

BIOTEC: development and evaluation of a mobile application for biotechnology teaching

ABSTRACT

Biotechnology is a multidisciplinary-study area that has associated science and technology. Biotechnology issues and its products have affected people's lives, so that its approach gets essential at school. Thus, this study aims at developing and evaluating an educational application (app) for mobile devices with the main concepts and applications of biotechnology. So, a mixed-methods research was carried out. The instrument for data collection was a printed questionnaire, and a thematic analysis was the technique for data analysis and discussion. Thirty students from high school of a state public school in Santa Helena city - PB participated in this research. The developed app was named as BIOTEC, and it is designated in the Curricular Proposal of Paraíba State for High School. The results showed that the use of BIOTEC app, as a Biotechnology teaching and scientific dissemination tool, can contribute to the scientific, technological and citizen training of students.

KEYWORDS: Biotechnology; Teaching Biology; Digital technologies.

BIOTEC: desenvolvimento e avaliação de um aplicativo móvel para o ensino de biotecnologia

RESUMO

A Biotecnologia é uma área de estudo multidisciplinar que associa diretamente ciência e tecnologia. As questões biotecnológicas e seus produtos afetam a vida da população, o que torna sua abordagem indispensável na escola. Diante disso, o objetivo deste estudo foi desenvolver e avaliar um aplicativo educacional para dispositivos móveis com os principais conceitos e aplicações da Biotecnologia. Para tanto, realizou-se uma pesquisa que se utiliza de métodos mistos. O instrumento de coleta de dados foi o questionário impresso, e a análise temática foi a técnica para a análise e discussão dos dados. Participaram da pesquisa trinta estudantes do Ensino Médio de uma escola pública estadual da cidade de Santa Helena (PB). O aplicativo desenvolvido foi denominado BIOTEC, indicado, inclusive, na Proposta Curricular do Ensino Médio do estado da Paraíba. Os resultados demonstraram que o uso do aplicativo BIOTEC como ferramenta de ensino de Biotecnologia tem potencial para contribuir com a formação científica, tecnológica e cidadã dos estudantes.

PALAVRAS-CHAVE: Biotecnologia; Ensino de Biologia; Tecnologias digitais.

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INTRODUCTION

Biotechnology is an overarching and diverse area of study that encloses the application of scientific and technological knowledge, as well as generates impacts on several areas of society. Thus, this science has applied a lot of multidisciplinary knowledge to develop available products and processes or even to solve problems, using biological agents (organisms, cells, molecules) and its by-products (Bruno, 2014; Malajovich, 2016).

Biotechnologies have changed the population at different levels and ways, although many people are not well prepared to understand the implications of these technologies in their lives (Fonseca & Bobrowski, 2015). Therefore, it is extremely important to foster an appropriate and enlightening approach to Biotechnology in the school environment to enable better interaction among students with both basic and applied scientific research. This approach is crucial to allow critical decision-making by society regarding issues involving different biotechnological artifacts, such as vaccination or consumption of genetically modified foodstuff (Krasilchik, 2019).

According to the National Common Curricular Base (BNCC) for the Natural Sciences area and its Technologies, during High School period, Biotechnology is highlighted as conceptual knowledge that must be mobilized to develop specific skills related to the investigation of problem situations and evaluation of the applications and implications of scientific and technological knowledge. The application of recombinant DNA technology, use of stem cells, neurotechnologies, production of defense technologies, biological pest control and vaccination, for example, are mentioned in this document (Brasil, 2018). However, Lima and Marques-Santos (2022) highlight that “[...] despite biotechnological themes take part of the Elementary Education curriculum, they have been neglected in daily school life” of High School.

Based on these aspects, the use of educational applications (apps) emerges as an available alternative for teaching and disseminating Biotechnology at school, considering the potential of digital technologies for educational processes. However, according to Silveira and Cogo (2017), it is important to observe that the simple application of technology does not guarantee advances in learning. It is essential to implement pedagogical strategies that allow a critical and contextualized approach, as well as evaluate student's reality and encourage their autonomy and collaboration to improve some knowledge.

Nevertheless, the integration of digital technologies in teaching-learning process has become increasingly essential, considering that the use of mobile devices is an undeniable reality for the majority of Brazilian and global population. According to the Global System for Mobile Communications (GSMC), a global mobile telephony institution, there are nearly 5 billion mobile devices connected to internet. In the state of Paraíba, for example, the National Telecommunications Agency (ANATEL) reported almost 4 million accesses to network in February 2019 (Table 1).

Table 1

Access to personal mobile services in Paraíba state

Brazil	Access in february, 2018	Accesss (Variation) from january, 2019	Accesss (Variation) from february, 2018
Region Northeast	52,416.742	52,525.990	55,202.150
Paraíba	3,958.746	3,946.437	4,070.063

Source: ANATEL (2019).

During Mobile Learning Week, an event held in Paris, France, in 2013, the United Nations Educational, Scientific and Cultural Organization (UNESCO) recommended the use of smartphones to improve learning in the school environment. Thus, UNESCO launched a guide that has 13 relevant reasons to support this indication to adopt mobile technologies at school, which are mentioned below:

- 1) Expands the reach and equity of education;
- 2) Improves education in areas of conflict or that have suffered natural disasters;
- 3) Attends students with disabilities;
- 4) Optimizes time in the classroom;
- 5) Allows them to learn at anytime and anywhere;
- 6) Builds new learning communities;
- 7) Supports learning *in loco*;
- 8) Lets that formal and informal learning get closer;
- 9) Predicts immediate evaluation and feedback;
- 10) Facilitates personalized learning;
- 11) Improves continuous learning;
- 12) Improves communication;
- 13) Improves the cost-benefit ratio of education (UNESCO, 2014, p. 4).

Based on this perspective, in accordance with Martins *et al.* (2018, p. 3), the learning way by mobile devices, such as smartphones and tablets, is called “mobile learning or m-learning”. These terms are applied by the authors to describe a set of educational practices and activities developed using technological devices. Several research studies have stated that mobile technologies application at school had provided important pedagogical opportunities, based on the collaborative construction of knowledge, since it is open to students' experiences, prior knowledge, and it is especially effective in arousing their interest (Nagumo & Teles, 2016).

It is undeniable that the didactic application of mobile technologies, notably smartphones, offers several possibilities and opportunities, but it also has challenges that need to be addressed and overcome. Firstly, technological tools have significant pedagogical potential, which are able to promote an efficient dynamic along the teaching and learning processes. Digital technology allows users to interact not only with the object itself (the machine or tool), but also with information, content and its dimensions (Lemos, 2013).

On the other hand, according to Coll and Monereo (2010, p. 80), Digital Information and Communication Technologies are “[...] increasingly present in the school context to change teaching-learning processes, however, they can

foster changes on the teachers' pedagogical work". Therefore, it is essential that teachers dedicate themselves and receive adequate ongoing training to develop teaching methodologies that can include digital environment.

So, the pedagogical application of technological tools in educational processes becomes crucial, especially when approaching themes that involve the relationship among Science, Technology, Society and Environment (STSE), since there is a need, as Cavalcanti and Persechini (2011) pointed out to make knowledge accessible in a simplified way that addresses concerns and demands of the modern world. According to this perspective, the question that guided this research was: can a mobile app contribute to Biotechnology teaching in school environment?

DIGITAL TECHNOLOGIES AND BIOLOGY TEACHING

Quite often teachers see the Natural Sciences and Technologies curriculum as a list of content to be memorized in a way that is disconnected from reality. In particular, Science and Biology subjects sometimes do not call the students' interest due to the excessive application of technical and complex language (Queiroz & Leite, 2022). Brazilian educational scenario as well as elementary and high school curriculum structures have been discussed by Krasilchik (2019, p. 13), who stated that "Biology can be one of the most relevant subjects and worthy of students' attention, or one of the most insignificant and unattractive subjects, depending on what is taught and how it is done".

The content-based teaching model, focused on extensive memorization of information and a predominantly expository approach in the classroom, is not aligned with the demands of contemporary society. Many traditional teaching practices are no longer justified, resulting in wasted time and inadequate levels of learning and meaning for students. Consequently, this model tends to demotivate not only students, but also teachers (Duré *et al.*, 2021).

So, the specific role of the Biology teachers is mostly to arouse students' interest and develop their critical and intellectual ways of thinking regarding biological concepts and socio-scientific issues. Among these demands, there are those related to Biotechnology, such as, for example, the production of genetically modified products (transgenics) and impacts and ethical dilemmas present at the intersection among science, technology, society and the environment (Lima *et al.*, 2023).

Technological progress has expanded the science ranges as well as the access to information, although it can be less important memorization in learning. As a result, there is an increasing demand for skills such as creativity, communication, critical reflection, investigation and understanding interaction among knowledge, environment and society (Duré *et al.*, 2021). The fifth skill of the National Common Curricular Base (BNCC) is foreseen in general competence so that the student from Elementary Education must have: "understand, use and create digital information and communication technologies in a critical, meaningful, reflective and ethical way in many social practices, including school practices" (Brasil, 2018, p. 9).

In this scenario, mobile apps are valuable tools for Biology Teaching. And, according to Aguiar *et al.* (2022), there are several applications that can be applied as supports in teaching Biology content. These authors also highlight that it is evident that the areas most covered in studies on mobile apps are Cytology and Botany, which suggests some gaps in other areas of Biology, including Biotechnology.

So, this research aimed at developing and evaluating an educational application for mobile devices with the main concepts and applications of Biotechnology.

METHODOLOGY

This study was characterized as mixed methods research. In these models, there happens the transposition of “[...] quantitative and qualitative dichotomy, putting aside the idea of paradigmatic confrontation and focusing on methodological complementarity of research in empirical area” (Coutinho, 2018, p. 355).

A printed questionnaire was chosen to collect data, with seven opened questions and a closed one, including the application of the Likert scale. Thirty students from the three grades of high school at a state public school in Santa Helena (PB) city took part in this study.

The technique for analyzing and discussing the data was thematic analysis, which, in accordance with Gil (2018, p. 150), “[...] constitutes, therefore, a process that focuses on examining themes and analyzing relationships that exist between them.”

Among the activities developed during the research, there can be listed some:

- a) Development of the BIOTEC educational app, which covers Biotechnology concepts and applications. The application was created by the authors of this study from December 2018 to May 2019.
- b) Application of a questionnaire to students who took part in this research, before and after using BIOTEC app (Table 2).
- c) Implementation of a didactic sequence using BIOTEC app entitled as “Uncovering Biotechnology” (Table 3), prepared by the authors and applied to all students involved in this research. It aimed to evaluate the acceptance and effectiveness of this app in clarifying biotechnological concepts. These activities were carried out in May 2019, with a total workload of 12 hours.
- d) Analysis of the questionnaires according to Bruno (2014) and Malajovich (2016) references. A parallel was established among the students' responses before and after using BIOTEC app to evaluate the knowledge level and the app competence in clarifying biotechnological concepts, as well as its acceptability by students.

Table 2

Questionnaire applied to students

QUESTIONS	OBJECTIVES
What is Biotechnology?	Present Biotechnology concepts.
Do you know any application of Biotechnology? Justify.	Indicate applications of Biotechnology.
Do you consider that Biotechnology has improved human living conditions? Justify.	Understand the impacts of Biotechnology on human development.
What is the relationship between Biotechnology and the preservation of biodiversity?	Establish relationships between Biotechnology and biodiversity conservation.
Are you aware of the Biosafety Law? Justify.	Mention, in a generic way, what determines Biosafety Law.
What is the difference between basic research and applied research?	Differentiate basic research from applied research.
On a scale of 1 to 5 (1 – no interest; 2 – little interest; 3 – average interest; 4 – above average interest; and 5 – very interested) what is your level of interest in biotechnology topics?	Indicate the level of interest in biotechnology topics.
How do you evaluate the BIOTEC application in terms of its approach to biotechnology themes? List criticisms and/or suggestions.	Evaluate the BIOTEC app regarding its approach to biotechnology themes.

Source: the author (2024).

Table 3

Thematic shown in a didactic sequence

THEMATIC	ACTIVITIES	OBJECTIVES
Concept enlightenment: biotechnology and biotechnological applications.	Reading and Quiz Resolution in BIOTEC app.	Discuss the main concepts and applications of biotechnology.
Biotechnology History: Classical Biotechnology and Modern Biotechnology.	Construction of a timeline using the BIOTEC app.	Present the history of biotechnology.
Biotechnology: concepts, products and services.	Exploring Biotechnology Terms and Concepts using QR codes in the BIOTEC app.	Establish relationships among concepts, products and services from biotechnology.

Source: The author (2024).

As for ethical aspects, it is noteworthy that this research was approved by the Research Ethics Committee (REC) of the Health Sciences Center (HSC) at the Federal University of Paraíba (UFPB), on May 27, 2018, according to CAAE 88998418.0.0000.5188.

RESULTS AND DISCUSSION

BIOTEC APP DEVELOPMENT

The developed educational application was named “BIOTEC” in order to publicize biotechnology in the formal learning context (and outside it), as well as to be used as a teaching tool. The production of BIOTEC app was by the no-code platform to build factory applications. In other words, the development process did not require software programming and, therefore, there was no need to establish collaborative partnerships.

The BIOTEC app is free and can currently be accessed in web app format, which is also compatible with Android and iOS platforms. Thus, you can simply go to the app.vc/biotecnologia1 link to apply it, by an internet browser on smartphones or computers. BIOTEC app manual and other additional information can be found by website application. The app is also in the Portal Educapes repository, in the “Mobile Application” area.

The BIOTEC app structure (Figure 1) was designed to make biotechnological concepts more accessible and interactive for users. Its main purpose is to serve as a teaching tool, to establish a connection between students and biotechnology, while it has an important potential in the scientific dissemination of biotechnological area. Students’ perceptions were collected during the research, which guided the selection of biotechnological concepts presented in educational application content.

The main menu of BIOTEC app consists of nine tabs that deal with several themes of biotechnology and a communication tab between the user and the developer (Figure 2), described below:

- a) “What is biotechnology?” In this tab, we present the concept of biotechnology, products and services that result from biotechnological processes and information related to the Biosafety Law;
- b) “Timeline”: here we provide a history of biotechnology, highlighting the main events of classical biotechnology and modern biotechnology;
- c) “Biotechnology and Health”: we disclose information on the applications of Biotechnology in Health area;
- d) “Biotechnology and Environment”: we highlight information that relates biotechnology to environmental issues;
- e) “Biotechnology and Industry”: we show information about industrial biotechnology;

f) "Biotechnology and Agriculture": we emphasize information on biotechnology application in the agricultural sector, especially regarding the use of genetically modified (transgenic) organisms;

g) "Explore the concepts": in this tab, we provide a glossary of terms related to biotechnology, based on Torres et al. (1999);

h) "Videos": we recommend videos on biotechnological themes by a YouTube channel, also called BIOTEC.

i) "Quiz": we offer the user the opportunity to perform a quick test to evaluate his/ her knowledge in biotechnology. At the end of the test, he/ she can check the correct and incorrect answers.

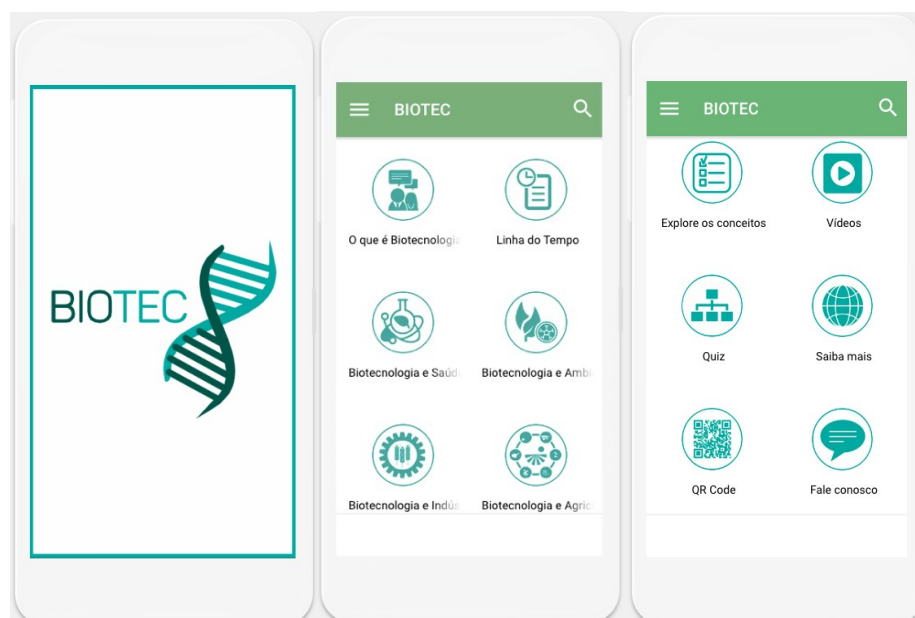
j) "Learn more": in this tab, we redirect the user to the website of the National Board of Information on Biotechnology (NBIB), where he/ she will find more information;

k) "Contact us": this space serves as a communication channel, which allows the user to send questions, suggestions or to deal with any issue related to his/her area of interest.

It is noteworthy that BIOTEC app was indicated at the Paraíba State High School Curriculum Proposal in the Pedagogical Guidelines of the "Biotechnology Applications" Curriculum Unit, within the "Technologies, Services and Sustainability" training itinerary, at Nature Sciences area and its technologies (Paraíba, 2020, p. 618).

Figure 1

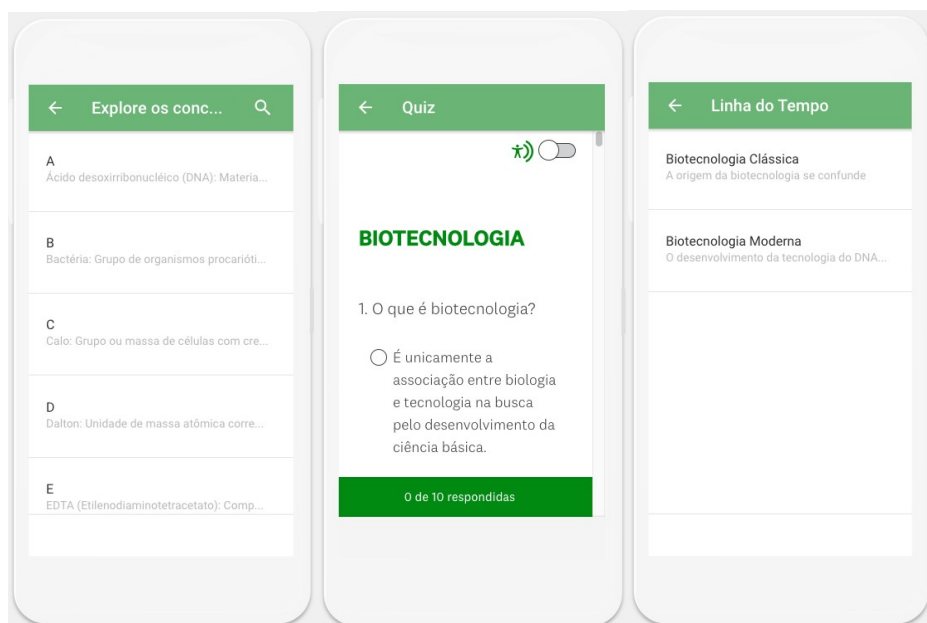
BIOTEC app main screens



Source: BIOTEC app (2024).

Figure 2

Examples of BIOTEC app tabs



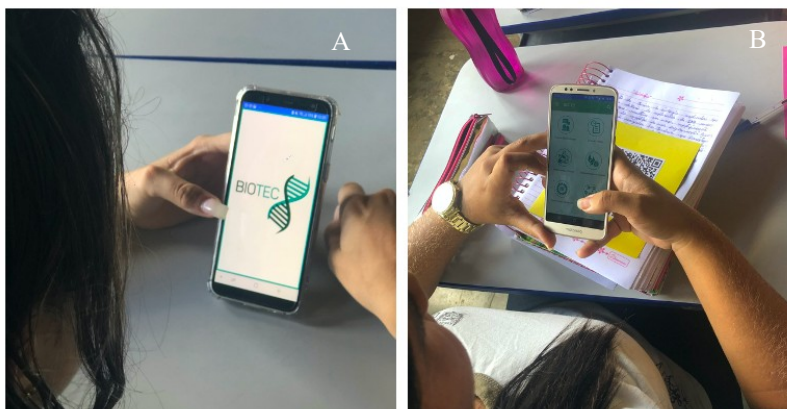
Source: BIOTEC app (2024).

BIOTEC APP EVALUATION

The BIOTEC app evaluation was carried out by implementing a 12 hour-didactic sequence time, involving thirty high school students, with ten students from each grade. Of the total participants, 65% were female and 35% were male. All activities were developed during the didactic sequence and directly related to the app use (Figure 3). The main goal of this evaluation was to verify the acceptance and effectiveness of this application (app) to enlighten concepts and Biotechnology applications, in addition to awakening interest in biotechnology themes.

Figure 3

A and B: Use of BIOTEC app by the students



Source: Authors' collection (2019).

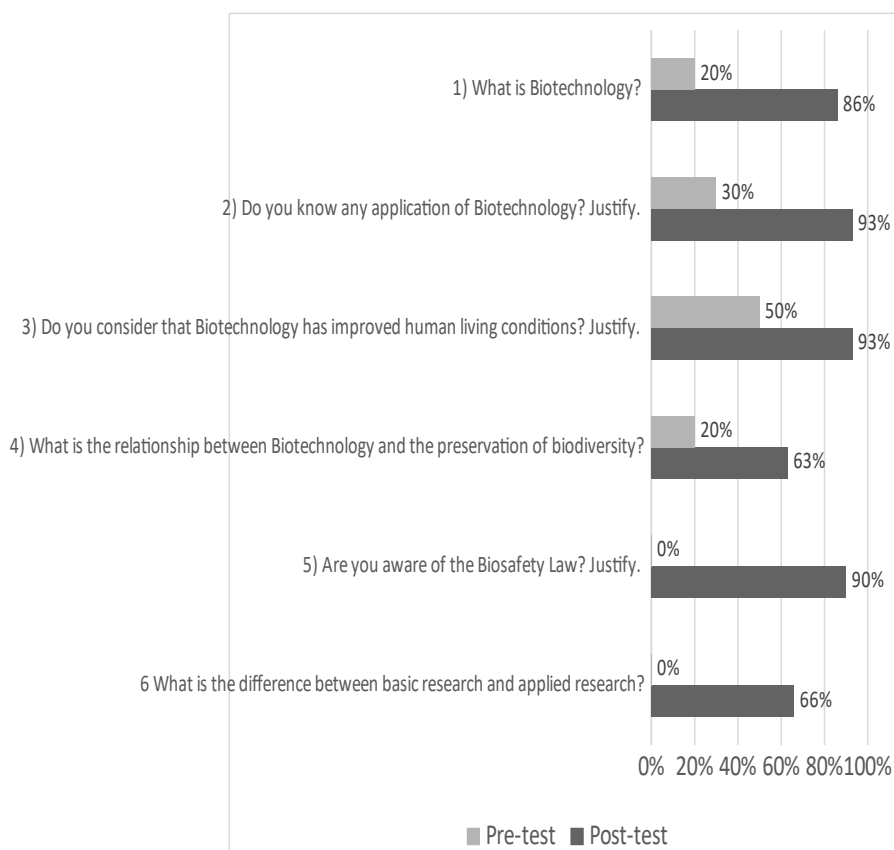
The following results refer to the questionnaire applied before and after using BIOTEC app, analyzed according to Bruno (2014) and Malajovich (2016), since these authors have shown some relevant theoretical support in the studied area. It is emphasized, however, that biotechnological themes are part of the curriculum of elementary and high school (Brasil, 2018), and, for that reason, the questionnaire was applied to students of the three high school grades.

In pre-test and post-test, students were asked about some aspects of biotechnology, especially concepts, applications, relationship with biodiversity conservation and impacts on human life (questions 1, 2, 3 and 4, respectively). Mainly in this group of questions, some students showed some knowledge regarding biotechnological themes even in the pre-test; however, after manipulating BIOTEC in the activities of the didactic sequence, the amount of correct answers increased considerably, as it is shown in Figure 4.

The students were also asked about the Biosafety Law and the differences between basic and applied research (questions 5 and 6). As it is shown in Figure 4, in these aspects, all students provided inappropriate pre-test responses, however, in the post-test, the number of correct responses increased largely. It is important to highlight that, regardless of each grade, there were no significant differences in the students' initial knowledge about the topics raised.

Figure 4

Percentages of the students' correct answer before and after using BIOTEC app

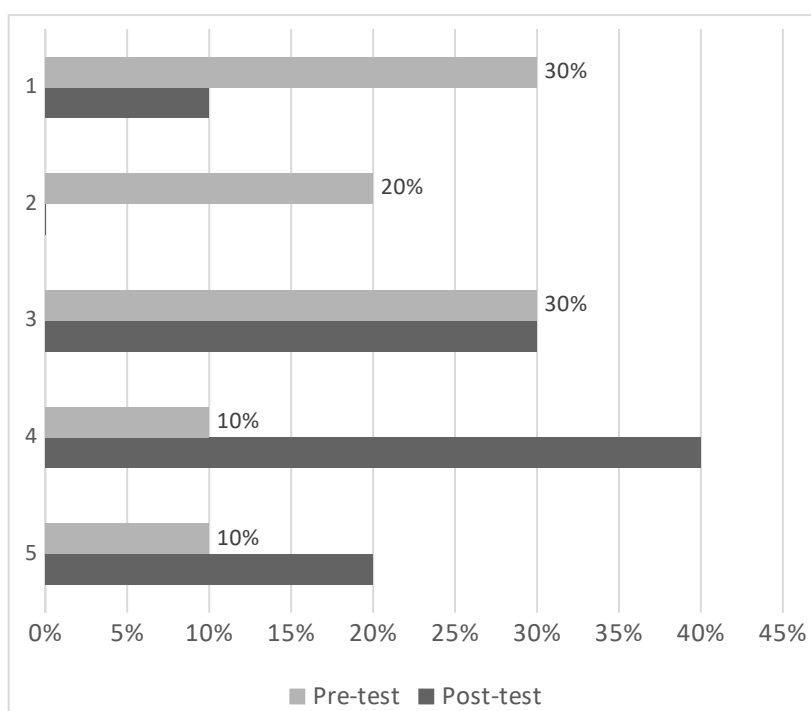


Source: The author (2024).

In addition, a survey was carried out to evaluate whether the BIOTEC app was able to arouse students' greater interest in biotechnology. In this regard, the evaluation came from the students' responses, before and after the use of BIOTEC app, to a question that requested their level of interest by biotechnology on a scale of 1 to 5: 1 represented little interest and 5 indicated a lot of interest about the theme. As it is shown in Figure 5, most of the students (90%) marked items 3 (average interest), 4 (above average interest) and 5 (very interested) in the post-test. Those answers attested to a considerable increasing level concerning their interest in Biotechnology, when compared to what was demonstrated in the pre-test (50% of students marked items 1 - no interest and 2 - little interest).

Figure 5

Students' responses regarding their level of interest by biotechnology before and after using BIOTEC app.



Source: The author (2024).

Finally, students were invited to share their opinions on BIOTEC Educational app relevance in expanding their knowledge about biotechnology, as well as providing criticism and/or suggestions. All interviewed students, corresponding to 100% of the total, stated that the studied app was fundamental to their understanding about themes regarding biotechnology.

Besides, some comments raised by the students are observed:

The app aims at broadening knowledge as it expanded mine and increased curiosity on this subject (student 1). I loved the app. It brings a lot of convenience (student 2). The app helps to better understand biotechnology covering everything in it (student 3). The app is very complete and brings us a lot of information (student 4). The app brings definitions and has everything about biotechnology and makes student's life easier (student 5). I learned deeper into biotechnology, its concepts and objectives (Student 6) (sic).

Thus, the results that deal with conceptual content, based on references from Bruno (2014) and Malajovich (2016), highlighted the positive impacts of the Biotechnology approach with Digital Information and Communication Technologies use during teachers' pedagogical decision-making and preparation, particularly with the use of BIOTEC app. In accordance with Silveira (2007), technology incorporation in education aims at improving teaching and learning processes, and making them more accessible and efficient. From this perspective, Nonato (2009, p. 84) highlighted that new technologies are, in contemporary education, "[...] very important instruments and it could be even say that they are essential, in achieving didactic-pedagogical practices and procedures".

Regarding students' motivation on the topic in discussion, the significant increase in their interest in Biotechnology, shown based on the results, after using BIOTEC app, constitutes a very important piece of research data. Such finding is justified by Moran et al. (2012) when they claim that on the one hand the educational app of Digital Information and Communication Technologies plays a key-role in culture improvement, rules and traditions of different social groups; On the other hand, it triggers a personal learning process that encourages motivation in students.

Another relevant result found in this research was the fact that the use of BIOTEC app enabled, according to the students' view, the expansion of knowledge in Biotechnology. Thus, Franco and Lopes (2004) ensure that the didactic-pedagogical use of Digital Information and Communication Technologies has potential to improve the building process of students' knowledge. Santos and Santos (2014, p.3) pointed out to the same question by reporting that "nowadays, the possibilities of disseminating knowledge given by technologies have opened new possibilities of action to expand accessibility [...]". The last authors also emphasize that this fact has paved the way to create new pedagogical and disciplinary methods, by promoting knowledge socialization.

In this direction, Gonçalves and Ferreira (2022) state that literature supports the integration of technologies in the classroom. However, these authors warn that digital tools should not be seen as the solution to problems in the classroom. Consequently, these technologies must be practiced as an auxiliary resource along the teaching and learning processes. It is necessary to consider both benefits and limitations of digital technologies in a pedagogical action, encouraging conscious use based on the reality of the school environment.

Regarding the challenges to settle down digital technologies in the classroom, Santos *et al.* (2023) show some significant obstacles. In addition to the lack of teachers' training to effectively integrate technologies into their pedagogical practices, it is also relevant to mention the lack of infrastructure in schools as a limiting factor. This last issue covers from insufficient technological devices available to the absence of stable internet access in schools. Such obstacles demand investments from public policies aimed at both teaching skills, and to improve school infrastructure at all levels of elementary education.

So, when limits and possibilities are analyzed in relation to the use of digital technologies in the classroom, we reinforce that the use of BIOTEC app in teaching Biotechnology has the potential to provide students with the development of knowledge that allows them to understand and express opinions

about an area of science with great added potential. Additionally, it is crucial to recommend that the adequate training of Science and Biology teachers in biotechnology also emerges as an outstanding and essential aspect to widely include biotechnological topics in elementary and high school terms.

FINAL CONSIDERATIONS

The present study aimed at developing and evaluating an educational app for mobile devices with the main concepts and applications of biotechnology to answer the main question that guided this research: Can a mobile app contribute to teach biotechnology in the school environment?

The developed app, named as BIOTEC, built to help on Biotechnology teaching, was also indicated in the Paraíba High School Curriculum Proposal. Its use can be associated with different teaching methodologies, as it was carried out in this study. The initial evaluation of BIOTEC app has shown its competence in approaching biotechnological topics, since it was widely accepted by students.

The obtained results indicated advances in students' learning process regarding the concepts and applications of Biotechnology, as well as a significant increase in their level of interest in the topic. Thus, the Biotec app, as a biotechnological teaching tool, has the potential to contribute to the scientific, technological and citizen training of students, as well as it is a vehicle to spread out biotechnological products and services.

Furthermore, it is worth emphasizing that, in teaching context, it is imperative to invest in studies aiming at training Biology teachers in Biotechnology Teaching, to foster discussions that associate biotechnological topics, teachers' training and Science Teaching.

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INFORMATION NOTE

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