

3D-printed dental models as a complementary resource for teaching dental sculpture

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ABSTRACT

The diversification of pedagogical practices aimed at improving the teaching process. New methodologies, which favor the interests of students and to provide better understanding, can be important tools in the teaching and learning process. The aim of this study was to evaluate the perception of undergraduate dental students regarding the use of 3D-printed dental models as an additional resource for teaching dental sculpture at FACIPLAC. The sample consisted of 44 students enrolled in the fifth semester. A total of 44 sets were printed using four three-dimensional models: maxillary central incisor, canine, first premolar and first molar, printed in plastic, resistant and colorful material. The sets were delivered to students at the beginning of each class and used to demonstrate the anatomical structures, collected at the end of the class, for improved memorization of knowledge. A questionnaire was applied regarding the use of the 3D models at the end of the school semester, and 38 answers were obtained. The research results indicated that the use of 3D models was a valid resource for facilitating technical understanding of dental sculpture; improved the learning process when compared to the use of slideshows; identified areas of greater difficulty in learning; contributed to the memorization of concepts and geometric shapes of tooth structures. Although students approved the use of 3D models, they did not replace practical demonstration.

Descriptors: Sculpture. Teaching. Learning. Printing, Three-Dimensional.

1 INTRODUCTION

Innovative practices for the education, training and motivation of dental students have been suggested. Different teaching methods for effective learning have been adopted with the purpose of interconnecting theory with laboratory and clinical practice, as well as

developing original and creative solutions for modifying the learning outcomes¹.

Traditional teaching methods using chalk, blackboard and handouts have long been replaced by lectures using slideshows and software. The need for constant reformulation of education has been considered in view of the demands of the media regarding content and form².

Traditional and outdated teaching methods do not motivate creative and intelligent young people. In addition, efficient college learning is low when classical methods are used. Therefore, education must be modernized to keep up with the technological changes that have taken place in the world³.

Chuck Hull, a North-American from the state of California, filed his own patent for three-dimensional printing in 1984. Additive manufacturing, also known as rapid prototyping, builds a three-dimensional object from a computer-aided design model by successively adding material layer by layer. These models can be created using software for three-dimensional modeling or three-dimensional scanning⁴. The most common materials used for 3-D printing are lactic polyacid (PLA) and acrylonitrile butadiene styrene (ABS). These plastic materials have good mechanical properties and may be used in different areas of industry as well as for domestic use^{5,6}.

Thus, globalization and the computerization of society require the modernization of methods and resources in the teaching and learning process. In view of the contemporary innovations, the greatest pedagogical challenge is to identify how professors, who have technical and scientific knowledge, recognized specialization, and merit in their field of studies, would use new technologies in their pedagogical practices to

improve teaching quality. One of the possibilities is to use technology as an aid in the process of active and intelligent teaching by using comprehensible language to facilitate the understanding and learning of knowledge⁷⁻⁹.

Studies using 3D-printed models as an aid in the teaching-learning process are scarce in the literature. Therefore, the present study investigated the use of dental models, using a 3D printer, for teaching dental sculpture, and analyzed the undergraduate student's perception of them to verify how the models influenced the memorization of concepts and geometric shapes of tooth structures and their real spatial arrangement.

2 MATERIAL AND METHODS

This study was conducted in accordance with the norms established by Resolution 466/12 of the National Health Council, Ministry of Health, and it was submitted and approved by the Research Ethics Committee of São Leopoldo Mandic School under report number 2.115. 848.

The sample consisted of 44 students from the fifth semester of the undergraduate Dentistry course enrolled in the discipline of dental sculpture at the Faculdades Integradas da União Educacional do Planalto Central (FACIPLAC), Brasília-DF.

ABS filaments of 1.75 mm diameter (colored in pink, yellow, blue and green), which is a durable, handy, light, washable and easy-to-handle material (figure 1) were used to create the dental models.

Four three-dimensional models of the maxillary right central incisor, canine, first premolar and first molar, measuring approximately 6.5 centimeters in height, were printed.

The dental models were randomly colored and delivered to each student. These dental

models were used to demonstrate the dental anatomical structures, such as the cingulum, cusp, surface, ridge, pit, crest, groove, sulcus,

fossa, gingival zenith, tubercle, and neck. All models were collected at the end of the activities. Slide shows and books were not used.



Figure 1. 3D dental models.

Students compared the use of 3D-printed models with traditional teaching methods from other disciplines in which only books and slideshows are used.

At the end of the semester, a validated and adapted questionnaire consisting of six closed questions (Table 1) and one open question for comments and suggestions was applied. The students' participation was voluntary after they signed the free and informed consent form (IC).

Data were tabulated and presented as absolute and relative frequencies for each question. The data analysis was important to interpret the students' perceptions and opinions regarding the use of new teaching methods and the learning process. Comments and suggestions have been compiled and discussed in the results.

3 RESULTS

Of the 44 students enrolled in the discipline of dental sculpture who received the questionnaire, 39 (88.63%) returned it, but one of them did not sign the IC, resulting in a response rate of 86.36%.

The mean age of participants was 25 years, ranging from 19 to 47, with a standard deviation of 5.87. There were 11 male students (28.95%) and 27 (71.05%) female students. The answers are shown in Graph 1.

In the section for comments and suggestions, 7.89% of respondents reported that the 3D models "are a great tool to assist the practical classes of dental sculpture, especially the anatomical structures"; "facilitate the visualization of the structures that are difficult to identify in slideshows"; and "besides being beautiful and well made, they help us memorize each tooth structure".

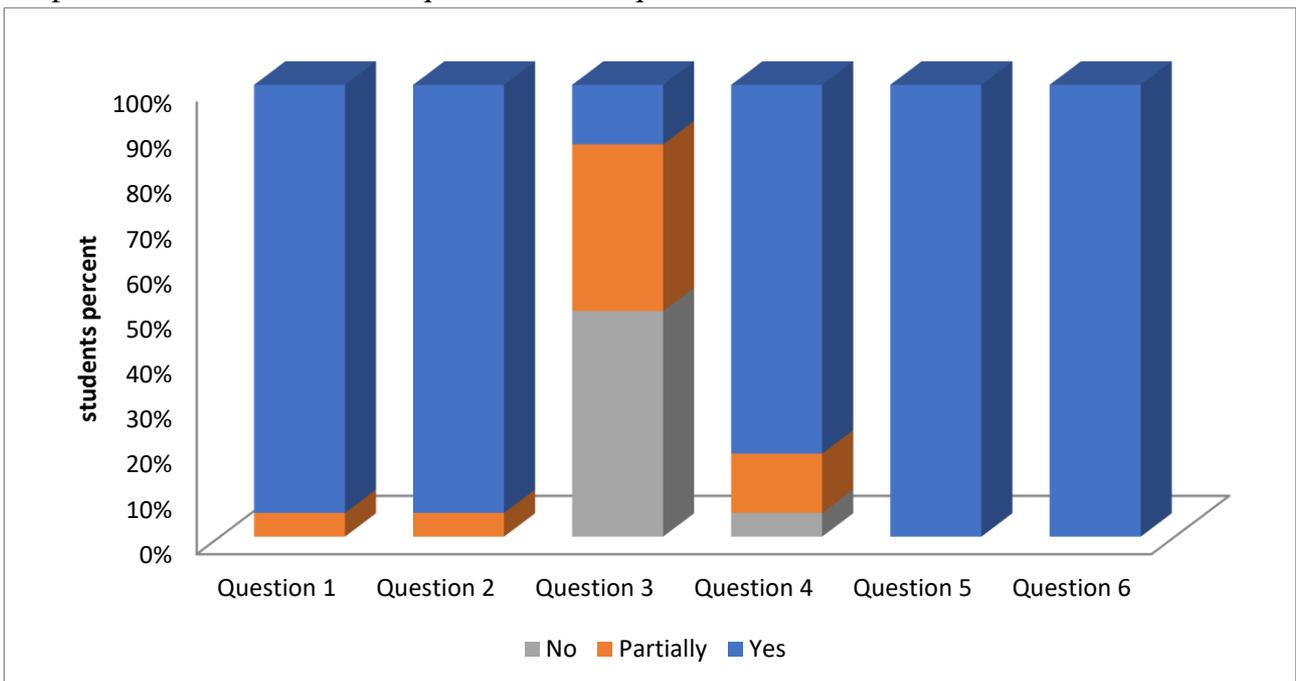
Chart 1. Questionnaire.

Age: _____ Sex: _____

1. Was the use of 3D-printed dental models a valid resource that facilitates the understanding of dental sculpture?
 yes partially no
2. Did you consider that the dynamic view and direct contact with the 3D models improved the learning process when compared to the static view of slideshows?
 yes partially no
3. Does the use of the 3D models replace the practical demonstration given by the teacher?
 yes partially no
4. Did the use of 3D models help identify areas of greater difficulty in learning dental sculpture?
 yes partially no
5. Did the use of the 3D models contribute to the memorization of concepts and geometric shapes of tooth structures?
 yes partially no
6. Would you suggest the use of 3D dental models for learning dental sculpture to someone you know?
 yes partially no

Comments and suggestions:

Graph 1. Answers to the closed questions of the questionnaire.



4 DISCUSSION

The absolute majority of students answered that the use of dental models was a valid method to facilitate the understanding of dental sculpture and it

improved the learning process due to the dynamic view and direct contact when compared to the static view of slideshows. In an essentially practical discipline, any auxiliary resource that awakens

students' senses could be capable of eliciting such a response. However, the absence of any negative response evidenced the quality of the three-dimensional models and significant contribution to the development of students' knowledge.

Three-dimensional perception develops as an individual experiences space, especially through sight and touch, which pick up stimuli, such as brightness, shades, color, type of contact, among others. These stimuli go to the brain, which interprets them by developing concepts of form, proportion, position, and orientation. Thus, this entire process leads to the formation of new concepts or refinement of existing ones¹⁰. Therefore, it is natural that 3D-printed dental models are a valuable resource to facilitate the understanding of dental sculpture.

In the same line, more than 80% of students identified areas of greater difficulty in learning dental sculpture using 3D models. Memory plays a key role in spatial intelligence. Spatial reasoning refers to the imaginative representation of spatial entities. Once the image of the model has been formed in the mind, representation is reasonably easy. When an object is appreciated, we instinctively pick it up, rotate and observe it from different angles. During this procedure, the senses of sight and touch are activated. Thus, details of the object, such as shapes, proportions, and positions are perceived. Subsequently, in the absence of the object, it can be brought to the mind by the evocation of the image memorized¹⁰. Thus, the development of spatial reasoning depends on spatial memory, which, in turn, depends on spatial perception, which may be facilitated by using three-dimensional models, such as the dental models used in this research.

The consensus among students concerning the last questions and section for comments and suggestions evidence a positive outcome regarding the use of three-dimensional models as a complementary resource for teaching dental sculpture. In general, this result is in agreement with

all the other questions: the use of three-dimensional models was extremely valid for the teaching process and learning of students who participated in the present research.

4 CONCLUSIONS

According to the research objective, the students understood that three-dimensional models were a valid resource for facilitating the understanding of the technique used; improved the learning process when compared to the use of slideshows; identified areas of greater difficulty in learning; contributed to sediment the concepts of the geometric forms of dental structures; and would be indicated by them for the learning of the discipline. However, they did not replace practical demonstration in the classroom.

This is a preliminary research on the proposed theme. Thus, more research must be conducted for further deepening and discussion of the subject.

RESUMO

Macromodelos odontológicos impressos em 3D como recurso complementar ao ensino em escultura dentária

A diversificação das práticas pedagógicas visa o aprimoramento do processo de ensino. Novas metodologias, que favoreçam o interesse dos alunos e que proporcionem melhor compreensão, podem ser ferramentas importantes no processo ensino-aprendizagem. O objetivo desse estudo foi avaliar a percepção dos estudantes sobre o uso de macromodelos odontológicos, confeccionados com impressora 3D, como recurso complementar de ensino na disciplina Escultura Dentária, no curso de graduação em Odontologia da FACIPLAC. A amostra foi composta por 44 estudantes, matriculados no quinto período. Foram produzidos 44 conjuntos com quatro macromodelos, sendo um incisivo central, um canino, um primeiro pré-molar e um primeiro molar, todos superiores, confeccionados em material plástico colorido e resistente. Os conjuntos foram entregues aos estudantes no início de cada aula e utilizados para

demonstração das estruturas anatômicas, visando à melhor fixação do conhecimento, sendo recolhidos posteriormente. Ao final do semestre letivo foi aplicado um questionário relativo ao aproveitamento do uso dos macromodelos, com resposta de 38 estudantes. Os resultados indicam que o uso dos macromodelos foi válido como recurso facilitador da compreensão da técnica de escultura dentária; contribuindo com o processo de aprendizagem em comparação ao uso de diapositivos; destacando as dificuldades no aprendizado; auxiliando na sedimentação dos conceitos das formas geométricas das estruturas dentárias. Os estudantes indicam seu uso, contudo consideram que não substitui a demonstração prática pelo docente.

Descritores: Escultura. Ensino. Aprendizagem. Impressão Tridimensional. Anatomia.

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