

Development and evaluation of a mobile application for teaching Dental Radiology

Francielle Santos de Santana*; Mariana Bispo Costa**; Jorge Dias Matos Neto**; André Batista da Silva***; Gilton José Ferreira da Silva****; Wilton Mitsunari Takeshita****

* Master in Dentistry, Department of Odontology, Federal University of Sergipe

** Undergraduate Student, Department of Odontology, Federal University of Sergipe

*** Bachelor of Science in Computer, Computer Department, Federal University of Sergipe

**** Professor, Department of Odontology, Federal University of Sergipe

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ABSTRACT

This study aimed to develop and evaluate a smartphone application with a web content management tool for the study of periapical radiographic anatomy. Design thinking activities were carried out to better understand the proposed problem. Then, a questionnaire was applied via Google Forms to 44 dental students to assist in the development of an App for the teaching of radiology. Then, the beta version of the App was evaluated in January 2019 by 51 undergraduate dental students by means of satisfaction and usability questionnaires. The Cronbach's alpha coefficient was applied to these questionnaires and values above 0.7 were obtained, demonstrating their reliability. In the evaluation of the App, which was called APPOLO, that means App of learning online, 98.04% of the students affirmed that the available content was certainly important. The number of images was considered either satisfactory or very satisfactory by 94.19% of the participants, and 100% of them judged the quality of the images also satisfactory or very satisfactory. The majority of the participants (94.11%) felt motivated to complement their study using this type of methodology. The classification easy and very easy was attributed to the metrics usability by 98.04% of the participants, access to offered contents by 100% of the participants, and access to the texts by 98% of the participants. The APPOLO App proved to be practical and easy to understand, navigate, and use, as was considered a potential aid to support the teaching of dental radiology students.

Descriptors: Radiology. Education, Distance. Dentistry. Smartphone.

1 INTRODUCTION

The popularization of mobile devices has been considered by many to be the technological revolution of greater impact in recent times after the advent of the internet and social networks¹. Smartphones and tablets have increasingly replaced desktop and laptop computers and become two of the world's most widely used devices, mainly because they offer more considerable advantages in terms of size, portability and connectivity, enabling access to communication in practically any place².

According to the Global System for Mobile Communications Association (GSMA), the number of single users of mobile handsets in the world reached over five billion in 2017, and for the first time, the number of chips surpassed the world population³. GSMA is an association that represents the mobile industry and organizes the Mobile World Congress (MWC), the largest world's fair in the sector. According to GSMA, the number of cell phones is expected to reach the sum of 5.9 billion in 2025, which will correspond to 71% of the world's population at that time. Among the more than five billion mobile phone users, 3.3 billion use this device to access the internet. It is estimated that this number will be of five billion by 2025³. The internet has transformed the way we live and work, and modern days witness the dawn of a new age in mobile phone technology with the imminent launching of the first 5G networks³.

The ease of acquiring mobile devices and facilitated access to the internet have transformed the way people interact. Activities that once were difficult to complete now are simple and practical. An excellent example of this is the use of smartphones in the academic environment. Students use mobile phones to read, replacing physical books with the so-called e-books⁴.

Mobile devices are a technological resource also applied to support teaching in the health area^{5,6}. In education, their use can be a fundamental

strategy in the process of learning and maintenance of health-promoting attitudes⁷.

Studies have shown that the use of information technology has brought excellent results to the teaching-learning process⁸. Undergraduate dental students have demonstrated a preference for web-based content provision over traditional methods due to aspects such as accessibility, ease of use, high-quality images, and the possibility to review the practice, in addition to continuous updating⁹. It is thus observed that technological resources cause a modernization or transformation of the traditional model of teaching¹⁰. Yet, this means of search for knowledge must complement traditional methods provided in the classroom⁹.

The objective of the present study was to develop a smartphone application (App) for the study of radiographic anatomy in a practical way so as to contribute to the learning and consolidation of content. The study also involved the creation of a web content management tool to serve as a base for some courses that may need to make their content available in a digital format. It is expected that this application will contribute to teaching, training and diagnosis in dental radiology.

2 METHODS

This was a prospective and descriptive study conducted with the purpose of evaluating the user satisfaction and usability metrics of a mobile App for the teaching of dental radiology to undergraduate students of the Federal University of Sergipe. The study consisted of the development of a product aimed at the building of virtual objects to be used as a digital educational resource, and its evaluation by the target public.

The inclusion criteria were students who attended the dental radiology course of the undergraduate program of the Federal University of Sergipe School of Dentistry. Students who did not participate in this course were excluded.

Students who were willing to participate in the investigation were invited to sign an Informed Consent Form. The risks were minimal, as the study involved only the application of questionnaires about smartphones or tablets. The direct benefit of this investigation was the improvement of the teaching-learning process. Indirect benefits for society are also expected, considering that a tool to improve the teaching of dental radiology, which can be applied in higher education in general, is being developed.

A group of students who demonstrated interest on digital information and communication technologies was initially selected. Then, face-to-face meetings and design thinking activities - with the elaboration of an Empathy Map - which is an approach taken from the design field to better understand the problem proposed by the research team were carried out in order to know the expectations and preferences about the development of a teaching App for the radiology course.

Exploratory research was then conducted to check the comprehension of the premises and the further needs of the project. To this end, a questionnaire was applied to undergraduate dental students via Google Forms, to aid in the development of this

digital tool for the teaching of dental radiology. The survey collected information on study methods, difficulties found along the course, problems faced when using Apps, and characteristics considered important in teaching Apps by the students.

For the understanding of the further needs of the project, another exploratory survey involving a second questionnaire applied via Google Forms was carried out to know the profile of the students. This questionnaire was geared at collecting information so as to understand the students' needs. Its content addressed the students' behavior when interacting with teaching Apps and with the radiology course.

Finally, the App was evaluated by students of the Department of Dentistry (figure 1). These students were invited to participate in a face-to-face meeting at a pre-scheduled date and time and were informed about the non-mandatory nature of their collaboration and participation. At the meeting, they explored the App (the product proposed by the investigation) for as long as they deemed necessary. Because the App was still in the beta phase (initial phase of use) as is not available for all users yet, the volunteers explored the App using the mobile phones of the researchers, working with the Android operating system.

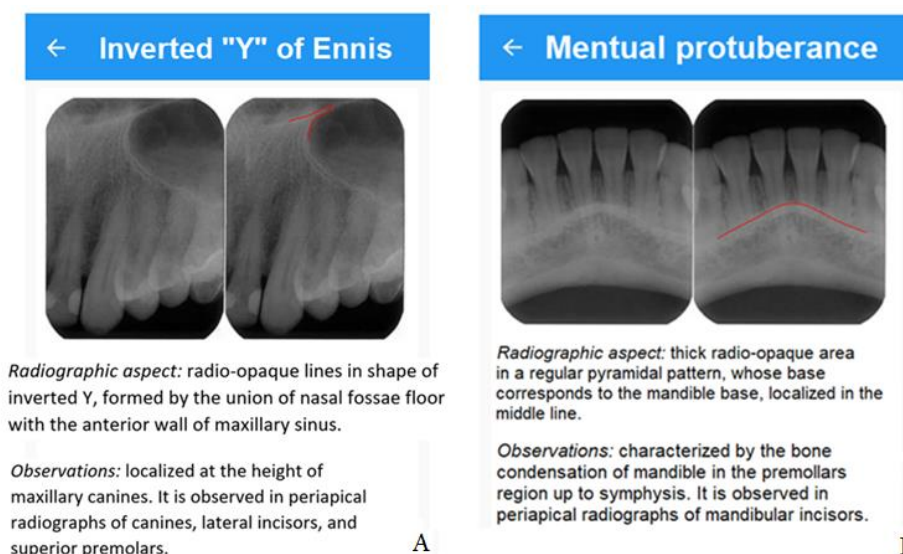


Figure 1. Application content examples: inverted Y of Ennis (A) and mental protuberance (B)

Of the invited students, 51 came to know the App and responded to the satisfaction and usability questionnaires, which had objective questions and a space for suggestions and comments. The proposed questionnaires were based on previously published ones, with adaptations^{11,14}.

To develop the App structure, an invitation was made for a teacher and a student from the Computer Science Department, a student of the master course in Dentistry, two undergraduate dental students, and a teacher from the School of Dentistry of the Federal University of Sergipe to participate in the project.

Face-to-face meetings occurred biweekly during fifteen months to discuss the progress and subsequent steps to achieve the App.

The content of the software was created by the researchers and addressed the study of radiographic anatomy in periapical radiographs from the files of the radiology course of the Federal University of Sergipe School of Dentistry. The description of each anatomic structure was based on a comprehensive survey in the available literature, conducted with the purpose of putting the researcher in direct contact with the state of the art of the theme¹⁵.

The principles of usability and accessibility were privileged in the App architecture. Usability is a synonym of the degree to which something is easy to use. If a product is easy to use, the user has larger productivity because learning is enhanced. Accessibility is the flexibility of access to functionalities of a given product or site. If a product is accessible, then it allows people with special needs caused by disability or limitation to use it for personal purposes¹⁶.

The computer science researchers created the coding of a web-based project management system (<https://gestao-odonto.herokuapp.com/>) for insertion of the content of the mobile App to meet the proposed goals. The tool was tested and

validated with stakeholders so that the results obtained with the use of the tool could be analyzed by users.

The answers of students were tabulated in the Microsoft Excel software version 2010 for 64-bit Windows (Microsoft Corporation, Redmond, WA, USA), and absolute and percentage frequencies were calculated. The Cronbach's alpha coefficient was used to evaluate the reliability of the questionnaires (Med Calc Corporation, Ostend, Belgium)¹⁷. To be reliable, the coefficient must have a value between 0.7 and 0.8^{18,19}.

3 RESULTS

The Cronbach's alpha coefficient was 0.730 for the satisfaction questionnaire and 0.770 for the usability questionnaire, indicating their reliability^{17,19}.

Regarding the evaluation of the satisfaction and usability metrics, 51 questionnaires were answered, being 30 (58.82%) of female students and 21 (41.18%) of male students. Their mean age was 23.84 years (SD \pm 3.81). As for the distribution of participants per semester, 27.45% were attending the 7th semester of the School of Dentistry, 15.69% the 8th, 13.72 the 6th, 13.72 the 5th, 9.8% the 10th, 9.8% had just graduated, 7.8% were attending the 4th semester, and 1.96% the 9th.

A high percentage of participants (96.06%) considered the APPOLO App very satisfactory. The majority of the participants (98.04%) believed the content available in the App was important. Regarding to the number of images, 64.69% of the students considered it satisfactory, and 29.5% very satisfactory, but 3.93% disagreed and considered it unsatisfactory. As for the quality of the images, 58.8% found it very satisfactory and 41.2% satisfactory. A proportion of 68.62% of the participants felt very motivated and 25.49% motivated to complement their study with this type of methodology. In contrast, 5.88% felt indifferent about this issue. As for the App structure and

appearance, 39.4% of the students considered them very good, 35.29% excellent, and 25.49% good. The majority (78.4%) of the participants said they absolutely would like to have access to these contents after graduated, and 84.3% believed to be very important to complement their professional training with this tool for digital learning.

Regarding usability, 66.66% of the students classified the handling of the App as very easy, 31.38% as easy, and 1.96% as very difficult. The access to the offered contents was described as easy by 51% and very easy by 49% of the students. In turn, the access to text information was considered very easy by 50.96% and easy by 47.04%; 1.96% of the students felt indifferent regarding this topic. About the exploration of the radiographs, 1.96% considered it difficult, 1.96% very difficult, 41.16% easy, and 1.96% very easy. Regarding the accessibility of the entire App, 60.78% judged it as excellent, 33.43% as very good, and 5.88% as good.

Among the main comments and suggestions offered by the students, 100% expressed commendations for the digital learning tool, 13.72% asked for more images per repair, 11.76% said that a zoom option for the radiographs is lacking, 9.80% suggested improvements in the design, 5.88% requested a change for a white background, 3.92% commented that an interesting option would be the inclusion of a quick search bar, and 1.96% suggested the insertion of a “home” button to return to the start page.

4 DISCUSSION

Smartphones and tablets have overcome computers and become the most used devices all over the world, mainly because of their greater portability and extensive connectivity network, which enable access to communication in practically any place². We observed that the population that participated in this study had wide access to cell phones and this characteristic is in

agreement with the scenario advocated by the authors, so that the use of APPOLO to support teaching is feasible in this reality. The results of this investigation are in accordance with the world panorama, as all the participants were mobile phone holders³.

In the context of education, technology has contributed to the development of knowledge, allowing to explore recurrent themes in an innovative and stimulating way¹⁵. An example of the use of technology to enhance learning is seen in the health area^{5,6}. Studies have shown that the use of information technology brings excellent results to learning⁸. Education should not be based only on the transmission of information from teacher to students, but rather on the construction of knowledge under the student/teacher dialectic and development of new competencies, something that could be achieved through the motivation of this generation employing the digital tools²⁰.

According to our study, 80% of the students spent four or more hours per day using mobile phones and 76% dedicated 2 to 8 hours every day to study using digital devices. The majority of the students who answered the questionnaires said they kept the mobile handset switched on while they are studying, use the Android operating system, and think that Apps could help in the teaching of radiology. These findings stress the importance of the proposition of the APPOLO tool as a teaching methodology. Technological innovation systems have positively interfered in education in the last decades, providing students and teachers with varied opportunities of knowledge propagation. In turn, this advent has prompted the need for higher education to develop digital mechanisms to adapt to the new teaching-learning process²¹. The APPOLO App proved to be practical, of easy understanding, navigation, and utilization, and represents a potential aid to support the teaching of radiology to dental students.

In the present investigation, the Cronbach's

alpha¹⁷ of the evaluation questionnaire was above 0.7 in all questions, indicating its reliability. The Cronbach's alpha coefficient is a measure of internal consistency between responses given by participants in a questionnaire through the analysis of their profile. It indicates how closely related a set of items is as a group²².

The literature shows other software similar to APPOLO that have been employed with the purpose of teaching and training in dentistry^{23,24,25}, such as RadioXstudy for teaching dental radiology and pathology, available in App stores. In the case of APPOLO, the web management tool and the presence of artificial intelligence in another version are traits that make it unique among other Apps available for the study of radiology.

The works in the dental area considered in the theoretical ground of this investigation report high levels of success resulting from the use of digital means - mostly intended for teaching radiology, anatomy, and dental morphology - when appropriately selected and applied^{20,21,26,27}. The present investigation endorses the literature in the sense that the proposed software was well accepted by 100% of the students¹³, who said to be very important to complement their learning with this teaching tool. This finding favors the insertion of digital content in the learning scenario of dentistry.

With regard to the App environment, all students approved the layout and the majority considered the available content as very important, confirming previous works^{13,28}. Other findings in the literature^{13,29,30} also demonstrate the positive evaluation of contents in virtual learning environments. Studies^{21,27,31} have shown that distance teaching is important for learning. Our present results support these studies because the use of the App, which can be considered a sort of distance learning tool, was evaluated as valuable.

Another study¹⁴ observed that there was some difficulty from the part of students to access the virtual learning environment, contrary to the

present investigation and others¹³. The accessibility of the App analyzed here was considered excellent. Our findings confirm study endpoints^{5,13,14,31,32} reporting excellent levels of satisfaction and usability. It is noteworthy that Santos et al. used a Virtual Learning Environment (VLE), what explained the low accessibility found in this case.

It is expected that the innovation brought by the inclusion of computational technologies in undergraduate training will support the teaching/learning process²⁷. As further investigation, we suggest the evaluation of the APPOLO App with respect to the enhancement in the students' gain of knowledge from the insertion of this complimentary methodology in the dental radiology course. The APPOLO App is in the beta phase, but the next version will include artificial intelligence, using the FUZZY network.

5 CONCLUSION

The software APPOLO was developed and evaluated in the present investigation. After the analysis of the questionnaires, wide acceptance by the participants was detected. They said the use of the App as a complimentary teaching methodology was feasible and relevant. We conclude that there was satisfaction among students about the content available in the App. This work confirms the importance to adapt contents to mobile devices, extending their use to information and education in health. Thus, regarding the concepts of satisfaction, usability, and accessibility, the investigation confirmed the absolute approval of the APPOLO App by students, who offered commendations in 100% of the evaluations. It is expected that this work will serve as a reference for the creation of other Apps for the teaching not only of dentistry courses, but those in many other sciences.

RESUMO

Desenvolvimento e avaliação de aplicativo móvel para ensino de Radiologia Odontológica

Este estudo teve como objetivo desenvolver e avaliar um aplicativo para smartphone com uma ferramenta de gerenciamento de conteúdo da web para o estudo da anatomia radiográfica periapical. Atividades de Design Thinking foram realizadas para melhor compreender o problema proposto pelo grupo de pesquisa. Em seguida, foi realizada uma pesquisa exploratória via Google Forms com 44 estudantes de Odontologia, aplicando-se um questionário para auxiliar no desenvolvimento de um aplicativo para ensino de Radiologia. Com o aplicativo na versão inicial, beta, foram aplicados questionários de satisfação e usabilidade com 51 alunos do curso de graduação em Odontologia, para avaliação do App. O coeficiente alfa de Cronbach foi aplicado a esses questionários e valores acima de 0,7 foram obtidos, demonstrando sua confiabilidade. Na avaliação do aplicativo, denominado APPOLO, que significa “App of learning online”, 98,04% dos alunos afirmaram que o conteúdo disponível era certamente importante. A quantidade de imagens foi considerada entre satisfatórias e muito satisfatórias por 94,19% dos participantes e 100% deles julgaram a qualidade das imagens também satisfatória ou muito satisfatória. A maioria dos participantes (94,11%) sentiu-se motivada em complementar seu estudo com esse tipo de metodologia. Quanto a usabilidade do aplicativo, 98,04% classificaram entre fácil e muito fácil o seu manuseio, 100% o acesso aos conteúdos ofertados e 98% o acesso aos textos, seguindo essa mesma métrica. O aplicativo APPOLO demonstrou ser prático, de fácil entendimento, navegação e utilização, e revelou auxiliar no apoio ao ensino dos alunos da disciplina de Radiologia Odontológica.

Descritores: Radiologia. Educação. Distância. Odontologia. Smartphone.

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Correspondence to:

Francielle Santos de Santana
e-mail: francielle26@yahoo.com.br
Rua Cláudio Batista – Palestina
49060-108 Aracaju/SE Brazil