Journal of Teacher Education for Sustainability,
vol. 21, no. 2, pp. 27–37, 2019

Detailed Images for Sustainability Development in Cross-Sectional Human Anatomy

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Abstract

In medical education and preclinical, clinical and transdisciplinary studies, tutors should be able to perform and offer qualitative study courses with more articulated perspective on higher educational sustainable development in higher education. Digital images have found their direct way to education in different medical areas. The aims of the study are to assess and verify the impact of cross-sectional images on the study process of Human Anatomy. In 2018, two randomly selected groups of 200 students from 2nd study year, Faculty of Medicine (Rīga Stradiņš University) were asked by tutors to identify several anatomical structures, using a three-dimensional virtual dissection table “Anatomage”. Group I analyzed cross-sectional images after cutting and segmentation of human body with interactive tools. Group II studied X-ray pictures, computerized tomography scans and magnetic resonance images of different regions and systems. The present paper focuses on the rate of cross-sectional image effectiveness in both groups. Analyzed detailed images represent their role in teaching and learning of Human Anatomy. Interpretation of these medical images will require very deep anatomical knowledge from basic studies until clinical courses.

Key words: higher education, medical images (x-ray, CT and MRI), anatomical studies for more sustainable perspective

Introduction

Nowadays digitalization offers a lot of possibilities to improve the study process at higher education institutions by adopting several innovative technologies and leading to transformative experience. The quality of medical education supported by different innovations can be evaluated in various ways, quantitatively and qualitatively. The innovative solutions can widen students' and teachers' learning and teaching opportunities, provide better outcomes and contribute to the sustainability of the academic program and study courses.

Development of medical technologies changes the role of tutors and shows new trends in their daily work with students (Abdollahi, Salarvand, & Saffar 2018; Wozniak, Ellaway, & de Jong 2018). They must be ready to these changes and be flexible to adapt different digital images in teaching (Miles, 2005; Grignon, 2012). In anatomical practical

classes, the usage of digital tools can be very helpful for studying different areas of the human body. Digital images not only give the possibility to students to acquire better regular materials and topics, but they can also be used as a great tool for visualization of medical information and data (Arulsamy, 2012; Jang, Oh, Choe, & Jang 2018). With the increasing use of digital and virtual technologies in medical study courses, Human Anatomy is no exception (Johnson, Charchanti, & Troupis 2012; Park, Chung, & Chung 2017). In the context of education for sustainable development, this study course has been considerably changing over the past years at Rīga Stradiņš University.

An increasing number of digital technologies have been introduced to perform some practical aspects of teaching and learning the study course “Human Anatomy”. Today for modern day students more and more cross-sectional images of the human body are available as materials in their studies (Arus et al., 2017; Grignon, Oldrini, & Walter 2016b). Digital 2D images and/or 3D images, such as high resolution computerized tomography (CT) scans and magnetic resonance (MR), have been received with much enthusiasm and have found their way to the anatomy course and practical classes. Special attention on sectional anatomy can help medical students improve their knowledge of cross-sectional imaging (Hu, Wattchow, & de Fontgalland, 2018).

The aims of the present study are to assess and verify the impact of cross-sectional images on the study process of Human Anatomy.

Materials and Methods

The investigation carried out in 2018 involved 200 students of the 2nd study year at the Faculty of Medicine, Rīga Stradiņš University. In practical classes, all students were asked by tutors to identify several anatomical structures, using a 3D virtual dissection table “Anatomage” (the USA). More than 100 cross-sections from 2 prepared specimens of the “Anatomage” (Table Application software from Anatomage, Inc. (Table EDU 4.0)) database were used and studied for both male and female cadavers, and over 50 clinical cases were examined from a digital library with a variety of visualization options (X-rays, CT, MRI, etc.) in different regions of the body.

Practical classes encompassing anatomical X-ray images, CT sections and MRI were provided for students. Apart from normal, regional and sectional anatomy images or radiological images, the study course also included some pathological images. Each practical class included a different set of digital images. All images were used as part of practical class topics. In some classes, a short animation was used for the presentation of current or previous materials.

Two groups were randomly created: Group I analyzed cross-sectional images after cutting and segmentation of the human body with interactive tools; Group II studied X-rays, CT scans and MRI images of different regions and systems. Similar images in all possible cross-sectional planes were displayed. The pathological findings from the cross-sectional images were used to develop several clinical questions and cases.

At the beginning of each practical class, the tutor spent about 30 min demonstrating the themes on the images for all students. At the end of the teaching session, understanding of the relationships between anatomical structures and the rate of cross-sectional image effectiveness was assessed in both groups by using discussion. Students analyzed several and specific anatomical structures regarding each image in a question/answer style.

Tutors attempted to evaluate the effectiveness of learning, by asking students what type of these images contributed to their understanding of body composition and several anatomical structures. In most of the practical classes, tutors did their best to perform interdisciplinary teaching.

Results

During research and students learning observation time from researchers, students acquired the orientation of bones and organs from the lectures, practical classes and dissections. Majority of students recognized the landmarks, anatomical structures and relationships between them on cross-sectional images in three planes. Removing of different kinds of tissue offered students of both groups to learn more difficult anatomical topics and to explain details in these complicated regions.

Self-assessment exercises helped students evaluate their understanding of topographical relations and regional anatomy. In these groups, students with less prior anatomy experience were willing to focus on basics of anatomy, while students with high prior anatomy experience were willing to see and study more complex and interactive materials in cross-sectional images.

Students agreed that all these possibilities helped them better improve and understand how to study different types of information and topics in a new learning environment. Students mentioned that digital images and slices helped them conduct simulations of several procedures and provided an active study platform. In discussion sessions, students mentioned many advantages and just several disadvantages regarding the effectiveness of cross-sectional images when compared with traditional pictures from anatomy books (Table 1).

In both groups, students easily used terminology and annotated cross-sectional images. Once images were uploaded and opened, they were annotated or used without any textual explanation. Majority of these cross-sectional images included multiple annotations with text, circles and lines placed exactly where needed. Students had the option whether to use or not the annotations. For students, who were willing to self-assess their knowledge and skills, it was also possible to “hide” the annotations and terminology. Medical case scenarios or pathological cases were included by uploading the whole images.

Table 1
Some Advantages and Disadvantages of Cross-Sectional Images from Students' Discussions

Advantages	Disadvantages
Ability to move, rotate, change image sizes	Costs, updates of data, cross-sectional image sets and storage
All users can view or work with the same image, set of images and topics	Large file sizes
Better memory for pictures than textual information	Special knowledge and skills for reading, interpretation and analysis of cross-sectional images
Collaboration between students	Speed of some large size loading images
Educational activities	

See next page for continuation of table

Continuation of Table 1

Large amount of medical and anatomical information	Students do not get the same experience like in real dissection
Medical and pathological cross-sectional images and cases	Students do not learn to dissect any region in reality
New and modern environment	Training requirements
Quality of cross-sectional images	
Possibility to use zooming and dissection effects	
Terminology in annotations of images	
Self-study, training and simulation of procedures	
Self-testing or testing of knowledge and skills	
Storage of cross-sectional images	
Students can learn to use the cross-sectional images	

Majority of students believed that these images were good visual materials in addition to their basic studies and helpful for clinical studies. Students developed new possibilities, trained their skills and improved their knowledge to cut, move, rotate, interpret and describe the anatomical structures in the images. Some of the students were independent in the study process and reviewed individually cross-sectional images.

Three questions about the usage and effectiveness of cross-sectional images were discussed with students. The results were positive (Table 2).

Table 2

The Answers of Students about Effectiveness of Cross-Sectional Images in Both Groups

Question	Answer	
	Yes, %	No, %
Do you feel that cross-sectional images or their sets will play an important role in the course “Human Anatomy” and in your future?	90	10
Did you obtain any new level of knowledge or skills using anatomical cross-sectional images or their sets?	75	15
Do you recommend these cross-sectional images for current and next studies of anatomy?	95	5

Computerized Tomography and Magnetic Resonance Imaging

In practical classes, the use of computerized tomography (CT) and magnetic resonance imaging (MRI) allowed for not only differentiation among structures, hard and soft tissue in gross anatomy, but also for the understanding of the complex pathologies and/or pathological situations. The use of CT (Figure 1 and Figure 2) and MRI images opened new possibilities in diagnostics and/or in planning of different procedures.

Students used the information from CT and MRI (Figure 3) for the description and analysis of the findings. These images not only represented educational tools of high quality, but also offered learning, teaching and training of radiologic image interpretation of different regions of the body, such as head, neck, trunk and extremities.

Figure 1. Digital examples of the used CT scan of the head, neck and part of the thorax

Figure 2. Digital examples of the used CT scan of some largest regions of the body

Figure 3. Digital examples of the MRI images of the head

Digital images differed in their content and quality. Majority of students preferred the cross-sectional or radiological images of a three-dimensional virtual table “Anatomage” over still images of books or any other sources used for acquiring the study course “Human Anatomy”. Several students performed simulation of different procedures on the virtual body to visualize normal anatomy and examined relevant problems or pathologies using digital tools.

Discussion

The contemporary educational system includes skills and competences that are required for modern economy (Jirgensons & Kapenieks, 2018). New technologies play a very important and powerful role in all areas of human activities (Fenesi, Mackinnon,

Cheng, Kim, & Wainman, 2017). It is clear that they comprise and/or transform different spheres of medicine and medical education (Starkey, 2012).

Education in cross-sectional Human Anatomy is linked with professional development of tutors and students. It is essential to periodically conduct special studies for tutors of education programs (Yoo, 2016). Some authors (Reid & Božena, 2016) state that achieving sustainable development requires competent professionals. Perhaps, future studies and new digital experience can be next steps towards sustainable development of the basic study course “Human Anatomy” and of its content.

Students and teachers should follow the development of technologies very intensively; they should be able to use digital tools, collect and interpret different types of information and sources. Today’s virtual reality can provide and open many possibilities for the study process (Sandars & Morrison, 2007). Several existing methods can be combined and improved for the education process in different medical courses and/or disciplines. It is known that every medical study course is different and, therefore, a today’s tutor should bring something new and special to the teaching and learning process (Mistry, Chetty, Gurung, & Levell, 2019). In the teaching and learning process of the study course “Human Anatomy”, new effects can be reached by the use of digital and detailed medical images.

Digital images are very powerful educational tools that effectively replace the traditional and previous standard teaching and learning methods (Foster, 2010; Norris, 2012; Chiu, Solez, & Sergi, 2014). In Latvia we have research about action research for creating knowledge in an e-learning environment (Kapenieks & Salite, 2012). This study has convinced us that visual tools can also be easily applied to medical students and tutors. The quality of teaching and learning processes can be detected by digital images, their usage and effectiveness. The literature review has shown that the imaging process comprises not only capturing and saving (storage) of digital images, but also their editing and sharing (Hamilton, Wang, & McCullough, 2012). There are different types of images that can be used to acquire digital images (Kotzé, Mole, & Greyling, 2012). In course “Human Anatomy”, digital and cross-sectional images were used in a variety of different settings, including teaching and learning.

The study presented our activities and experience with digital and cross-sectional images in medical education and their inclusion into the study course “Human Anatomy”. In our study course, a three-dimensional virtual table “Anatomage” was used for combination of anatomy with some other courses or disciplines. The unique capabilities of this technology are the ability to rapidly store large volumes of the images and different data that are very important and helpful for assistance in medical education, for students’ activities and their assessment (Kish, Cook, & Kis, 2013). It has become an important tool in the contemporary study process. In practical classes, the education process was much more effective because a lot of digital resources were available there. It is an excellent tool of technology that can be used for storage of 3D digital images in medicine. This digital tool involves all the topics of Human Anatomy, thus changing and supporting the education process. Students and tutors used this technology for incorporation of regional and sectional anatomy, radiology or surgery into lectures and practical classes of Human Anatomy. It allowed students at all levels to have access to Human Anatomy and virtual dissection. The possibilities of a three-dimensional virtual table “Anatomage” included not only the segmentation features, but also options for separation of each anatomical structure or system.

From the literature analysis it is clear that virtual tools, visual slices and images can help students adapt their learning to the new study platform and technology (Chan & Rilly, 2002; Lee, Goldman, & Hortsch, 2018). It was recognized that virtual images can enhance the understanding of the clinical and diagnostic concepts for undergraduate students (Yammine & Violato, 2015). These activities provided students and tutors with hands-on experience, in which our students showed and improved knowledge of Human Anatomy, regional and sectional anatomy, radiology or surgery, and at the same time learned the general principles of this virtual technology (Dettmer, Tschernig, Galanski, Pabst, & Rieck, 2010). The ability to use all these digital images provided very important links among real anatomy, virtual anatomy and several images such as CT and MRI scans (Erkonen, Albanese, Smith, & Pantazis, 1992; Pathiraja, Little, & Denison, 2014). The general aim of the study was to teach medical students to understand, describe, interpret and visualize the anatomical structures of the human body using various methods and tools, ranging from classical dissection to modern imaging. One very helpful aspect of cross-sectional images was the changing possibility of their sizes and levels, directions and regions just by using fingers.

The quality of medical images plays an important role in the identification of structures not only in basic anatomy studies (Saco, Bombi, Garcia, Ramírez, & Ordi, 2016). It is also of significance for students and medical professionals in future training and clinical procedures (Pantanomitz, Szymas, Yagi, & Wilbur, 2012). Digital images offer many advantages and benefits. The usage of digital images in tandem with normal, regional and sectional anatomy, radiology and surgery presents one of the great opportunities for direct anatomy relationship with different medical courses and/or disciplines (Furness, 1997; Schramek et al., 2013; Custer & Michael, 2015).

The educational applications and advantages for medical digital images are growing. Independent anatomy studies can be encouraged, supported and facilitated with the use of organs-systems-based image sets. Level of knowledge and some skills can also be assessed with these sets not only in practical classes, but also in tests, colloquiums and exams. The use and adoption of digital images in the study course “Human Anatomy” take time (Paech et al., 2017). Students must prepare for tomorrow and tutors should practice the timing of their practical classes (Fazal, Khan, & Yunus, 2012). Digital images have been successfully used for teaching anatomy and integrated into our academic practice. Learning observations help researchers find that the current research case was open to a broader perspective for participants on more integrated learning, which was emerging as more sustainable through deeper involvement in research/studying participation. We can hypothesize that in both groups our students showed a very high level of knowledge of normal, regional and sectional anatomy in detailed cross-sectional images. Our experience and visual demonstration of digital images improved the incorporation of basic concepts into research development. As Human Anatomy and clinical medicine grow increasingly regarding the usage of digital technologies, it is ever more important that we will continue to use detailed digital images and develop new and modern directions in the anatomy study process. In the coming years, the effectiveness of digital images, short- and long-term outcomes of our study course should be tested using different hypotheses.

Conclusion and Future Research

The study demonstrated the role of 3D virtual dissection table “Anatomage” in facilitating students’ ability to interpret digital medical cross-sectional images and to understand the relationships among different anatomical structures. All used X-rays, CT scans and MRI cross-sectional images played an important role in teaching and learning of Human Anatomy. In this period, the use of cross-sectional detailed images demanded new skills and competences, created the need to repeatedly and regularly improve knowledge. Interpretation of these medical images required anatomical knowledge from basic studies to clinical courses. The incorporation of digital images and 3D visualization can range from teaching and learning anatomy to many other situations, such as development of the knowledge, skills, medical profession and research.

Our students were very motivated to improve their knowledge. Students mentioned that they were more comfortable with reading X-rays and CTs, identifying anatomical structures in different digital images, as well as training on the basis of virtual human bodies and tools for educational programs.

The chance to use the virtual technology, anatomical cross-sections and digital images of the different structures, organs and systems played an important role in the study course “Human Anatomy”. The learning experience gained by 90% of students may have a potential influence on their future choice of specialty.

It should be noted that 95% of students recommended using these digital medical images for current and next studies in future.

Acknowledgements

We would like to thank all our current and previous students for their feedback on the study course “Human Anatomy”.

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