Development of a Mobile Application to Measure Youth Health Using Machine Learning and Smart Band

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Abstract

The present research aims to use Machine Learning technologies and wearable technologies, as well as the development of a framework for creating a mobile application, to develop a solution that emerges from the convergence of the tools. The solution consists of developing an application that allows the visualization of data collected by a wearable technology known as "Smart Band," which captures a series of measurements related to physical activity (steps, calories burned, among others). Using a model built from tools in the artificial intelligence subfield, the application can determine the user's health status, automating motor competence evaluations aimed at schoolchildren in Arequipa aged 6 to 17. A questionnaire for the usability evaluation "System Usability Scale" was applied, according to which an average of 82.5 was obtained, demonstrating that the software passed the usability test and was considered efficient. The mobile application can be used by those interested in school health.

Keywords

Mobile application, machine Learning, smart band, health, youth

1. Introduction

In today's digital age, mobile technology has become relevant in various areas of society. Educational and medical fields have yet to be immune to this technological revolution, where integrating mobile applications has opened many possibilities to improve the teaching and learning experience. Among these opportunities, the need arises to use technology to measure and monitor students' physical health, promote healthy lifestyles, and optimize their academic performance.

This research proposes the development of an innovative mobile application, which is complemented using a "Smart Band," to accurately and continuously measure various parameters related to student's physical health. This application would allow teachers to access the health history of each student, providing valuable information to understand her physical condition, identify possible health problems, and design personalized interventions that promote comprehensive development.

The importance of measuring physical health in schoolchildren lies in its impact on their general well-being and academic performance [1]. Globally, the incidence of overweight in age groups 5 to 19 years is increasing; the WHO in 2015 [2] estimated that almost one in five school-age children and adolescents were overweight, representing 338 million students who have problems related to obesity, lack of physical activity and poor diet, which can lead to chronic diseases and learning difficulties. According to UNICEF, [3] Latin America is in second place in the prevalence of obesity in this age group with a percentage of 33.5%. In the Peruvian context, a worrying increase in obesity and a sedentary lifestyle has been observed in schoolchildren, with

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one in four Peruvian children having some degree of excess weight. In adolescents, this prevalence reaches 14.2% [4]. At the regional level, Arequipa has a high obesity rate in children and adults, being one of the ten regions that exceed the general average of overweight at the national level [5]

Implementing this mobile application, supported by Machine Learning techniques, would represent a significant advance in monitoring students' physical health. Analyzing and processing the data collected and generating predictions would facilitate interpreting the information and help identify relevant patterns.

In this sense, the main objective of this study is to design and develop a mobile application that, using a Smart Band and data analysis using Machine Learning, contributes to improving students' physical health and promotes a healthier educational environment. Implementing this technological tool is expected to provide teachers with a more complete and objective view of the health of their students, allowing timely and personalized interventions that promote healthy lifestyles and improve their comprehensive well-being.

2. State of the Art

As the first related work, it presents an independent and portable system for detecting driver drowsiness using a smartwatch. The system is based on collecting motion data and using a support vector machine (SVM) classifier to determine the driver's drowsiness level [6].

Other related work was also found, oriented towards research using portable technology in preschoolers and schoolchildren. They indicated that wearable devices can be used as a motivational tool to improve physical activity behaviors and evaluate physical activity interventions. However, the different levels of reliability of the other devices used in the studies may compromise the analysis and understanding of the results [7]

At an international level, the research work “Smart Real-Time Health Monitoring Band Using Machine Learning and IoT” [8] can be highlighted, which proposes the integration of different technologies, such as IoT and ML, to use calculations to examine the clinical problem of people. Data on the person's heart rate, blood pressure, and temperature are collected using IoT. This information can be obtained through a smart band or a mobile phone application. The data is sent to the cloud and analyzed using machine learning techniques. The testing stage checks for any abnormalities in the clinical problem from the sensor data collected through the IoT framework. A genuine evaluation is performed on the data collected in the cloud from the IoT devices to evaluate the accuracy of the prediction rate.

Certain similarities are presented in this work, such as data collection in real-time and the use of calculation tools from ML. However, it is clear to highlight the difference between the scope proposed in both projects, the one presented in this article being oriented to a particular target audience, and that said information serves to evaluate their physical performance, which subsequently has an academic effect of being considered by the teacher who carries out the evaluation.

At the same time, the work titled “Smart Band for Senior Citizens” [9] focused on senior citizens seeking to develop a portable device that monitors them and uses machine learning algorithms to detect their falls and send alerts to the caregiver. The models are trained and tested on the generated dataset by collecting various accelerometer sensor values for different actions [walking, falling, and sitting]. Furthermore, our system monitors the body parameters like temperature, heart rate, and SpO2 levels of senior citizens and provides the facility for a reminder system. This work uses the same technologies and contemplates the same parameters as this document's proposed project. Still, without the focus of its model, it is different from helping older people.

Another notable work is “Mental Health Monitoring with Multimodal Sensing and Machine Learning” [10], which begins by highlighting personal and ubiquitous detection technologies, such as smartphones, which have allowed the continuous collection of data in a non-intrusive manner. Machine learning methods have been applied to sensor data to predict contextual user information, such as location, mood, physical activity, etc. Relatedly, it is essential to recognize that there has been growing interest in leveraging ubiquitous sensing technologies for mental healthcare applications, enabling continuous automatic monitoring of different mental conditions, such as depression, anxiety, stress, and so on. Based on this, the present research reviews recent work on mental health monitoring systems (MHMS) using sensor data and machine learning. It focuses on research work on mental disorders/conditions such as depression, anxiety, bipolar disorder, stress, etc. Of these, the one that is most closely related to the project that is being proposed in this document is the one titled “A survey on wearable sensor-based systems for health monitoring and prognosis" [11] that focuses on patient health monitoring, which, although it applies the same approach, does not seek to achieve the same objectives previously stated in this article.

In the local environment of the study, a work was developed where Machine learning for the classification of motor competence with wearable technology in schoolchildren [12] was applied, which allowed for generating the percentiles of the evaluation metrics and classifying motor performance using machine learning techniques in schoolchildren from educational centers. I used smart bands as wearable technologies for data capture during the evaluation of motor competence tests. As a result of applying the decision tree algorithm, an accuracy of 96.97% was obtained in the classification of motor performance in these students.

Within the Backend as a Service area, the work “An API-first methodology for designing a microservice-based Backend as a Service platform” [13] was recognized. This document addresses the creation of its Backend as a Service (BaaS) platform instead of relying on third-party providers. The approach is based on microservices architecture, allowing loose coupling, scalability, and integration with third-party services. An architectural design is proposed based on an appropriate and representative API of the BaaS platform. The proposed method was implemented and tested to meet the functional requirements, using specific test cases that reflect the actual workflow of the BaaS platform.

3. Materials and Methods

To carry out the development of the mobile application that serves as a conduit to visualize the information obtained from the Machine Learning model to measure youth health, the following steps are proposed:

- Develop a mobile application that allows student registration with their essential data.
- Collect data from the smart bands of the different students to create a database with which to train the model.
- Analyze the possibility of building and implementing an ML model.

From these and following the planning in phases using the scrum framework, the next project is defined, the scope of which will be the design of a mobile application that automates motor competence evaluations (physical activity) in schoolchildren in Arequipa.

The software tools used were the Flutter framework, an open-source SDK developed by Google to create high-quality, high-performance mobile applications for iOS, Android, and the web using the Dart programming language for design. Of the interface, such as the Python language and some of its libraries available for calculations. The entire structure of the prototype will be raised in the source code editor, Visual Studio Code.

A database will also be designed to preserve the information collected to retrain the model and periodically improve its accuracy.

3.1. Scrum Methodology

The Scrum methodology is an agile project management methodology focusing on continuously delivering functional software in short cycles called sprints. Additionally, Scrum encourages flexibility and adaptability, allowing development teams to respond quickly to changes in the Project environment [14].

The workflow was carried out following the Scrum methodology, which was implemented to improve efficiency and organization in project development. In this sense, the practice of daily meetings known as sprint daily was established in which a structured monitoring and planning process was carried out.

During these meetings, a detailed report was made of the activities carried out the previous day, giving the team a clear vision of the progress and achievements. In addition, the activities to be carried out during the current day were discussed, establishing priorities and collaboratively assigning responsibilities.

Likewise, a space was dedicated to identifying and addressing any impediments or obstacles that could delay the progress of the work. This approach facilitated collaboration and participation across the team, ensuring all members were informed of each other's activities and working together to overcome challenges.

3.2. Kanban Methodology

Kanban is a visual management methodology to optimize workflow and improve project efficiency. It is based on using a Kanban board, a visual tool that clearly and organized shows tasks or work items, their status, and their progress over time.

Using this Kanban board made it possible to maintain precise control over activities, allowing each team member to assign a task and evaluate the difficulty associated with its completion. The cards representing the activities were completed following the best practices established by Kanban.

In this way, the Kanban board became an invaluable tool for managing and monitoring tasks, providing a clear and concise view of work progress. Additionally, it encouraged efficient allocation of responsibilities and effective collaboration among team members. By following the guidelines and principles of Kanban, greater efficiency was achieved in the project's development, guaranteeing quality and compliance with established objectives.

The Kanban board is visualized in Fig. 1, where each activity includes four states: new activity, in progress, ready to test, and completed; the activities were separated into three types: those dedicated to the front end, those dedicated to the back end, and those dedicated to preparing the report, allowing the division of responsibilities under the same approach.

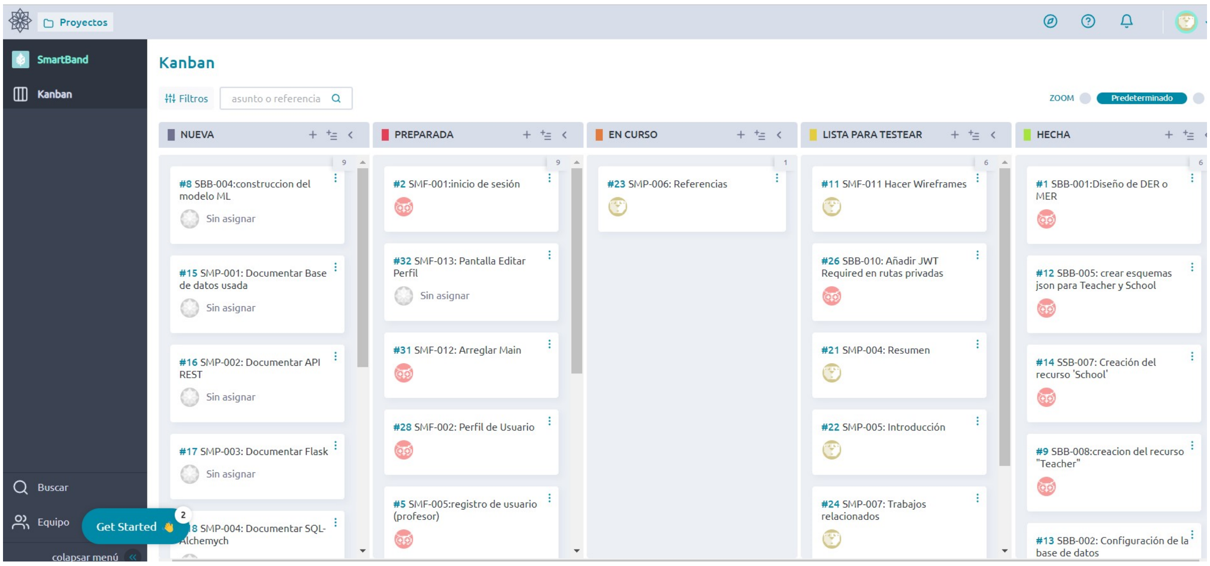

Figure 1: Kanban board used

3.3. Good practices in Git

Gitflow [15] is an alternative for managing branches. This functionality allows for better control of the development of the application, where there are two main branches: the branch generated by default when creating the repository and the development branch, which is where the project is developed for each task assigned in our kanban methodology a branch is made with the task code, so we do not generate conflicts in the development of the project, as we see in Figure. 4.

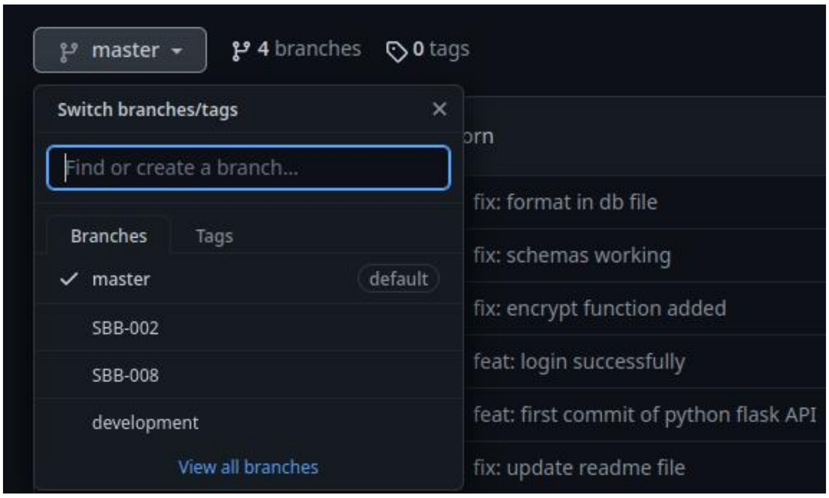

Figure 2: Branch structure

3.4. Scrumban Methodology

Scrumban is a combination of Scrum and Kanban methodologies. This hybrid approach seeks to take advantage of the strengths of both methods for project management.

In Scrumban, some elements of Scrum, such as sprints and roles, were used along with Kanban visualization and visual workflow management. This allows flexibility and adaptability by combining the planning and iterative delivery of Scrum with the transparency and visual control of Kanban.

The combination of Scrumban allowed for more fluid and adaptable project management. The Kanban board provided a clear and up-to-date visualization of task status, while Scrum elements such as daily scrums and sprints made it easy to coordinate and track the team. In this way, greater transparency, agility, and responsiveness were achieved as the development of the application progressed.

To build the application, a series of data necessary for the evaluation of the health and physical condition of the students was used. The fields to be used are specified below:

			Birthdate							
N°	Names	Gender	Day	Month	Year	Age	Weight (kg)	Height (m)	Sitting height (cm)	Waist circumference (cm)
1	Mary James Lee	F	9	12	2016	7	22	1.23	63.4	53

Figure 3: Student Information

Distance	Medium pace (min,sec)	Average cadence	Steps	Calories	Speed Average (km/h)	Average stride (cm)	Frequency. Cardiac mean HR	Frequency. Cardiac Max HR
0,26	59'52''	19	309	71	1,00	84	127	157

Figure 4: Evaluation information

The Functional and Non-functional requirements of the software product are detailed below:

3.4.1. Requirements

1. Functional Requirements
   Functional requirements are shown from Table 1 to Table 6:

Table 1
User register Requirement

Requirement number	RF-1.1
Requirement name	User register
Description	The application allows users to register and create a new account with their basic information, such as ID, name, email, and school where they teach.
Priority	High

Table 2
Log in Requirement

Requirement number	RF-2.1
Requirement name	Log in
Description	The user must be able to access the mobile application with their unique account, entering their email and password as credentials.
Priority	High

Table 3
Manage promotions Requirement

Requirement number	RF-3.1
Requirement name	Manage promotions
Description	The user must be able to see the promotions they have registered with updated information on the class they belong to and the number of students and create a new one with the year of graduation.
Priority	Medium

Table 4
Manage students Requirement

Requirement number	RF-4.1
Requirement name	Manage students
Description	The user must be able to add and remove students from a promotion, view their information and results history, and add them to future evaluations.
Priority	Medium

Table 5
Manage evaluations Requirement

Requirement number	RF-5.1
Requirement name	Manage evaluations

Description	The user must be able to create assessments, assign promotions of the evaluation, assign activities to the review, view their pending assessments, and record assessment results for each student.
Priority	High

Table 6
See results Requirement

Requirement number	RF-6.1
Requirement name	See results
Description	The user must be able to see the ML-processed result of the assessment, modeled in a statistical graph demonstrating their students' performance.
Priority	High

2. Non-functional Requirements
   Non-functional requirements are shown in Table 7

Table 7
Non-functional Requirement

Requirement number	Requirement name	Description
RNF-1	Security	The security requirements allow the user to have privacy in their data; the assigned authorities will access their private information.
RNF-2	Interface	The interface requirements allow the system to be understandable and intuitive.
RNF-3	Compatibility	Compatibility requirements allow the application to be adaptable to different mobile operating systems.
RNF-4	Efficiency	The resource efficiency requirements allow the application not to harm the equipment and the user in its use in the foreground and background.
RNF-5	Maintenance	The Maintenance Requirements allow the application always to be adaptable to new versions of the device and always correct bugs.

3.4.2. Design

For the design phase of the application, different design proposals have been evaluated and proposed, thus achieving a series of mockups that represent the interfaces that will be implemented; these were built considering the previously proposed requirements. These were developed in Figma, a tool for modeling and designing interfaces that allow collaborative work and description of the flow of activities, among many other attributes.

In Figure 5, you can see the first interface displayed when the user accesses the application; this refers to how an account will be accessed in the application, either by registering a new account or by logging in. from an existing account. You can see the login screen, which contains an email and password entry form to validate and authorize the entry.

Figure 5. Initial screen

Next in Figure 6 is the registration screen, which will be in 2 steps; the first is shown on the left, filling out a form with the vital information to create the account, including email and password, and the rest of the data is shown on the right. Personal information of the user, including names, surnames, ID, and school to which they are associated, the latter being a multiple selection.

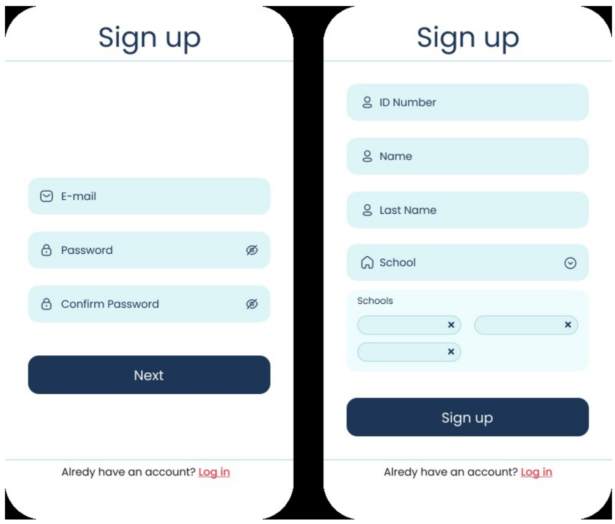

Figure 6. Registration screen

Figure 7 is the main screen that includes the directions to the different options that the application allows; it consists of a button that redirects to the profile, three control options that meet requirements 3, 4, and 5 that will enable you to see the registered promotions, create evaluations and view the history of these evaluations, in addition, the screen has a panel with the pending, completed assessment so that they are easily accessible to the user, including crucial information such as the year of the assigned promotion, the class of the rise, the date of creation and current status of the evaluation. The user's personal information can be seen as the teacher's registered information and the ability to modify it if necessary.

Figure 7. Main screen

In Figure 8, you can see the view promotions screen where you can manage promotions by creating and viewing them. You know, a promotion screen where you can see its information, add students, see the students on the rise, see evaluations, and edit its information.

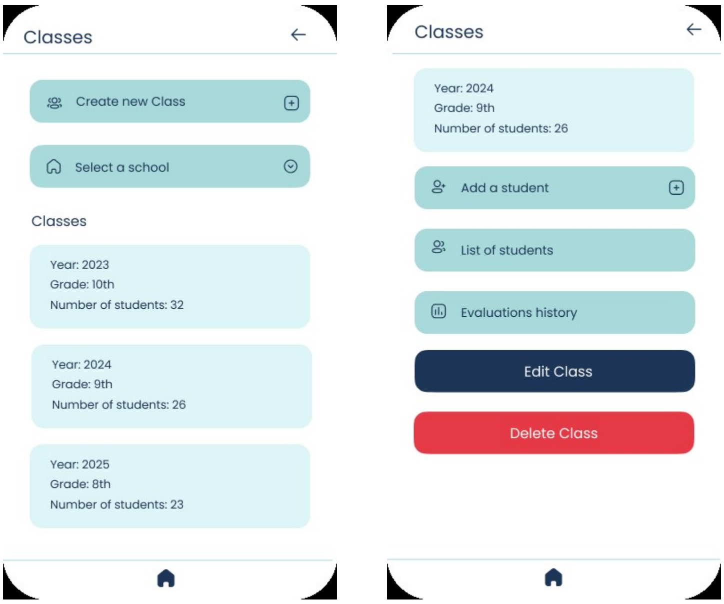

Figure 8. See Promotions

In Figure 9. The view students screen displays all the students of a selected school and allows you to create students. Likewise, there is a screen to create a student where their information on height, weight, height, etc., is recorded.

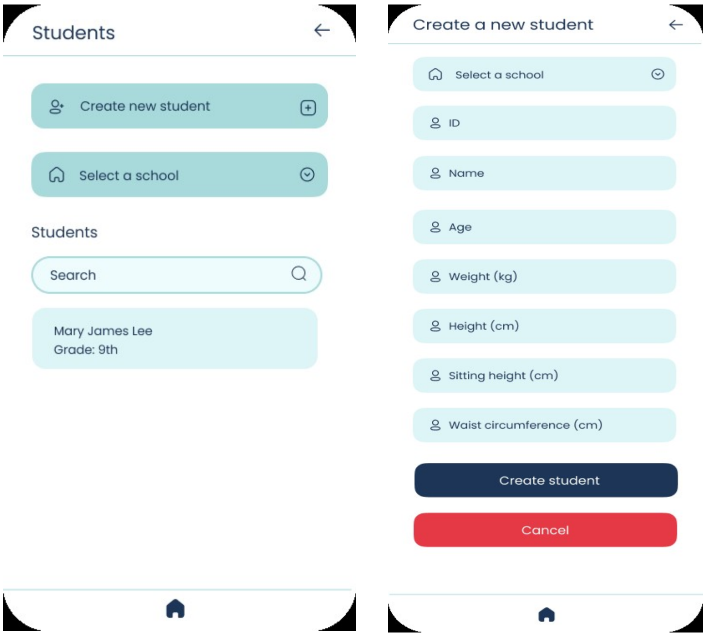

Figure 9. See students

Figure 10 shows the Entity-Relationship Model of the proposal.

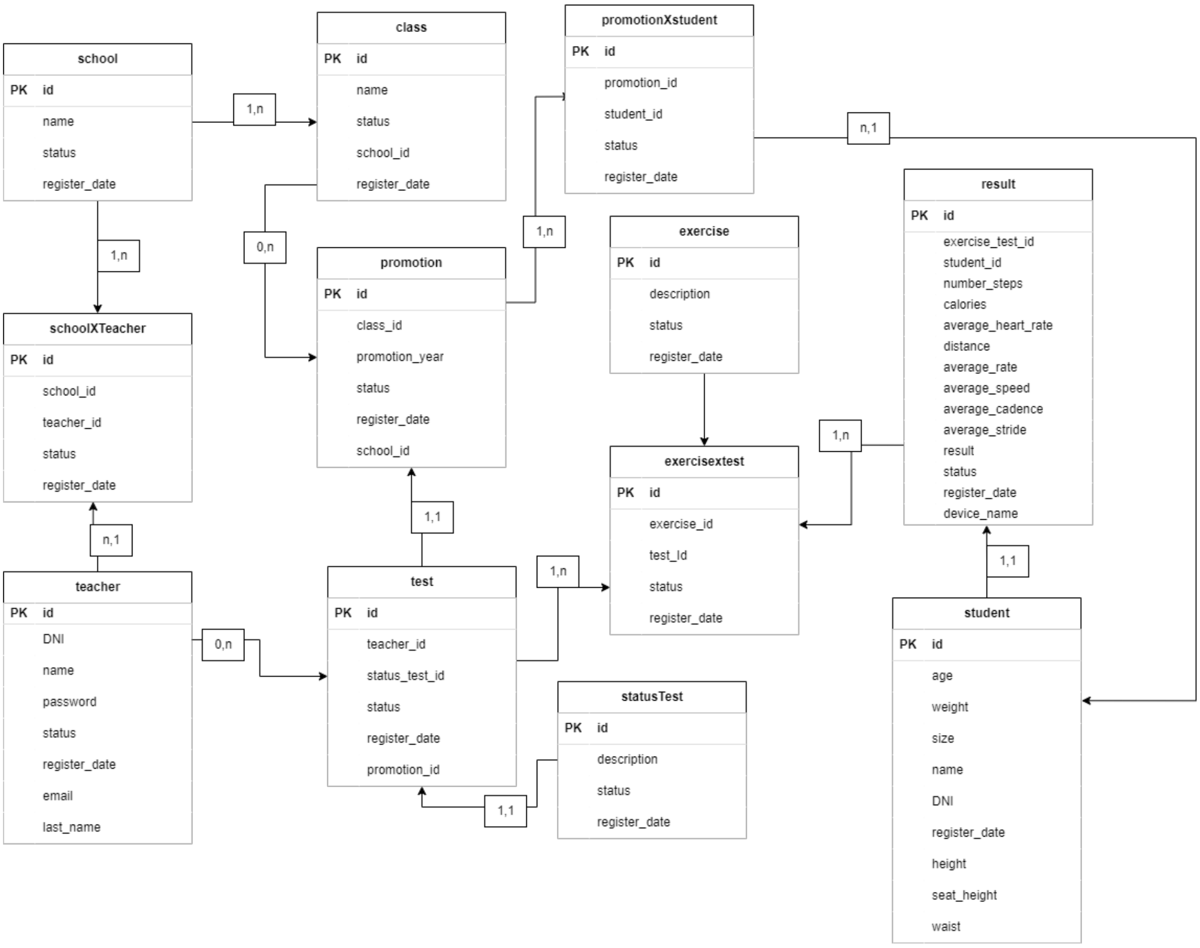

Figure 10. Entity-Relationship Model

3.4.3. Development

This work proposes that, based on the application of computer science and a branch of artificial intelligence defined as Machine Learning, the creation of a mobile application that allows users to access physical state data collected by the device known as Smart Band and through a machine learning algorithm to determine whether it is suitable for carrying out high or moderate performance physical activities. It is intended that the teacher in charge of the motor competence evaluation can, with the knowledge acquired from the model and the information treated, optimally evaluate the physical condition of his students and eventually prevent pre-existing pathologies unknown to the students before the exercise, such as It can be respiratory or cardiac. For the construction of the model, agile methodologies were used, as mentioned in the materials and methods section, both being highly effective for the performance of tasks.

1. Persistence

For data persistence, it was decided to use a PostgreSQL database, that is, a relational database. We began by creating the entity-relationship model, as shown in Fig. 10. This model has how the recorded information will be stored. The students have data such as:
The school table stores the school's name and records the date when the new record is created. We also have the class table, which holds the school class, related by a foreign key to school_id. Next, the teacher table stores the teachers ' ID, name, password, and email fields. We also have the promotion table, which identifies the promotion year.
In addition, there is also the exercise and result table, which in the exercise table mentions the exercises performed, and in the result table, the results of the activities are shown; all tables are related through Foreign Keys. We reached step 4 of normalization.

2. SQL-Alchemy

Sql-Alchemy [16] is a library that allows you to treat databases directly from the programming language; this tool is known as object-relationship mapping (ORM) [17], as we see in Figure 11.

```python
from datetime import datetime
from database.db import db
from marshmallow import Schema, fields

class Class(db.Model):
    __tablename__ = "class"
    id = db.Column(db.Integer, primary_key=True)
    name = db.Column(db.String(100), nullable=False)
    status = db.Column(db.Boolean, default=True, nullable=False)
    register_date = db.Column(db.DateTime, default=datetime.utcnow())
    school_id = db.Column(db.Integer, db.ForeignKey("school.id"), nullable=False)
    school = db.relationship("School", backref="class", uselist=False)


class ClassSchema(Schema):
    id = fields.Integer()
    name = fields.String()
    status = fields.Boolean()
    register_date = fields.Date()
```

Figure 11. database treatment

3. API-REST

The Flask framework was used to connect to the database, using it as a backend area. Flask is a lightweight and flexible web framework written in Python that allows you to build fast and efficient web applications. With its minimalist approach, Flask offers URL routing, view controllers, database integration, templates, extensions, and a built-in development server. It is widely used due to its ease of use and ability to adapt to different projects, from small applications to complex web projects.

4. Authentication

The authentication was carried out using the Flask framework; that is, it was done by creating a database that was done previously, where the user will be registered and can be verified with the data entered in real time.

5. Development of intelligent model

As stated in previous sections, it was necessary to carry out a data survey in different institutions throughout the city of Arequipa. For this first stage, only two exercises were defined to train the model only with data from said exercises. These exercises were a 6-minute walk and recreational activities for 15 minutes.

From these exercises, 330 records were collected for both years. Both datasets will be used for training the model, which, due to the nature of the data and the absence of a critical value that serves as a label for its classification, will require using an unsupervised learning algorithm over a supervised one.

Of the known algorithms, the k-means algorithm was chosen to initially group the data into 2 clusters if they predispose to good or bad health. Centroids are defined from both adjusted as the model is trained with the data. This way, the model can be consolidated after appropriately cleaning the data obtained. This was achieved using the scikit learn library in Python.

After training the model, the results can be seen in a comparative average heart rate and age graph. If it has a suitable status, it is denoted in blue. Otherwise, it is red. This is visible in Figure 12:

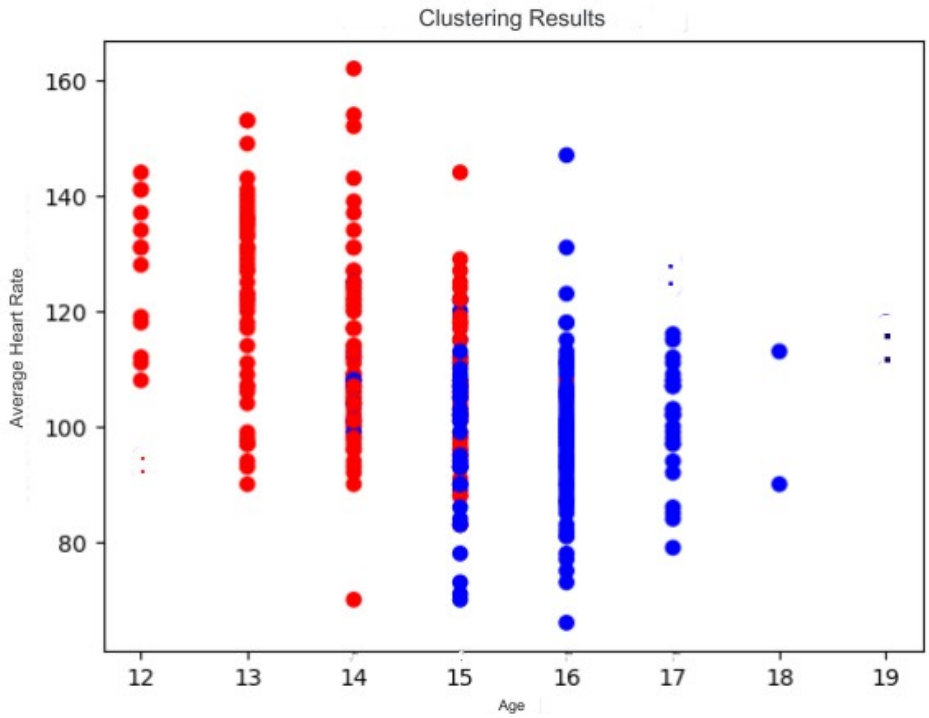

Figure 12. Points depend on the model used.

It should be noted that this model cannot currently be implemented in the REST service built in Flask and hosted on the Render cloud platform due to the resources that it demands to process the data that train the model and the response times that could be generated. Provide the same since no complete hosting plan provides primary processing services. For practical or demonstration purposes, the model was evaluated based on the passage of data in a dictionary, thus emulating the behavior it would have if it received the data with the same format that the back-end would receive from an HTTP POST request, as can be seen in figure 18:

```
# Datos del nuevo estudiante
new_student = {
    'age': 14,
    'weight': 45.5,
    'size': 155.0,
    'seat_height': 75.0,
    'waist': 60.0,
    'average_rate': 1800,
    'average_cadence': 50,
    'number_steps': 1200,
    'calories': 200,
    'average_speed': 2.5,
    'average_stride': 80,
    'average_heart_rate': 110,
    'average_max_heart_rate': 140
}

# Escalar los datos del nuevo estudiante
scaled_student = scaler.transform([list(new_student.values())])

# Predecir el cluster del nuevo estudiante
predicted_cluster = kmeans.predict(scaled_student)[0]

# Imprimir el resultado
print("Cluster asignado al nuevo estudiante:", predicted_cluster)

Cluster asignado al nuevo estudiante: 0
```

Figure 13. Testing the model with false registration.

4. RESULTS

A questionnaire that follows the usability evaluation “System Usability Scale” was applied to know the users' appreciation and identify areas for improvement.

Opinions were collected from the users from whom the results shown in Table 8 were obtained, from which a total of 82.5 was considered the final average, demonstrating that the software passed the usability test and was considered efficient. In addition, a general view of the responses from the users is found in Figure 14 as a bar graph. From this, we can conclude that, for the most part, the application was not complex and that the evaluators considered that it would be easy for other people to learn to use this system, demonstrating satisfaction with what was developed.

In the future, it is planned to improve the view of results so that the analysis is more precise with ML and to extend the number of exercises proposed to provide better evaluation to teachers. In addition, they are implementing a new user guide to better introduce new users to the various functionalities of the application so they can take advantage of all the services provided.

Table 8
Evaluation results

Questions	Person 1	Person 2	Person 3	Person 4	Person 5	Person 6
1. Overall, I would use this app frequently.	4	2	4	4	3	3
2. I find the app needs to be simplified.	2	2	4	2	2	2

3. The app is easy to use.	4	3	5	4	4	4
4. I need technical support to use this application.	2	3	5	3	5	3
5. The app's different functions are well integrated.	4	3	4	4	3	4
6. I find the app to be too inconsistent.	2	3	5	2	1	2
7. Most people would quickly learn how to use this app.	4	3	4	4	4	4
8. I find the app very difficult to use.	2	2	5	2	1	3
9. I feel confident using the application.	4	4	4	4	4	3
10. I need to learn many new things before using this application.	2	4	5	2	5	3
PROMEDIO INDIVIDUAL	75	72.5	112.5	77.5	80	77.5
PROMEDIO			**82.5**			

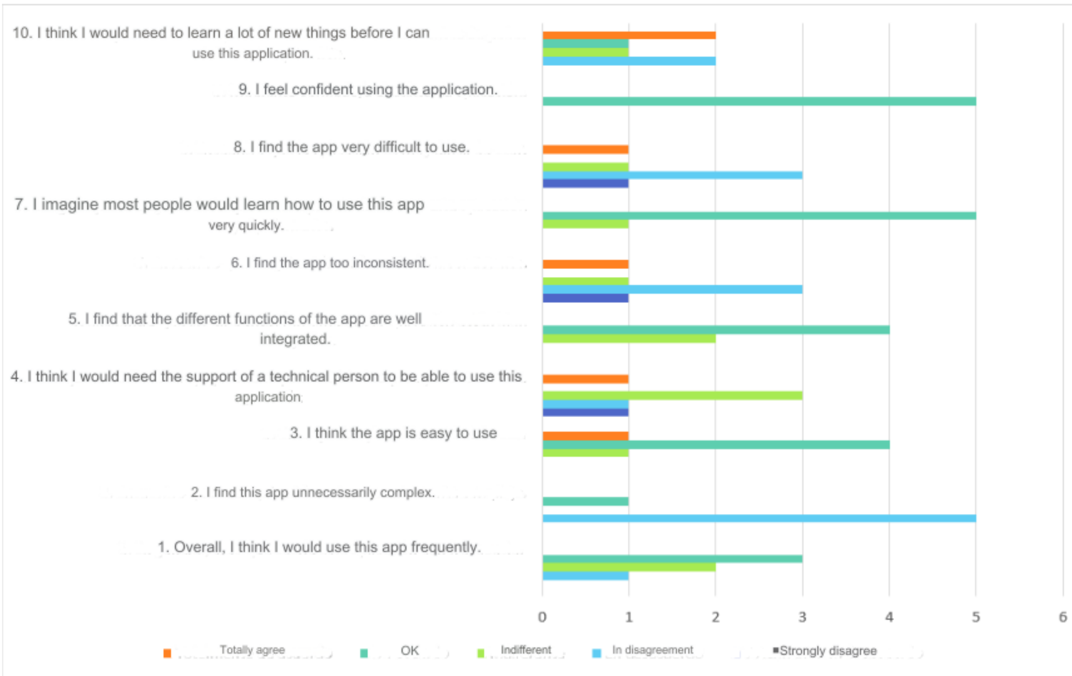

Figure 14. Results per question.

5. Conclusions

The development of the "Vital" mobile application made it possible to design the data capture, processing, and analysis of the physical activity motor tests that determined the health of schoolchildren in their educational centers.

The importance of measuring and monitoring physical health in schoolchildren is highlighted by the increasing incidence of problems related to overweight and lack of physical activity in this population. The proposed mobile application not only addresses this problem but also provides teachers with a comprehensive tool to understand and improve students' overall well-being, positively impacting their academic performance and adoption of healthy lifestyles.

Through the Usability Scale System evaluation, 82.5 was obtained as a final average, demonstrating that the software passed the usability test and was considered efficient.

As a final point, the satisfactory results of the research are recognized, achieving the development of the application and good feedback from the users with hopes of improving the application. Expanding the physical activity tests to be evaluated to contrast the results obtained is suggested as a future recommendation.

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