education, Sport and Kinesiotherapy, specialization in Kinesiotherapy and Special Motricity, Romanian – American University of Bucharest;
- acceptance to participate in this study, by completing the questionnaire;
- both gender;
- any age.

The exclusion criteria were:

- students who refused from the beginning to complete the questionnaire;
- students who withdrew during the completion of the questionnaire.

The methods of the research

We used the following research methods: bibliographic study, questionnaire - based survey, statistical - mathematical method, computer graphic method and technique. The applied questionnaire (inspired from MacKenzie, 2022, 53-55) contained a number of 10 closed questions, with the students having the possibility to choose only one answer from the five provided answers.

The results and their interpretation

There were 23 students who wanted to participate in the study, of which 10 female students and 13 male students, aged between 19 and 25 years, the average age being 20.43 years.

Regarding the state of comfort during the use of digital technology in learning activity (Figure 11), 7 students (30.43%) rated that they feel *very comfortable*, 14 students (60.87%) feel *comfortable*, 2 students (8.70%) declare that they have a *neutral* state, and for *uncomfortable* and *very uncomfortable* no student ticked.

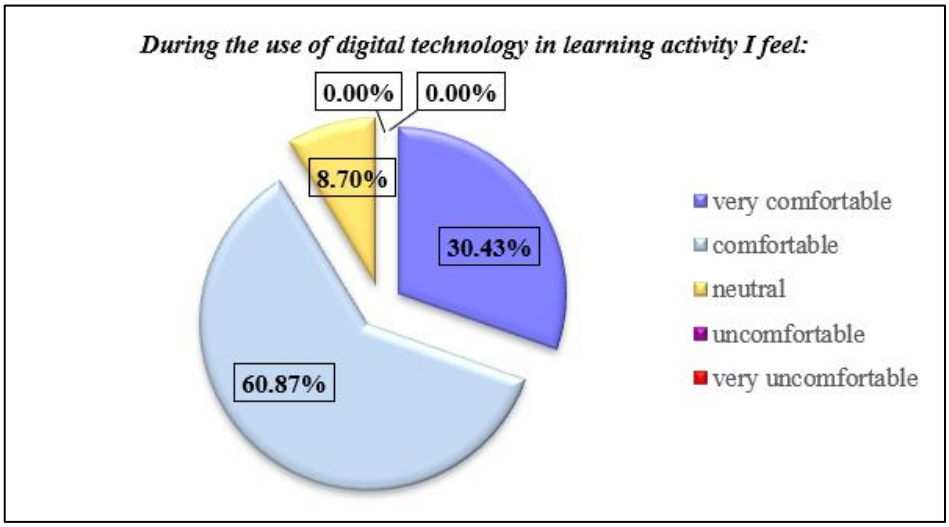


Figure 11. Comfort state while using digital technology in learning activity

Regarding the level of stress during the use of digital technology in learning activity (Figure 12), 13 students (56.52%) ticked for the stress level *not at all*, 9 students (39.13%) mention that they have *a little* stress, and 1 student (4.35%) ticked *moderately* for the level of stress; no student felt that using digital technology during study caused *quite a bit* or *very much* stress.

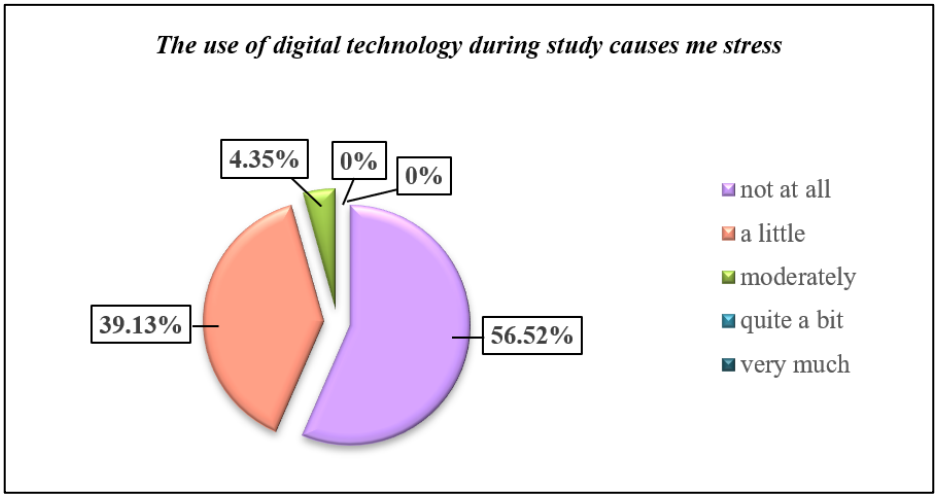


Figure 12. Stress level during the use of digital technology in learning activity

On the item *I feel comfortable getting help in using digital technology for my learning activity*, the student`s state of comfort when receiving help in using digital technology during study is observed: 9 students (39.13%) are *strongly agree*, 8 students (34.78%) *agree*, 5 students (21.74%) declare *neutral*, 1 student (4.35%) declare *disagree* and no student mention *strongly disagree*, as can be seen in Figure 13.

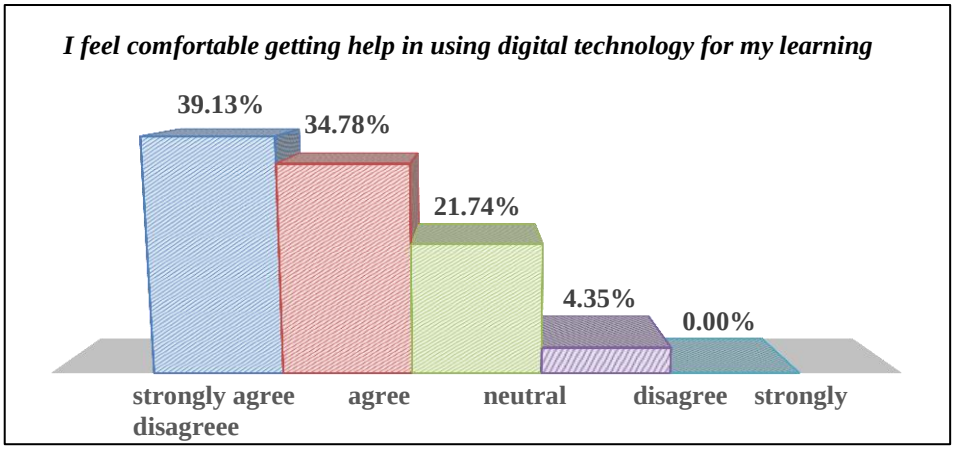


Figure 13. Appreciation of the state of comfort when the student get help in using digital technology

Regarding the influence of the use of digital technology on the degree of concentration in the learning activity, 4 students (17.39%) mention *very much*, 8 students (34.78%) declare *quite a bit*, 8 students (34.78%) declare *moderately*, 1 student (4.35%) mention *a little*, and 2 students (8.70%) mention *not at all*, as can be seen in Figure 14.

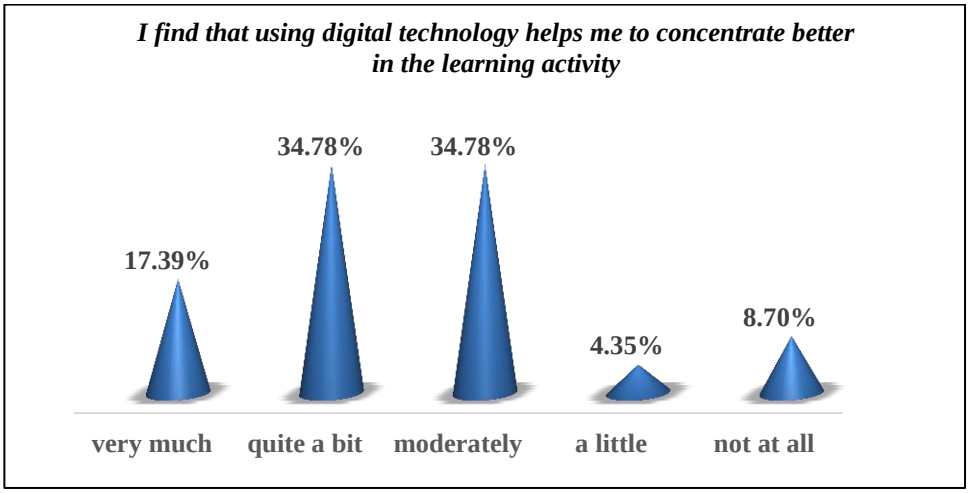


Figure 14. The influence of the use of digital technology on the degree of concentration

Of the 23 students participating in the study, 11 students (47.82%) mention that the use of digital technology helps them *very much* in the efficient organization of the time needed for study, 4 students (17.39%) it helps them *quite a bit*, 6 students (26.09%) it helps them *moderately*, and 2 students (8.70%) it helps them *a little*; no student mentions that digital technology does *not* help them *at all* in organizing their time for learning (Figure 15).

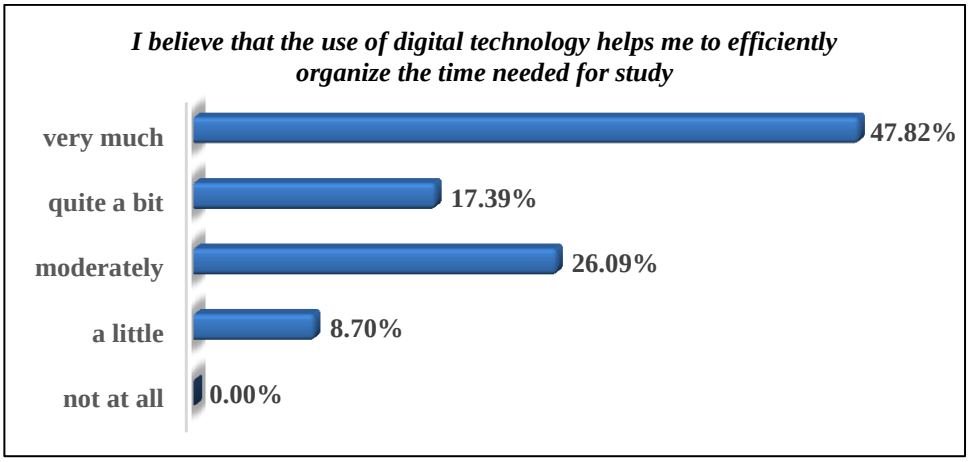


Figure 15. The influence of the use of digital technology in the efficient organization of the time required for study

On the item *I find it easy to learn how to use a new application*, 10 students (43.48%) *strongly agree* that it is eaasy for them to learn to use a new application, 9 students (39.13%) *agree*, 3 students (13.04%) declare *neutral*, 1 student (4.35%) mentions *disagree*, and no student ticked for *strongly disagree* (Figure 16).

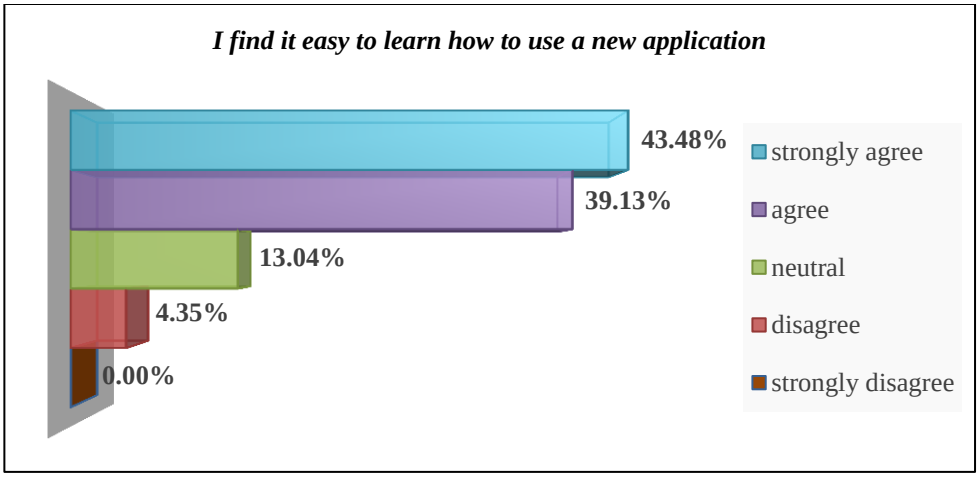


Figure 16. Appreciation of the ease of learning to use a new application

Asked if in their previous activity they used an application in the learning activity, 4 students (17.39%) mentioned that they used an application *very frequently* in the learning activity, 8 students (34.78%) used *frequently*, 6 students (26.09%) mentioned that they used *sometimes*, 4 students (17.39%) *rarely* used, and 1 student (4.35%) *never* used an application in the learning activity, as seen in Figure 17.

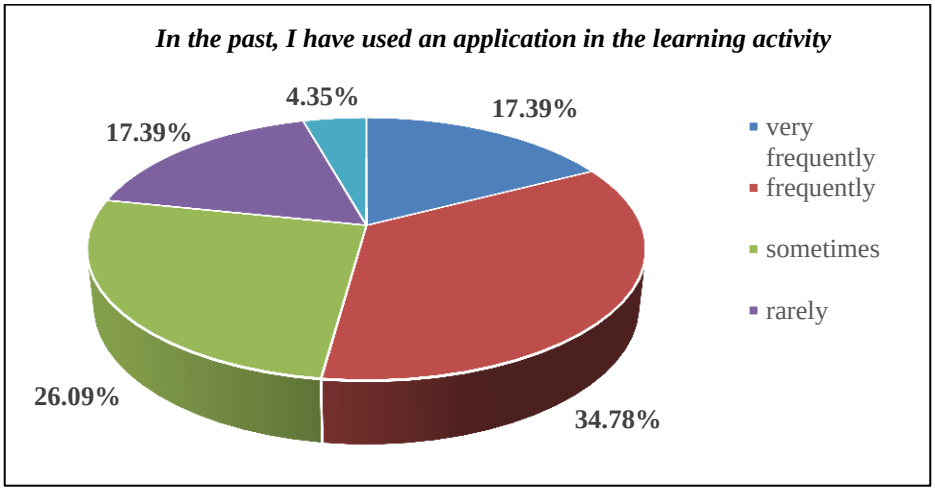


Figure 17. Frequency of past use of an application in the learning activity

Regarding the desire of students to study human anatomy using, in addition to traditional means, also digital technology, 14 students (60.87%) declare themselves *strongly agree*, 9 students (39.13%) mention *agree*, and for *neutral*, *disagree* and *strongly disagree* no student ticked, as illustrated in Figure 18.

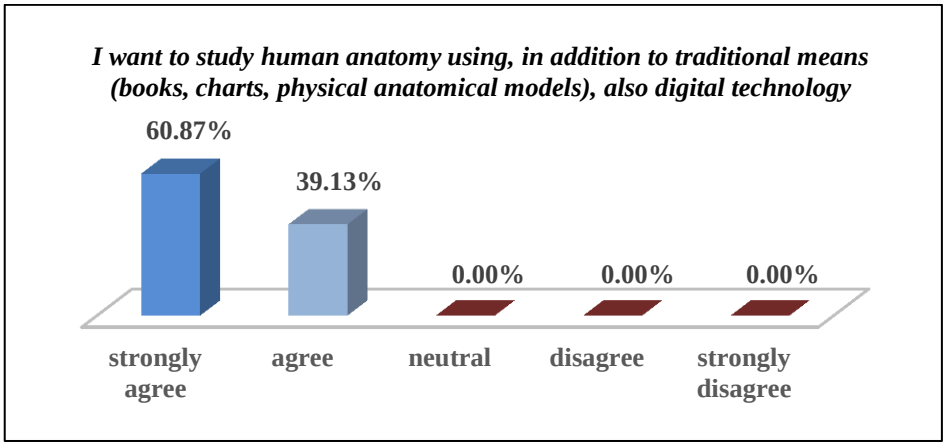


Figure 18. Students` desire to study human anatomy using traditional means and digital technology

Regarding students` desire to use the *Complete Anatomy* application for studying human anatomy, 9 students (39.13%) mention *very much*, 7 students (30.43%) mention *quite a bit*, 6 students (26.09%) mention *moderately*, 1 student (4.35%) mention *a little* and no student ticked for *not at all*, as illustrated in Figure 19.

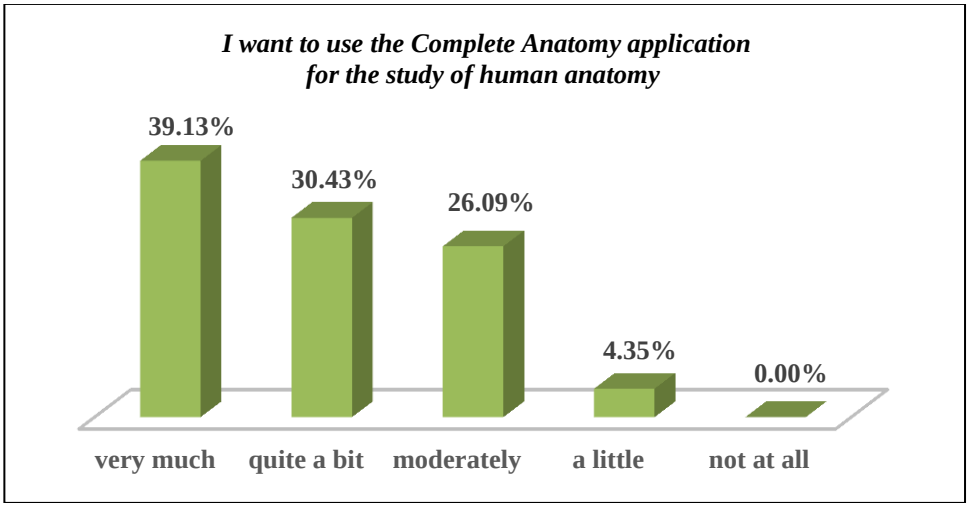


Figure 19. Students` desire to use *Complete Anatomy* application for studying human anatomy

Asked if using the *Complete Anatomy* application will help them understand human anatomy better and implicitly achieve better learning results, 10 students (43.48%) answered *strongly agree*, 9 students (39.13%) *agree*, 4 students (17.39%) mentioned *neutral*, and for *disagree* and *strongly disagree* no student ticked, as can be seen in Figure 20.

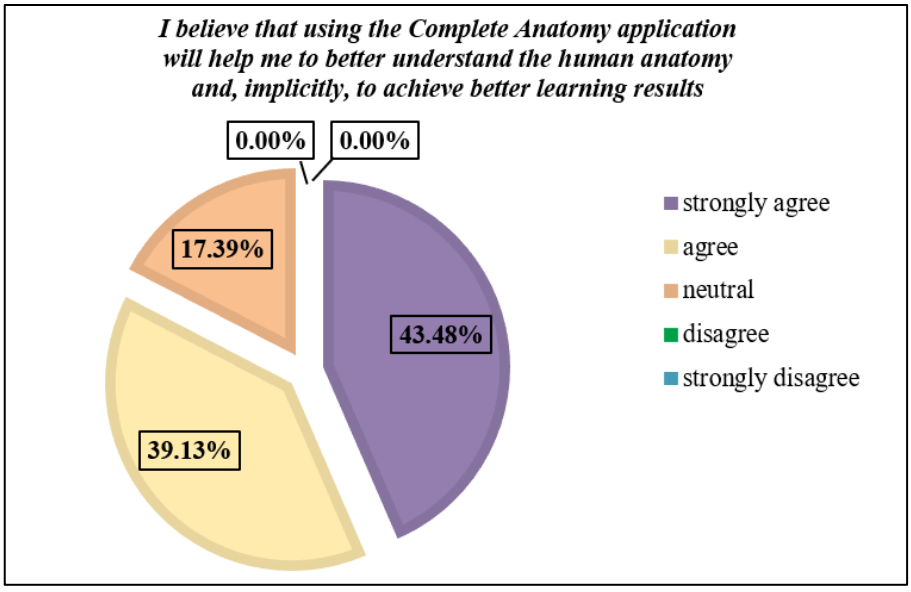


Figure 20. Appreciation of the *Complete Anatomy* application as a tool that will help students to better understand human anatomy and, implicitly, to achieve better learning results

Limitations and future study

This study was conducted on a small sample of subjects, with students from a single institution. Although the sample size was reduced, there was noticeable interest among students in using the *Complete Anatomy* application for studying human anatomy. This interest lays the groundwork for future research, which would involve collaboration with other specialized institutions and gathering more data to broaden the applicability of the findings. As the research was limited to one university, the results lack international relevance.

Conclusions

Following the use of an opinion questionnaire, it was found that, regardless of the experience of previous use or not of some applications in learning, students are eager to use digital technology for learning human anatomy through the *Complete Anatomy* application, the knowledge of human anatomy being a support for their entire activity. Thus, the research hypothesis was confirmed.

Since society is in a continuous evolution, it is necessary that the education process in general, but especially that in universities, should consider the use of the most useful teaching-learning methods, combining traditional methods with digital technology, for a good integration on the labor market of graduates, future professionals, in this case – future kinesiotherapists.

Authors` contribution

Both authors have equally contributed to this study and should be considered as main authors.

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