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EDUCATION & TRAINING

Evaluation of the Applicability of 3d Models as Perceived by the Students of Health Sciences

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Abstract

The methodology and style of teaching anatomy in the faculties of Health Sciences is evolving due to the changes being introduced as a result of the application of new technologies. This brings a more positive attitude in the students, enabling an active participation during the lessons. One of these new technologies is the creation of 3D models that reliably recreates the anatomical details of real bone pieces and allow access of anatomy students to bone pieces that are not damaged and possess easily identifiable anatomical details. In our work, we have presented previously created 3D models of skull and jaw to the students of anatomy in the Faculties of Health Sciences of the University of Salamanca, Spain. The faculties included were odontology, medicine, occupational therapy nursing, health sciences and physiotherapy. A survey was carried out to assess the usefulness of these 3D models in the practical study of anatomy. The total number of students included in the survey was 280.The analysis of the results presents a positive evaluation about the use of 3D models by the students studying anatomy in different Faculties of Health Sciences.

Keywords 3D models · Bones · 3D printing · Teaching anatomy · Health sciences · Survey

Introduction

In this era of technological development, a rapid progress is being made for obtaining and disseminating the information leading to the emergence of new technologies that facilitate the students and teachers to access this information, thus generating a different approach at the university-level teaching [1–3]. Within the universities, the faculties of Health Sciences are incorporating these changes and designing new pedagogical supports for teaching these subjects [4–6]. Some of these innovations are clinical simulation and virtual learning, with Internet or multimedia materials that facilitate students' knowledge and skills in the clinical field in the most realistic environment, without affecting the integrity of patients or involving corpses [7, 8]. These new technologies of providing information and enabling communication in the classrooms and student study time, allow greater access to information and a more interactive way of learning [9, 10].

The technical difficulties of teaching anatomy are partly diminished with the application of new technologies [11]. The change in the use of 2D images provided by the atlas to 3D and 4D images provides a better understanding of anatomical structures as well as looking into the fine details of these structures [12, 13]. During the last years there has been tremendous progress in the technology and as a result the virtual reality has become a part of these imaging technologies that can be applied to the teaching of anatomy, allowing the student to interact with the artificial environment that recreates a real situation, through devices such as helmets or gloves connected to a computer and allowing detection and understanding using the senses of touch, sight and hearing [14–16].

Another aspect of these new technologies is the manufacture of 3D bone models and their use in practical anatomy classes that try to cover the unavailability and deterioration of the bone remains that were being used previously by Health Sciences students [17–19]. In our work, we fabricated a 3D model of the skull and jaw to assess its usefulness in the anatomical study of bones in the lessons of anatomy and in the

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faculties of Health Sciences from the University of Salamanca, Spain. The manufacture of these 3D models is increasingly affordable due to the lower cost of printers [20]. The field of 3D models printing is going through a fast evolution that allows making more accurate models that reflect the details as presented by the real objects [21–24].

Since these models are used by students for the learning of anatomy, it is very important to carry out a study on the assessment of the usefulness of these models by the students in their learning process. It is important to evaluate if the anatomical details of these models reflect the real bone pieces as well as assessing the conservation status of skeletal remains because the bone materials get deteriorated due to prolonged use.

The use and effectiveness of these technologies in the learning of anatomy needs to be evaluated by the students through a statistical model in qualitative and quantitative way. This study involves conducting a survey, including 280 students of first and second year of graduate degree from five faculties of health sciences from the University of Salamanca, Spain. These faculties included odontology, medicine, occupational therapy nursing, health sciences and physiotherapy. Through a set of questions and studying the responses, it was intended to assess the usefulness of the 3D printed models by the students and also comparing their use against the real bone samples in their learning process. We also evaluated the results based on the perception of using the 3D models based on the gender of the students. To the best of our knowledge, no studies have been found in the consulted bibliographic bases that collects such a high number of samples and includes a range of different faculties of Health Sciences.

Methodology

The survey has been based on an intervention study, qualitative and prospective in students of health sciences. The study by means of a survey, after using both 3D models and real bone pieces, was carried out in the anatomy laboratories. The 3D models used in this survey were manufactured in previous studies and the detailed description of the process can be found in M.T.Ugidos et.al. [19, 22]. The models were manufactured by additive manufacturing after computer processing using Geomagc Desing X 3D software of the images obtained by scanning the real bone pieces with FaroArm Scam Platinum model scanner at the Polytechnic University of Madrid. A Colido 3045 3D printer manufactured these 3D models using PLA (polylactic acid). Once these models were obtained, a survey of the students of the faculties of Health Sciences of the University of Salamanca and their opinion of the models against real skeletal remains was carried designed.

The survey included 280 students of five faculties of Health Sciences from the University of Salamanca, Spain, where 42 were from Physiotherapy, 116 from Medicine, 56 from Nursing, 42 from Occupational therapy and 24 from Dentistry. The type of scale we used is the Likert scale, which is an easy scale to build and allows measuring and knowing the degree of student's compliance in case of complex statements. On this scale, the answers are recorded from 1 to 5, where 1 stands for strongly agree, 2 for disagree, 3 for neutral, 4 for agree and 5 for strongly agree. The opinion of the participants was evaluated before and after the use of the 3D models of different bone pieces, handling 3 types of materials (real bones, 2D anatomy atlas and 3D printed models). The parameters that have been evaluated attribute to subjective variables were presented to the students in the form of Table 1.

An interactive statistical study of the data obtained in our survey was carried out through the statistical program, in its latest version of IBM SPSS 22.

Results

The response of the participants was analysed based on the parameters mentioned in Table 1. It was observed that there were more female students, as shown in Fig. 1a, therefore, it was considered necessary to evaluate the opinions classified by the gender of the participants. Fig. 1b shows an analysis on the responses of male and female participants in relation to their inclination towards the use of real bones and 3D printed models.

From the results it is clear that there were no significant differences in the perception of the quality of the compared models when separated by sexes. In case of women the results were 97% while for men it was 98.1%. Based on this analysis the contribution of gender in the preference and perception of use of either of the models was discarded. Therefore, the opinion from 280 students was analysed altogether to evaluate the level of their satisfaction in the use of 3D models with real bone pieces. Different skeletal structures including skull, small bones, vertebrae and thorax, in 3D printed material and original bone samples were provided to the participants including to observe the state of conservation and ability to

Table 1 Satisfaction survey of students

Parameters	1	2	3	4	5
Title					
1. Is it useful to incorporate real bones in practice sessions?					
2. Is the bone material in good condition?					
3. How helpful is it to use a real bone even if it is in worse shape?					
4. Do you prefer bones to study the anatomical features?					
5. Do you prefer 3D models of the bones to study anatomy?					

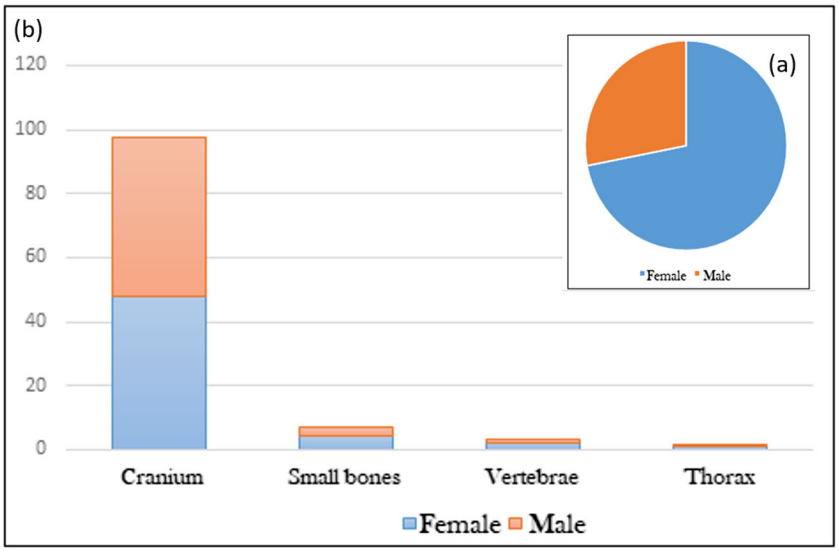

Fig. 1 (a) Proportion of participants based on the gender (b) Assessment of the real bone pieces based on the gender of the participants

observe the fine anatomical details. The results can be seen in Fig. 2.

The results showed that there was a greater deterioration of the pieces of skull (93.2%) with respect to other pieces (short bones, vertebrae, thorax), with a very discreet the difference between the remaining ones. Nevertheless, all the 3D models and bone pieces obtained a value of quality and satisfaction in similar way, having a very positive difference (4.3/5 Likert scale) in favour of the 3D model. The analysis of the responses showed that the participants gave more preference to the applicability of 3D models in contrast to the real bones.

Furthermore, a comparison was also made between the type of resources used in traditional anatomy teaching and the 3D printed models created for the students. The sources presented to the students included 2D atlases, real bone pieces and printed 3D models. The results shown in Fig. 3 demonstrate a positive feedback for the use of 3D models in comparison to traditional items used.

In the comparison based on the faculties in health sciences (Fig. 4), a similar assessment of the teaching material has been detected.

The acceptance and satisfaction in the use of the 3D model exceeds a value of 4.85/5 on the Likert scale globally compared to the real model (4.71/5) on the Likert scale and the anatomy atlas (3.70/5) on the Likert scale, so we understand that there are no significant differences between the different

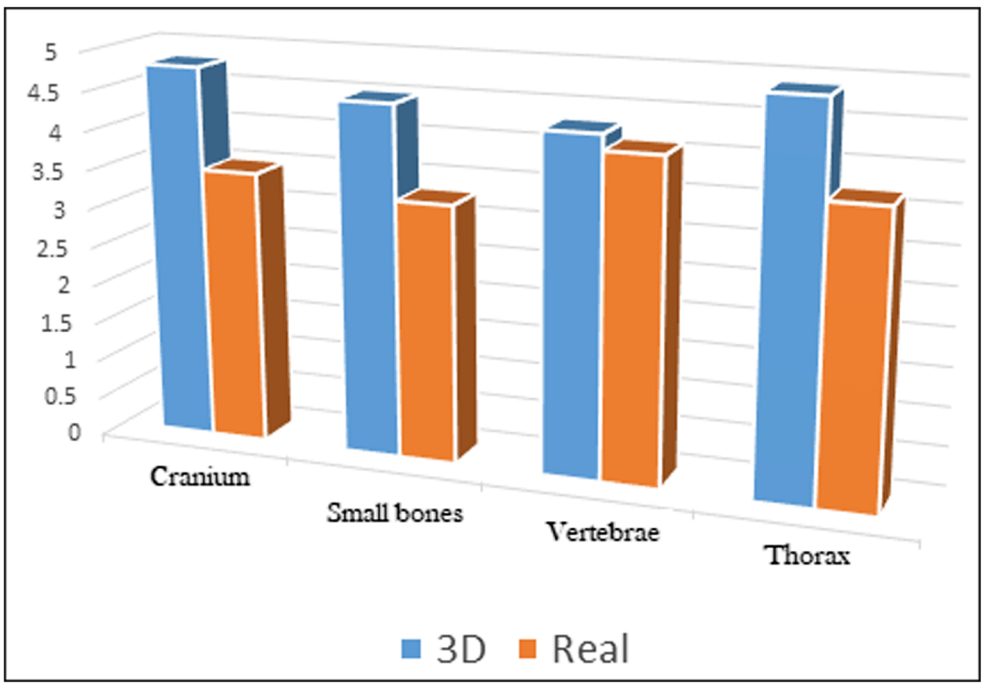

Fig. 2 Level of satisfaction on the use of 3D models versus real bone pieces obtained from the opinion of 280 participants

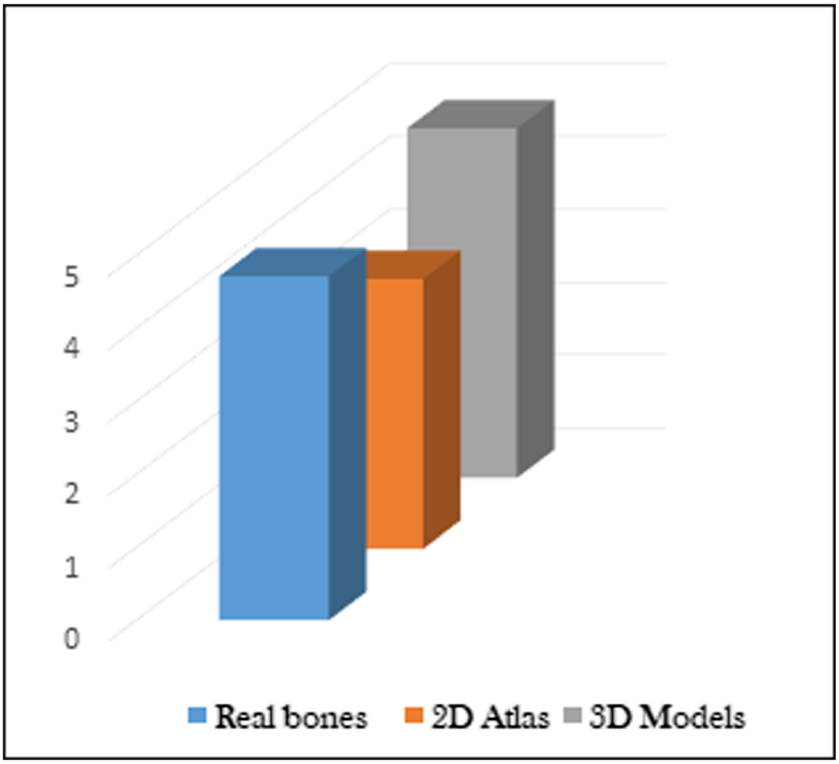

Fig. 3 Assessment based on the use of different resources used in the study of anatomy

types of studies with respect to the quality and satisfaction in their use. The general level of satisfaction and specific to faculties in the use of 3D, is discretely superior with respect to real skeletal remains and exhibiting important difference with the anatomy atlas (2D).

Discussion

The introduction of new methodologies such as mobiles and tablets is leading to an evolution in the style of teaching and learning of anatomy in the faculties of health sciences. To this

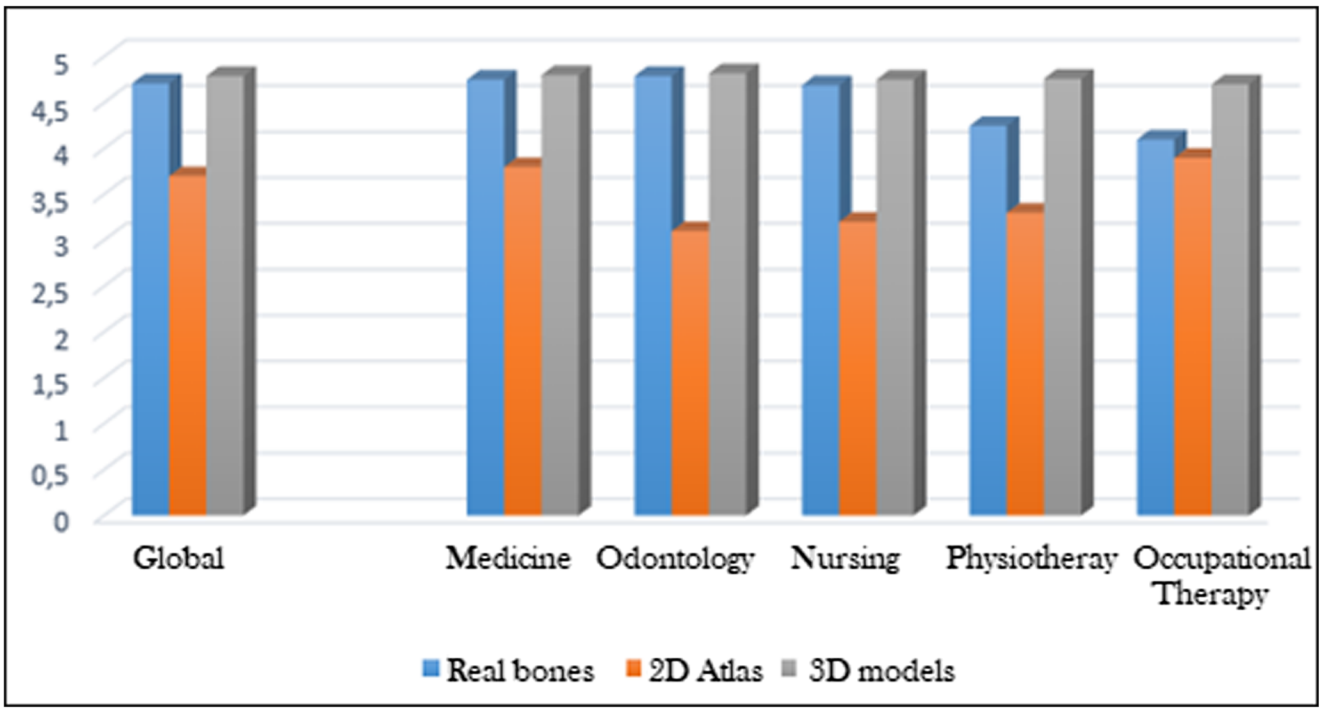

Fig. 4 Assessment based on the use of different resources according to different faculties of health Sciences in the study of anatomy

end, there has been inclusion of 3D printed models of the original bone pieces from the corpses, in the laboratories of the faculties of health sciences. The application of these models has resulted due to the difficulties in observing fine anatomical details associated with the deterioration caused by the prolonged use and excessive handling of real bone pieces. However, the use of 3D models in contrast to the original bones has raised a debate between the defenders of traditional methods relying on skeletal remains and those accepting the introduction new technologies such as mobile applications and 3D models [25–27]. 3D models provide advantages in being readily available and robust thus presenting less deterioration and more anatomical details whereas real bone bon pieces allow students to have a direct contact with the real pieces.

Since, students are at the learning end and these resources ultimately affect their knowledge and training, it is necessary to acquire their opinion about the use and effectiveness of 3D models in comparison with the traditional resources. Several publications support the incorporation of new technologies in the teaching of including the faculties of Health Sciences but we find fewer published studies that make an assessment by the students of these new technologies in their learning [18]. As mentioned before, it is necessary to assess the knowledge that students acquire with the use of both traditional models and the application of new pedagogical methods. Therefore, the main purpose of this study was carrying out a survey including 280 students from five different faculties of health sciences. The study is significant, firstly because the participants belonged to a wide range of departments and secondly to the best of our knowledge no bibliographical references has been found that focuses on collecting statistical studies that assess student satisfaction by comparing bone remains and 3D models [12, 28–30].

The results demonstrate that there are no significant differences between the perception between men and women for the use of 3D models and real bone pieces. Students graded 3D models with a positive feedback in all of the aspects studied in this survey. The teaching methods using real bones, Atlas and 3D models in different faculties also graded 3D models with more applicability. The survey shows that students of anatomy are open to new learning methods and these resources must be included in the laboratory settings.

Conclusions

New technologies are making their way into the teaching and learning of anatomy for the students of the faculties of Health Sciences. The results of our work with the survey including the anatomy students show that the use of 3D models can be useful in the teaching of anatomy, being a material with easy availability, less deterioration of use and with good level of quality and acceptance by the students. The introduction of new technologies is bringing a positive change in the learning of students. Therefore, the combination of 3D models with the original bone pieces can be very advantageous. A new field of research is opened to obtain 3D models, increasingly similar to the real bone pieces, in terms of the materials and quality of the models, for later use as teaching material in the Faculties of Health Sciences.

Compliance with ethical standards

Informed consent Informed consent was obtained from all individual participants included in the study.

Conflict of interest The authors declare that they have no conflict of interest.

Ethical Approval This article does not contain any studies with human participants or animals performed by any of the authors.

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