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Original Research Article

ANATOMY AND MOBILE TECHNOLOGY: DEVELOPMENT AND EVALUATION OF AN INTERACTIVE DIGITAL BOOK WITH 3D FEATURES FOR THE STUDY OF ANATOMY ON MOBILE DEVICES

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ABSTRACT

Traditionally, the methods used in learning anatomy are based on the use of textbooks, 2D diagrams and dissection sessions meanwhile the human body is three dimensional (3D). However, students who have low-spatial ability have difficulties in understanding the structures in 3D space and finding muscles, nerves, and organs during dissection. Many students also experience discomfort with the use of cadavers in the dissecting room which has been considered to bring about a barrier to the teaching and learning of anatomy. Mobile devices allow students to have access to learning materials and information at their convenience, thus referred to as mobile learning or individualized learning which is integrated with anytime and anywhere learning. The study of anatomy is perceptible to the sense of touch and with the incorporation of "anatomy apps" on mobile devices, there is possibility of high level of interactivity whereby users can either rotate, flip, enlarge or reduce three dimensional anatomical structures to get a better understanding of these structures. This study was aimed at developing and evaluating an interactive 3D e-learning resource tool for study of the anatomy of the cervical vertebra. The ADDIE (Analysis, Design, Development, Implementation and Evaluation) model of instructional design was used in this study for the development of the resource tool and evaluation of the impact of the resource on the participants. 90% of the respondents favored the fact that the iBook is user friendly and easy to navigate, 93% agreed that the user interface, layout and appearance of the iBook is well organized. 75% agreed that the written content of the e-learning tool provides appropriate knowledge for the study of the region. 80% of the respondents strongly agreed that the tool is a helpful educational tool for medical students, 80% of the respondents also agreed that the tool compliments the medical curriculum and 85% strongly supported that fact the tool is flexible and saves reading time. The e-learning resource tool produced as can serve as a teaching and a learning aid in the study of human anatomy and improve the teaching and learning process in general as it combines education and entertainment thereby, making anatomy a lot more intuitive.

KEYWORDS: 3D, iBooks, Cervical vertebra, Anatomy, e-learning, Mobile learning.

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INTRODUCTION

As technology becomes part of our everyday lives with the birth of digital technologies, schools are making attempts to utilize technology to help provide the best learning experience for students [1]. Many students experience discomfort with the use of cadavers in the dissecting room which has been considered to bring about a barrier to the teaching and learning of anatomy, this discomfort could arise from a number of factors including anxiety, the use of formalin, appearance irritation, how the dissecting room smells, or mostly the presence of the dead [2].

Mobile devices allow students to have access to learning materials and information at their convenience, thus referred to as mobile learning [3]. Mobile learning assumes that students can move continuously with their mobile devices and that they possibly have wireless Internet connection [4]. Individualized learning integrated with anytime and anywhere learning is the key to mobile learning [5,6]. Mobile learning is made possible due to the widespread use of mobile devices amongst students, and the fast growing amount of functions that are useful for study purposes [6]. Mobile technologies have undergone major advances, resulting in a growing body of functions that can be used for mobile learning [2]. Mobile devices allow access to activities, such as audio recording, image capturing and reading digital books. They also allow access to the Internet and online available learning materials when a wireless connection is available. Due to these developments, mobile learning has become a major trend of educational applications for new technologies [3].

Scientific literature has primarily focused on the effects of mobile learning and on developing mobile learning systems or applications to assist learning [3,7]. Many mobile learning tools are currently available for use in the study of anatomy. Mobile learning tools can provide training and education to large number of students with diverse cultural backgrounds and educational levels. However, this tools could be failed in education when overestimating what mobilelearning can accomplish [8].

Mobile learning involves devices that are affordable and easier to obtain [9] thus enabling students to learn on the go. In this present generation of university students, the use of smart phones and touch screen tablets is becoming a norm and there is expectation of high level of engagement in their learning with the use of such devices [10,11].

Traditionally, the methods used in learning anatomy are based on the use of textbooks, 2D diagrams and dissection sessions meanwhile the human body is three dimensional (3D). However, students who have low-spatial ability have difficulties in understanding the structures in 3D space and finding muscles, nerves, and organs during dissection. There is change in the way students chose to master a subject in this age of digitization [12]. Reports have it that there is a continuous interest in the use of 3D anatomy models over traditional methods by students suggesting that 3D anatomy in both digital and physical form are favoured by medical, biomedical and allied health students and also by the schools too this is because it has the ability of improving the curriculum thereby making learning more interactive and intuitive [13]. The study of anatomy is perceptible to the sense of touch and the incorporation of “anatomy apps” on mobile devices brings about a high level of interactivity whereby users can either rotate, flip, enlarge or reduce three dimensional anatomical structures to get a better understanding of these structures [14,15]. This study was aimed at developing and evaluating an interactive 3D e-learning resource tool for study of the anatomy of the cervical vertebra.

METHODOLOGY

This study employed the use of iPads for the purpose of its high quality user interphase and being relatively straightforward. An Apple Macbook computer with 2.66 GHz Intel® Core 2 duo processor, 4GB memory (Apple Inc.), containing software for 3D modelling, animation and rendering was used. The software used in this study includes; Autodesk Maya, Osiri X, Amira, ZBrush, Adobe Photoshop and iBooks Author version 1.0.1(Apple Inc.). The text content was gotten mainly from Drake et al., (2009) [16] Gray’s anatomy for students. Cannon EOS 1000D

Fig. 1: Showing Screenshot of modeling stage in ZBrush. (**A**;) and Screenshot of rendering and lightening stage in Autodesk Maya (**B**).

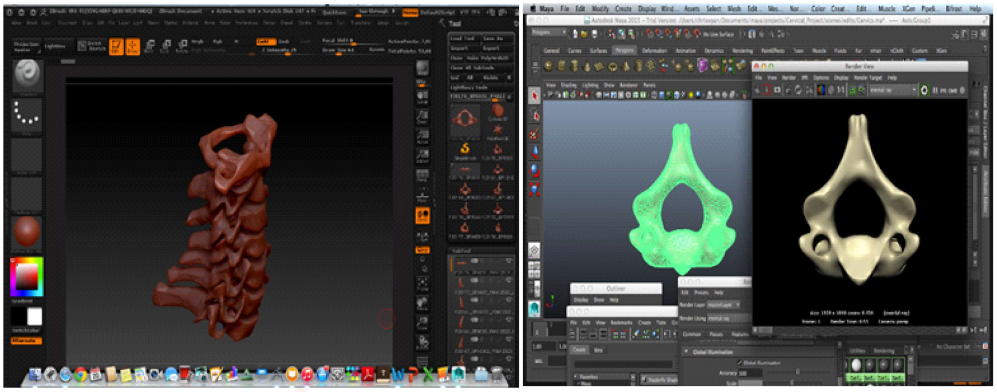
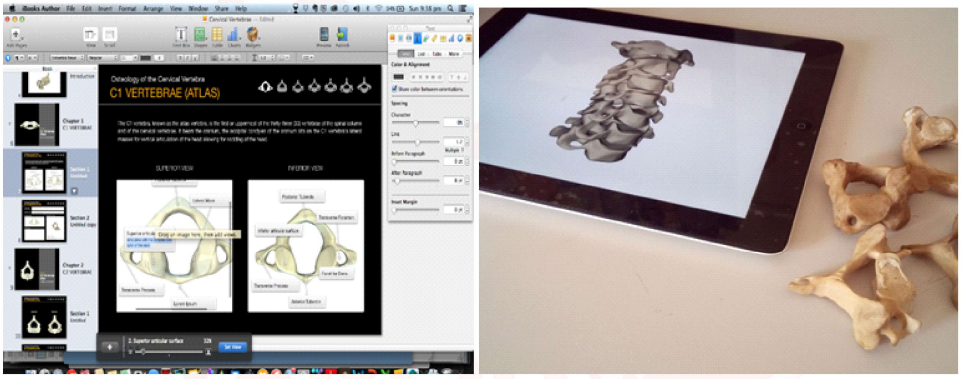
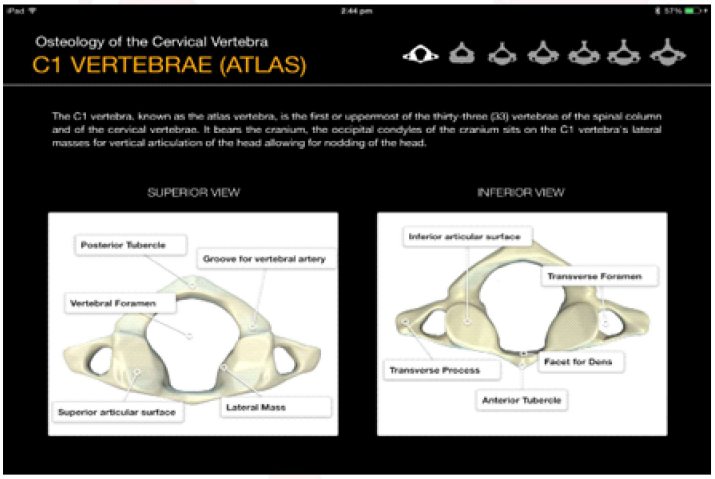


Fig. 2: Showing Screenshot of package design and compilation in iBooks author. (**C)** and photograph and screenshot of the finished tool on the iPad (**D&E)**





camera was used for photography. The ADDIE (Analysis, Design, Development, Implementation and Evaluation) model of instructional design (Dick et al., 2014) [17] was used in this study which is a framework adopted by Stewart and Choudhury, (2014) [18]. Modifications are made to the ADDIE framework where emphasis are placed on design, development and evaluation.

Design and development of iBook: Photographs of the cervical vertebra were taken using a cannon EOS 1000D camera, at the Cross River University of Technology, Department of Anatomy museum. The photographs were to serve as reference images for the cervical vertebra while modeling and texturing in ZBrush® and rendering in Maya®. The DICOM CT data of the vertebral column used to create the models were extracted to object format (Obj) using the OsiriX® software. OsiriX® software is a stage II software dedicated to viewing DICOM images in 3D format. The 3D data were exported from the OsiriX software as object (Obj) files for modeling using ZBrush4R6®. The details of the cervical vertebra were modelled using real cervical spines gotten from the Department of Anatomy as reference materials. Thismodels

were exported for rendering and lightning in Autodesk® Maya® to give it a crisp high definition look. After the 3D images were rendered in Maya, they were converted to Collada files and exported to iBooks author where they form the interactive part of the iBook. In iBooks author there are varieties of inbuilt templates with pre-defined layouts, which could be used for any iBook design, one of the templates was chosen. The table of content was first created, followed by an introductory page and then the different vertebrae were put as different chapters and text and labels were added.

Evaluation/Implementation Of iBook: Questionnaires were administered to the participants and they were allowed some time to read through. The reason for the questionnaires was to test the impact of this tool on the learning and understanding of the student. The questionnaire evaluation took about twenty (20) minutes and then it was gathered for analyses.

Seventy (70) students successfully participated in this process and gave their perception and comment about the e-learning resource tool.

RESULTS

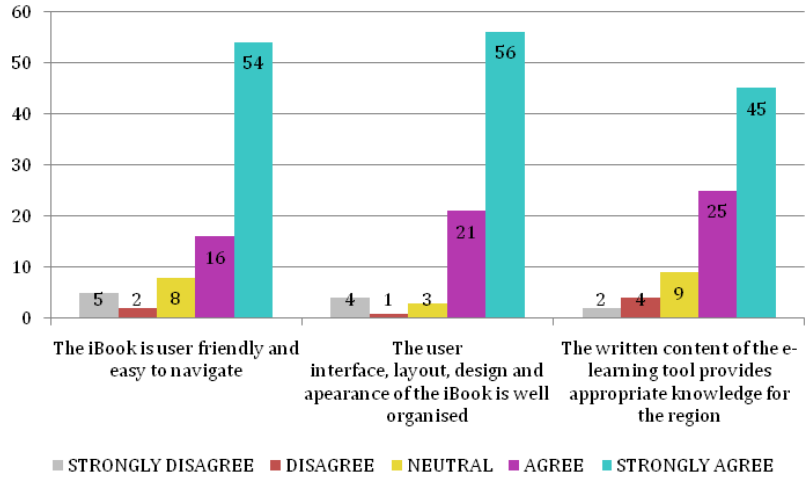


Fig. 3: Evaluation of the iBook resource tool

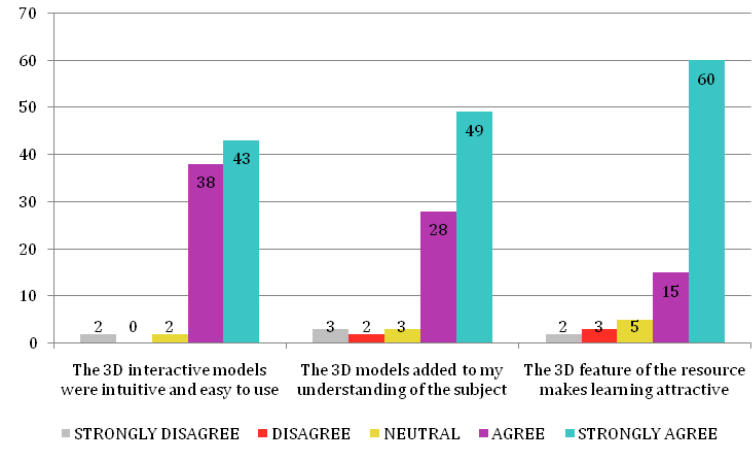


Fig. 4: Evaluation of the 3D models.

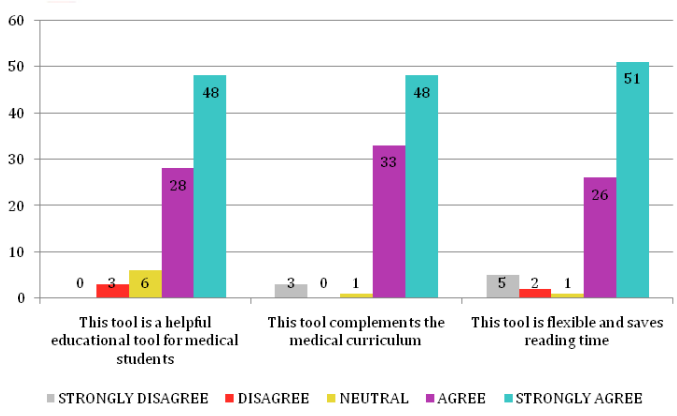


Fig. 5: Evaluation of the suitability and applicability of the iBook resource tool.

57% of the participants were males while 43% were females. The age group was categorized into 16-18 years, 19-25 years, 26-30 years, 31-35 years, and 36+ years.

86% of the participants were between the ages 19-25 years, 7% were between the ages 26-30 years, 5% were between the ages 30 years and above while 2% were between the ages 16-18 years.

Survey: Results of the survey for this study is represented in bar charts (figure 3-5). For the resource too in general, 90% of the respondents favored the fact that the iBook is user friendly and easy to navigate, 93% agreed that the user interface, layout and appearance of the iBook is well organized. 75% agreed that the written content of the e-learning tool provides appropriate knowledge for the study of the region.

When evaluating the 3D models, respondents affirmed strongly that the created models were intuitive and easy to use (61%), and the models added to their understanding of the cervical vertebra anatomy (70%) and over 85% of therespondents that the resource makes learning attractive. For the suitability and applicability of the resource tool, 80% of the respondents strongly agreed that the tool is a helpful educational tool for medical students. 80% of the respondents also agreed that the tool compliments the medical curriculum and 85% strongly supported that fact the tool is flexible and saves reading time.

DISCUSSION

Anatomy by its very nature is three-dimensional (3D). Dissection, prossection, and surface anatomy are the traditional 3D methods used to teach and learn anatomy. When using two- dimensional (2D) representations such as 2D digital images, textbooks, or chalk and maker drawings, understanding complex relationships of human anatomy requires an important amount of cognitive representation to fully understand anatomical structures and their functions [19] Learning aids, particularly digital e-learning tools such as iBooks with interactive 3D models are unavailable in many schools of higher learning which could be as a result of the time involved in creating such tools or the lack of awareness of people to such technology [20].

This study was aimed at the development and Evaluation of an Interactive Digital book with 3D features for the study of Anatomy on Mobile Devices.In this regard, we set out to use the limited materials available to create a 3D e-learning resource tool of the cervical vertebra for use by students especially in Nigeria which would go a long way to make the study of anatomy intuitive. The idea is to show that a 3D enabled digital book can be created with the features of a traditional textbook but with something much more: interactive 3D models.

The present work is out to prove that computer technology can be applied in the study of anatomy which agrees with Boisvert, *et al.,* (2008) [21] who created 3D models of the cervical spine from 2-D radiographs and their results demonstrated that it would be possible to use this method to digitize complete models from a small number of vertebrae, thus saving physicians and researchers a lot of time and money of which the resulting complete spine models can be used in applications such as: diagnostic, surgical planning, and biomedical research.

Success was made in developing the mobile book as illustrated in fig. 1 & 2 hence the need to evaluate the acceptability and effectiveness of the tool.

Cui et al., 2017 [22] designed a study to investigate aspects of computer-assisted learning in teaching the structure of the vasculature of the head and neck. They examined the effectiveness of stereoscopic presentation of 3D vascular models of the head and neck when learning human anatomy. Their results suggested that 3D viewing during a short lecture improved the students' knowledge more than an identical lesson using identical but 2D images. Other studies also suggested a relationship between student's spatial ability and their performance in learning structural anatomy [19,23,24,25].

Previous research suggest that 3D models are superior to traditional 2D illustrations such as PowerPoint slides and textbook figures in teaching complex anatomical structures [23,25] and are particularly helpful to students with lower spatial ability.

The results from this study are consistent with

Noguera et al., 2013 [26] which was a study on the Development and evaluation of a 3D mobile application for learning manual therapy in the physiotherapy laboratory which showed that the students, are willing to use our proposed e-learning tool on a regular basis. This present study suggests that digital learning with mobile devices would yield significant improvements in student learning which is consistent with Murakami et al., (2014) [27] who found that using 3D models yielded strongly positive student perspectives and improvements in radiology skills in later clinical courses.

Majority of the students believed that the e-learning tool is user friendly (92%) and easy to use why just few people, about 8% disagreed with the friendly nature of the tool. Almost all the participants, 86% agreed that the user interface, layout, design, and appearance of the iBook are easy to understand and navigate. Majority of the participants equally agreed that the different features (text and images) and the written content of the e-learning tool provides appropriate knowledge in the study of the anatomy of the cervical vertebra as illustrated in figure 5. respondents affirmed strongly that the created models were intuitive and easy to use and the models added to their understanding of the cervical vertebra anatomy and over of the respondents that the resource makes learning attractive.

For the suitability and applicability of the resource tool, the respondents strongly agreed that the tool is a helpful educational tool for medical students. They also agreed that the tool compliments the medical curriculum and they also supported that fact the tool is flexible and saves reading time. These results are consistent with Sieben et al., 2017 [28].

CONCLUSION

The overall results showed positive outcome on the e-learning tool, with the tool recording a remarkable support from students who participated in the survey. The questionnaires, used in this study was all encompassing. It included the questions relating to the participating student, the resource tool, the 3D models and the value it will add to the students in general. The results suggested that students (97%) strongly support and prefer the use of digital learning with the iBook created than the traditional methods of using textbooks, chalk or black boards and cadaveric dissection. The e-learning resource tool produced as can serve as a teaching and a learning aid in the study of human anatomy and improve the teaching and learning process in general as it combines education and entertainment thereby, making anatomy a lot more intuitive.

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Conflicts of Interests: None

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