Mobility: Encouraging Physical Activity among High School Students

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***Abstract*—With technological advancement, there is a high level of daily interaction with screens and mobile devices among the youth population, leading to a sedentary lifestyle and a reduction in the time dedicated to physical exercise. Given this context, it is essential to find solutions to address the increasing sedentary lifestyle among adolescents. In this way, this study presents the Mobility app to motivate high school students to engage in physical activities through playful physical challenges, utilizing smartphone sensors and a scoring system based on the activities completed. The goal is for students to adopt regular yet straightforward healthy habits, contributing to their overall well-being and preventing diseases associated with a sedentary lifestyle. To evaluate this proposal, a real-world evaluation was conducted with 23 students. The results show that the tool constitutes an approach that is easily integrated into the school environment and contributes to the reduction of sedentary behavior, although further technical refinement is still required.**

Keywords-technology; health; mobile app.

I. Introduction

The socio-technological context has strongly influenced the population's lifestyle in recent decades. In the contemporary period, marked by the predominance of the digital age, it is clear that society has become dependent on mobile devices, resulting in excessive use of screens in everyday life, which, in turn, can contribute to problems, such as reduced physical activity and increased sedentary lifestyle, compromising physical and mental health, especially among young people [1].

Several factors contribute to low adherence to physical activity, including the lack of suitable spaces, prolonged technology use, and inadequate public policies to encourage healthy habits [2]. Similarly, the COVID-19 pandemic has worsened this situation by restricting movement in collective spaces, intensifying social isolation, and increasing the population's screen time [3].

Specifically among school-age adolescents, the rates of physical inactivity are worrying. The World Health Organization (WHO) studies indicate that four out of five young people aged 11 to 17 are considered insufficiently active [4]. This scenario is exacerbated by the combination of factors, including intense school workloads, the lack of incentives from educational institutions, and excessive mobile device use [5]. Given this, it is necessary to invest in actions that promote regular physical activity among these young people to improve both their physical and mental health and consequently enhance their academic performance [6].

However, the use of mobile devices in everyday life should not be considered an entirely negative trend, as these resources can help encourage physical activity, depending on how they are used. Studies show that health (or mobile health) applications can be effective in promoting healthier habits, especially among physically inactive individuals [7]. Internet-based technologies, including body movement sensors, can be considered a promising, scalable approach to addressing the high prevalence of physical inactivity [8].

Given this scenario, it is essential to find solutions that mitigate the impacts caused by physical inactivity. Adequate physical exercise improves the health of the body, which consequently benefits brain health, increasing mental well-being and reducing symptoms of anxiety and depression. In this context, we present the "Mobility" application, developed to encourage physical activity among high school students, along with the findings of its initial analysis regarding the effectiveness of this proposal.

This paper is organized as follows: Section II presents related work; Section III describes the application and its functionalities; Section IV presents the results of the experimental evaluation; Section V discusses the results achieved through the evaluation; and Section VI brings the conclusion and future directions.

II. Related work

It is essential to find solutions that mitigate the harm caused by a sedentary lifestyle to health, making it necessary to develop approaches that promote health promotion, especially for the younger population. To consolidate this study, articles investigating the relationship between mobile applications and health promotion were reviewed in the literature.

The study by Zhang et al. [7] conducted a systematic review of the effectiveness of mobile applications (mHealth) in promoting physical activity and reducing sedentary behavior among physically inactive individuals in the health area. The research analyzed nine clinical studies involving a total of 1,495 participants, comparing application-based interventions with broader approaches that combined the use of apps with other complementary strategies, such as educational sessions, pedometers, or online support groups. The results indicated that the mHealth interventions significantly increased daily physical activity time (an average of 8.72 minutes/day) and reduced sedentary behavior time (an average of 90.94 minutes/day).

Similarly, a systematic review and meta-analysis was conducted on the effectiveness of interventions based on digital technologies Stephenson et al. [9], such as computers, mobile devices, and wearables, in reducing sedentary behavior in healthy adults. The results indicated an average reduction of 41 minutes per day in sedentary time between the intervention groups, with a significant impact in the short term (up to 3 months) and a decrease over time. The most commonly used behavior change techniques were reminders and warnings, self-monitoring, social support, and goal setting.

The study by Ueno et al. [10] presents a scoping review to map the effects of instructions based exclusively on mobile health apps (mHealth apps) aimed at reducing sedentary behavior in adults. The results indicated that most apps contributed to a reduction in sedentary time, with decreases observed in activities such as watching television and total sitting time, in addition to an increase in the number of breaks taken throughout the day. The apps analyzed incorporated features such as reminders, visual feedback, goal setting, and motivational messages, although none of them were commercially available.

Recent studies on mobile health monitoring have highlighted several technical challenges, including variability in sensor accuracy, difficulties in integrating with data collection platforms, and malfunctions in real-world environments. The study carried out by Oliveira et al. [11] reports the challenges faced during longitudinal health monitoring with mobile devices in the wild. Among the main lessons learned, the difficulties with participant engagement and the technical limitations of the sensors stand out. These aspects also impact the use of applications designed to promote physical activity in educational environments, such as Mobility.

The studies presented reinforce the need for solutions such as Mobility, which combines technology and gamification to overcome problems related to physical inactivity. Thus, this study stands out for presenting the use of mHealth in the school context through the integration of gamified resources and a ranking system. Self-monitoring, feedback, rewards, as well as goal setting and review, appear in the literature as some of the most important strategies [12]. Unlike other strategies aimed at promoting physical activity among young people, Mobility stands out by integrating technology and gamification, fostering social interaction among students through healthy competition. It also adapts seamlessly to the school environment, enabling teachers to monitor students' performance in real time through challenge rankings.

III. MOBILITY APP

It is worth noting that this study builds upon a previously published study on the Mobility application, presenting enhancements to the tool's functionalities and new experimental data [13]. Furthermore, the project has been submitted to the Research Ethics Committee (REC) and is currently under review.

Considering the challenges identified about physical inactivity among adolescents, the Mobility application was developed to encourage healthier habits within the school environment. The following are the characteristics of the application, its operation, and the principles that guided its development as a tool to encourage physical activity practice.

The Mobility application was designed with a primary focus on the 17 UN Sustainable Development Goals (SDGs), aiming to align with SDG 3 (Health and Well-being): "Ensure healthy lives and promote well-being for all at all ages" [14].

The application was developed on the Kodular platform, which enables the creation of Android applications through block programming. This approach facilitates the creation of software, especially in educational contexts, as seen with Mobility, which high school students developed.

Firebase Realtime Database was used to store data related to physical challenges and registration/login in the app. Chosen for its ability to provide data in real-time, as well as allow easy integration into Kodular, allowing ranking and challenge information to be updated instantly.

Mobility was designed to integrate seamlessly into school routines, leveraging available resources and capitalizing on young people's familiarity with mobile devices. Its interface is intuitive and seeks to motivate users through its color palette. Orange is associated with energy and vitality, while blue is often used to convey strength and security.

A. Features

The application has the following functions:

- **Registration/Login** (Figure 1): To access the Mobility application, students must complete an initial registration, providing their name, email, password, age, and gender. After this step, access to the platform is done by logging in with the previously registered email and password credentials.

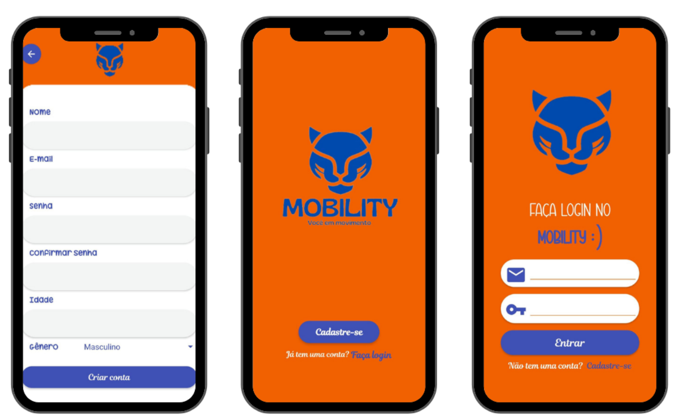

Figure 1. Home screen, registration and login.

- **BMI Calculator** (Figure 2): Allows students to calculate their Body Mass Index based on weight and height data, checking if they are at the correct weight.
- **Physical Challenges** (Figure 2): There are four tasks available on Mobility, which encourage the practice of physical activity in a fun way within the school structure.

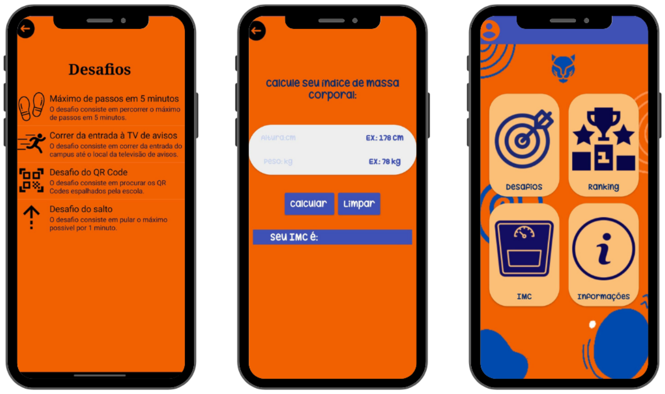

Figure 2. BMI Calculator, Challenges Screen, Features Screen.

- **Ranking:** Allows students to access their position in the ranking of the challenge completed. This system aims to encourage engagement in the application through healthy competition while also facilitating a reward system based on points.
- **About:** Area dedicated to talking about Mobility and its founders.

B. Challenge Modalities

The application has the following challenge modalities:

- **Maximum steps in 5 minutes** (Figure 3): Consists of walking as much as possible for five minutes. The participant with the highest score takes the lead in the ranking.
- **Hallway to TV Announcement Race** (Figure 3): Students must walk the route from the school entrance to a fixed point in the shortest possible time.
- **QR Code Challenge** (Figure 4): Simulating a treasure hunt, students must look for QR Codes spread throughout the school environment. Each code directs to a question, and for each correct answer, the student earns 10 points. The winner is the one who accumulates the highest score.
- **Jump Challenge:** (Figure 4): Proposes that the student performs the most significant number of jumps possible within one minute. The student with the most repetitions wins the challenge.

The development of Mobility demonstrates that it is possible to combine technology and health in an accessible and effective solution in the school context. The following section presents the methods used to conduct the preliminary evaluation of the application, along with a discussion of the results obtained.

IV. Evaluation

To verify the usability and functionality of the application, an evaluation was conducted with 23 first-year high school students, examining the functions available within the application.

Figure 3. Challenge screen: Maximum steps in 5 minutes, Hallway to TV Announcement Race.

Figure 4. Challenge screen: QR Code Challenge, Jump Challenge.

This stage aimed to identify the level of engagement of students with the application, as well as its practical functioning.

The assessment was based on the ISO/IEC 25010 standard [15], following its five steps, as proposed in previous studies on software quality evaluation [16]:

- **Activity 1: Define the assessment**

At this stage, the purpose of the evaluation was established: to analyze the suitability of Mobility in the school context.

- **Activity 2: Design the assessment**

Criteria were defined based on the quality characteristics provided for in ISO/IEC 25010:

Usability: ease of use and understanding of the interface;
Efficiency: time required to complete tasks;
User satisfaction: general opinion about the tool;
Reliability: stability of the application during testing;
Functionality: suitability of functions in relation to the

proposal.

To validate this stage, a form created through Google Forms was designated at the end of the test, containing six questions, with the first four questions allowing answers of 'yes', 'partially', or 'no'. The remaining questions included the participant's written opinion about the application. At the end, they were asked to evaluate the application with a score ranging from 1 to 5, with 1 (does not meet the programmed criteria) and 5 (is suitable for the school context). The questions in the questionnaire are:

1) Does the software perform all the expected functions?
2) Does the application frequently fail?
3) Is the interface easy to navigate?
4) Can the software be used with the infrastructure available at the school?
5) Mobility's strengths:
6) Points for improvement:

- **Activity 3: Plan the assessment**

It was decided that the assessment would take place at the educational institution itself, requiring the use of an Android device.

- **Activity 4: Carry out the assessment**

During this stage, students registered on the platform and, upon logging into the app, explored the available resources. They used the BMI calculator and participated in the activities proposed by Mobility. The test was conducted over two days in different weeks, allowing the class's performance to be assessed more accurately. At the end of the assessment, participants were asked to complete the questionnaire in Activity 2.

- **Activity 5: Complete the assessment**

The students who participated in the evaluation chose to participate voluntarily, having been informed about how Mobility works, including its proposal and the evaluation method.

V. Results and Discussion

The students who participated in the evaluation did so voluntarily and were informed about the functioning of Mobility, including its purpose and the evaluation method.

The challenges were assessed in terms of their functionality during the evaluation and the level of student interest. Regarding student engagement during the activities, a high level of engagement in the activities was observed. During the first challenge (5-minute step challenge), participants spread out throughout the school and competed healthily to take first place in the app's ranking.

Subsequently, the QR Code Challenge was implemented, distinguishing itself as the longest-lasting activity among the proposed challenges. This stage was notable for its integration of technology and physical movement, as each code was linked to a unique Google Sheets URL. Students spontaneously organized themselves into small groups and began searching for the codes distributed across various locations within the school. This phase not only facilitated active physical movement throughout the school environment but also fostered interaction among participants, promoting cooperation, socialization, and sustained engagement in physical activity throughout the task.

At the end of the challenge, it was observed that the students exhibited signs of physical fatigue due to the intense physical activity required by the previous tasks. Therefore, a short break was granted to allow participants to rest before continuing with the next challenge, respecting the limits of the participants and preserving the quality of the evaluated experience.

After the break, the next challenge to be completed was the "maximum jumps in one minute" challenge. This activity was performed individually, but during the execution, the students' engagement was noticeable, even though some showed signs of fatigue.

Finally, the last challenge proposed consisted of running from the school entrance to the announcement TV, recording the shortest possible time. However, this activity had technical limitations, as the geolocation system (GPS) did not work correctly on all devices. Only one of the cell phones used was able to record the route correctly.

The Global Positioning System (GPS) operates through a network of satellites, providing the geographical location of any point on Earth via latitude and longitude coordinates. However, GPS signals generally do not perform accurately in indoor environments (i.e., covered spaces such as houses or buildings) [17]. When used within the school environment, the sensor did not function properly, thereby limiting the users' experience.

Furthermore, since the application was developed on the Kodular platform—which generates only APK files—it is compatible exclusively with the Android operating system. As Kodular does not support the generation of executable files for iOS, the application could not be made available on the App Store or installed on Apple devices. Consequently, students using iOS devices faced access restrictions and had to rely on borrowed Android devices.

Mobility was designed as a secure digital environment that ensured the integrity of the proposed activities. Each QR Code used within the application is linked to a unique URL hosted in a Google Sheets document, which prevents tampering or modification. Therefore, each code corresponds to a specific question, and any attempt to alter the link renders the code unreadable by the application. For example: Code 1 $\rightarrow$ Link 1 $\rightarrow$ Question 1.

Despite some technical limitations, such as sensor failures on specific devices, which especially impacted the GPS-based challenge, the execution of the tasks went well, demonstrating the potential of the Mobility app as a tool to encourage physical activity in the school environment. Furthermore, because it was developed on the Kodular platform, the app is currently only compatible with the Android system. Therefore, students using iOS faced access restrictions and had to use borrowed devices.

After completing the physical challenges proposed by the Mobility app, participants answered an evaluation questionnaire aimed at identifying their perception of the tool's effectiveness, usability, and functionality. In total, 23 students completed the form.

1) Does the software perform all the functions it is supposed to?

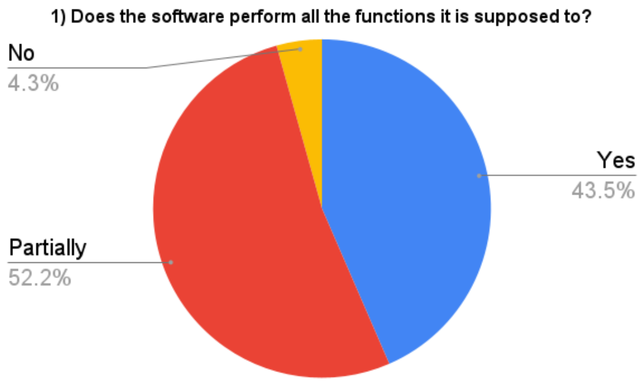

Figure 5. Results of the first question.

The majority of students (52.2%) believe that the application only partially meets the expected functionalities, which can be attributed to failures related to the use of GPS, which limited the experience of the Mobility activities.

2) Does the application crash frequently?

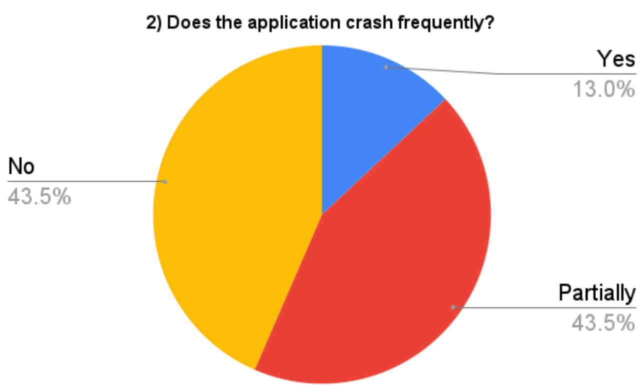

Figure 6. Results of the second question.

For the same reason, there was a balance concerning application failures. While 43.5% stated that there were no frequent failures, the other 43.5% reported partial failures due to the use of GPS. With this result, it means that despite the occasional error, no serious problems were encountered during the evaluation.

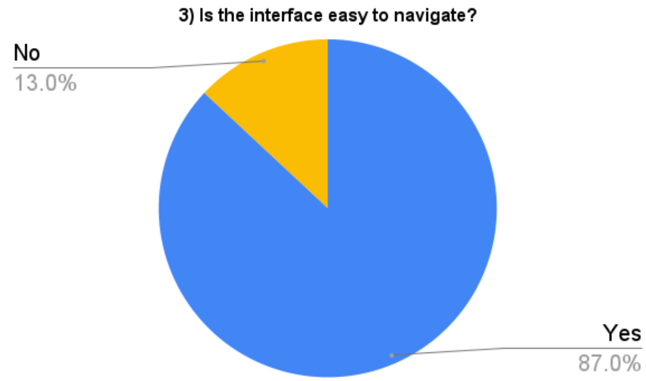

Figure 7. Results of the third question.

3) Is the interface easy to navigate?

On a positive note, 87% of participants found the app's navigation simple and intuitive. This result is a significant feature, as it enables students with varying levels of technology familiarity to interact with the app.

4) Can the software be used with the infrastructure available at the school?

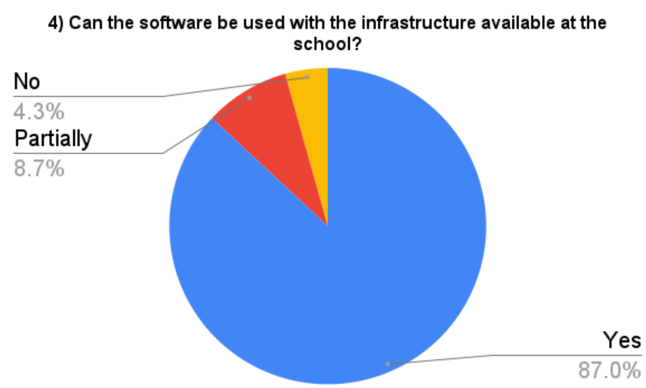

Figure 8. Results of the fourth question.

Regarding compatibility with the school's infrastructure, 87% also stated that the application could be used without significant difficulties, and only a minority reported difficulties: the limitations indicated were related to the quality of the internet connection or the need for Android devices.

Regarding the last two questions, the strengths of Mobility highlighted by the students were the software interface and the activities, which encouraged the practice of physical activities in a fun way. However, they reported the need to create new physical challenges to intensify the practice, in addition to correcting errors related to GPS and making the application available for iOS devices. Finally, Mobility received an average score of 4.22 (on a scale of 1 to 5), indicating a positive acceptance of the tool in the school environment.

VI. Conclusion and Future Work

Based on the results of the Mobility assessment, the persistent objective was to highlight the value of the tool in promoting health and well-being in the school environment, emphasizing its direct contribution to the UN Sustainable Development Goals (SDGs), particularly those related to health and well-being (SDG 3).

By proposing challenges that encourage physical activity through playful approaches, Mobility stands out as a creative and accessible solution to combat inactivity among young people. The combination of educational technology and gamification promoted student engagement, facilitating learning and participation in the proposed activities.

A. Study limitation

One of the limitations of Mobility is related to technical issues, such as incompatibility with iOS devices, in addition to the limitation of the Running Challenge, which requires the use of GPS.

The evaluation was conducted in a specific setting with only twenty-three students, which does not allow for a general assessment of the application's acceptance among high school students. Another challenge to be addressed is student engagement with the application, as some students may resist using the software due to leading a predominantly sedentary and inactive lifestyle.

B. Future Work

For future research, it is intended to implement Mobility in different schools over a defined testing period, with the aim of analyzing students' reactions and their level of engagement with the application, in order to ensure more objective and reliable results. In addition, strategies will be developed to overcome challenges related to the infrastructure required for the app's use, such as the limited performance of GPS in indoor environments.

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