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ORIGINAL

3D biomodels to integrate an imaging diagnosis as an aid in learning clinical diagnostics in dentistry

Biomodelos 3D para integrar un diagnóstico imagenológico como auxiliar en el aprendizaje del diagnóstico clínico en odontología

José Antonio Jerónimo Montes[1], Angélica Rosalva Martínez Rodríguez[2], Juan Ignacio Cruz[1]

[1]Facultad de Estudios Superiores Zaragoza. México.
[2]UNAM. Facultad de Estudios Superiores Zaragoza. México.

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Corresponding Author: José Antonio Jerónimo Montes

ABSTRACT

The work presented here corresponds to the purpose of the PAPIT Project IN306823 Emerging pedagogies and open educational movement, particularly in digital and 3D printed format; applied in learning activities in Health Sciences, in dentistry. In the salud area, the challenge is to attract the attention and interest of students to learn anatomy, pathology and promote the integration of knowledge of the basic areas referred to above in the process of identifying lesions, in that formative experience focused on the use of radiographic images of patients. The learning experiences that are shared incorporate 3D printed models that have been generated with DICOM data obtained from CT scans, which are transformed into a geometry data. STL (Blue Sky Plan software) data are transformed into slices (SLICER) for 3D printing in the CURA program. These resources have been a support for teaching and learning. The 3D models are called Biomodels and have been tested in small groups as part of the Design Thiniking methodology; the results have been identified through open interview and online forms.

Keywords: 3D Printing; 3D Biomodels; Open Educational Resources.

RESUMEN

El trabajo que aquí se presenta corresponde con el propósito del Proyecto PAPIT IN306823 Pedagogías emergentes y movimiento educativo abierto, en particular en formato digital e impreso 3D; aplicados en las actividades de aprendizaje en Ciencias de la Salud, en odontología. En el área de la salud el reto es atraer la atención e interés de los estudiantes para el aprendizaje de la anatomía, la patología y fomentar la integración de los conocimientos de las áreas básicas antes referidas en el proceso de identificación de lesiones, en esa experiencia formativa centrada en el uso de imágenes radiográficas de pacientes. En las experiencias de aprendizaje que se comparten se incorporan modelos impresos en formato 3D que se han generado con datos DICOM obtenidos de tomografías computarizadas, que se transforman a un dato de geometría. STL (Blue Sky Plan software), los datos, se transforman en cortes (SLICER) para impresión 3D, en el programa CURA. Estos recursos han sido un apoyo para la enseñanza y el aprendizaje. Los modelos 3D los denominamos Biomodelos y se han probado en pequeños grupos como parte de la metodología Design Thiniking; los resultados se han identificado, mediante la entrevista abierta y con formularios en línea.

Palabras clave: Impresión 3D; Biomodelos 3D; Recursos Educativos Abiertos.

INTRODUCTION

We start by considering the rapid changes in the professional practice of dentistry in the health field. We are consequently committed to innovative professional training in the context of rapid technological advancement.

Based on reflection on educational experiences during the pandemic, it has been necessary to adjust or change existing teaching patterns to respond to the problems of a complex and constantly evolving reality that considers, among other things, evaluating the relevance of information and the construction of meanings related to problem-solving; with students who have sophisticated technological skills; with teachers who are mostly adults over 40 years of age, many of whom are just beginning to incorporate "new information and communication technologies for the educational process." The challenges identified so far have been developing alternative teaching practices, exploring alternative communication and online teaching strategies, seeking creative strategies for interaction through electronic means of communication, generating digital resources, and creating appropriate materials and playful exercises to facilitate learning and the development of students' psychomotor skills for the development of the dentistry degree program.

DEVELOPMENT

The experiences gained during the pandemic provided an opportunity to practice collaborative learning among teachers, which, among other things, allowed for:

- The discovery of new resources for teaching and learning.
- The creation of materials and exercises that facilitate the understanding and learning of theoretical and practical content.
- Accepting help from students to solve technical problems with the use of "novel" devices.
- Sharing experiences and carrying out creative, collaborative work for the development of laboratory practices.

The relationship between teachers and students was also a learning experience for both, with the mediation of open educational resources in an environment of:

- Isolation.
- Little interaction with peers.
- Willingness to venture into different learning experiences.
- Recovery of diverse communicative experiences.
- Collaborating and offering alternatives for improved online learning and skill development interaction.

In this context, recovering learning through interaction processes that promote acquiring knowledge, skills, aptitudes, attitudes, and values through diverse experiences to solve problems facilitates the recovery of prior knowledge and experiences, resulting in new learning in a given context. In addition, training is understood as the set of procedures and activities carried out to encourage the analysis of processes and identify and understand the results obtained, allowing conclusions to be reached that facilitate the issuance of a judgment or the implementation of actions to solve one or more problems.[1]

In higher education, the teaching, learning, and training process involves, among other things, performing professional functions and comparing models and guidelines that facilitate professional training by the historical and social context in which it takes place. In this context, the teaching and learning process has changed significantly. Teachers have had to learn to look at students from different perspectives, identify new obstacles, and find new ways of perceiving reality.[2]

Based on the above experience, teachers and students face new challenges after the pandemic as they return to face-to-face academic activities in a climate of desolation due to human and material losses, fear of infection, and expectations for learning in a different context. Therefore, teaching practice and didactics cannot be the same as before the pandemic, nor can they be the same as those developed during isolation. Some challenges faced by teachers:

- Incorporating digital technologies into the face-to-face learning process.
- Resistance and difficulty of students in addressing a topic with traditional teaching strategies.
- Difficulty in paying attention for more than 10 minutes.
- Carrying out teaching practice based on a climate of respect, collaboration, solidarity, and support
- Becoming involved in a learning process in unique, complex situations that require interaction to facilitate the development of the study program.
- Interact with students who, in the last two years, have lived in an interconnected world, which involves using information networks with the opportunity to find accessible, simplified information that requires critical thinking to identify false or unsubstantiated information from valid and meaningful contributions.

That being the case, it is considered that advances in digital technology offer alternatives for teaching with playful 3D Open Educational Resources (OER) that facilitate interaction with students of a generation facing situations of uncertainty in a reality of rapid change and the daily and, in some cases, excessive use of social networks, which lead them to individualized learning experiences in a complex context.[1,3,4] In the case of learning anatomy, this is simplified through interactive 3D image and model applications, which facilitate access to complex anatomical structures by relating the model to the image, a fortunate process for learning diagnosis and treatment planning.

In the context of the first year of the Dental Surgery degree program, in the module "Basics for the diagnosis of the stomatognathic system," first-year students are introduced to:

- Learning the language of the discipline.
- Identifying anatomical structures with marked differences between them.
- Structures that resemble geometric figures, elevations, linear depressions, orifices.
- Identification of imaging images (X-rays and CT scans) (figure 1).
- This exercise has greatly benefited from access to 3D images and models, which are already available in applications as open educational resources.

Radiografía panorámica. Paciente real. Aportada por Cruz- Juan I. 2024

Figure 1. Panoramic X-ray

In the teaching and learning process for diagnostic imaging, students are challenged to integrate the knowledge acquired in other modules of the same school year. Training for students to identify the anatomical structures of the head, face, and neck (figure 2) in a two-dimensional image with overlapping structures requires the development of skills to:

- Identify changes in shades of black, gray, and white that correspond to anatomical structures according to their location and degree of mineralization.
- Identify the presence of soft tissues and spaces between structures.
- Define which images are normal.
- Differentiate between altered structures and the presence of any pathology.

Figure 2. Learning to identify head and neck structures in humans

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To facilitate this training, it was proposed that 3D images be generated to allow the anatomical structures present to be observed from different angles and planes and differentiate between normal and abnormal. For teachers, designing open educational resources that attract students' attention and interest involves:

- Breaking down resistance.
- A learning and training process.
- An open and creative attitude.
- Developing skills for designing these resources.
- Having access to a scanner, 3D printers, and the appropriate hardware and software.
- Having an instructor who can facilitate learning and training in diagnosis using 3D resources.

In the Dental Surgery degree program, an innovation and technological research project was developed to use 3D design and printing technology to support the learning process, which consists of the stages of the design thinking methodology (figure 3):

1. Empathize with and determine the 3D resources with which the topic will be developed based on the learners' needs.
    - At this stage, it was decided to interview the students, taking into account their concerns and fears about using an image of a patient's skull obtained by computed tomography.
    - Draw up a list of common dental pathologies in small groups, the students created files with images and radiographic descriptions of some common pathologies (dental caries, periodontal pockets, root remnants, among others).

2. Build the visual model and materials to test the resource with the students, observing their interests, skills in integrating knowledge, identification of healthy and altered structures, and persistence in repeating the exercise.

Figure 3. Empathizing Stage, trainees in learning activity with 3D models-Biomodels

The 3D digital model developed in both image and physical form has the following purposes (figure 4):

- Identify anatomical structures.
- Identify alterations and pathologies.
- Integrate a diagnosis based on the 3D model.
- Design and perform virtual treatments that facilitate identification of the clinical process.
- Analyze the effectiveness of mechanical therapeutic alternatives and develop the proposed devices.

The model was designed using resources obtained from the PAPIIT project and software (Blue Sky), hardware (i7 processor laptop, 16 GB RAM, rtx4060 graphics card), and a scanner (DICOM). DICOM is an international standard for storing medical images such as Computed Tomography (CT) and Magnetic Resonance Imaging (MRI). Usually, each portion of a CT or MRI image is saved in an individual DICOM file with the file extension ".dcm," although this is not always the case. The process consisted of Defining the anatomical structures to be segmented. To do this, different CT scans from other patients are evaluated. The important thing here is to have the DICOM data (pure CT files). The next step is to define which program will be used to transform the

DICOM data into geometric data. STL (Blue Sky Plan software) is used once the STL data has been segmented and processed (optimization). It is then transferred to the program for cutting (SLICER) for 3D printing. In this case, the CURA program was used, as the printing method is 3D printing. STL data has been segmented and processed (optimization) and transferred to the program for cutting (SLICER) for 3D printing. The CURA program was used in this case since the printing method is FDM. Once calibrated, experiences from other authors in the field of dentistry are retrieved (figure 5).[5]

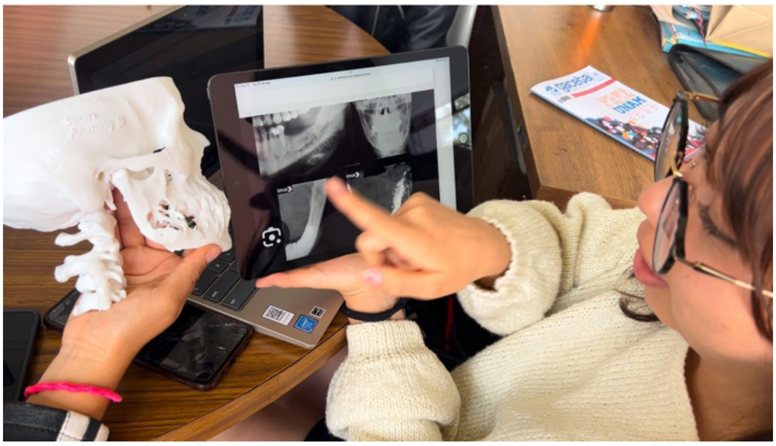

Figure 4. Learning activity with 3D biomodel comparing patient X-ray

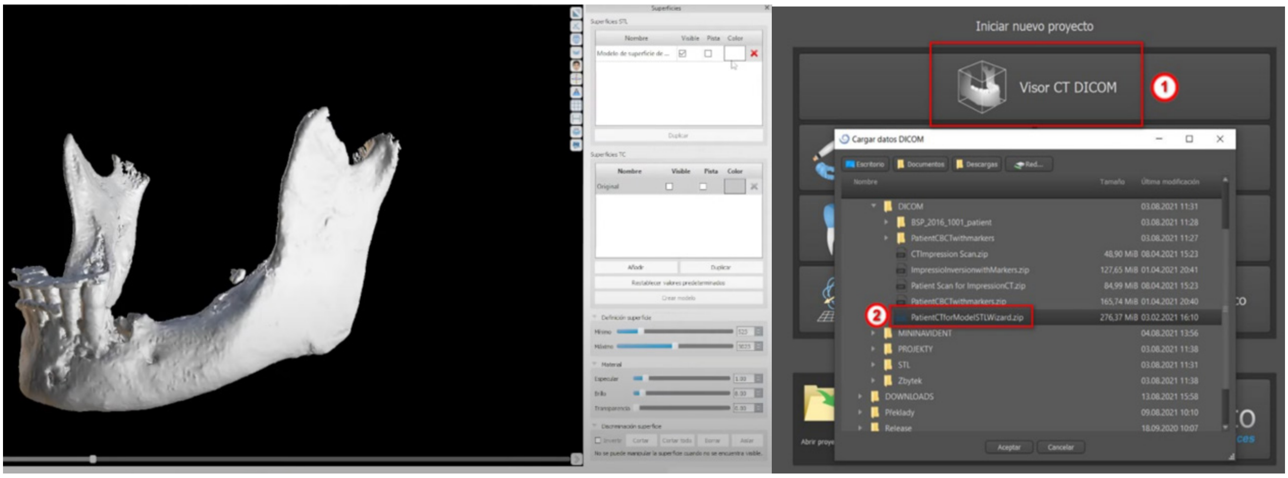

Figure 5. Blue Sky software DICOM data conversion plan for the design of a 3D printed biomodel

Figure 6. PAPIIT project 3D models

3D printing takes around 24 hours, after which the 3D biomodel is obtained.

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3. The 3D visual model was tested on a group of first-year dental surgery students at the FES Zaragoza, which consisted of:
    - Showing the 3D image of a patient with a root remnant.
    - Asking volunteers to identify the anatomical structures present in the 3D image shown on a screen
    - Instruct the volunteer students to move the image from side to side, rotate it, and fragment it.
    - They were asked to identify some of the anatomical structures present, which they had already learned about in the stomatognathic system module of the biology course.
    - They were asked to point out any abnormalities, such as locating a root remnant.
    - The group was asked for their opinion on the use of this technology to facilitate learning for radiographic identification:
        a. The preliminary result obtained through the didactic questioning was:
            I. Difficulty in expressing the result obtained; however, some students said: "I realized that I need to know the anatomy well and learn it better."
            II. "When will the application be uploaded to the virtual classroom so we can play with it?"

        b. They were asked what alteration they found and were suggested to consult their information cards.
            I. Three students quickly located the root remnant, and others stated, "That's what I have on the card."
            II. The reflection process on the experience allowed us to identify the importance of generating these resources to facilitate the learning of anatomy and the identification of structures,
            III. Teachers' training needs for designing and managing open educational resources in 3D. The challenge is to work with an image similar to an X-ray, in this case using tomography, to create open educational resources so that students can explore these resources at their own pace in a game-like manner and assess their relevance to promote meaningful learning.

To test the efficiency of the 3D physical model for learning, a tomographic image of a second upper left molar of an adult patient undergoing endodontic treatment for a deep carious lesion involving the dental pulp with a chronic infectious process was considered.

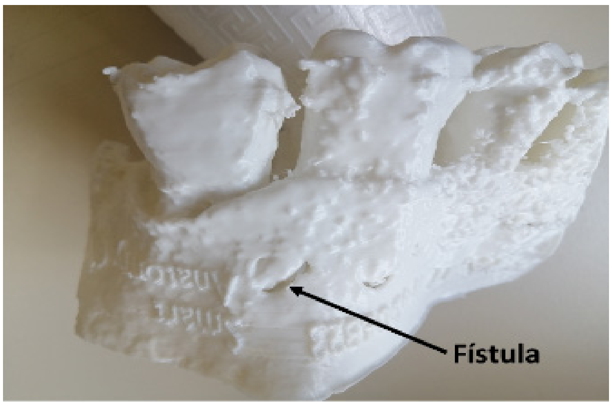

Imagen No 1. Obtenida por el equipo de trabajo del proyecto PAPIIT -IN306823 UNAM FES Zaragoza

Figure 7. PAPIIT project biomodel, segment of maxillary bone and affected tooth

A 3D image of the upper left molar region was used to assess the condition of the bone tissue adjacent to the second molar undergoing endodontic treatment due to a chronic infection. An occlusal view (upper horizontal view) shows the three widened root canals undergoing treatment (figure 7).

The tomographic image showed a thin layer of apparently intact bone tissue. When the image was printed, the model showed a lack of continuity in the bone structure in the vestibular portion at the bottom (figure 8).

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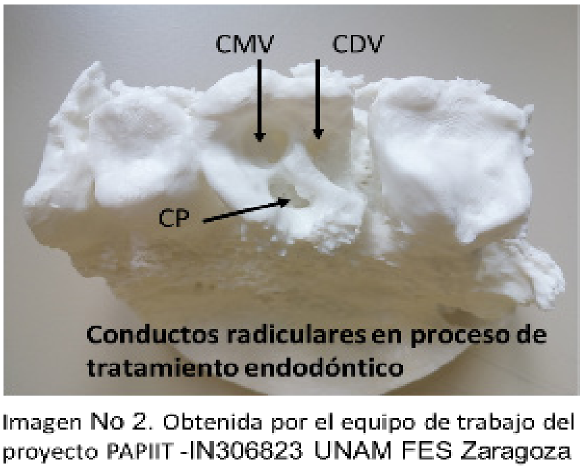

Figure 8. Biomodel PAPIIT project, affected dental organ

Figure 9. Biomodel PAPIIT project. Upper jaw

In a view of the membrane of the inner surface of the maxillary sinus, perforated by chronic root infection, which was not visible in the CT scan or X-ray. 3D prints of CT images allow visualization of alterations in hard tissues that are difficult to identify clinically and imaging (figure 9).[(6)]

In the process of learning about intact or altered anatomical structures, 3D models are an objective and attractive teaching tool. Students' comments included: "They have more models. We want to see the other pathologies that are in the program and that we have only seen on X-rays." "We can have models of all the alterations." "How nice to see the lesion in this model."

CONCLUSIONS

Significant progress has been made in the technological innovation and research project, and the foundations have been laid for a mini-maker lab, which has produced resources in the form of models, such as 3D printing, applied to learning processes in health sciences and stomatology. This has made it possible to capture students' interest, promote close observation of changes in anatomical structures using 3D models, and, through fun activities involving identifying structures in 3D images, awaken curiosity and generate interest in furthering the knowledge acquired. Although the development of these models takes time, it is recognized that they facilitate better teacher-student interaction in the teaching and learning process of anatomy, pathology, and diagnosis; they make it easier for teachers to learn innovative educational resources, acquire skills for the development of visual models and materials, incorporate playful learning strategies, and open spaces for gamified learning. The group of academics responsible for the project plans to continue this line of educational research to acquire other resources to develop these models further to strengthen teaching and continue the process of academic research on learning mediated by open educational resources, among other things.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHORSHIP CONTRIBUTION

Data curation: José Antonio Jerónimo Montes, Angélica Rosalva Martínez Rodríguez, Juan Ignacio Cruz.
Methodology: José Antonio Jerónimo Montes, Angélica Rosalva Martínez Rodríguez, Juan Ignacio Cruz.
Software: José Antonio Jerónimo Montes, Angélica Rosalva Martínez Rodríguez, Juan Ignacio Cruz.
Drafting - original draft: José Antonio Jerónimo Montes, Angélica Rosalva Martínez Rodríguez, Juan Ignacio Cruz.
Writing - proofreading and editing: José Antonio Jerónimo Montes, Angélica Rosalva Martínez Rodríguez, Juan Ignacio Cruz.