REVISTA DA ABENO
Associação Brasileira de Ensino Odontológico
https://revabeno.emnuvens.com.br ISSN 2595 0274

Anatomy alive: a mobile application to facilitate the teaching-learning of Head and Neck Anatomy applied to Dentistry

Ana Maria Catonio da Silva[1]
0000-0001-9773-995X

Maria Jessiane de Almeida Silva[1]
0000-0002-6978-9877

Nicholas Newton Queiroz Silva[1]
0000-0003-0003-553X

Eduarda Correia Moretti[2]
0000-0002-3994-8689

Fernando José Camello de Lima[2]
0000-0003-1593-7747

Olavo Barbosa de Oliveira Neto[2]
0000-0003-1280-659X

George Azevedo Lemos[2]
0000-0002-2140-216X

[1]Faculdade de Odontologia, Universidade Federal de Alagoas (UFAL), Maceió, Alagoas, Brasil.
[2]Instituto de Ciências Biológicas e da Saúde, Universidade Federal de Alagoas (UFAL), Maceió, Alagoas, Brasil.

Correspondence:
George Azevedo Lemos
E-mail: george.lemos@icbs.ufal.br

Received: Nov 27, 2023
Approved: Mar 18, 2024
Last revision: May 02, 2024

Abstract Human Anatomy is an essential content in the curriculum of health courses, with a growing demand in higher education for new technologies that can help in the study process. Thus, the objective was to develop and validate, in terms of content and usability, a mobile application to support the teaching-learning of Head and Neck Anatomy, applied to Dentistry. The study was developed in five stages: (1) scope definition and trademark registration, (2) preparation of anatomical parts, (3) prototype development, (4) content evaluation and (5) usability evaluation and degree of satisfaction. To evaluate the content, 5 teachers/judges with expertise in the area of Human Anatomy answered an online questionnaire containing 8 questions related to the content and functionality of the prototype. Usability was assessed by 15 undergraduate Dentistry students, using the Brazilian version of the System Usability Scale (SUS) and a visual analogue scale of 0-10 points for satisfaction. The team developed a hybrid application, compatible with the Android operating system, allowing the identification of anatomical structures in real cadaveric parts and knowledge tests using objective questions. The average rating score from the judges was 9.6, indicating adequate content and functionality. The final score on the SUS scale was 90.33 (excellent usability) and the average user satisfaction was 9.13. It is concluded that the application presented adequate compatibility, content, functionality and usability, and can be used as a free resource to support the teaching-learning of Head and Neck Anatomy.
Descriptors: Anatomy. Software Validation. Computers, Handheld. Education, Dental.

Anatomy alive: aplicación móvil para facilitar la enseñanza-aprendizaje de la Anatomía de Cabeza y Cuello aplicada a la Odontología

Resumen La Anatomía Humana es un contenido esencial en el plan de estudios de las carreras de salud, con una demanda creciente en la educación superior de nuevas tecnologías que puedan ayudar en el proceso de estudio. Así, el objetivo fue desarrollar y validar, en términos de contenido y usabilidad, una aplicación móvil de apoyo a la enseñanza-aprendizaje de la Anatomía de Cabeza y Cuello, aplicada a la Odontología. El estudio se desarrolló en cinco etapas: (1) definición del alcance y registro de la marca, (2) preparación de las piezas anatómicas, (3) desarrollo del prototipo, (4) evaluación del contenido y (5) evaluación de usabilidad y grado de satisfacción. Para evaluar el contenido, 5 profesores/jueces con experiencia en el área de Anatomía Humana respondieron un cuestionario en línea que contenía 8 preguntas relacionadas con el contenido y funcionalidad del prototipo. La usabilidad fue evaluada por 15 estudiantes de la carrera de Odontología, utilizando la versión brasileña de la Escala de Usabilidad del Sistema (SUS) y una escala visual analógica de 0 a 10 puntos de satisfacción. El equipo desarrolló una aplicación híbrida, compatible con el sistema operativo Android, que permite la identificación de estructuras anatómicas en partes cadavéricas reales y pruebas de conocimientos mediante preguntas objetivas. La puntuación media de los jueces fue de 9,6, lo que indica contenido y funcionalidad adecuados. La puntuación final en la escala SUS fue de 90,33 (excelente usabilidad) y la satisfacción media de los usuarios fue de 9,13. Se concluye que la aplicación presentó adecuada compatibilidad, contenido, funcionalidad y usabilidad, y puede ser utilizada como un recurso gratuito para apoyar la enseñanza-aprendizaje de Anatomía de Cabeza y Cuello.
Descriptores: Anatomía. Validación de Programas de Computación. Computadoras de Mano. Educación en Odontología.

Anatomy alive: aplicativo móvel para facilitar o ensino-aprendizagem de anatomia de cabeça e pescoço aplicada à Odontologia

Resumo A Anatomia Humana é um conteúdo indispensável na matriz curricular de cursos da área da saúde, sendo crescente a demanda no ensino superior por novas tecnologias que possam ajudar no processo de seu estudo. Assim, objetivou-se desenvolver e validar, quanto ao conteúdo e usabilidade, um aplicativo móvel para apoio ao ensino-aprendizagem de Anatomia de Cabeça e Pescoço aplicada à Odontologia. O estudo foi desenvolvido em cinco etapas: (1) definição do escopo e registro de marca, (2) preparação de peças anatômicas, (3) desenvolvimento do protótipo, (4) avaliação de conteúdo e (5) avaliação de usabilidade e grau de satisfação. Para avaliação de conteúdo, 5 docentes/juízes, com *expertise* na área de Anatomia Humana, responderam a um questionário online contendo 8 perguntas relacionadas ao conteúdo e funcionalidade do protótipo. A usabilidade foi avaliada por 15 estudantes de graduação em Odontologia, por meio da versão brasileira da escala *System Usability Scale* (SUS) e uma escala visual analógica de 0-10 pontos para satisfação. A equipe desenvolveu um aplicativo híbrido, compatível com o sistema operacional Android, permitindo a identificação de estruturas anatômicas em peças cadavéricas reais e testes de conhecimento a partir de questões objetivas. A pontuação média da avaliação dos juízes foi de 9,6, indicando conteúdo e funcionalidade adequados. O escore final da escala SUS foi 90,33 (usabilidade excelente) e a média de satisfação dos usuários foi 9,13. Conclui-se que o aplicativo apresentou compatibilidade, conteúdo, funcionalidade e usabilidade adequados, podendo ser usado como um recurso gratuito para apoio ao ensino-aprendizagem de Anatomia de Cabeça e Pescoço.

Descritores: Anatomia. Validação de Programas de Computador. Computadores de Mão. Educação em Odontologia.

INTRODUCTION

Human Anatomy is one of the oldest sciences in the world. It comprises the study of the shape, development, and constitution of the human body[1,2] and is therefore considered indispensable in the curriculum healthcare courses[3-5].

In the field of Dentistry, the study of Head and Neck Anatomy is essential for the development of cognitive and clinical skills of future professionals[6,7]. In addition, a recent study conducted with 100 undergraduate Dentistry students at the Federal University of Campina Grande (UFCG) showed that the discipline is also recognized as important by 90% of the anatomy students, as evaluated at both the beginning and the end of the course, who considered the discipline of Anatomy as very important for their academic trajectory[8].

Despite its historical importance, the teaching of Human Anatomy involves some problems. Among them, the availability of cadavers and anatomical specimens in good condition for laboratory practices stands out. This issue is particularly acute in recently established Higher Education Institutions (HEIs) situated far from the larger urban metropolitan centers[5,9,10]. In addition, it has been shown that the utilization of poorly preserved anatomical specimens negatively impacts students' learning and engagement[10]. Furthermore, in recent years, it has been observed that it has been difficult to obtain new cadavers, largely due to the decline in the availability of unclaimed corpses as well as the lack of centers to manage the process of their allocation to both public and private HEIs [10]. While there have been some successful experiences, the use of voluntarily donated bodies is still incipient in Brazil and largely unknown among the general population[11]. Furthermore, Law No. 8.501 of 1992 limits the use of unclaimed cadavers for educational and research purposes in Human Anatomy to higher education institutions (HEIs) with medical courses[12]. This poses a challenge for HEIs that offer healthcare courses outside of Medicine to acquire cadavers[13].

Formaldehyde is a frequently utilized method for preserving anatomical specimens due to its affordability and ease of use[14]. While other techniques, such as glycerination, cryodehydration, and plastination, are available, they are more costly and not widely adopted in Brazil[15]. Nonetheless, formaldehyde has some disadvantages, including a pungent odor, mucous membrane irritation, carcinogenic properties, and a tendency to render anatomical specimens rigid and

fragile[14,15].

A concerning issue is the notable decrease in the curriculum over the past few years. This undermines the instruction and advancement of conventional anatomical teaching methods, such as the dissection of cadavers[5,9], which is renowned for imparting superior comprehension of topographic associations, tactile sensitivity, and manual proficiency[3,16-18].

On the other hand, in recent decades, society has undergone constant technological revolutions, which has enabled the advancement of several fields of knowledge. In the study of Human Anatomy, several technological resources have been used to minimize the difficulties faced by this discipline[19]. These resources include the use of videos and podcasts, social media, multimedia software, three-dimensional (3D) virtual models, 3D dissection tables, tomography, and magnetic resonance imaging software, augmented virtual reality resources, and smartphone applications[19-21].

In this context, the use of mobile devices has revolutionized communication and education in the last decade[22]. Thus, m-Learning (Mobile Learning), which refers to the use of mobile devices in the teaching-learning process[23], has become very popular among higher education students[22], due to its accessibility and quick sharing capabilities[23].

Despite the existence of several resources available in the Brazilian market, most of them are high-cost, limiting their use to small classes, HEIs with greater financial resources, and students with higher purchasing power[19]. In addition, most of these resources are in English, which can be a barrier for some users, or may even have translation problems. Furthermore, it's important to note that most of the available technological devices use virtual imagery or drawings, which can hinder the understanding of anatomical details in real human bodies, particularly those related to anatomical variations.

To address these challenges, this study aims to create and validate a mobile application that supports the teaching and learning of head and neck anatomy in Dentistry. The application will be evaluated for both its content and usability.

METHODS

This is a technological development study, carried out at the Federal University of Alagoas (UFAL), from September 2021 to September 2023. The study followed all the recommendations of CNS resolutions No. 466/2012 and No. 510/2016 and was approved by the Human Research Ethics Committee of UFAL (CAAE: 48010421.1.0000.5013).

The purpose of this work was to develop a mobile application that streamlines the instruction and comprehension of Head and Neck Anatomy. Furthermore, the app underwent validation and assessment to determine its usability. To this end, five steps were followed: (1) definition of the scope and trademark registration; (2) preparation of the anatomical parts, (3) development of the application prototype, (4) evaluation of content by expert judges, and (5) usability and degree of satisfaction assessment.

Definition of scope and trademark registration

This stage was developed according to the brainstorming technique. This approach fostered a welcoming environment for greater freedom of ideas, ensuring that every idea was valued, and no discrimination occurred during the creative process[24]. In this way, this phase was marked by constant open dialogue between all members of the team involved in the project, to present ideas, troubleshoot problems, and develop solutions.

At this stage, the app's target audience was defined as undergraduate students in Dentistry who are studying Head and Neck Anatomy applied to Dentistry or individuals seeking to review this material.

The team has established the required features for the application. It should boast a straightforward, user-friendly interface that is easy to navigate. A home screen should communicate the app's information, aims and functionalities, with a table of contents screen with redirection to specific content. The application should display high-resolution images of real anatomical structures. Users should be able to click on these structures to be directed to a box with their names

according to the Anatomical Terminology. The app should allow for the isolation of anatomical structures through color changing. It should also provide the ability to visualize different regions of the head and neck across different anatomical planes, from the most superficial to the deepest. Finally, the application should give access to objective questions related to different anatomical regions.

At this stage, the team collaborated remotely via Google Meet and in-person meetings to create the application's logo. Various logo designs were reviewed by the teachers and students involved until the most suitable one was chosen. After deliberation by the team, the Anatomy Alive trademark was established (Figure 1) and registered with the National Institute of Industrial Property (INPI). Figure 1 showcases the final logo.

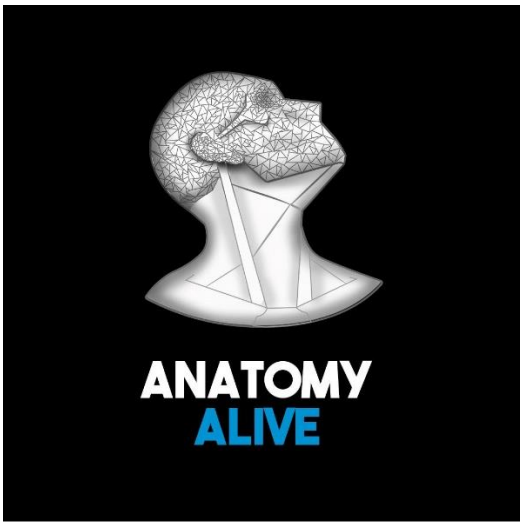

Figure 1. Logo of the developed educational resource.

Preparation of anatomical specimens

At this stage, the selection of eligible cadaveric specimens and the preparation of new specimens took place. For this purpose, human cadavers preserved in formaldehyde and/or glycerin in good condition and dried human skulls, belonging to the Descriptive and Topographic Human Anatomy sector of the Institute of Biological and Health Sciences (ICBS/UFAL), were used.

The preparation of the new pieces was done through dissection with appropriate instruments, to provide the visualization of structures that were not present in the laboratory's collection or were damaged.

All selected pieces were photographed with a DSLR digital camera equipped with a 24.2-megapixel resolution and 18-55mm lens. The photographs were conducted in an appropriate setting with a black background to ensure optimal visibility. Then, the selection of the photographs that best represented the structures to be marked was carried out, defined using a pre-designed script based on textbooks and atlases. Multiple images of each piece were captured from different perspectives and analyzed thoroughly to identify the best representations. Factors such as size, position, luminosity, and legibility were taken into consideration during the selection process. Finally, the chosen images were edited to achieve optimal quality.

In addition, questionnaires with multiple-choice questions were developed with pertaining to different anatomical regions and structures of the head and neck and were distributed in the sections of the application.

Prototype development

The application was created according to the prototyping model[25], which is ideal when researchers are not aware of all the requirements and resources needed to develop the application [26, 27]. In this method, prototypes are developed and evaluated before the final version is created[25-27].

To build the app, key topics on Head and Neck Anatomy were chosen from images and used to create a website using HTML (Hypertext Markup Language). CSS (Cascading Style Sheets) was used for styling, while JavaScript was used for programming actions.

The website was then hosted on UFAL's "UfalSites" system (https://icbs.ufal.br/grupo/mco/) developed by the Information Technology Center (NTI).

Next, the website was converted into an application using the WEBSITE 2 APK program. After downloading and installing the program, the website link was inserted, properties were chosen, and the application logo was added. An APK (Android Application Pack) was generated, which is a package of applications that can be unzipped and installed on Android, working as a hybrid application.

Content evaluation

Content evaluation refers to the conceptual analysis carried out by judges with notable expertise in a discipline, allowing the identification of possible conceptual flaws/errors and suggestions for modifications to the application prototype[25, 28]. Thus, professors with at least a doctorate and 5 years of teaching experience in Anatomy disciplines applied to Dentistry were included as judges, regardless of gender and age. For this study, 5 judges were consulted to evaluate the application content according to previous studies[29, 30].

The app evaluation questionnaire was adapted from previous studies[25, 28] and organized into three parts on the Google Forms online platform. It was sent to the professors included in the study via email, along with a link to download the app on their smartphones.

The first part of the questionnaire collected general data to characterize the sample, such as age, gender, area of higher degree, and teaching experience in higher education. The second part consisted of eight questions, related to the content and functionality of the application. The answers to each question were organized on an 11-point Likert-type scale where zero meant strongly disagree and ten meant strongly agree. The third part consisted of four discursive questions aiming to collect information about possible errors or flaws in the content and suggestions for application improvements. The questions were as follows: Dq1 - Did you observe any flaws/errors in the identification of anatomical structures? Which one (s)? Dq2 - Have you observed flaws/errors in anatomical terminology? Which one (s)? Dq3 - Did you observe flaws/errors in the definitions of the sections and visualization planes of the anatomical regions? Which one (s)? Dq4 - Do you have any suggestions to improve the app? What suggestions?

Usability evaluation

A group of 15 undergraduate Dentistry students over 18 years of age from the Federal University of Alagoas participated in a usability evaluation. These students were enrolled in the Head and Neck Anatomy discipline during the second semester of their course and were selected for convenience during a class break. The sample size of 15 was chosen based on literature recommendations for individuals who have not previously evaluated application usability. With 14 evaluators, it is possible to identify more than 75% of usability problems[31].

Students who agreed to participate in the study received an email with a link to download the app on their smartphone and an electronic form organized on the Google Forms platform to evaluate usability. The students tested the app for 30 days and then rated it based on their satisfaction and perceived usability.

The Brazilian version of the System Usability Scale (SUS)[32] was used to measure usability. It is a widely used scale in this type of study and was translated and validated for Brazilian Portuguese[33]. The SUS consists of 10 items with positive and negative phrases related to usability. Each statement has a Likert scale ranging from 1 ("strongly disagree") to 5 ("strongly agree"), and only one number per statement should be selected to represent the perception of the product evaluated. The final SUS score was calculated by subtracting odd-numbered statements by 1 from the score marked on

the Likert scale, while even-numbered statements were subtracted from 5. The sum of all values obtained in each statement was then multiplied by 2.5, resulting in a score that could be categorized as "worst imaginable" usability (less than or equal to 20.5), "poor" usability (21 to 38.5), "ok" usability (39 to 52.5), "good" usability (53 to 73.5), and "excellent" usability (86 to 100)[32, 33].

In addition, the degree of satisfaction with the developed application was measured using a visual analog scale (VAS) ranging from 0 to 10. Volunteers were also allowed to provide suggestions for improvement to further enhance the final product.

Statistical analysis

Data were tabulated and presented descriptively, in the form of frequency, mean, and standard deviation (SD) values.

RESULTS

As a result of this study, the application Anatomy Alive was obtained and registered with the Brazilian Patent and Trademark Office (INPI) as a computer program, process No. BR512022003270-8.

Application features

Anatomy Alive is an innovative and valuable tool for anyone keen on exploring human anatomy. This user-friendly resource is available in Brazilian Portuguese and showcases high-quality images of real anatomical specimens with excellent resolution. Users can view specimens from different dissection planes and identify specific anatomical structures in the images. Additionally, the app offers objective questions related to each subject.

The platform of this application boasts an intuitive design, with the UFAL logo displayed at the top. A click directs users to the official website of this institution. Furthermore, users can easily identify the application's logo. Just below, a menu featuring various topics covered by the application is readily accessible, as depicted in Figure 2A.

By selecting one of the topics, one can view its subtopics. This will allow the user to further select the structures they wish to study. Figure 2B demonstrates this feature. The subtopic "Masseter" was selected, which is within the "Muscles of mastication" topic and, in turn, is part of the "Muscles" theme on the main menu. With this, the user can access to the screen that shows the images that are directly related to the masseter muscle. On the right-hand side of the screen, other cuts of the muscle that focus on other specific structures are also available. In the example, the masseteric vessels and nerves are highlighted in pink (Figure 2B).

At the bottom of the page, it is possible to have access to an email where one can send possible questions or suggestions about the application. Additionally, there is a link to download the app for Android devices (Figure 2A).

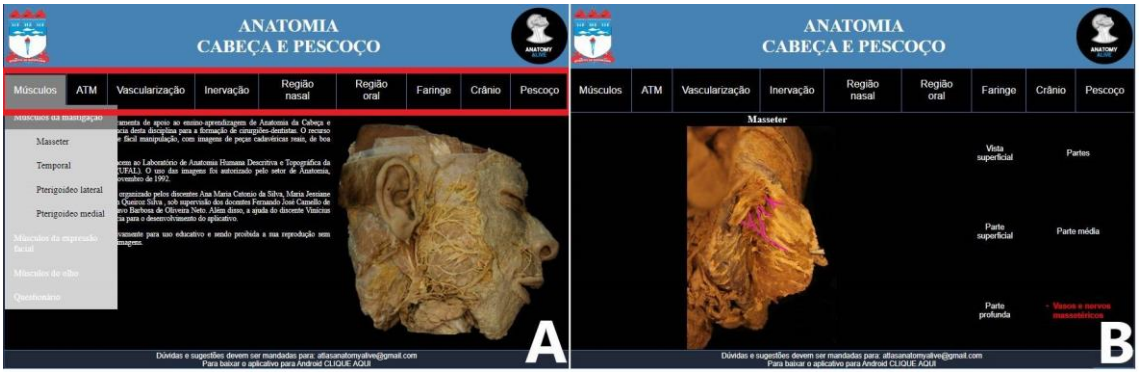

Figure 2. Application home menu (A); Masseter muscle topic (B).

The application provides a comprehensive examination of anatomical structures from various perspectives to pinpoint an increased number of details (Figure 3). When selecting one of the topics on the right-hand side of the screen, the desired structure is highlighted using arrows. For example, Figure 3 demonstrates the identification of some bone structures located in the mandible, such as the oblique line in the frontal view (Figure 3A), the mandibular foramen in the posterior view (Figure 3B), the condylar process in the lateral view (Figure 3C) and the mandibular canal in the lateral view, but in a deeper way (Figure 3D).

Figure 3. Visualization of bone structures located in the mandible. Front view (A); Back view (B); Side view (c); Lateral view, with the removal of the external bone plate (D).

Figure 4 presents an objective question related to the "Muscles" topic. The aim is to verify the user's learning. A question is displayed (Figure 4A) related to an image of a highlighted anatomical structure (Figure 4B).

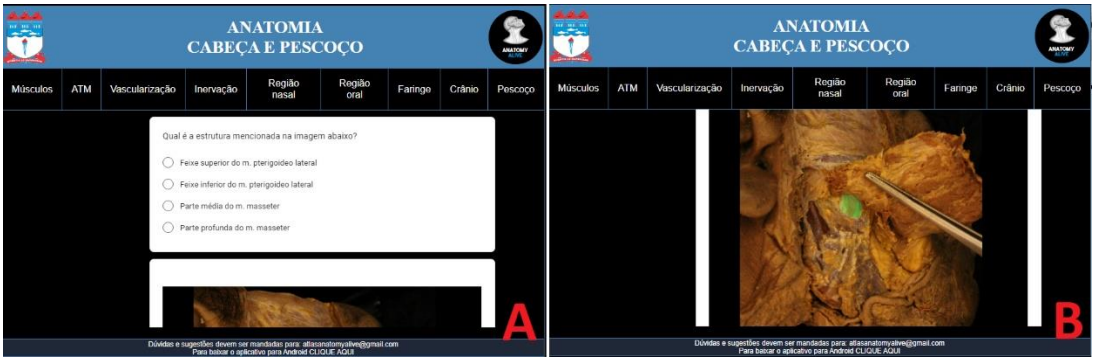

Figure 4. Example of an objective question present in the application (A); Image related to the described question (B).

Content evaluation

The evaluators consisted of males between the ages of 34 and 47 with teaching experience in higher education ranging from 5 to 21 years, averaging at 11.6±6.58 years.

Table 1 presents the results of the content evaluation of the 5 judges. It is observed that the average score of all evaluators was 9.6±0.44, indicating that the application has excellent functionality, compatibility, and adequate content.

Table 1. Content evaluation by 5 judges with expertise in Human Anatomy.

Judges	Questions								Total Score
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	
1	9	10	10	10	9	9	10	10	9.625
2	9	10	10	10	10	10	10	10	9.875
3	10	10	10	10	10	10	10	10	10.000
4	8	9	9	10	10	9	10	10	9.375
5	8	7	10	10	9	9	10	10	9.125
Mean	8.8	9.2	9.8	10	9.6	9.4	10	10	9.600

The judges also answered 4 discursive questions (Dq1, Dq2, Dq3 and Dq4). Only one of the judges noted an error regarding the absence of marking of a structure. No errors were reported regarding the use of anatomical terminology. It was observed that 40% of the judges reported failure to define a cut and visualization plan. And none of them provided suggestions for improvements to the application prototype. All the judges' considerations were accepted by the team and the flaws/errors in the prototype were corrected for the final version.

Usability evaluation

As can be seen in Table 2, the final score of the SUS scale was 90.33±11.56, considered "excellent" usability[32,33]. Furthermore, the average satisfaction rating obtained with the VAS was 9.13 ±0.91, indicating great acceptance by users (Table 2).

Table 2. Usability evaluation and degree of satisfaction carried out by 15 undergraduate students. The final SUS score considers the total sum of odd and even scores.

Evaluator	Sum of odd scores	Sum of even scores	Total sum	Final SUS score	Level of satisfaction
1	19	19	38	95.00	8.00
2	20	16	36	90.00	10.00
3	19	17	36	90.00	9.00
4	18	18	36	90.00	9.00
5	15	18	33	82.50	10.00
6	19	19	38	95.00	10.00
7	20	20	40	100.00	9.00
8	20	1	21	52.40	10.00
9	19	19	38	95.00	9.0
10	16	20	36	90.00	7.00
11	20	20	40	100.00	9.00
12	18	17	35	87.50	10.00
13	19	19	38	95.00	8.00
14	18	19	37	92.50	9.00
15	20	20	40	100.00	10.00
Final mean				90.33	9.13

DISCUSSION

The use of the cadavers is considered the best method for teaching Human Anatomy. It provides students with the mastery of different skills that are important for their training in the healthcare area, such as the ability to perceive syntopies between different tissues and organs, an understanding of texture and depth and respect for human beings and the vulnerability of life, teamwork, responsibility, and confidentiality[3,16,17,34]. However, the use of different technological tools can supplement the teaching of this subject and facilitate its understanding[20,21]. Specifically, applications for mobile devices can be important support tools, as they allow access to content quickly and at any time. This is particularly advantageous for users that are far from traditional teaching locations such as classrooms and Anatomy laboratories[22,23]. Thus, when using the resource developed in this study, students can visualize different anatomical structures of the head and neck during their laboratory sessions, as well as review them at their convenience.

Based on the principles of M-learning, this study developed an application to support the teaching-learning process of Head and Neck Anatomy, targeted at undergraduate Dentistry students who aim to learn or review this content. On the topic, we found only one study specifically related to the development of an educational resource that addresses Anatomy applied to Dentistry. However, the resource is based on virtual reality and 3D models[35], differing from the product developed in our study. Furthermore, the researchers did not carry out content and usability evaluations, making comparisons with our results impossible.

On the other hand, studies involving students from other healthcare courses have demonstrated that mobile applications can be valuable tools for supporting the teaching-learning process. A study conducted in the United Kingdom with 120 undergraduate medical students revealed that nearly all of them (98%) owned smartphones, and a significant portion (64.3%) used medical education apps. And 61.9% of these applications focused on Human Anatomy content[36]. For these researchers, the use of smartphone applications offers an opportunity to reach the target audience and can be important supplementary resources for teaching Human Anatomy.

Another study conducted at a German Faculty of Medicine evaluated an application to aid in the study of the Anatomy of the skeletal system. The researchers observed that students who utilized the application more frequently achieved higher scores on the content mastery assessment[22]. Furthermore, another research[37] regarding the perception of academics about an application to support the teaching of Human Anatomy carried out with 25 Physical Education students, demonstrated that for 83% of them reported increased study time due to the accessibility of the evaluated product.

Regarding the characteristics of the devices adopted in an educational context, availability across different operating systems and being free of charge are desirable[38]. In this context, the application developed in this study was offered to the academic community free of charge and is compatible with the Android operating system, one of the most popular systems in Brazil. Furthermore, the researchers intend, when they have more financial resources, to update the application, expanding its compatibility with the iOS system.

Another requirement of educational resources inherent to the area of Anatomy is the appropriate use of Anatomical Terminology[39] to accurately describe the human body structures and the correct definition of the section planes. Therefore, to guarantee the development of an educational resource with adequate terminology and content, an evaluation was carried out by judges with great expertise in Anatomy, who indicated that the developed application presented adequate functionality and content. Furthermore, some flaws pointed out by the judges, such as the absence of marking on an anatomical structure, and the definition of a section and a viewing plane were addressed at this developmental stage.

The quality of a software product is defined by its usability, which relies on its ease of understanding, operation, visual appeal, and usage. To ensure a product has satisfactory usability, aspects such as functionality and efficiency must be taken into consideration. In this sense, user satisfaction is determined in response to their experience with the product and encompasses actions related to handling it[40]. ISO 9241-11[40] describes that measuring usability is crucial in

identifying the complexity of user interactions with different resources. as it directly impacts the success or failure of this kind of application[41]. If a software product's usability falls short, it may be replaced with a more user-friendly alternative at any time[42]. Thus, in the present study, usability was assessed using the SUS scale, which was translated, and validated into Brazilian Portuguese[33], demonstrating an excellent usability value.

ISO 9241-11[40] also recommends the assessment of user satisfaction, defined as both the absence of discomfort and positive attitudes towards using the product, which can be evaluated/estimated by subjective or objective measures. In this study, satisfaction was assessed through a subjective question, recorded on a Visual Analogue Scale, demonstrating a high level of user satisfaction.

Limitations include incompatibility with the iOS system, absence of accessibility for the visually impaired, and the lack of evaluation of the developed application regarding its effectiveness on users' cognitive abilities, such as grades obtained in subjects and learning tests. However, the results of the usability and user satisfaction evaluations indicate that the product has great potential as a support tool in the teaching-learning process and a resource for future research.

CONCLUSION

A hybrid application for smartphones compatible with the Android operating system was developed, which can be used as a support tool for teaching and learning Head and Neck Anatomy. The application presents adequate content and functionality, as well as excellent usability and high user satisfaction.

REFERENCES

1. Dângelo JG, Fattini CA. Anatomia humana sistêmica e segmentar. 3th ed. revista. São Paulo: Atheneu; 2011.
2. Moore KL, Dalley AF, Agur AMR. Anatomia orientada para a clínica. 7th ed. Rio de Janeiro: Koogan; 2014.
3. Rizzolo LJ, Stewart WB. Should we continue teaching anatomy by dissection when ...? Anat Rec [Internet]. 2006;289(6):215-218. doi: https://doi.org/10.1002/ar.b.20117
4. Piazza BL, Chassot AI. Anatomia Humana, uma disciplina que causa evasão e exclusão: quando a hipótese principal não se confirma. Cien Mov [Internet]. 2011;14(28):45-59.
5. Tavano PT, Almeida MI. A reconfiguração do ensino anatômico: tensões que incidem na disciplina básica. Rev Bras Educ Med [Internet]. 2011;35(3):421-428. doi: https://doi.org/10.1590/S0100-55022011000300017
6. Guttmann GD. The Current Status of the Anatomical Sciences Curriculum in U.S. and Canadian Dental Schools. J Dent Educ [Internet]. 2003;67(3):375-9. doi: https://doi.org/10.1002/j.0022-0337.2003.67.3.tb03639.x
7. Rafai N, Lemos M, Kennes LN, Hawari A, Gerhardtszép S, Classen-Linke I. Anatomy meets dentistry! Linking anatomy and clinical practice in the preclinical dental curriculum. BMC Med Educ [Internet]. 2016;16(1):305. doi: https://doi.org/10.1186/s12909-016-0825-8
8. Bastos RFS, Gomes NKA, Almeida MSC, Silva MAD, Pereira AC. Na percepção do aluno, a disciplina de Anatomia é importante para o curso de odontologia? Rev UNINGÁ [Internet]. 2019;56(S3):92-100. doi: https://doi.org/10.46311/2318-0579.56.eUJ2783
9. Barry DS, Marzouk F, Chulak-Oglu K, Bennett D, Tierney P, O'keeffe GW. Anatomy education for the YouTube generation. Anat Sci Educ [Internet]. 2016;9(1):90-6. doi: https://doi.org/10.1002/ase.1550
10. Cordeiro RG, Menezes RF. A Falta de Cadáveres para Ensino e Pesquisa. Rev Bras Educ Med [Internet]. 2019;43(1):579-87. doi: https://doi.org/10.1590/1981-5271v43suplemento1-20190217
11. Rocha AO, Tormes DA, Lermann N, Schwab RS, Canto RT. The body donation program at the Federal University of Health Sciences of Porto Alegre: a successful experience in Brazil. Anat Sci Educ [Internet]. 2013;6(3):199-204. doi: https://doi.org/10.1002/ase.1335
12. Brasil. Lei nº 8.501, de 30 de novembro de 1992. Dispõe sobre a utilização de cadáver não reclamado, para fins de estudos ou pesquisas científica e dá outras providências. Diário Oficial da União:1992; Seção 1:16519 [cited 2024 Feb 19]. Available from: https://www.planalto.gov.br/ccivil_03/leis/l8501.htm

13. Neto J, Baú M, Loch J, Bilhalva G, Feijó A. O corpo humano morto: utilização do cadáver para a pesquisa científica e para a doação de órgãos. Rev Bras Bioetica [Internet]. 2007;3(2):218–235. doi: https://doi.org/10.26512/rbb.v3i2.7926
14. Silva GRS, Cortez POB, Lopes ISL, Teixeira BACB, Leal NMS. Métodos de conservação de cadáveres humanos utilizados nas faculdades de medicina do Brasil. Rev Med [Internet]. 2016;95(4):156-161. doi: https://doi.org/10.11606/issn.1679-9836.v95i4p156-161
15. Fontoura ELL, Mello ST, Gomes CRG, Mello JM. Conservação de peças anatômicas: vantagens e desvantagens de diferentes métodos. Rev UNINGA [Internet]. 2020;57(2):34-46. doi: https://doi.org/10.46311/2318-0579.57.eUJ2942
16. Pawlina W, Lachman N. Dissection in learning and teaching gross anatomy: rebuttal to McLachlan. Anat Rec B New Anat [Internet]. 2004;281(1):9-11. doi: https://doi.org/10.1002/ar.b.20038
17. Arráez-Aybar LA, Bueno-López JL, Moxham BJ. Anatomists' views on human body dissection and donation: An international survey. Ann Anat [Internet]. 2014;196(6):376-386. doi: https://doi.org/10.1016/j.aanat.2014.06.004
18. Yan J. Difficult points in current gross anatomy education and research. Edorium J Anat Embryo [Internet]. 2015;5:18–19. doi: https://doi.org/10.5348/A04-2015-5-ED-4
19. Trelease RB. From Chalkboard, Slides, and Paper to eLearning: How Computing Technologies Have Transformed Anatomical Sciences Education. Anat Sci Educ [Internet]. 2016;9(6):583- 602. doi: https://doi.org/10.1002/ase.1620
20. Estai M, Bun S. Best Teaching Practices in Anatomy Education: A Critical Review. Ann Anat [Internet]. 2016;208:151-157. doi: https://doi.org/10.1016/j.aanat.2016.02.010
21. Clunie L, Morris NP, Joynes VCT, Pickering JD. How Comprehensive Are Research Studies Investigating the Efficacy of Technology-Enhanced Learning Resources in Anatomy Education? A Systematic Review. Anat Sci Educ [Internet]. 2018;11(3):303-319. doi: https://doi.org/10.1002/ase.1762
22. Golenhofen N, Heindl F, Grab-Krol C, Messerer DAC, Bockers TM, Bockers A. The Use of a Mobile Learning Tool by Medical Students in Undergraduate Anatomy and its Effects on Assessment Outcomes. Anat Sci Educ [Internet]. 2019;13(1): 8–18. doi: https://doi.org/10.1002/ase.1878
23. Basak KS, Wotto M, Bélanger P. E-learning, M-learning and D-learning: Conceptual definition and comparative analysis. E-Learning and Digital Media [Internet]. 2018;15(4):191-216. doi: https://doi.org/10.1177/2042753018785180
24. Mongeau PA. The Brainstorming Myth. In: Annual Meeting of the Westem States Communication Association [Internet]. Westem States Communication Association: 1993; p. 1-27 [cited 2024 Feb 19]. Available from: https://eric.ed.gov/?id=ED357399
25. Sousa VEC, Lopes MVO, Keenan GM, Lopez KD. Developing and Testing of a Software Prototype to Support Diagnostic Reasoning of Nursing Students. Int J Nurs Knowl [Internet]. 2018;29(2):124-132. doi: https://doi.org/10.1111/2047-3095.12145
26. Pressman RS. Engenharia de Software: uma abordagem profissional. 7th ed. NY: AMGH; 2011.
27. Wazlawick RS. Engenharia de Software: conceitos e práticas. Rio de Janeiro: Elsevier; 2013.
28. Dantas RAN, Torres GV, Salvetti MG, Dantas DV, Mendonça AE. O instrumento para avaliação da qualidade da assistência pré-hospitalar móvel de urgência: validação de conteúdo. Rev Esc Enferm USP [Internet]. 2015;49(3):380-386. doi: https://doi.org/10.1590/S0080-623420150000300004
29. Duarte AM, Mandetta MA. TMO-App: construção e validação de aplicativo para famílias de crianças/adolescentes com câncer. Acta Paul Enferm [Internet]. 2022;35:eAPE03502. doi: https://doi.org/10.37689/acta-ape/2022AO03502
30. Muniz IAF. Desenvolvimento de aplicativo de teleinterconsulta em Disfunção Temporomandibular [thesis]. João

Pessoa: Universidade Federal da Paraíba; 2023.
31. Nielsen J. Finding usability problems through heuristic evaluation. Anais da 10th SIGCHI Conference on Human Factors in Computing Systems. Monterrey: ACM: 1992; p. 373-380. [cited 2024 Feb 19]. Available from: https://doi.org/10.1145/142750.142834
32. Lourenço DF, Carmona EV, Lopes MHBM. Tradução e adaptação transcultural da System Usability Scale para o português do Brasil. Aquichan [Internet]. 2022;22(2):e2228. doi: https://doi.org/10.5294/aqui.2022.22.2.8
33. Robertson KA, Organ JM, Yard M, Byram JN. First patient project: Engaging pathology through the donor dissection experience and its role in professionalism. Anat Sci Educ [Internet]. 2024;17(1):199-212. doi: https://doi.org/10.1002/ase.2341
34. Silva LA. Desenvolvimento de aplicativo como objeto de aprendizagem: Atlas virtual interativo para o ensino da anatomia cabeça e pescoço direcionado à odontopediatria [dissertation]. Bauru: Universidade de São Paulo; 2016 [cited 2024 Feb 19]. Available from: https://repositorio.usp.br/item/002775965
35. Zargaran A, Turki MA, Bhaskar J, Spiers HVM, Zargaran D. The Role of Technology in Anatomy Teaching: Striking the Right Balance. Adv Med Educ Pract [Internet]. 2020;11(1):259-266. doi: https://doi.org/10.2147/AMEP.S240150
36. Costa RDA, Almeida CMM, Nascimento JMM. Percepções de acadêmicos sobre o desenvolvimento de um aplicativo para dispositivos móveis como ferramenta de apoio ao ensino e a aprendizagem em anatomia humana. Redin [Internet]. 2015 [cited 2024 Feb 19];4(1).
37. Nichele AGG, Schlemmer E. Aplicativos para o ensino e aprendizagem de Química. RENOTE [Internet]. 2014;12(2):1-9. doi: https://doi.org/10.22456/1679-1916.53497
38. Sociedade Brasileira de Anatomia. International Anatomical Terminology. Anatomical CdT. São Paulo: Editora Manole; 2001.
39. Associação Brasileira De Normas Técnicas. NBR 9241: Requisitos Ergonômicos para Trabalho de Escritórios com Computadores. Rio de Janeiro: ABNT; 2020 [cited 2024 Feb 19]. Available from: https://www.inf.ufsc.br/~edla.ramos/ine5624/_Walter/Normas/Parte%2010/ISO9241parte10.pdf
40. International Organization For Standardization. Ergonomics of Human System Interaction: Usability, Definitions and Concepts. ISO 9241-11, 2018 [cited 2024 Feb 19]. Available from: https://www.iso.org/standard/63500.html
41. Matera M, Rizzo F, Carughi G. Web Usability: Principles and Evaluation Methods. In Mendes E, Mosley N. (Eds). Web Engineering. Berlin: Springer; 2006 [cited 2024 Feb 19]. Available from: https://link.springer.com/chapter/10.1007/3-540-28218-1_5
42. Vaz VT, Conte T, Bott A, Mendes E, Travassos GH. Inspeção de Usabilidade em Organizações de Desenvolvimento de Software – Uma Experiência Prática. Anais do VII Simpósio Brasileiro de Qualidade de Software. Florianópolis: SBQS; 2008. p. 369-77 [cited 2024 Feb 19]. Available from: https://sol.sbc.org.br/index.php/sbqs/article/view/15557

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

Funding: No funding to declare.

Author' Contribution: Study conception and planning: AMCS, MJAS, GAL. Data collection, Analysis and interpretation: AMCS, MJAS, NNQS. Manuscript preparation and review: AMCS, MJAS, GAL, ECM, FJCL, OBON. Final version approval: AMCS, MJAS, NNQS, GAL, ECM, FJCL, OBON. Public responsibility for article content: AMCS, MJAS, NNQS, GAL, ECM, FJCL, OBON.