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Mobile learning platform for undergraduate medical students: a hands-on approach to infectious diseases education

Plataforma Móvel de Aprendizado para Estudantes de Medicina: Uma Abordagem Prática para a Educação em Doenças Infecciosas

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***Abstract**: The rapid progression of technology within the healthcare sector has markedly influenced medical education in a positive manner. The extensive adoption of digital resources, particularly accentuated during the Covid-19 pandemic, has spurred the development of innovative means to impart education through digital platforms, catering to both hybrid and distance learning. This study aimed to create a mobile educational support platform specifically tailored for undergraduate medical education in Infectious Diseases. An assessment of the platform's applicability, usability, impact on educational facilitation, and user satisfaction was conducted. Employing a quantitative, experimental, and descriptive approach, 42 fourth-semester medical students at Christus University Center (Unichristus) participated in evaluating the platform's effectiveness through questionnaires, particularly gauging its influence across various educational scenarios and user satisfaction levels. The System Usability Scale (SUS) was applied to measure effectiveness, resulting in an SUS score of 84.64 with a standard deviation of 13.8. The statistical analysis, specifically a significant Spearman correlation ($p<0.05$), underscored the platform's efficacy. In summary, the mobile platform dedicated to Infectious Diseases exhibited commendable acceptability and user-friendly attributes, presenting itself as a viable and effective alternative in undergraduate medical education.*

***Keywords**: Medical Teaching. Mobile Apps. Infectious Diseases.*

***Resumo**: A rápida progressão da tecnologia no setor de saúde influenciou de maneira significativa a educação médica de maneira positiva. A ampla adoção de recursos digitais, especialmente destacada durante a pandemia de Covid-19, estimulou o desenvolvimento de meios inovadores para fornecer educação por meio de plataformas digitais, atendendo tanto à aprendizagem híbrida quanto à distância. Este estudo teve como objetivo criar uma plataforma móvel de apoio educacional especialmente projetada para a educação médica de graduação em Doenças Infecciosas. Foi realizada uma avaliação da aplicabilidade da plataforma, usabilidade, impacto na facilitação educacional e satisfação do usuário. Utilizando uma abordagem quantitativa, experimental e descritiva, 42 estudantes de medicina do quarto semestre da Universidade Christus Center (Unichristus) participaram da avaliação da eficácia da plataforma por meio de questionários, especialmente avaliando sua influência em vários cenários educacionais e níveis de satisfação do usuário. A Escala de Usabilidade do Sistema (SUS) foi aplicada para medir a eficácia, resultando em uma pontuação SUS de 84,64 com um desvio padrão de 13,8. A análise estatística, especificamente uma correlação de Spearman significativa (p <0,05), destacou a eficácia da plataforma. Em resumo, a plataforma móvel dedicada a Doenças Infecciosas apresentou aceitabilidade louvável e atributos amigáveis ao usuário, apresentando-se como uma alternativa viável e eficaz na educação médica de graduação.*

***Palavras-chave**: Educação Médica, Aplicações Móveis, Infectologia.*

1. Introduction

The medical education worldwide is undergoing a moment of profound transformation, requiring adaptation from both the faculty and students to teaching methodologies directly linked to digital tools. The association between digital technologies and active methodologies that promote student autonomy, and the development of reflective critical thinking implies new challenges in the context of education during the Covid-19 pandemic. The use of digital tools such as digital platforms and remote access were some widely used strategies (SILVA et al., 2022). Technologies may be integrated into a context of virtual, augmented reality, or mixed reality, favoring omni-learning, a concept defined as the ability to learn anywhere, anytime, with anyone (PEARS et al., 2020). Current learners have grown up immersed in technology, being less productive in traditional teaching scenarios (MORAN, 2018).

Progression of new technologies and internet accessibility highlights a new form of education because access to information is broader and more advanced, emphasizing the need for new ways of learning and teaching (SCHMITZ et al., 2016). The learning process requires innovative teaching approaches, as flipped classroom, that aims to capture the attention of learners and generate teacher-student interaction during classes. This contributes to the student's enthusiasm, success, and interest, promoting the development of their learning, which is related to manifestations employed in their individual behavior (WEI, 2021).

There is also a need to adapt research methods to keep up with the new reality, with changes in the transmission of content and to keep students interested (CORDATO et al., 2023). It is worth noting the transition of basic sciences, health system sciences, and behavioral sciences content to online platforms, with group meetings and updates to online content during pandemic. Medical education has changed and evolved over the years and has been significantly influenced by technological advancements (ROSE, 2020; MARKOWITZ, 2018). According to the National Curricular Guidelines (DCN), medical education should be

critical, reflective, ethical, humanistic, and transformative. This is to be translated through the integration of knowledge, skills, and attitudes in the areas of competence in healthcare, management, and health education (SILVA et al., 2022).

Considering the new "Information and Communication Digital Technologies" (ICDT), there are various tools for health education, whether in undergraduate or postgraduate programs. These tools can create space and motivation for the construction of knowledge in education and health promotion (GERMANI, 2013). Learning involves the use of new technologies with updates in the curriculum. In the process of study and learning, investigative habits are required to enhance the formation of lifelong learners, integrate science and healthcare, and create new experiences during the provision of care. This ensures the preparation of future doctors who are updated and capable of managing studies and healthcare (SKOCHELAK, STACK, 2017).

According to Carabetta Júnior, learning should be active, involving interactions between students and dialogues with teachers, colleagues, and various contents. This aims to build competencies and skills that should be part of the student's social and general knowledge (FRANÇA JUNIOR, MAKNAMARA, 2019). Distance Learning (DL) emerges as a strong tool for the development of cognitive mastery, enabling the sharing of information, conducting research, and theoretical deepening. It also reaffirms dominant values in current society, such as distinction and individualization (MACHADO et al., 2018). Within this context, there is remote teaching (RT), characterized using technologies to promote real-time or asynchronous education, simulating what would happen in a face-to-face classroom. In this context, the element is real, access is virtual, and the learning experience is legitimate (SIMÃO et al., 2013).

Infectious disease's themes are an area that requires assimilation of content, as topics are often broad and extensive, such as the subject of antimicrobials, reported by students as challenging. When encouraged to use new learning methods like team-based learning (TBL), which involves sending materials beforehand for problem-solving, a significant improvement in subject consolidation was observed. This reinforces the idea that new teaching methods should be encouraged (GUILARDE et al., 2022). The National Curricular Guidelines (DCNs) for undergraduate medical courses, published in 2014, advocate the use of active learning methodologies in medical education. Additionally, in medical education, technology presents itself as a promising option to meet needs and support the possibilities that arise in our current society, such as time and space flexibility, cost reduction, greater geographical reach, among others (VILAR et al., 2010).

Most medical schools have an extensive computerized network, which has evolved from a simple information tool to become a central component in the teaching and learning environment. Currently, in the academic environment of medical courses, there are various strategies involving the use of Information and Communication Digital Technologies (ICDT) to support students' knowledge construction. Examples include interactive virtual simulation, videoconferencing, virtual learning environments, research in databases, games, interactive animations, immersive virtual reality, and georeferencing software. All these strategies promote constructive teaching in medical education (MAGALHÃES et al., 2020).

A commonly mentioned belief is that, until recently, simulators used in the education of healthcare professionals were simple and somewhat inaccurate models. The historical development of simulators is presented in terms of their application in medical training. Simulators allow, to some extent, practical training without any inconvenience to patients, mainly intended for the instruction of laypeople (OWEN, 2012; BUCK GH, 1991).

Currently, it is observed that technology is increasingly encompassing all areas of the job market and studies, and medicine is no exception. In this perspective, the use of digital technologies and active methodologies in teaching medical processing and analysis can contribute significantly to medical practice, making it more efficient and dynamic (NASCIMENTO et al., 2021). Thus, it is worth noting the need for better adaptation of this practice to function and promote improved working conditions in the future job market. Furthermore, the enhancement of computer techniques that facilitate the efficiency of medical practice is advocated as the current model of medical education (NASCIMENTO et al., 2021). Indeed, teaching strategies that use digital resources are seen as a complementary form in the teaching-learning process, favoring self-instruction and the student's protagonism in their formative trajectory (SILVA et al., 2012). The objective of this study is to develop a mobile platform in Infectology for undergraduate medical students at the Centro Universitário Christus (Unichristus), enrolled in the fourth semester, called UNINFECTO, and evaluate its usability using the System Usability Scale (SUS) questionnaire to enhance knowledge.

2. Methods

This is a cross-sectional study with a descriptive design and a quantitative approach, adhering to ethical principles regulated by Resolution No. 466/12 of the National Health Council (2012). The research project was submitted to the Research Ethics Committee of Unichristus - Plataforma Brasil. It is emphasized that, in accordance with Resolution CNS No. 196/96, the guarantee of confidentiality, anonymity, and non-use of information to the detriment of individuals was fulfilled. There were no risks to the research subjects, and the data were used only for the purposes outlined in this study. Additionally, the benefits obtained through this study would be returned to the individuals and the community in which it was conducted.

The benefit involves the addition of a new didactic tool for teaching Infectology, evaluating the usability and satisfaction of students with this medium. It contributes to the creation of future platforms in different areas. The approval number from the Research Ethics Committee is 5.516.865, and the CAAE (Certificate of Presentation for Ethical Consideration) is 59309422.6.0000.5049.

The study population consisted of students in the fourth semester of the medical program at Centro Universitário Christus (Unichristus), specifically those enrolled in the Infectology discipline. Students who agreed to the Informed Consent Form (ICF) by signing it immediately were included, while those who did not complete the questionnaire in its entirety were excluded.

The first phase of the study involved the development of a platform to assist learning and support teaching in Infectology for undergraduate medical students. The interface can be quickly accessed through the link https://plataforma-uninfecto.firebaseapp.com/, which does not require a password or collect user data, thus respecting the General Data Protection Law (LGPD). The platform, named UNINFECTO and registered with the National Institute of Industrial Property (INPI), features folders with materials to contribute to students' education in this crucial area of study. It was designed to facilitate students' use and learning, including a Study Plan for a structured path, questions for practical exercises, tips/FlashCards for memorization, audio for convenient review, chapters, books, and articles for in-depth study, videos for a visual approach, and a platform assessment for user feed-

back. With this accessible organization, the platform aims to offer a comprehensive educational experience.

The multidisciplinary team responsible for the platform consisted of two medical doctors and professors in the field of infectology, three undergraduate medical students, a systems analyst, programmer, interface designer, and a biostatistician. The texts were developed by students and medical professionals. After literature review, they were digitized in collaboration with professionals from the Information Technology sector at Centro Universitário Christus (LIT). A bibliographic survey of topics to be covered in the chapters was conducted: overview, clinical manifestations, diagnosis, treatment, and prevention of the addressed themes. The search was carried out in Infectology books, articles from databases, and guidelines on the subject. Then, chapters were written, and an initial model was created to facilitate organization. This enabled a didactic planning of writing, teaching, and learning, with the aim of benefiting students.

The UNINFECTO Platform consists of chapters, each titled with the theme of the respective classes that will be addressed by the professors at Unichristus throughout the semester. This allows students to have a study mechanism before each class, with sections for "questions," "books and articles" in PDF format, "tips and flashcards," "videos" recorded by the guiding professors, and "audios," including a podcast for introduction and welcoming to those accessing the platform. This serves to instruct them about the materials that make up the platform, ensuring that the content can be worked on and learned in the best possible way (Figure 1).

In the second phase of the study, the platform was made available to students through communication apps, allowing them access and the possibility of usage one month before the assessment. To evaluate the usability of the platform, the System Usability Scale (SUS) was employed, which is a versatile instrument with easy administration and interpretation, and good reliability (KORTUM; BANGOR, 2013). In SUS, a score ranging from 1 to 5 is assigned, following the Likert scale, with the lowest score corresponding to "strongly disagree" and the highest to "strongly agree." The instrument was developed by Brooke in 1986 and is used in the evaluation of various products such as websites, hardware, and applications.

Figure 1. Main screen of the UNINFECTO platform

Source: Authors' own. Available at: https://plataforma-uninfecto.firebaseapp.com/

After the usage period, the infectology professors conducted a flipped classroom session with a discussion of clinical cases for a class of 100 students on the topic of antibiotic

therapy, with the class divided into 5 groups. At the end of the class, students were invited to fill out the questionnaire. The questionnaire was administered through a virtual form (Google Forms®), obtaining responses from 42 medical students at Centro Universitário Christus (Unichristus) who were users of the platform. After data collection, the data were organized, tabulated, and subjected to statistical analysis.

The data were tabulated in Microsoft Excel for Windows®, followed by export to the Statistical Package for the Social Sciences (SPSS), version 20.0 (IBM). A confidence interval of 95% was adopted, with a p-value less than 0.05 considered statistically significant. The SUS scale data were expressed as mean, standard deviation, absolute frequency, and percentage of each response. After that, they underwent internal consistency analysis through the calculation of Cronbach's alpha coefficient, and each item was correlated with the main SUS score through Spearman's correlation. After categorization into high and low usability (cut-off = 80), the data were associated with other student characteristics using Fisher's exact tests or Pearson's chi-square. Following the categorization of the SUS scale into below and above 80 points, there are two categories: low usability (<80) and high usability (>80).

3. Results

A total of 42 students participated in the questionnaire containing the System Usability Scale (SUS) after testing the platform during the infectious diseases topic in the fourth semester. Female respondents predominated, representing 78.6% of the participants, and the average age of the students was 24 years. It was observed that the majority of students did not have prior undergraduate degrees. Additionally, clinical cases were identified as the platform topic that most satisfied the students. The platform also had a significant impact on learning during theoretical classes (Table 1).

Table 1 - Data from two students who responded to the UNINFECTO platform questionnaire.

Variable	**n (%)**
Age (24.52±5.95)	
Under 20	16 (38.1%)
Above 20	26 (61.9%)
Sex	
Female	33 (78.6%)
Male	9 (21.4%)
Preview gradation	
No	30 (71.4%)
Yes	12 (28.6%)
SUS	
until 80	14 (33.3%)
>80	28 (66.7%)
Which topic of the mobile platform were you most satisfied with?	
Case discussion	22 (52.4%)
Chapters	10 (23.8%)

Tips	4 (9.5%)
Books and articles	6 (14.3%)
Do you consider that the mobile platform mainly impacted your learning in Infectious Diseases during this semester?	
Lectures	30 (71.4%)
Simulations	4 (9.5%)
Tutored classes	5 (11.9%)
Patient practice	3 (7.1%)

Data expressed in terms of absolute frequency and percentage. Source: Authors

Regarding the Usability Evaluation, Table 2 provides a summary of the analysis of questions based on the SUS scale to assess the system's ease of use. The results demonstrate that the application received a good usability evaluation, with an average SUS score of 84.6. Studies suggest that a minimum SUS average score of 70.0 is considered for a system to have a good level of usability (BANGOR, KORTUM, AND MILLER, 2009; SAURO AND LEWIS, 2012). Additionally, it can be stated with 95% confidence that the SUS score for this population falls between 80.3 and 88.9 (considering the obtained margin of error as 4.3).

Table 2 - Summary of the analysis on the Usability of the application (N = 42).

Variable	Value
Sample Size	42
Median score SUS	**84,6**
Confidence interval	80,3 – 88,9
Error	4,3
Confidence level	95%
Standard Deviation	13,8
Confiability	0,74

Source: Authors

To assess the reliability of the obtained data, the Cronbach's alpha coefficient was used (BONETT AND WRIGHT, 2015). The highest possible value for this coefficient is 1.00, with 0.70 considered the lower limit for acceptable internal reliability (SAURO, 2011). As observed in Table 2, the Cronbach's alpha coefficient obtained in this study was 0.74, indicating that the sample had a good level of reliability. There was a statistically significant result regarding SUS score values when comparing them with previous graduation, with a P-value of 0.030.

4. Discussion

The Uninfecto platform, according to information obtained in the statistical analysis, demonstrates a highly satisfactory and positive impact. As it falls within the range of 80 points in the SUS score, it can be concluded as good, exceeding the acceptable range (BANGOR et al., 2009). The SUS questionnaire, validated for Portuguese, has been previously used in various applications focused on patient assistance or information (ZBICK et al., 2015;

FARIA et al., 2021; HÄGGLUND & SCANDURRA, 2021), validating the appropriate analysis of the present study.

Distance learning programs, including electronic platforms and other information technologies, can offer unique, cost-effective, easily scalable, and valuable opportunities to expand access to medical training in developing countries. Web-based education proves didactic and introduces students to the fundamentals of the subject. This can be accomplished through recorded video lectures, PDF files, and web-based teaching materials that can be downloaded from respective institutions and used offline. Live video conferencing and in-person teaching will reinforce web-based didactic education through discussions of key points, as well as case- and problem-based teaching, with an emphasis on clinical application, as evidenced in the present study (DAWD, 2016).

The present study revealed a high level of agreement among evaluators regarding using the platform as a complementary tool in learning infectious diseases. Overall, students considered themselves confident in using the system in its entirety and were very satisfied, believing that the mobile platform had a considerable impact on learning infectious diseases. An article described the application of an active teaching strategy called "Four Corners" in an integrated Medicine and Infectious Diseases internship program at the University of São Paulo. Like this and other active teaching methods, such as flipped classrooms and gamified training, showed mixed results compared to traditional approaches. These learning strategies demonstrate greater acceptance and motivation by students, enhancing their ability to interact with peers and apply theoretical concepts in practical situations. It can be a useful tool to include extensive theoretical content in a short period and engage students in online teaching modalities. However, the successful implementation of active learning strategies requires a clear institutional approach and technical support for both students and teachers (HENRIQUES, 2021).

The topic that most satisfied users was clinical cases, and according to the students' responses, the platform had a significant impact on learning Infectology during lectures. This highlights the platform as an excellent ally in learning, providing versatility and ease of home access, both before and after lectures, facilitating the consolidation and review of content in a practical manner, anytime and anywhere with internet access.

Approaches to teaching basic sciences in medical schools are undergoing rapid changes. This study observed that Infectious Diseases learning sessions are associated with curricula moving away from traditional lectures, emphasizing more case-based training and laboratory work. Additionally, mentorship, scholarships, and conference participation positively influence the choice of this field. Recommendations from the Infectious Diseases Society of America (IDSA) suggest avoiding excessive use of PowerPoint lectures and multiple-choice tests, promoting long-term understanding over short-term memorization. Strategies such as real-time teaching, peer instruction in large groups, and small group discussions are suggested to enhance learning and rekindle interest in Infectious Diseases. The search for effective teaching platforms aligns with the goals of the Global Independent Commission for Education of Health Professionals (CERVANTES, 2020).

It's essential to note some limitations in the study, such as the limited number of participants and the scarcity of studies on the use of digital tools in infectious disease teaching, making it challenging to compare with other results. Furthermore, the impact of the Uninfecto platform could be further assessed through additional observational methodologies, such as cohorts or case-control studies, although these approaches may involve ethical considerations, logistical challenges, and higher financial costs (FRONTEIRA, 2013).

Improving medical education through the integration of cutting-edge technology in teaching, learning, and assessment is crucial. These activities are also strategies to stimulate greater interest among medical students in infectious diseases, which is essential given the need for expertise in this area. The shortage of infectious disease specialists has significant implications for combating threats like the global COVID-19 pandemic (CERVANTES, 2020). It is crucial to identify the challenges faced by medical students and interns as they progress in their medical training toward specialization in Infectious Diseases.

5. Conclusion

Health education has undergone significant modifications over time, especially with changes initiated by the COVID-19 pandemic, which facilitated the use of new teaching and learning methods through technological methodologies. Consequently, there has been an increased adoption of technologies to support student-centered teaching, providing practical and objective learning experiences.

The results reveal that the mobile platform UNINFECTO received extremely positive feedback from students and had a favorable impact on the teaching and learning process in Infectology, particularly highlighting its usability. These findings suggest that the platform not only met students' expectations but also proved to be a highly effective teaching tool in the context of medical sciences, especially in the critical field of Infectious Diseases, where its potential for enhancing learning stood out prominently. The integration of this platform into medical education can be seen as a promising strategy to promote a more solid and in-depth understanding of the complex and evolving topics in Infectology, thus equipping future generations of physicians with enhanced skills and updated knowledge to tackle global health challenges.

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