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PAPER

Optimizing Attendance Management in Educational Institutions Through Mobile Technologies: A Machine Learning and Cloud Computing Approach

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ABSTRACT

The primary goal of the study is to optimize and streamline the attendance recording and monitoring process for learning sessions by leveraging advanced technologies such as machine learning and cloud computing. The methodology employed is based on the extreme programming (XP) project management approach. Throughout its phases, the entire implementation process of the application, from conception to launch, is described in detail. Firebase is used as the database manager to ensure the efficiency and security of student information and attendance records. Additionally, the Firebase machine learning kit is used to verify attendance registration through QR codes. The application was tested with fifth-year high school students from an educational institution. The user interface has been designed to be attractive, intuitive, and easy to use for both teachers and students. The study results demonstrate that the use of this application significantly reduces the time spent on attendance recording compared to traditional methods. There has been a high level of satisfaction and acceptance of the "ASYS" application among teachers and students. In conclusion, this study has successfully implemented a mobile application that revolutionizes attendance recording and monitoring in educational institutions. It harnesses the power of machine learning and cloud computing to enhance efficiency and the user experience.

KEYWORDS

attendance records, mobile application, machine learning, cloud computing, education, process optimization

1 INTRODUCTION

1.1 Literature review

The process of attendance registration and control in educational institutions is essential, but it is often complex and time-consuming. Traditional methods of

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registration, which often involve paper attendance sheets or rudimentary electronic systems, can be error-prone, inefficient, and require a significant amount of manual administrative work by teachers and institution staff. Additionally, these methods may not be effective enough to ensure accurate tracking of student attendance [1]. During the first quarter of 2021, 88.5% of the total internet user population accessed it through mobile phones or smartphones, 16.7% through a laptop, and the remaining percentage through other internet-connected devices [2]. Comparing this to the figures recorded in a similar quarter in 2020, there was a 0.6 percentage point increase in internet access via mobile phones. An increase in this figure is expected for 2022. On the other hand, applications are what make mobile phones useful. There are numerous advantages to using mobile applications from an educational perspective that can be considered today. For instance, manual attendance recording by teachers can be a time-consuming and error-prone process [3], as well as consuming teachers' time when calculating averages. The use of a mobile attendance system eliminates the disadvantages of the manual system.

The primary motivation for this research is to enhance the efficiency of attendance tracking for teachers, as it can become a cumbersome task when managing a large number of students [4]. It also aims to gain experience in mobile application development as part of our professional growth, utilizing methods and new technologies such as database management, persistence, authentication, and storage with Firebase, BrainShop [5], and the Firebase machine learning kit [6]. The goal is to create a better-organized, robust, and consistent application capable of meeting all the basic requirements for its launch, thus complying with all stages of the extreme programming (XP) methodology.

1.2 Research background

Similar research, such as that conducted by [7], presents an automated solution where a mobile application based on Java was developed. It was wirelessly connected to a central database implemented using MySQL and tasked with recording attendance information, among other functions. The system was implemented at a university to record student data, absence time, presence time, and accumulated attendance per month, resulting in the efficient and effective utilization of the system. Likewise, in the research conducted by [8], an application for Android and iOS devices was developed to record student attendance as an alternative to manual registration. The proposal involves developing an application designed for teachers and students. This application will display information about the courses taught by teachers and the courses in which students are enrolled. When attendance is recorded, the data is synchronized with the Moodle platform, reflecting this information on the virtual platform. Tools such as MariaDB were used as the database manager, while web services were utilized to synchronize the application with the Moodle and institutional databases. The implementation of this application was justified by a survey indicating that 100% of teachers would support using an application for taking attendance. Similarly, in another study by [9], researchers collected information from 367 students to measure their class attendance, online learning activities, and performance in online formative assessments. This study utilized learning analytics methods to measure class attendance, online learning activities, and performance in online formative assessments. The research results contribute to understanding the impact of class attendance on academic performance in courses and the interaction of participation factors in online learning within the

context of technology-enhanced courses. In the research proposed by [10], a solution to the attendance control problem is presented. It involves developing a hybrid Android application prototype using open-source technologies such as the Ionic framework and the face-api.js library for JavaScript. The proposal focuses on efficient and agile monitoring of student attendance within the classroom, utilizing facial recognition as a key element to achieve faster and more secure control. 92.8% of teachers expressed satisfaction with the use of the application because they feel more secure using facial recognition to verify student attendance.

Regarding the use of the XP methodology, [11] developed a mobile application for managing attendance records and evaluating university students. SQLite was utilized for database management in conjunction with Android Studio and the XP methodology. This approach guaranteed acceptance and adherence to the client's proposal and requirements. The results showed the high availability and integrity of information concerning attendance records and evaluations. Additionally, the utilization of the XP methodology facilitated continuous feedback with the client, leading to ongoing improvements in the application.

The data analysis presented in [12] is utilized to examine different skills by collecting unstructured data to identify trends in job positions within the oil and gas industry. Although the context of the case study differs from that presented in this document, it is evident that data analysis enhances comprehension of the skills and performance of a group of individuals. It categorizes them on a scale from 1 to 10 based on job recurrence, aligning with the goals of attendance and academic performance analysis. In this context, [13] demonstrated that the use of the XP methodology ensures the development of small- to medium-scale applications. Unlike traditional processes and tools, XP emphasizes the rapid development of mobile applications and enables immediate responses to changes that occur during the development process. Therefore, its use in developing a mobile application for student learning in multiple schools is efficient and effective.

For predictions and data analysis to be accurate, it is necessary to use sensors or tools that collect data in real-time, as demonstrated in the study by [14], where Google tools (Firebase) were utilized to collect and promptly organize data for the detection of cardiovascular diseases. It demonstrated great effectiveness in recognizing and handling a large amount of data. In the research conducted by [15], which focuses on the use of frameworks in mobile application development, extensive investigation was carried out on the requirements and features that a mobile application should offer. A systematic mapping study, consultation with experts, implementation in projects using agile methodologies, and testing in a university environment were employed to identify these characteristics. The results demonstrated an enhancement in development and provided a valuable guide for addressing all the requirements or aspects of the mobile application. This not only improved development times but also served as educational material.

Finally, in the research proposed by [16], an application was developed to monitor the health status of patients with heart problems, considering that data must be updated in real-time. The researchers concluded that Firebase was the most suitable platform for managing cloud data. They highlighted that this tool provides various services, such as analytics, which offer data and graphs of user interactions. In conclusion, the research demonstrates the accuracy of the application in offering advice and predictions in sensitive areas such as healthcare.

Regarding the use of NoSQL databases (non-relational databases), the study [17] introduces a method based on computer vision to automate the reading of water and electricity meters through a mobile application. It stores photos and reading

data in a NoSQL database. Using firebase storage allows a concessionaire to store and process these readings for future predictive analysis of water or electricity resource management. This method was patented, producing successful outcomes in the meter reading market in Brazil. On the other hand, [18] proposes a personal and decentralized cloud data model to manage health data in schools using real-time NoSQL databases provided by the Firebase platform. Through this service, a school health information system can have full control over sensitive data such as the student's school number, name, temperature test time, temperature data, and test machine number. This model was tested and applied, achieving its goal of providing students with more active control over their personal health information.

2 METHODS AND MATERIALS

The XP methodology is used, consisting of the following phases [19]: planning, design, coding, testing, and deployment, as illustrated in Figure 1. The XP methodology is crucial in this research because it ensures that the development of the mobile application for attendance recording is customer-centric, adaptable, communicative, high-quality, and efficient. These characteristics are essential for the success of a project of this nature, as they directly impact academic management and the experiences of users and teachers in educational institutions. Firebase is used as the database management system because it is a fast and efficient technology for handling a large amount of unstructured data [20]. Android serves as the development platform, and the XP methodology is employed to manage the development of the proposal.

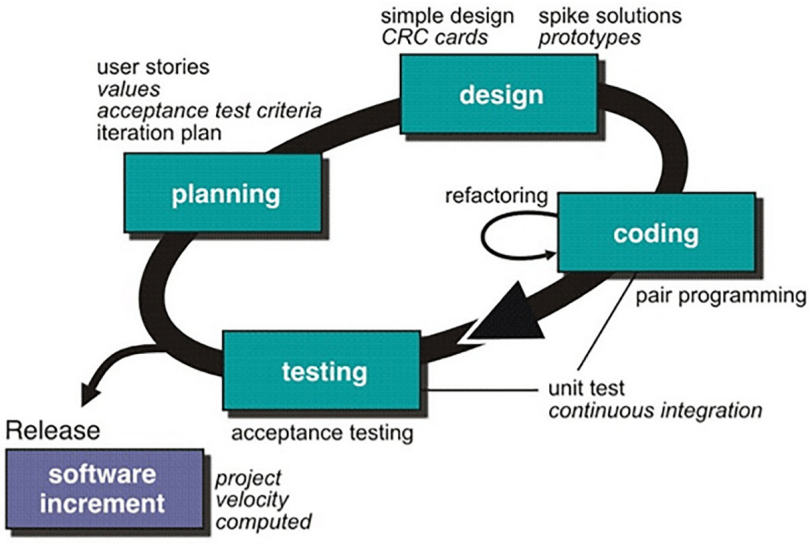

Fig. 1. Phases of the XP methodology [21] cited by [20]

2.1 Phase 1: Planning

According to reference [22], it is crucial to prioritize the functions that will be developed first. This approach allows for the gradual implantation of the application, ensuring that it meets the primary needs of the users. In the operation of the

application developed in [22], two types of data are used: primary data and secondary data. In this research, the primary and secondary data are related to student attendance (refer to Table 1).

Table 1. Student attendance data, adapted from [22]

Primary Data	Secondary Data
Student identification code and name	University profile
Student enrollment data	Location data
Calendar data (Day, Month, Year)	Student academic performance data
Global time data	Attendance recap report format
Internet fee	Application development time
	Development difficulty level
	Application design difficulty level
	Feature development rate

In this context, the first thing defined in this phase was user stories, which in other development methodologies are known as requirements, and later, they were prioritized. Below, Table 2 displays one of the identified user stories [23].

Table 2. User story

Number: 1	Name: Access to the Application
User: Teacher, Student	Assigned Iteration: 1
Business Priority: High (High/Medium/Low)	Estimated Points: 2
Development Risk: Medium (High/Medium/Low)	Actual Points: 2
Description: Users will have a unique username and password for logging in	
Observations: Only users who are registered in the application will have access to its functionalities.	

2.2 Phase 2: Design

During this phase, all the application's mockups were developed for end users to interact with. In other methodologies, deliverables such as sequence diagrams are typically developed; however, in this case, the client-server model was chosen [23]. Below, Figure 2 displays the primary interfaces of the mobile application.

- Students
  - Screen for user login.
  - Screen displaying the list of students' courses and their respective attendance schedules.
  - Screen for marking student attendance upon entry and exit.
- Teachers.
  - Screen for user login.
  - Screen to view the list of courses they teach.
  - Screen for downloading the attendance list for a specific course.

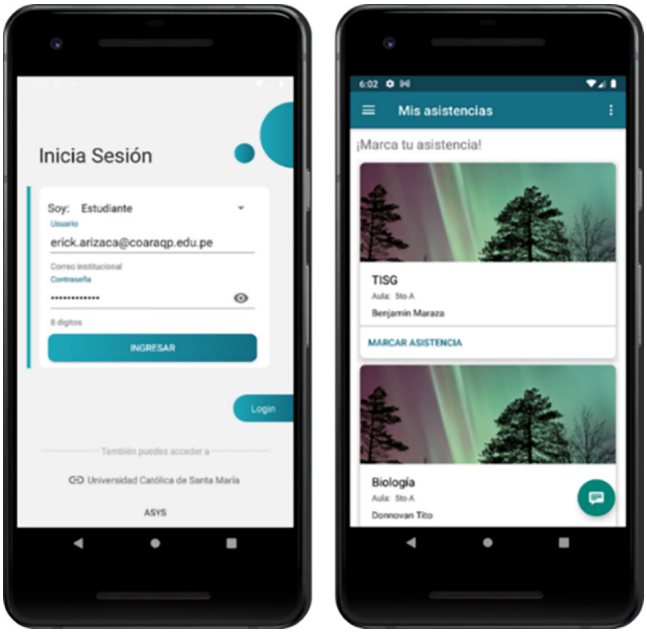

Fig. 2. Mobile application interfaces

2.3 Phase 03: Coding

Implementation of the model-view-view model design pattern. In this phase, the application's functionalities began to be coded using the model-view-model (MVVM) design pattern. This pattern was chosen because it enables the development of more robust Android applications and aligns with the development methodology employed [24], particularly for development in Android Studio (see Figure 3).

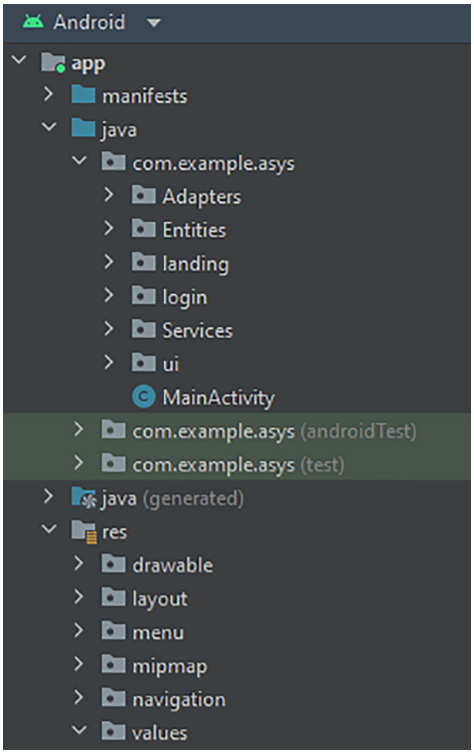

Fig. 3. MVVM pattern of the application

In the model layer, data is translated and delivered to the view model. The view-model layer connects to the database or external APIs, and the view layer presents the data, which can be accessed through commands.

Use of firebase as a database manager. Firebase was chosen as the database manager because of its benefits, including cloud storage, rapid scalability, and its data analytics add-on for creating reports on application usage by users (see Figure 4).

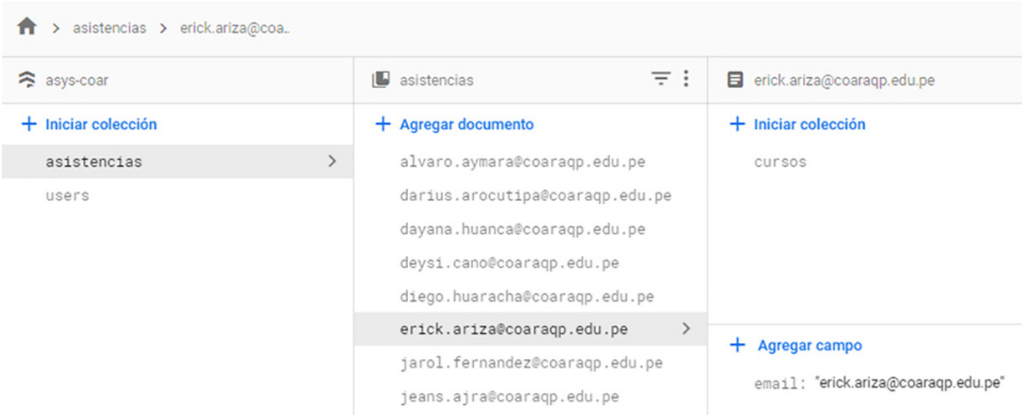

Fig. 4. Firebase as a database manager

In Figure 4, you can observe the database implemented in Firebase. It displays the code of the courses and their corresponding fields, including the classroom, day, entry time, exit time, course name, and teacher. In Cloud Firestore, the unit of storage is the document. A document is a data record with limited resources that includes fields with assigned values [25], such as the "email" field. On the other hand, there are collections. Documents are stored in collections, which are simply containers of documents [25]. For example, in Figure 5, there is a collection named "attendances," which contains a set of documents capable of storing collections. One of these collections is store collections, such as the "courses" collection, which keeps track of the courses in which each student is enrolled.

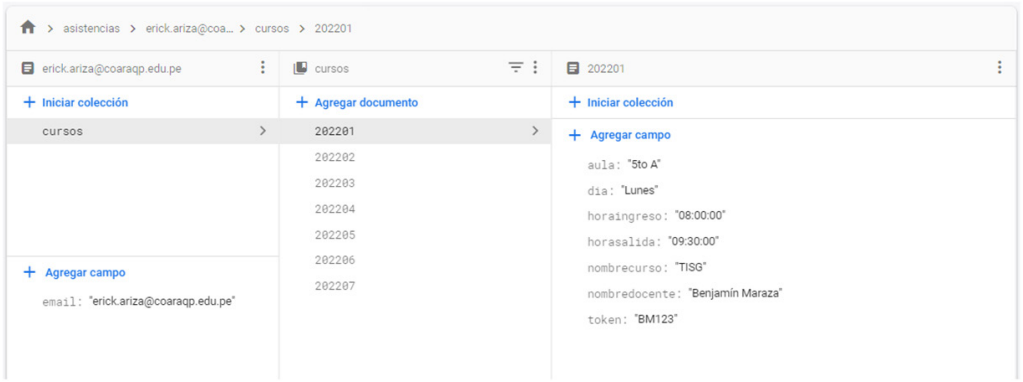

Fig. 5. "Courses" collection cloud firestore

Figure 5 illustrates the "courses" collection, which stores the courses in which the student is enrolled. Each subject is uniquely identified by the subject code.

Below, the data model for students and their corresponding courses is detailed in a data dictionary.

Data model. The attributes that manage the primary functionalities of the mobile application were gathered from students and their respective courses, as depicted in Tables 3 and 4, respectively.

Table 3. Data dictionary – student

Attribute	Description	Encoded Domain	Data Type
Student Code	Student's code	code	String
Email	Student's institutional email	email	String
Grade	Grade the student is in	grade	String
Name	Student's full name	name	String

Table 4. Data dictionary – courses

Attribute	Description	Encoded Domain	Data Type
Classroom	Classroom where the student attends classes	classroom	String
Day	Day when the student has classes	day	String
Entry time	Time of entry to classes	entrytime	String
Exit time	Time of exit from classes	exittime	String
Course name	Name of the course	coursename	String
Teacher name	Name of the teacher who teaches the course	teachername	String
Token	Token generated to validate attendance registration	token	String

Implementation of machine learning

QR code scanner. To implement the attendance registration functionality using QR codes, we employed the Firebase machine learning kit [6] to verify students' attendance records. Figure 6 illustrates the architecture used for QR code validation in the application.

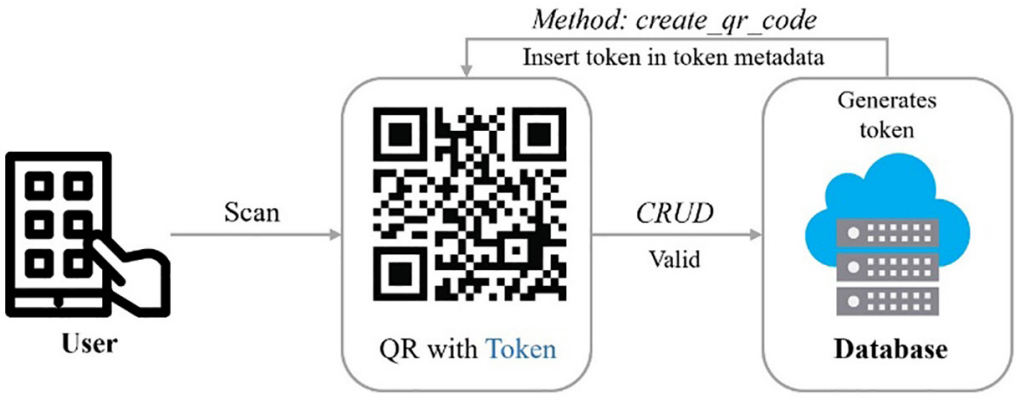

Fig. 6. Architecture for QR validation

In the architecture, the application connects directly to the database to retrieve the course token. This token is inserted into the QR code's description by the teachers, as only they are aware of it.

Automatic responses. In order to generate automatic responses to user inquiries, such as obtaining instructions on how to use the application or how to mark

attendance [26], we utilized the BrainShop.ai machine learning kit. This kit is capable of responding to user queries based on a knowledge base (a set of previously entered responses in the model) and generating automatic responses for users [27]. Figure 7 illustrates the knowledge base in BrainShop.ai that is utilized to generate automatic responses.

Fig. 7. BrainShop.ai knowledge base

Figure 8 illustrates the training phase of the machine learning model's knowledge base. This model takes a character string as input, which will be used as the basis for user queries. Additionally, for training purposes, an output containing the text that the model will generate in response to user queries is provided.

Fig. 8. Training of the machine learning model's knowledge base

Results of the coding phase. Next, the main screens of the resulting application, based on the user stories from the planning phase (Phase 01 of the XP methodology), are shown. It is worth noting that these results come after the testing phase (Phase 04 of the XP methodology).

User Story 01: Access to the application. Figure 9 displays the interfaces for accessing the application, which include welcome screens and a login screen based on roles (student and teacher).

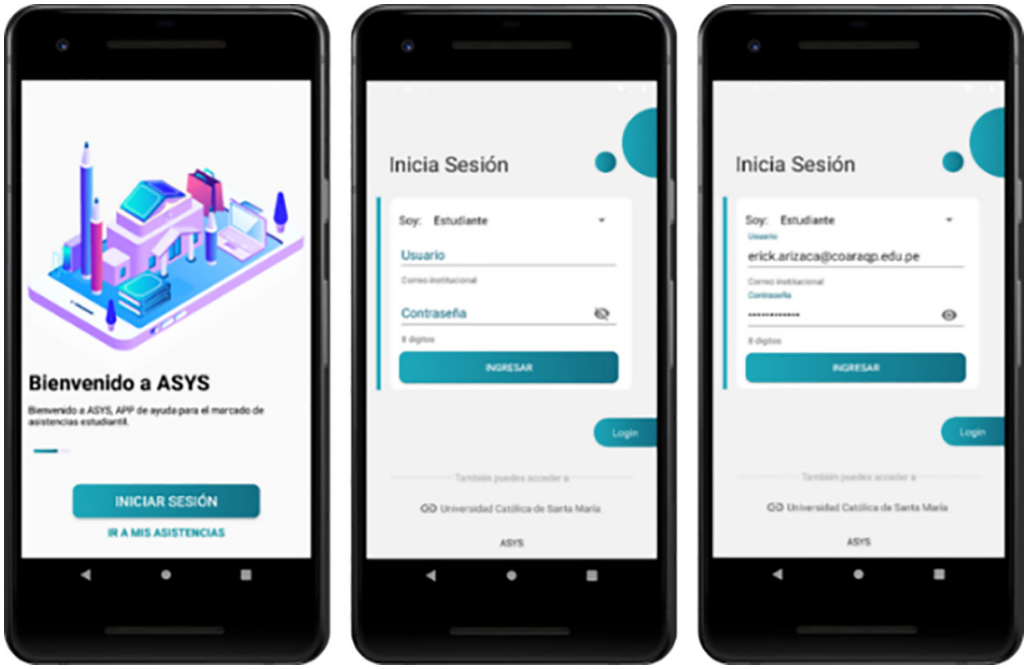

Fig. 9. Application access interfaces

User Story 02 and 03: Attendance registration and QR code attendance validation. Figure 10 displays the list of courses in which the student is enrolled. When the student clicks on the "REGISTER" button, a new activity is initiated, allowing the camera to scan the QR code (which contains a registered token). If the QR code is verified with the token from the database, the student's attendance is recorded accurately.

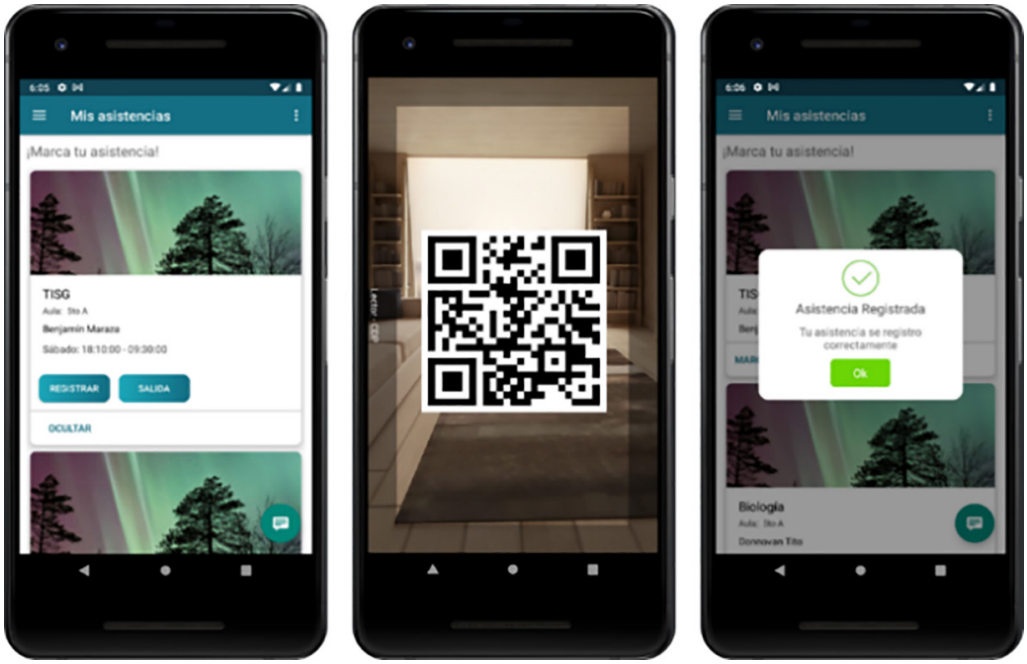

Fig. 10. Attendance registration and validation interfaces

User Story 04: Attendance control. Figure 11 illustrates the interfaces for attendance control conducted by teachers, which involve the following steps:

- Log into the application with the role of “Teacher” (only users with this role will be recognized).

Navigate to the corresponding course and click on “DOWNLOAD ATTENDANCE RECORD,” which will generate and download a CSV spreadsheet for teachers.

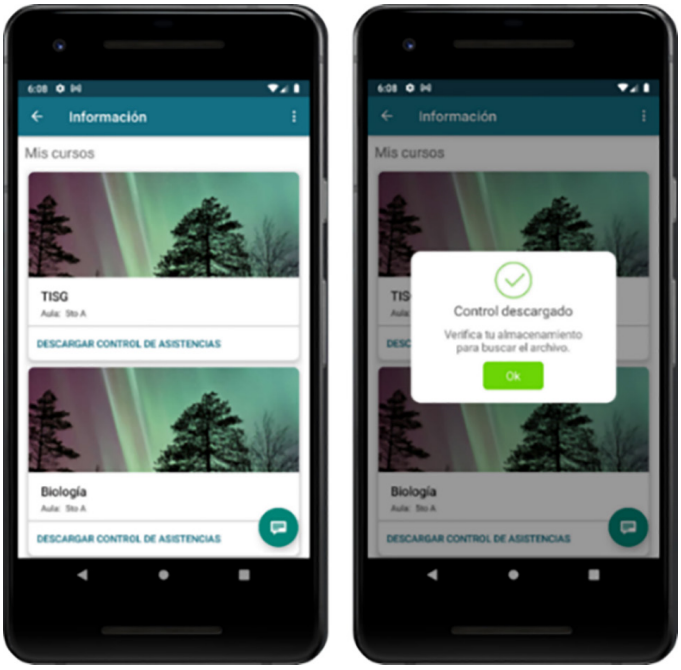

Fig. 11. Screen to download student attendance report

Figure 12 displays the attendance control file. The record includes the date, entry time, and exit time recorded by the student. The record corresponds to the “Mobile Technologies: Practical Group 1” course, scheduled for Tuesdays from 15:00 to 17:00.

G29

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Fig. 12. Attendance control file “mobile technologies – practice group 1”

2.4 Phase 04: Testing

When using the XP methodology, it is recommended to utilize unit tests and acceptance tests [28]. In the former, we will verify the code developed by the

programming team, and in the latter, we will check if the final product meets the expectations set in the planning phase. In our project, each module will be tested to ensure that correct values are entered, guide the client in performing the right activities, and maintain the integrity and security of the data provided by students and teachers. Finally, customer satisfaction will be assessed through surveys and scheduled presentations of the final product to ensure that all requirements and end-user expectations have been met. Table 5 displays the functional tests that have been implemented.

Table 5. Functional tests

Identifier	Functional Requirement	Detected Errors or Failures	Improved
CU01	Student registration in the application	No access errors detected	No
CU02	Student attendance marking	Incomplete interface	YES
CU03	Attendance saving	Inconsistency in Firebase date format	YES
CU04	Teacher login to the application	Incomplete interface	YES
CU05	Attendance list download	Incomplete downloads	YES
CU06	Attendance viewing	Disordered viewing	YES
CU07	Attendance marking	Attendance could not be recorded	YES
CU08	Log in with email and password	Lack of email recognition	YES

For the application launch, a survey was conducted, which can be accessed through the following link: Satisfaction survey. The survey includes a variety of questions to validate and assess user satisfaction with the application's use. Below, Table 6 shows the criteria considered for developing the survey.

Table 6. Evaluation criteria

No.	Evaluation Criteria	Description
1	Satisfaction and Ease of Attendance	Marking Assesses the ease and user satisfaction with the attendance marking process through communication with students.
2	Organization of ASYS Application	Elements Collects feedback on the organization of application elements, divided into various views of the application.
3	Application Colors	Presents a list of colors, including the current application color, and asks users to vote for the most comfortable color.
4	Application Navigation Style	Engages users to assess their comfort level with the application's navigation style.
5	Ease of Use of the Application	Gathers feedback from users about their initial experiences using the application.
6	Ease of Learning the Application	Collects information from users regarding the time it takes to adapt to the application.
7	Intuitive Application	Asks users to rate the application's ease of use for performing various factions within it.
8	Recommendation of the Application to Others	Engages users in discussing the likelihood of recommending the application to others.
9	Level of Satisfaction with the Application's	Use Provides a form with different areas of the application for users to measure satisfaction levels for each view and provide an overall rating.

2.5 Phase 05: Launch

For the application launch, the following steps were followed:

- Generate the application's APK file.
- Distribute the application installer to teachers and students within the institutional group.
- Evaluate the results obtained through the survey link.

This launch method was chosen due to its flexibility and ease, as the application is still in its validation stage.

3 RESULTS

Information was collected from 100 high school students and teachers during the first academic semester of 2022 over a period of one month. The general results of the surveys are shown in Figure 12.

3.1 Satisfaction level with the use of the application

According to a satisfaction survey conducted, out of the total surveyed individuals, 18 (18%) consider their interaction with the application as good, 51 (51%) consider it very good, 28 (28%) consider it excellent, and 2 (2%) consider it regular. The latter cases may be due to a lack of Internet connectivity or inappropriate use of the application by users.

3.2 Acceptance level of the application

Furthermore, since one of the long-term objectives of this research is to scale the use of the application to all years and campuses of the educational institution, a question was asked about whether users would recommend the application to others. The responses to this question are shown below. The results are displayed in Table 7.

Table 7. Application acceptance criteria (Adapted from [10])

Criteria	Results	Fulfillment Level
Functionality	The system fulfills the essential functionalities for accurate registration and control of student attendance	100%
Operability	The system integrates seamlessly with the database manager for subsequent functionalities implemented in the application	100%
Satisfaction	The results show a high level of satisfaction among both teachers and students regarding the use of the application.	98%
Acceptance	The "ASYS" application fulfills the registration and control of student attendance.	92.9%

In Table 7, all functionality and operability criteria meet the acceptance criteria at 100%. However, the satisfaction and acceptance criteria reach 98% and 92.9%, respectively, showing a slight deviation of 2% and 7.1% from the ideal.

4 DISCUSSION

When comparing the results of similar proposals in terms of functionality, we can highlight both similarities and differences, as outlined below:

Attendance automation: Similar to other studies [7] [8] [10], the current study aims to automate the attendance registration process in educational institutions. This is achieved through the development of a mobile application that simplifies and expedites the task for teachers, thus enhancing the efficiency of the process.

Use of advanced technology: The current study, similar to some previous studies [7] [8] [10], leverages advanced technologies such as machine learning and cloud computing to improve attendance registration. This reflects a trend towards integrating cutting-edge technology into educational management.

Interaction with teachers and students: Some previous studies [8] and [10] emphasize the importance of interaction between teachers and students in the attendance registration process. In the current study, both teachers and students are taken into consideration when designing the user interface and evaluating the acceptance of the application.

Facial recognition focus: In contrast to other studies [10], the current study does not depend on facial recognition as a primary method element for attendance control. Instead, QR code technology is used to verify student attendance.

Development methodology: While some previous studies [7] [8] [11] mention the use of specific methodologies such as XP in application development, the current research does not focus on methodological details but places a greater emphasis on technological implementation.

Application context: Each previous study addresses the attendance registration problem in specific educational contexts, such as universities [7], virtual institutions [8], or even in the oil and gas industry [12]. In contrast, the current study focuses on the broader context of educational institutions.

According to [29], early detection of students with issues can help take necessary actions and ultimately prevent students from being dropped or failing. Therefore, attendance at learning sessions may be a factor in this prediction.

This study utilizes advanced technology for attendance recording in education, incorporating QR codes and a comprehensive educational approach. It builds on previous studies to assess its effectiveness.

5 CONCLUSIONS

It has been demonstrated that the XP methodology, applied in the first three development phases, is highly effective in ensuring the quality of the mobile application. Its customer-centric approach has resulted in a final product that efficiently meets user requirements and expectations compared to traditional methodologies.

The use of tools and techniques associated with the XP methodology has facilitated the identification of functional and non-functional requirements. This has been essential for developing an application that complies with the guidelines and requirements specified by the client.

The successful application of the XP methodology has enabled constant communication and feedback with the client and users. This flexibility has led to rapid responses to changes suggested by the client, significantly improving the application's adaptability to changing needs.

The implementation of the mobile application has shown positive outcomes in utilizing Firebase services, including Cloud Firestore and Firebase Authentication, within the access and attendance registration modules. This has contributed to the system's robustness and reliability. The use of the application has simplified the attendance registration process for both students and teachers. Automatic attendance record generation has saved time and resources, enhancing academic management efficiency.

The app utilizes machine learning for auto-responses, improving the user experience and support efficiency, particularly for inquiries regarding app usage.

6 REFERENCES

[1] A. F. Abdul, R. Mohamad, F. Abdul, and N. Izzati, "Student attendance system using an android based mobile application," in *IEEE 11th IEEE Symposium on Computer Applications & Industrial Electronics (ISCAIE)*, 2021, pp. 224–227. https://doi.org/10.1109/ISCAIE51753.2021.9431771

[2] INEI, National Institute of Statistics and Informatics, Gob.pe. [Online]. Available: https://bit.ly/3IwNHHd/. [Accessed: 23 May 2024].

[3] I. Milon, H. Kamrul, B. Masum, and U. Manik, "Development of smartphone-based student attendance system," in *IEEE Region 10 Humanitarian Technology Conference, Dhaka, Bangladesh*, 2017, pp. 230–233. https://doi.org/10.1109/R10-HTC.2017.8288945

[4] B. Maraza-Quispe, "Impact of the use of the video game simcity on the development of critical thinking in students: A quantitative experimental approach," *IEEE Revista Iberoamericana de Tecnologias del Aprendizaje*, vol. 18, no. 4, pp. 411–418, 2023. https://doi.org/10.1109/RITA.2023.3327066

[5] BrainShop, "Brainshop documentation: Quick start," 2020. https://brainshop.ai/node/260732

[6] "AA Kit for Firebase," Firebase. [Online]. Available: https://firebase.google.com/docs/ml-kit?hl=es-419. [Accessed: 23 May 2024].

[7] O. A. Akinola, S. O. Olopade, and A. S. Afolabi, "Development of mobile and desktop applications for a fingerprint-based attendance management system," *Indones. J. Electr. Eng. Comput. Sci.*, vol. 24, no. 1, p. 570, 2021. https://doi.org/10.11591/ijeecs.v24.i1.pp570-580

[8] C. Roca Espinosa and A. Villafuerte Benavides, "Aplicación móvil para registro de asistencias de la universidad central del ecuador," *Quito: UCE*. 2017. https://bit.ly/3Iw8Ykf

[9] C. Lu and M. Cutumisu, "Online engagement and performance on formative assessments mediate the relationship between attendance and course performance," *Int. J. Educ. Technol. High. Educ.*, vol. 19, 2022. https://doi.org/10.1186/s41239-021-00307-5

[10] Y. J. Lee, S.-H. Jeong, and Y. Li, "Korean pre-service teachers' flipped learning experiences in a teacher education program," *Int. J. Educ. Method.*, vol. 8, no. 4, pp. 711–717, 2022. https://doi.org/10.12973/ijem.8.4.711

[11] J. Martínez-López and D. R. Obregón-Colina, "Mobile application for managing attendance records and evaluations of university students," *Dialnet*, vol. 18, no. 3, pp. 97–111, 2020. https://bit.ly/3IrYSRz

[12] A. Alibasic *et al.*, "Evaluation of the trends in jobs and skill-sets using data analytics: A case study," *J. Big. Data,* vol. 9, 2022. https://doi.org/10.1186/s40537-022-00576-5

[13] N. Qotrun Nada, U. Khotimatus Saadah, A. Khoirul Anam, and S. Widianingrum, "Design on 'FunPhy: Fun Physics' educational game apps using agile extreme programming," in *Journal of Physics: Conference Series*, 2019, vol. 1179. https://doi.org/10.1088/1742-6596/1179/1/012071

[14] A. Shah, S. Ahirrao, S. Pandya, K. Kotecha, and S. Rathod, "Smart cardiac framework for an early detection of cardiac arrest condition and risk," *Front. Public Health*, vol. 9, 2021. https://doi.org/10.3389/fpubh.2021.762303

[15] D. Martinez, X. Ferre, G. Guerrero, and N. Juristo, "An agile-based integrated framework for mobile application development considering ilities," *IEEE Access*, vol. 8, pp. 72461–72470, 2020. https://doi.org/10.1109/ACCESS.2020.2987882

[16] D. Forum, D. Chowdhury, K. Rupinder, P. Marloes, R. Chand, G. Singh, S. Singh, and R. Buyya, "A system for monitoring health status of heart patients using machine learning and cloud computing," *Internet of Things*, vol. 17, p. 100485, 2022. https://doi.org/10.1016/j.iot.2021.100485

[17] S. Athanassopoulos, P. Manoli, and V. Komis, "The use of ChatGPT as a learning tool to improve foreign language writing in a multilingual and multicultural classroom," vol. 3, no. 2, pp. 818–824, 2023. https://doi.org/10.25082/AMLER.2023.02.009

[18] X. Weng, H. Wu, Y. Pan, and H. Chen, "Decentralized personal cloud data model and its application in campus health information system," in *IEEE Intl. Conf. on Dependable, Autonomic and Secure Computing Congress,* 2021, pp. 879–883. https://doi.org/10.1109/DASC-PICom-CBDCom-CyberSciTech52372.2021.00146

[19] S. L. Syed-Abdullah and J. Karn, "The positive affect of the XP methodology," in *Extreme Programming and Agile Processes in Software Engineering*, Lecture Notes in Computer Science, H. Baumeister, M. Marchesi, and M. Holcombe Eds., Springer, Berlin, Heidelberg, 2005, vol. 3556. https://doi.org/10.1007/11499053_31

[20] C. Khawas and P. Shah, "Application of firebase in android app development – A study," *International Journal of Computer Applications*, vol. 179, no. 46, pp. 49–53, 2018. https://doi.org/10.5120/ijca2018917200

[21] R. Pressman, *Software Engineering*, Americo: Mc-Graw Hill, 2010.

[22] T. Katrilia, P. W. Anggoro, and P. K. D. Sp., "Optimization of innovation features in mobile-based attendance application," *Manag. Syst. Prod. Eng.*, vol. 30, no. 1, pp. 18–26, 2022. https://doi.org/10.2478/mspe-2022-0003

[23] R. Robles and J. Luis, "Aplicación móvil multiplataforma para mejorar la gestión de ventas en la veterinaria Janavet de Trujillo, 2020," *Universidad César Vallejo*, 2021. https://hdl.handle.net/20.500.12692/64405

[24] M. I. S. B. Khairat, Y. Priyadi, and M. Adrian, "Usability measurement in user interface design using heuristic evaluation & severity rating," in *IEEE 12th Annual Computing and Communication Workshop and Conference*, 2022, pp. 0974–0979. https://doi.org/10.1109/CCWC54503.2022.9720876

[25] "Cloud Firestore data model," Firebase. [Online]. Available: https://firebase.google.com/docs/firestore/data-model?hl=es-419. [Accessed: 23 May 2024].

[26] B. Ranoliya, N. Raghuwanshi, and S. Singh, "Chatbot for university related FAQs," in *International Conference on Advances in Computing, Communications and Informatics (ICACCI),* 2017, pp. 1525–1530. https://doi.org/10.1109/ICACCI.2017.8126057

[27] K. Chung and R. C. Park, "Chatbot-based heathcare service with a knowledge base for cloud computing," *Cluster Comput*., vol. 22, no. S1, pp. 1925–1937, 2019.

[28] J. Gutierrez, "System testing in extreme programming," Department of Computer Languages and Systems, University of Seville, 2022. https://bit.ly/3Vchblb

[29] M. Bellaj, A. Ben Dahmane, S. Boudra, and M. Lamarti Sefian, "Educational data mining: Employing machine learning techniques and hyperparameter optimization to improve students' academic performance," *Int. J. Onl. Eng. (iJOE)*, vol. 20, no. 3, pp. 55–74, 2024. https://doi.org/10.3991/ijoe.v20i03.46287

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