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Usability and utility evaluation of an application for dentists and dental students to manage dental injuries

Allan Abuabara[1]
0000-0003-2454-3360

Thais Vilalba Paniagua Machado do Nascimento[2]
0009-0008-2624-3445

Ludmylla Gomes de Lima[1]
0009-0001-1659-4814

Mariana de Oliveira Espindola[1]
0009-0002-0591-3506

Cristiano Miranda de Araújo[2]
0000-0003-1325-4248

Flares Baratto-Filho[1,2]
0000-0002-5649-7234

[1]1Universidade da Região de Joinville (Univille), Joinville, Santa Catarina, Brasil.
[2]Universidade Tuiuti do Paraná (UTP), Curitiba, Paraná, Brasil.

Correspondence:
Flares Baratto-Filho
E-mail: fbaratto1@gmail.com

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Abstract This study aimed to apply usability and utility tests to the Dental Trauma application (app), available for free in Portuguese on the App Store and Play Store. Students and dentists participated in the study (n = 20). The System Usability Scale (SUS) test was used for usability analysis, and the Technology Acceptance Model (TAM) test, adapted to the dental trauma context, was used for utility analysis. The Mann-Whitney test was applied to compare SUS scores between students and dentists, and the Spearman test was used to correlate utility questions. The SUS score at the 50th percentile was 83.75. Scores above 68 are classified as acceptable. The Mann-Whitney test did not show a significant difference in the SUS score when analyzing dentists and dental students separately (p = 0.442). The app was widely evaluated as useful (95% to 100%), with robust, positive, and significant correlations observed between responses to each question. However, it does not cover traumas in deciduous teeth, presenting an opportunity for updating or developing other apps. The Dental Trauma app fulfilled both usability and usefulness criteria, garnering an "excellent" rating in its outcomes. Users acknowledged its utility as a valuable technological tool aiding professionals in diagnosis, management, and comprehension of dental trauma-related concepts.
Descriptors: Education, Dental, Continuing. Tooth Injuries. Diagnosis. Mobile Applications. Dental Informatics.

Evaluación de usabilidad y utilidad de una aplicación para odontólogos y estudiantes de odontología en el manejo de traumatismos dentales

Resumen
El objetivo de este estudio fue aplicar pruebas de usabilidad y utilidad a la aplicación (app) Dental Trauma, disponible de forma gratuita en portugués en App Store y Play Store. Participaron en el estudio estudiantes de odontología y Odontólogos (n = 20). Se utilizó la Escala de Usabilidad del Sistema (*System Usability Scale* - SUS) para el análisis de usabilidad y el Modelo de Aceptación de Tecnología (TAM), adaptado al contexto de la investigación, para el análisis de utilidad. Se aplicó la prueba de Mann-Whitney para comparar los puntajes SUS entre estudiantes y dentistas, y la prueba de Spearman para correlacionar preguntas de utilidad. El puntaje SUS en el percentil 50 fue de 83,75. Los puntajes por encima de 68 se clasifican como aceptables. La prueba de Mann-Whitney no mostró una diferencia significativa en el puntaje SUS al analizar por separado a los Odontólogos y estudiantes de odontología (p = 0,442). La aplicación fue ampliamente evaluada como útil (95% a 100%), observándose correlaciones robustas, positivas y significativas entre las respuestas a cada pregunta. Sin embargo, no aborda traumas en dientes deciduos, lo que representa una oportunidad para actualizar o desarrollar otras aplicaciones. La app Dental Trauma cumplió con los requisitos de usabilidad y utilidad, logrando resultados calificados como “excelentes”. Los usuarios reconocieron que se trata de una tecnología útil que puede ayudar a los profesionales en el diagnóstico y manejo y en la comprensión de conceptos relacionados con el traumatismo dental.
Descriptores: Educación Continua en Odontología. Traumatismos de los Dientes. Diagnóstico. Aplicaciones Móviles. Informática Odontológica.

Avaliação da usabilidade e utilidade de um aplicativo sobre traumatismos dentários para cirurgiões-dentistas e estudantes de Odontologia

Resumo O objetivo deste estudo foi avaliar a usabilidade e a utilidade do aplicativo (app) Dental Trauma, disponível gratuitamente e em português nas lojas App Store e Play Store. Participaram do estudo estudantes de Odontologia e Cirurgiões-dentistas (CDs) (n = 20). Utilizou-se o teste de Escala de Usabilidade do Sistema (*System Usability Scale* - SUS) para análise da usabilidade e o teste de Aceitação de Tecnologia (*Technology Acceptance Model* - TAM) adaptado ao contexto da pesquisa para a análise da utilidade. Foi aplicado o teste de Mann-Whitney para comparar o escore SUS entre estudantes e CDs e o teste de Spearman para correlacionar as questões da utilidade. A pontuação SUS no percentil 50 foi de 83,75. Valores acima de 68 são classificados como aceitáveis. O teste de Mann-Whitney não evidenciou diferença significativa na pontuação SUS ao analisar separadamente CDs e estudantes de Odontologia (p = 0,442). O app foi amplamente avaliado como útil (95% a 100%), sendo observadas correlações robustas, positivas e significas entre as respostas para cada questão. O app não contempla traumatismos em dentes decíduos, sendo uma oportunidade de atualização ou desenvolvimento de outros apps. O app Dental Trauma atendeu aos requisitos de usabilidade e utilidade, alcançando resultados classificados como "excelente". Os usuários reconheceram se tratar de uma tecnologia útil que pode auxiliar o profissional no diagnóstico e conduta e na compreensão dos conceitos relacionados ao traumatismo dentário.
Descritores: Educação Continuada em Odontologia. Traumatismos Dentários. Diagnóstico. Aplicativos Móveis. Informática Odontológica.

INTRODUCTION

The actual availability of mobile devices, such as smartphones and tablets, as well as internet access have changed the way people interact and acquire knowledge. It is estimated that 242 million cell phones are currently in use in Brazil, which has just over 203 million inhabitants[1]. Through these devices, it is possible to access academic content, replacing print books by e-books[2]. Health areas including dentistry follow this trend. The increasing use of applications (apps) in this area offers opportunities for undergraduates, professors, dentists and patients to integrate this technology into clinical practice and teaching[2,3].

Dental trauma is recognized by the Ministry of Health as a public health problem in Brazil due to its high prevalence in children and adolescents, with a likely psychosocial and quality of life impact[4]. In a systematic review and meta-analysis study with a sample of 40,194 children and teenagers in Brazil, dental trauma prevalence reached 21% in permanent teeth, and 35% in primary teeth[5]. In a global view, a prevalence of 15.2% in permanent dentition and 22.7% in primary dentition is estimated, which means one of the five most frequent dental injuries in the world[6].

Dental trauma events cause stress, fear and anxiety in patients and their families, requiring from professionals a quick and accurate response, which can also count on app assistance. Following a search carried out on May 24, 2023 in the Google (Google LLC, Mountain View, California, United States) and Apple (Apple Inc, Cupertino, CA, United States) app stores, using a series of keywords equivalent to the term 'dental trauma', beyond 'dentistry' and 'endodontics', 236 apps were found. Among them, only one (called ToothSOS), in English, had the purpose to assist professionals in cases of dental trauma. The other apps were related to dental news, practice management, games, shopping, equipment and dental plans. In a wide systematic search using terms in English, Spanish and Portuguese, other authors initially found 486 apps, but only 13 met the criteria for relevance to the context of dental trauma[7]. Among them, 4 apps had dentists and patients as their target audience; 4 apps were aimed exclusively at professionals; and 4 apps were available in Portuguese[7]. The authors observed variation in content, images and illustrations availability, and classification. Most of them (61.5%) did not address prevention aspects[7]. These findings indicate opportunities for innovation and the need for more studies on new technologies in the clinical and dental teaching environments.

Thus, the Dental Trauma free app was developed and launched in January 2023, available in Portuguese on the App Store and Play Store. The app has a horizontal menu at the bottom where we can navigate through 4 tabs. In the first tab, we find app general information. In the second tab, there is an area containing buttons for professionals and patients avulsion cases, another area for diagnosis and management of fractures, and another area with guidance on soft tissue injuries. Still in the second tab, there is a questionnaire aimed at supporting tissue trauma cases. After responding, the app suggests the diagnosis and course of action. Third tab contains the classification of events, where their descriptive content and images can be accessed. Fourth tab includes information about the app creators. The app also provides description, characteristics, management, prognosis and images of the trauma. The app provided traumatic dental injuries real cases images whenever possible. It was developed by professors and researchers and followed the Guidelines of the International Association of Dental Traumatology[8]. This study aims to evaluate the usability and usefulness of the Dental Trauma app.

METHODS

This study was approved by the Research Ethics Committee of the Joinville Region University (UNIVILLE - Universidade da Região de Joinville), with certificate (CAAE - Certificado de Apresentação de Apreciação Ética) number 69869223.0.0000.5366, and was carried out in accordance with the guidelines established by the National Health Council in Resolutions nº 466 /12[9] and nº 510/2016[10].

The study included 20 participants who were part of the dental clinic of the Univille Dental School in Joinville, SC, Brazil (n=20). Among them, 14 were undergraduate students in the sixth or seventh semester of the Dentistry course, and 6 were dentists with different specialties. All participants were over 18 years old, accepted the conditions set out in a consent form (TCLE - Termo de Consentimento Livre e Esclarecido) and were willing to install the app on their mobiles for testing it. The sample size estimate was obtained following previous studies[3,11-13].

The Dental Trauma app (registered Crescendo Estruturas Avançados Ltda, Curitiba, PR, Brazil) was installed on each participant 's cell phone. The most recent version at the time of this research was used (version 1.4, dated May 2023). Figure 1 exhibits some of the app screens. The sample characterization included data on age, gender, smartphone operating system and previous experience using mobile app. Participants completed Google Forms questionnaires between August and October 2023. All participants agreed to the consent form (TCLE) provided during the introduction of the research and before answering the questionnaires. After accepting the terms, participants accessed the electronic questionnaire, which was displayed on a single screen, divided into three parts: sample characterization data, usability and usefulness. Only participants who completed the questionnaire and sent their answers were considered in the study.

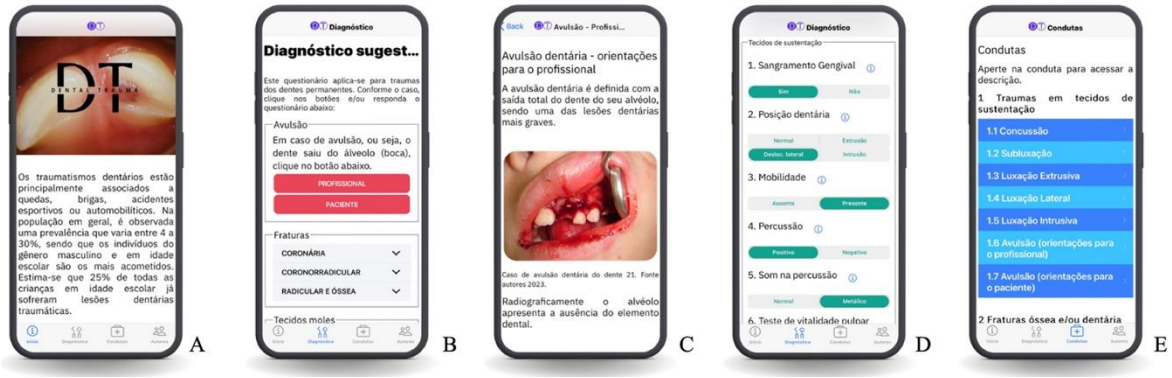

Figure 1. A (home screen – first tab), B (second tab, exhibiting the links to avulsion content), C (avulsion image and description), D (questionnaire intended for cases of trauma to supporting tissues), E (third tab – list of possible events).

After freely using the app during a period of 30 days, Dentistry students and dentists were invited to answer two questionnaires: the usability test (System Usability Scale - SUS)[14] and the utility test based on the Davis Technology Acceptance Model (TAM)[15], this latter adapted in the context of dental trauma. The questionnaires were available for 90 days for participants to respond.

The SUS usability test is a pre-formatted model to verify the usability of systems[11]. The questionnaire consists of 10 questions, each with 5 options that follow a 5-point Likert scale (from 1, I totally disagree, to 5, I totally agree and 3, I don't care). Participants shall rate each question from 1 to 5. For each of the odd-numbered questions (1, 3, 5, 7, 9), the value 1 is subtracted from the score obtained, as such questions are formulated in a positive way (for example, "I think I would like to use the system frequently"). For each of the even questions (2, 4, 6, 8, 10), the value 5 is subtracted, as these questions are formulated negatively (for example, "I found the system unnecessarily complex"). These new values are added together to obtain the total score. This value is then multiplied by 2.5, converting the original scores from a scale of 0-40 to 0-100. SUS-test scores are not percentages, although they return values between 0 and 100[14]. The outcomes were assessed at the 50th percentile and classified according to the rankings of Bangor et al. (2009)[16] and Lewis and Sauro (2018)[17]. The original SUS is a binary test, being 'acceptable' if the score is equal to or greater than 68, and 'unacceptable' if the score is below 68. The ranking by Bangor et al. (2009)[16] varies between "worst imaginable" (0-25), "bad" (26-39), "acceptable" (40-52), "good" (53-74), "excellent" (75-85), "best imaginable" (86-100). The classification by Lewis and Sauro (2018)[17] is carried out by letters as follows: F (0-51.6), D (51.7-62.6), C- (62.7-64.9), C (65.0-71.0), C+ (71.1 -72.5), B- (72.6-74.0), B (74.1-77.1), B+ (77.2 -78.8), A- (78.9-80.7), A (80.8-84.0) and A+ (84.1-100). The classifications by Bangor et al. (2009)[16] and Lewis and Sauro (2018)[17] allow for a greater number of classifications of results, allowing future comparisons with similar studies considering that the SUS is a binary test (acceptable/unacceptable). The Mann-Whitney statistical test was performed to compare SUS scores between dental students and dentists. For the utility test, descriptive statistics and Spearman's test were applied to correlate the questions. A 5% significance level was considered for both analyses.

Data extraction was performed in Google Sheets. Analyzes were performed using Jamovi v.2.3.17 software (http://www.jamovi.org).

RESULTS

Table 1 presents data from participants who underwent usability and usefulness tests after using the Dental Trauma app. A total of 14 undergraduate dental students and 6 dentists (n = 20) participated in the tests. All participants stated that they had already used apps other than the Dental Trauma app for educational or professional purposes. The average age of dentists and students was 39 ± 14 and 23 ± 3 years, respectively. The overall average age was 28 years ± 11 years.

The results of the usability test (SUS) are presented in Table 2. The SUS score in the 50th percentile is 83.75. Scores above 68 are classified as acceptable. Table 2 also contains the scores according to the ranking proposed by Bangor et al. (2009)[16] and Lewis and Sauro (2018)[17]. The Mann-Whitney test did not show a significant difference in the SUS score when analyzing dentists and undergraduates separately ($p = 0.442$).

Table 3 presents the answers to the usefulness assessment test. When grouping the positive answers ("totally agree" and "agree"), we frequently observed that the evaluation of the app is useful, reaching a range of 95% to 100% of participants.

Table 4 presents the Spearman correlation analysis for the usefulness assessment test. We observed statistically significant associations between Q1 and Q2; Q1 and Q4; Q2 and Q3; Q2 and Q4; Q2 and Q5; Q3 and Q4; Q3 and Q5; Q4 and Q5 ($p < 0.05$).

Table 1. Sample characterization.

Variables	Undergraduates		Dentists		Total	
Participants	14	70%	6	30%	20	100%
Prior use of apps for professional or educational purposes	14	70%	6	30%	20	100%
Android devices	3	15%	1	5%	4	20%
iOS devices	11	55%	5	25%	16	80%
Age (mean ± SD)	23 ± 3		39 ± 14		28 ± 11	

Table 2. System Usability Scale test results.

Groups	SUS score at the 50th percentile	SUS's ratings	Bangor et al.'s ratings[16]	Lewis & Sauro's ratings[17]
Undergraduates	80.00	Acceptable	Excellent	A-
Dentists	87.50	Acceptable	Best imaginable	A+
Total	83.75	Acceptable	Excellent	A

Table 3. Usefulness test results.

Questions	Undergraduates		Dentists		Total	
Q1 - The app can help dentists in making decisions during dental care.						
1. Totally agree	9	64%	4	67%	13	65%
2. Agree	4	29%	2	33%	6	30%
3. Neutral	1	7%	-	-	1	5%
4. Disagree	-	-	-	-	-	-
5. Totally disagree	-	-	-	-	-	-
Q2 - The app can assist in diagnosing dental trauma and choosing treatment.						
1. Totally agree	11	79%	3	50%	14	70%
2. Agree	3	21%	3	50%	6	30%
3. Neutral	-	-	-	-	-	-
4. Disagree	-	-	-	-	-	-
5. Totally disagree	-	-	-	-	-	-
Q3 - I believe that the app can help undergraduate dentistry students learn.						
1. Totally agree	11	79%	4	67%	15	75%
2. Agree	3	21%	2	33%	5	25%
3. Neutral	-	-	-	-	-	-
4. Disagree	-	-	-	-	-	-
5. Totally disagree	-	-	-	-	-	-
Q4 - I consider the app to be a useful technology for diagnosing and treating dental trauma.						
1. Totally agree	10	71%	3	50%	13	65%
2. Agree	4	29%	2	33%	6	30%
3. Neutral	-	-	-	-	-	-
4. Disagree	-	-	1	17%	1	5%
5. Totally disagree	-	-	-	-	-	-
Q5 - The app helped me better understand the concepts related to diagnosis and conduction in situations of dental trauma.						
1. Totally agree	9	64%	2	33%	11	55%
2. Agree	5	36%	3	50%	8	40%
3. Neutral	-	-	1	17%	1	5%
4. Disagree	-	-	-	-	-	-
5. Totally disagree	-	-	-	-	-	-

Table 4. Spearman correlation analysis for the usefulness assessment test.

Question		Q1	Q2	Q3	Q4	Q5
Q1	Spearman	—				
	p-value	—				
Q2	Spearman	0.678*	—			
	p-value	0.001	—			
Q3	Spearman	0.263	0.630*	—		
	p-value	0.262	0.003	—		
Q4	Spearman	0.708*	0.893*	0.574*	—	
	p-value	< 0.001	< 0.001	0.008	—	
Q5	Spearman	0.434	0.743*	0.570*	0.619*	—
	p-value	0.056	< 0.001	0.009	0.004	—

Q1 - The app can help the dentist in making decisions during dental care. Q2 - The app can assist in diagnosing dental trauma and choosing treatment. Q3 - I believe that the app can help undergraduate dentistry students learn. Q4 - I consider the app to be a useful technology for diagnosing and treating dental trauma. Q5 - The app helped me better understand the concepts related to diagnosis and management related to dental trauma. * p < 0,05

DISCUSSION

Information and communication technologies related to the health sector are being widely used by practitioners and patients, and allow them to collaborate with the evolution and improvement of health practitioners[18]. One contributing factor to this advancement is the utilization of frameworks. These frameworks comprise a collection of libraries designed to cater to various functionalities and structures essential for app development. They facilitate development and programming, enabling individuals with limited knowledge of programming languages to engage in a swift learning curve. Still, there are many opportunities for innovation in the dental field due to the few options of apps available to practitioners[7]. Therefore, we believe in an emerging trend for dental care apps in the coming years.

Practitioners and students should ask themselves which characteristics would identify a good app in the health area. There is still not a robust questionnaire to understand and evaluate the different dimensions of mobile apps in health area[19]. In this study, usability and usefulness were evaluated. Usability determines whether the product is quick to learn and easy to use, difficult to forget, does not cause operational errors, offers a high degree of satisfaction to its users and efficiently solves the tasks for which it was designed[20]. The SUS was conceived as quick and dirty, that is, a superficial assessment instrument, which aims to quickly identify possible inconsistencies in the system[21]. If additional detailed identification is needed, other instruments and methods shall be used[21]. Usability tests are performed by users and not by analysts. In this way, it is possible to identify how software's functionalities are used by users aiming to identify in which parts they have greater difficulty interacting. Usefulness test quantifies the degree of usefulness perceived by users of a given app[15], contributing to its holistic assessment. Both usability and usefulness tests are classified as black box, that is, the external part of the software is evaluated, the way it works and whether it is working properly. There are also other tests, among which accuracy, performance, security and integration are evaluated, and which were not the subject of this study.

There is controversy in the literature regarding the influence of the operating system used and the results of usability tests. Some studies found such a relationship[22], while others did not[23]. Both Google's Android and Apple's iOS have their own user interface guidelines which shall be followed by developers when launching their apps, thus, this aspect should be discussed in studies. In the present study, 80% of users used the iOS operating system and only 20% Android. Due to this divergence, this variable was not included in the analysis, therefore, results shall be evaluated with caution. Even so, the average SUS score for Android users is noteworthy, which was 73.12 (± 13.75), while for iOS users it reached 83.90 (± 12.91).

The Spearman correlation analysis for the the utility test questions (Table 4) indicated statistically significant associations between the pairs of questions Q1 and Q2, Q1 and Q4, Q2 and Q3, Q2 and Q4, Q2 and Q5, Q3 and Q4, Q3 and Q5, Q4 and Q5, suggesting a consistent and significant relationship between the variables:

Responding that the app can help dentists in decision-making (Q1) is associated with agreement that the ap can help in the diagnosis of dental trauma (Q2);

Responding that the app can help dentists in decision-making (Q1) is associated with agreement that the app is a useful technology for diagnosing and treating dental trauma (Q4);

Responding that the app can help in the diagnosis of dental trauma (Q2) is associated with the agreement that the app can help undergraduate dentistry students learn (Q3);

Responding that the app can help in the diagnosis of dental trauma (Q2) is associated with agreement that the app is a useful technology for diagnosing and treating dental trauma (Q4);

Responding that the app can help in the diagnosis of dental trauma (Q2) is associated with agreement that the app helped to better understand the concepts related to diagnoses and conduction in situations of dental trauma (Q5);

Responding that the app can help undergraduate dentistry students learn (Q3) is associated with agreement that the app is a useful technology for diagnosing and treating dental trauma (Q4);

Responding that the app can help undergraduate dentistry students learn (Q3) is associated with agreement that the app helped to better understand the concepts related to diagnoses and conduction in situations of dental trauma (Q5); and

Responding that the app is a useful technology for diagnosing and treating cases of dental trauma (Q4) is associated with agreeing that the app helped to better understand the concepts related to diagnoses and conduction in situations of dental trauma (Q5).

These results reinforce the app's perceived usefulness among the participants. With regard to teaching, we highlight the consistent and significant relationship between questions Q5 and Q3, which address the understanding of concepts and learning, respectively.

The increased utilization of technologies can enhance the skills of dentistry students through continuous dental education, assignments, formative assessments, case descriptions, and treatment modalities[24]. Studies have shown that the use of Kahoot!, for example, a tool used in game-based learning, improved final grades in medical education disciplines[25,26]. A study conducted with dental students in Turkey concluded that they are eager and willing to utilize mobile technologies in the teaching process[27]. This is a group that spends an average of 4.49 hours per day on the internet and is familiar with using apps in the learning process[27]. The favorite apps among students were WhatsApp, YouTube, Dental-lite (anatomical models), foreign language learning, and Atlas of Anatomy[27]. Even though these resources and technologies are not formally present in the curricula, such students already use them for their education[28]. This could represent an opportunity for professors to design methods, activities, and educational materials suitable for smartphones, enabling students to use this technology and accommodating different learning approaches[28].

Most apps about dental trauma cover content specific to permanent dentition and do not include material on prevention[7]. Dental Trauma followed this pattern. The app does not contain information about trauma to primary teeth nor does it provide guidance on how to prevent it, being an opportunity to update or new app development. In a survey carried out on November 28, 2014, only 7 relevant apps on dental trauma were identified, of which only one had exclusive content for dentists[29]. Almost 6 years later, in a survey carried out by different authors, on July 19, 2020, only 13 relevant apps were found, of which 4 were exclusive to dentists[7]. In addition to the possibilities of new apps, we highlight the need to evaluate them in terms of usability, usefulness, reliability and accuracy, when applicable, from the point of view of students, practitioners or patients, according to the target audience.

The results of the usability and usefulness tests were very favorable for the Dental Trauma application. However, one of the limitations of this study was that it was carried out in a single center and with a small number of participants. This limitation is mitigated by the fact that the SUS test can be used with small samples (8 to 12 users), allowing for a good assessment of how the system is perceived[12]. Some of the authors are also developers of the app here evaluated, therefore, other authors were invited to participate in the study. We believe that innovation through the inclusion of computational technologies in undergraduate training supports the teaching and learning process[2]. As additional research, we suggest evaluating the Dental Trauma app with regard to improvement and effectiveness in students' learning by including it as a complementary methodology in the Dentistry course and comparing it to other apps and methodologies.

CONCLUSION

The Dental Trauma app met the usability and usefulness requirements, obtaining results classified as excellent. Users recognized that it is a useful technology that can assist professionals in understanding concepts, diagnosing and managing dental trauma.

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