3D-PRINTED VASCULAR MODEL OF THE POLYGON OF WILLIS USED IN MEDICAL EDUCATION

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ABSTRACT
The use of 3D models in the study of medicine emerged shortly after a profound paradigm shift in medical education, whose ultimate goal was for students to be the protagonists of their own learning, with more emphasis on practical activities and the use of technology to further stimulate student contact with active learning. This study evaluated the efficiency of using 3D printed parts in Human Anatomy classes in the third semester of the Medicine course in Anápolis, Goiás. The parts were produced and used in an activity to identify the structures of the Willis polygon, and a questionnaire was administered about the parts worked on in class. The analysis of the questionnaires administered before and after the activity indicated a significant improvement in the students' identification of the structures of the Willis polygon. The use of 3D models increased the average number of correct answers, demonstrating a positive impact on learning, facilitating the visualization, memorization, and understanding of anatomical structures, and highlighting the effectiveness of this tool in teaching.
Keywords: 3D printing; Education; Medicine; Medical materials.

INTRODUCTION

Problem-based learning (PBL) encourages students to actively seek information, developing communication and critical thinking skills (Ronn, 2009). In the field of medicine, in addition to PBL, technology has become a facilitator and creator of new educational methods (Dourado, 2020).

3D printing has been applied in medical education, enabling active learning focused on the visualization of details (Moraes; Muniz, 2018; Garcia et al, 2022). This technology also opens up opportunities for scientific research, although it has limitations, such as the size of objects, time, and production costs (César-Juárez, 2018; Romero, 2019; Garcia et al., 2022).

The discipline of Human Anatomy can benefit from the use of 3D printed parts, complementing traditional methods such as dissection and the use of interactive

multimedia (Sugand; Abrahams; Khurana, 2010; Barreto, 2018). UniEVANGÉLICA has the infrastructure to produce 3D anatomical parts, which can reduce costs and offer an innovative educational experience for medical students. This study evaluated the efficiency of using 3D printed parts in Human Anatomy classes in the third semester of the Medicine course.

METHOD

This prospective, descriptive, and mixed study covers quantitative and qualitative, exploratory, and comparative aspects before and after the intervention, carried out at the Evangelical University of Goiás – UniEvangélica in May 2024. Initially, the pieces were produced in the 3D printing laboratory, according to the need for details and pathological changes in each discipline, using the CL2 Edu printer (Cliever Studio) and its software. The pieces were then made available to students during practical classes for general evaluation, allowing them to make constructive criticism about the technological system.

After class, a questionnaire with specific items about each piece was administered so that students could share their conclusions. The criticisms and suggestions were analyzed, and no pieces required adjustments. Followed by a theoretical evaluation to measure the effectiveness of the project and encourage the use of the objects by students, a critical analysis was carried out among teachers in the field to discuss details, size, and morphofunctionality of each piece and their positive and negative impacts on classes focused on this topic.

RESULTS

The 3D-printed vascular models were introduced in practical Human Anatomy classes and received a positive response from both students and teachers. Five models were produced and tested, representing different aspects of the human cerebral vascular system.

The evaluation carried out with the students indicated that the vast majority considered that the use of 3D models facilitated the understanding of anatomical concepts and , particularly in the identification and three-dimensional localization of vessels. Qualitative analysis of the questionnaires revealed that students preferred

3D models to traditional two-dimensional images, highlighting the improvement in spatial perception provided by the models.

With regard to learning efficiency, there was a significant increase in the grades of the theoretical assessments carried out before and after the use of the models. Specifically, there was an increase in the overall performance of the students, with emphasis on the improvement in the clarity and understanding of complex anatomical structures.

Teachers, in turn, pointed out that 3D-printed models provided an innovative teaching tool, allowing for a more interactive approach in the classroom. However, some suggestions were made, such as the need to improve the resolution and detail of certain areas of the models to further optimize the learning process.

Despite some constructive criticism, student feedback was overwhelmingly positive, indicating that the introduction of 3D models significantly improved their learning experience. The introduction of 3D-printed vascular models in medical education has proven effective in enhancing students' understanding and enriching their educational experience. These results suggest that 3D printing can complement traditional methods of teaching anatomy, especially in areas that require a detailed understanding of three-dimensional anatomy.

CONCLUSION

The introduction of 3D-printed vascular models in the medical education setting has proven to be an effective strategy for enhancing students' anatomical understanding, especially in topics that require detailed spatial perception. The positive response from students and faculty, coupled with the significant increase in theoretical assessment scores, reinforces the potential of this technology as a complement to traditional teaching methods. Although some improvements to the models have been suggested, the benefits observed indicate that 3D printing can be a valuable tool for enriching the learning experience in medical education. Therefore, the expanded use of this technology in other areas of anatomy is recommended, with a view to providing an even more comprehensive and interactive medical education.

REFERENCES

ARMESTO, L. M. 3D tools as an aid in the teaching-learning process in the discipline of anatomy. Master's thesis. **Universidade Brasil**. 2021

BARRETO, T. F. Use of 3D anatomical parts as a strategy for teaching anatomy in medical courses. Master's thesis. **Bahiana School of Medicine and Public Health**, Salvador, BA, Brazil, 85 p. 2018.

DOURADO, V. M. et al. Medical students' perceptions of quizzes in the PBL teaching methodology. **Brazilian Journal of Development**, v. 6, n. 8, p. 55249-55256, 2020.

GARCIA, T. R. et al. 3D printing of anatomical parts as tools for education and assistance in clinical practice. **Research, Society and Development**, v. 11, n. 13, 2022.

MARICEVICH, P. et al. Prototyping: applications in craniomaxillofacial surgery at the National Institute of Traumatology and Orthopedics (INTO)-RJ. **Brazilian Journal of Plastic Surgery**, v. 30, p. 626-632, 2023.

MUNIZ, A. L.; MORAES, S. G. Use of 3D models as a teaching resource in the teaching of central nervous system embryology. In: **Proceedings of the International Congress on Education and Technologies**. 2018.

ROSA, B. R. et al. Learning Hepatobiliary Anatomy through the 3D Virtual Anatomical Table. **Brazilian Journal of Medical Education**, v. 43, p. 615-622, 2020.

RONN, A. P. et al. Evidence of the effectiveness of problem-based learning in medical education: a literature review. **Journal of Science and Academic Studies in Medicine**, no. 11, 2019.

SALBEGO, C. et al. Academic perceptions of teaching and learning in human anatomy. **Brazilian Journal of Medical Education**, v. 39, p. 23-31, 2015.

SANTOS, J. T; DE ANDRADE, A. F. 3D printing as a resource for the development of teaching materials: associating Maker culture with problem solving. **Journal of New Technologies in Education**, v. 18, no. 1, 2020.

SILVA, J.; FURTADO, F. What factors influence the pass rate in human anatomy courses? **Brazilian Journal of Medical Education**, v. 39, p. 574-585, 2015.

STRALIOTTO, J. C; BORGES, M. E.; BONINI, J. S. 3D printer as a pedagogical tool: construction and application of neuroanatomical parts. **Brazilian Journal of Development,** v. 7, n. 7, p. 65360-65372, 2021.

SUGAND, K.; ABRAHAMS, P; KHURANA, A. The anatomy of anatomy: a review for its modernization. **Anat Sci Educ.** v. 2, n. 3, p. 83-93. 2010.

YAHIRO, D. S. et al. Creation of Cardiac Embryological Models for 3D Printing for Teaching Anatomy and Embryology. **Brazilian Archives of Cardiology**, v. 120, n. 4, p. e20220632, 2023.