

Article

# Developing new teaching materials to enhance students learning and engagement at university

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**Abstract:** Pandemic scenario has significantly changed several factors of life, including teaching, and learning at university. The development of suitable teaching materials to support university studies is mandatory to overcome distance learning difficulties and improve traditional teaching methodologies. This work explains a novel method for the preparation of teaching materials for medical sciences, but also plausible for other learning fields. An encephalon was extracted and prepared by using this methodology for teaching purposes. More than 200 students evaluated several factors of the material prepared this way, indicating a better understanding (up to 80%) of theoretical contents related to this human section, together with a high usability and good physical appearance.

**Keywords:** COVID-19; active learning; science learning; applied technology, assessment for learning; new teaching material development

## 1. Introduction

At the beginning of 2020 (11 March), the World Health Organization (WHO) declared the Public Health Emergency of International Concern related to the COVID-19 pandemic, caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) [1]. From that moment to now, COVID-19 has spread worldwide and affected the world-human population, causing millions of cases to be divided into several waves. The Spain kingdom has not been an exception to this pandemic. The first case was located on 31 January 2020 in La Gomera, Canary Islands, in a German tourist [2].

All over the world, the COVID-19 pandemic has significantly changed several factors of the current society [3], mainly during lockdown periods that many countries established for their population to stop the spreading. Although massive vaccination [4] has brought us to a new normality, some of those changes will remain in our society for generations. For example, but not all, social interaction, remote working from home, medical science, and even pedagogical strategies of education [5]. In this sense, e-learning, considered before the pandemic only as a side of traditional learning, has become a central part of the high education at university. This result is probably one of the most visible digital transformations from the current fourth industrial revolution in educational sciences [6].

The digital transformation has affected university institutions in several different ways. In the current literature, it is possible to find interesting cases of how the educational sciences have changed, motivated by this new pedagogical scenario. In this sense, X.Z.

Gordy et al. [7] reported that, despite a significant increase in teaching workload and harder work, some students increased their interest in this distance learning due to the absence of time and place limits. Also, in this line, P.R. Weerathunga et al. [8] has reported an increase in the acceptance ratio of E-Learning among the university students and teachers as a reliable way to continue education during the extreme situation as the COVID-19 pandemic. Several universities have reported an apparent motivational factor from including these e-learning techniques in the educational pedagogical strategies pool [9,10]. This effect is a significant positive, and fights against the depression and mental disorder cases increased related to COVID-19 isolation or family loss [11].

Medical sciences, far from being negatively affected by the pandemic situation [12,13], have shown their importance to the current society once again. In this context, medical science education is the basis of sanitary professionals [14]. Thus, each education innovation in this field will affect future doctors and nurses and positively affect society's health. One of the pillars of medical education sciences consists of practical laboratory experiences, in which the students must get familiarized with human body sections by observing real examples. However, this represents a challenge to overcome in the online university pedagogy strategies.

Several references offer an attractive solution to this problem, such as 3D printing models [15] or an aggressive extraction method and plastination [16-18] that offers a poor conservation property with high material deterioration in a short period. Therefore, there is a knowledge gap about a plausible and cheap methods that allows long period conservation of real human sections for presential education and online teaching on medical science education. This work aims to develop new teaching material in high education, consisting of the extraction of a human part (encephalon) and its preservation on gelatin in an alcohol medium inside a methacrylate structure. The first teaching experiences with this material has been positive. The students showed a significant interest in the material prepared in this way, positively evaluating its inclusion as a part of their laboratory experiences in medical sciences. This methodology can be easily implemented in other human parts to support medical teaching and ensure a safe contact of students and teachers with human material.

## 2. Materials and Methods

### 2.1. Raw materials and key equipment

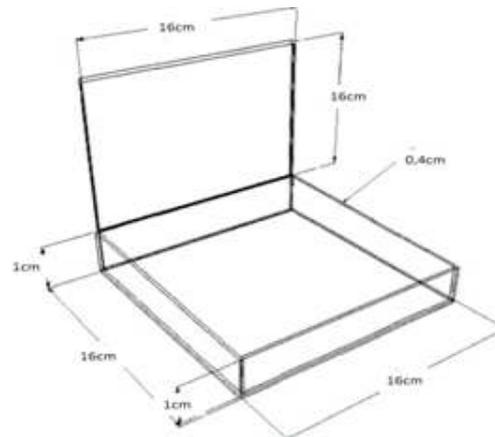
Anatomic material was prepared using a human body donation to the University of La Laguna. Encephalon was extracted with standard surgery equipment of stainless steel. Extracted encephalon was preserved on unflavored gelatin, cut by sections, and introduced inside a methacrylate structure with 70/30 %v/v ethanol/water solution for preservation. Standard construction tools were used to build the methacrylate structure, including drills, glue, screws, threads, and a power saw.

### 2.2. Material preparation methodology

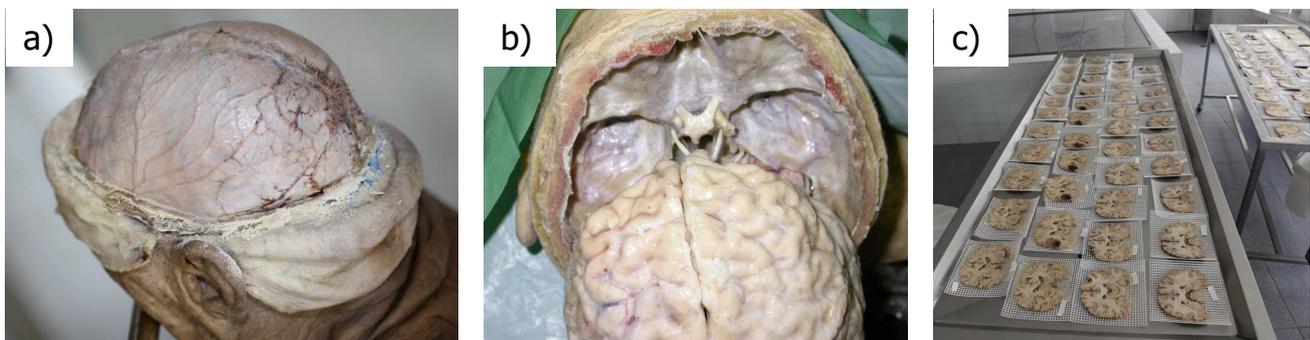
As the first step, methacrylate structures were designed and built as two coverts of 16x16 cm for coronal cuts and 16x22 cm for horizontal cuts. A central panel of methacrylate (8 mm thickness) is placed in the middle of the content structure, fixed by several holders. Methacrylate structures were glued according to Figure 1 to form a box to contain the encephalon sections. A drill ensures a hole in the top section of the methacrylate structure (3.2 mm diameter) to fill it with ethanol/water solution after sample depositing.

The next step consisted of extracting the human encephalon by a routinary extractive surgery. For this purpose, the cranial vault was opened, and the severing of cranial nerves, vessels, and brainstem. Extracted encephalon is submerged in unflavored gelatin to preserve the organ and make it viable for cutting. After gelation, the material is cut into several sections of 6 mm thickness to be able to study the different sections of this human

section. Figure 2 gathers photos of extractive surgery and encephalon sections after the cut. 96  
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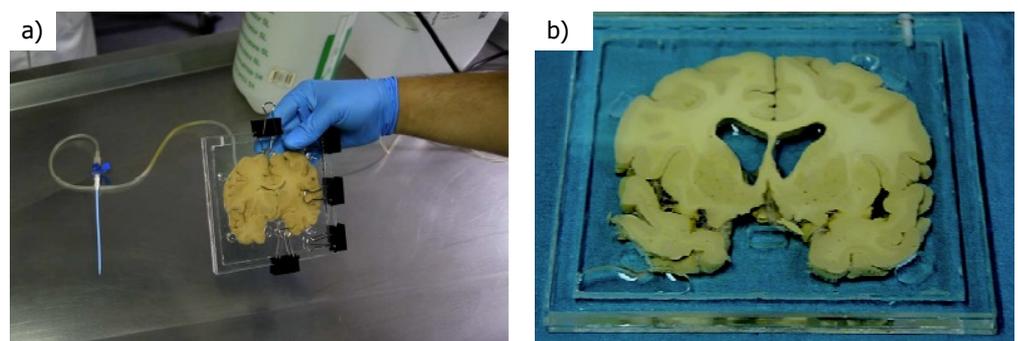
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**Figure 1.** Methacrylate structure schema to content coronal cuts from the encephalon.



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**Figure 2.** Material preparation methodology: (a) Encephalon surgery; (b) Encephalon extraction; (c) Encephalon on gelatin after cut.

103 Each gelatin-encephalon section is placed inside and in the middle of the central  
104 methacrylate panel. Several holders are placed around the organ section to fix it to the  
105 middle of the methacrylate box structure. After glutted, the intermedium space is filled  
106 with an alcohol/water solution of 70/30 v/v.% to avoid material degradation. A 4 mm nylon  
107 screw is used to close the filling hole and keep it tight. This process was repeated for  
108 each cut of the gelatin-encephalon section.

109 Using the alcohol solution instead of other chemicals such as water-diluted formal-  
110 dehyde means a significant improvement. That is because of the lower risk for students  
111 and teachers managing and using the new materials during learning and teaching. Figure  
112 3 shows photos of the alcohol process filling and the new material's appearance.  
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**Figure 3.** Material preparation methodology: (a) Alcohol/water solution filling system; (b) Example of encephalon new material.

### 2.3. Material assesstment

After preparation, the new material was used for teaching lessons to 230 students from several grades of the University of La Laguna, i.e., 130 students in the second year of Medicine degree, 70 students in the first year of Speech Therapy degree and 70 students of Physiotherapy degree. The encephalon material was included as part of their laboratory and theory lessons to support teaching and learning. After finished, the students were invited to fill out 8 questions poll with 1 to 5 range of answers ("1 - not satisfied at all" and "5 - very satisfied").

### 3. Results and Discussion

The evaluation of this material consisted in several parameters, such as its physical appearance, usability, and understanding, including the link between theory and practice contents, and learning outcomes. Table 1 shows the poll's questions and its category.

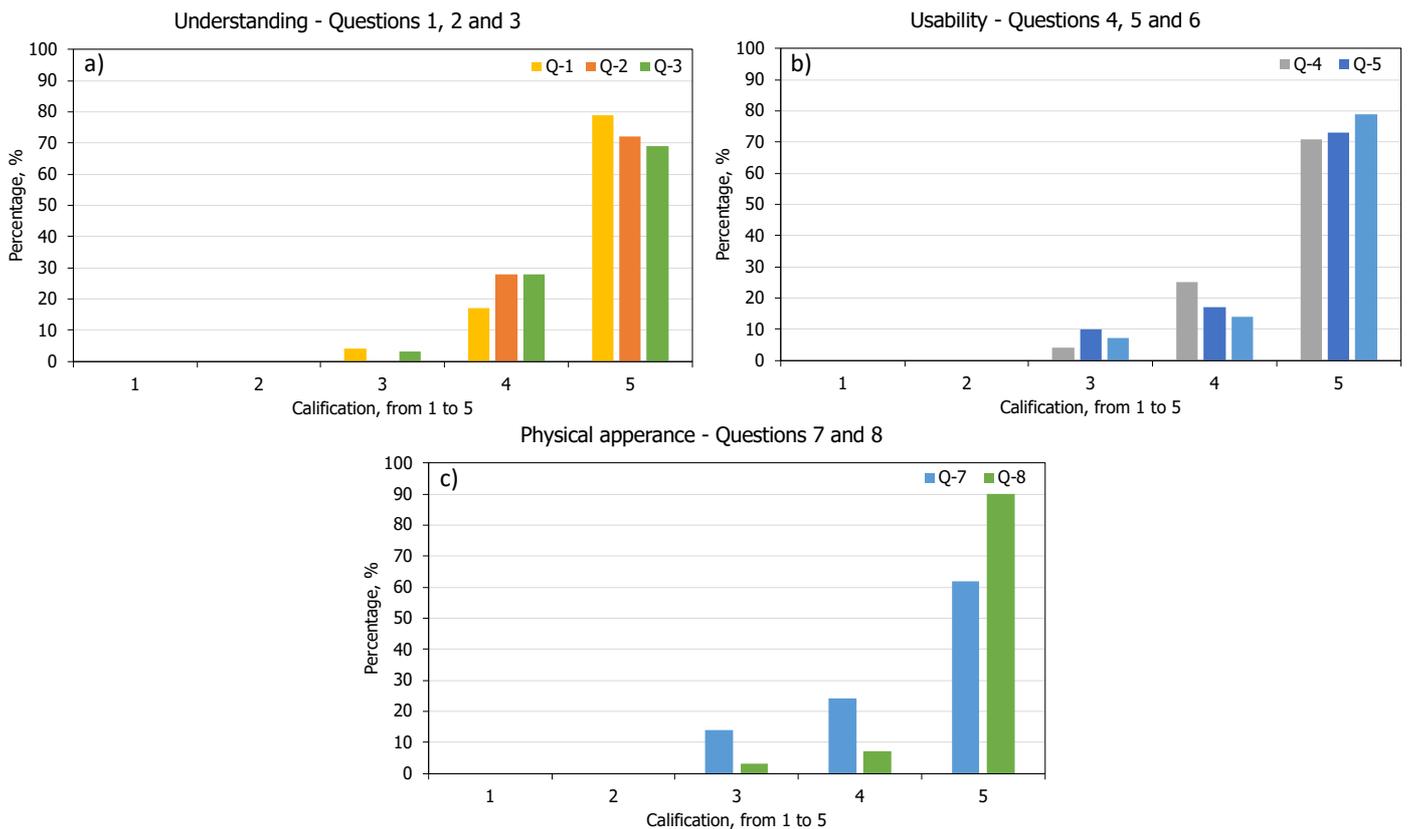
**Table 1.** Questions form the poll to evaluate the learning materials divided by categories

Number	Question	Category
Q-1	The use of encephalon sections has contributed to a better interrelationship between theory and practice.	Understanding
Q-2	The encephalon sections material is suitable for the studying of the main anatomical structure of the encephalon.	Understanding
Q-3	Do you believe that this kind of material allows better spatial understanding and learning of the encephalon structure?	Understanding
Q-4	Do you believe the encephalon sections material allows a wide and conformable encephalon structure learning and comprehension?	Usability
Q-5	Do you believe that the encephalon sections material there is less exposure to other chemicals such as formaldehyde?	Usability
Q-6	The new materials in the experimental learning have been useful?	Usability
Q-7	The encephalon section was in good condition?	Physical appearance
Q-8	Do you believe that this kind of material allows a longer durability of the encephalon sections?	Physical appearance

Figure 4 shows the results of the poll filled by the students, divided by categories. These results indicate a general positive evaluation of the new learning material preparation. In the sense of understanding (up to 80% with 5/5 points), this material performance supports the interrelationship between theoretical and practice content. This point is significant importance in the goal of the learning outcomes achievement, and it is due to its use helps to understand the spatial structure of the encephalon.

In the same way, the answers to usability questions (up to 80% with 5/5 points), support understanding results, indicating an easy use of the material for learning, teaching, and a safer manipulation of the materials for students and teacher. It is necessary to take into that, traditional teaching materials related to body sections required aggressive chemicals for preservation, which made hard the students learning process.

Finally, in the regard of the physical appearance, in line with previous questions, most of the students considers (up to 90%) considered that this kind of material preparations allowed a longer durability of the encephalon section. The material condition was not straight related to the material way of presentation, but with the age of the human section.



**Figure 4.** Students' material evaluation: (a) understanding; (b) Usability; (c) Physical appearance

## 5. Conclusions

A human encephalon was extracted, cut, and preserved in gelatin on a methacrylate structure in the aim of producing a new and suitable material for medical sciences teaching and learning. According to the first teaching experience, more than 200 students for several medical sciences degrees (including medicine, Speech Therapy and Physiotherapy degrees), the experienced was significantly positive. The teaching material prepared this way, offers a solid combination of usability and understanding that support the link between theory and practice content, which a key point to get the learning outcomes. Moreover, it offers a safer learning and teaching process due to the absence of dangerous chemicals. This methodology described in this paper means a significant advance regarding previous preparations methods. This fact is because it is a flexible method able to be applied with other human sections and offer a solid way to be used during online classes, without the need of the student physical assistance to the laboratory.

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**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** Not applicable.

**Conflicts of Interest:** The authors declare no conflict of interest.

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