

## Toward optimized attendance management in education: A machine learning and cloud computing approach

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### Abstract

The main objective of the research is to optimize and streamline the attendance recording and monitoring process for learning sessions by applying advanced technologies such as Machine Learning and Cloud Computing. The methodology employed is based on the XP (Extreme Programming) 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 leveraged to validate 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 research 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 research has successfully implemented a mobile application that revolutionizes attendance recording and monitoring in educational institutions, harnessing the power of Machine Learning and Cloud Computing to enhance efficiency and the user experience.

**Keywords:** Attendance records; cloud computing; education; machine learning; mobile application; process optimization.

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## 1. Introduction

The process of attendance registration and control in educational institutions is an essential but often complex and time-consuming task. Traditional methods of 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 (Auer et al., 2022; Lu & Cutumisu 2022). Additionally, these methods may not be effective enough to ensure accurate tracking of student attendance. During the first quarter of 2021, of the total internet user population, 88.5% accessed it through mobile phones or smartphones, 16.7% through a laptop, and the rest through other internet-connected devices (Instituto Nacional de Estadística e Informática, 2021). 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, what makes mobile phones useful are applications that are academic and non-academic (Oliveira et al., 2021; Llorent-Vaquero et al., 2023; Basdogan et al., 2022). There are various advantages to using mobile applications from an educational perspective that can be considered today. For example, manual attendance recording by teachers can become a time-consuming and vulnerable process (Milon et al., 2017; Mojapelo, 2022), as well as consuming teachers' time when calculating averages. The use of a mobile attendance system eliminates the disadvantages of the manual system.

The main motivation for the development of this research is to maximize the efficiency of attendance taking by teachers, as it can be a tedious process when dealing with a large number of students (Maraza et al., 2022). It also aims to gain experience in mobile application development as part of our professional growth, using methods and new technologies such as database, persistence, authentication, and storage with Firebase and the BrainShop (BrainShop, 2020) and Firebase (Firebase, 2022) Machine Learning kit. 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 XP methodology.

Similar research, such as that conducted by Adewale et al., (2022), presents an automated solution in which a mobile application based on JAVA was developed. It is wirelessly connected to a central database implemented using MySQL, with the task of recording attendance information, among other things. 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 use of the system. Likewise, in the research conducted by Roca, et al., (2017), an application for Android and iOS devices was implemented to record student attendance as an alternative to manual registration. The proposal consists of an application dedicated to teachers and students that displays information such as the courses taught by teachers and the courses students are enrolled in. 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, and Web Services to synchronize the application with Moodle and institutional databases. The implementation of this application was justified through a survey showing that 100% of teachers would support the use of an application for attendance taking.

Similarly, a study was conducted to collect information from 367 students to measure their class attendance, online learning activities, and performance in online formative assessments (Lu, 2022). This study applied learning analytics methods to measure class attendance, online learning activities, and performance in online formative assessments. The research results contribute to understanding

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the impact of class attendance on course academic performance and the interaction of participation factors in online learning in the context of technology-enhanced courses. In the research proposed by Padilla, et al., (2020), a solution to the attendance control problem is presented, consisting of the development of 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, using 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, as they feel more secure using facial recognition to verify student attendance.

Regarding the use of the Extreme Programming (XP) methodology, (Martinez-Lopez & Obregon-Colima, 2020) developed a mobile application for managing attendance records and evaluating university students. SQLite was used for database management, along with Android Studio and the Extreme Programming methodology, which ensured acceptance and compliance with the proposal and the requirements of the client. The results included high availability and integrity of information regarding attendance records and evaluations. Additionally, the use of the XP methodology allowed for continuous feedback from the client and, therefore, continuous improvement of the application.

The data analysis presented in Alibasi, et al., (2022) is used to analyze various skills through the collection of unstructured data to identify trends in job positions in the oil and gas industry. Although the context of the case study is different from that presented in this document, it can be observed that data analysis provides a better understanding of the skills and performance of a group of individuals, identifying them on a scale from 1 to 10 in terms of job recurrence, which is what is sought to be achieved with attendance and academic performance analysis. In this context, Nadal et al., (2019) demonstrated that the use of the XP methodology guarantees the development of small to medium-scale applications because, compared to processes and tools, it focuses on the aggressive development of mobile applications and allows for immediate response to changes that arise 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 exemplified in the study by Shah, et al., (2021), where Google tools (Firebase) were used to collect and immediately 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 Martinez, et al., (2020), which focuses on the use of frameworks in mobile application development, extensive research was conducted on the needs and characteristics that a mobile application should provide. A systematic mapping study, consultation with experts, implementation in projects with agile methodologies, and testing in a university environment were used to discover these characteristics. The results showed an improvement in development and a useful guide for covering all the needs or aspects of the mobile application, improving development times, and also serving as teaching material.

Finally, in the research proposed by Forum, et al., (2022), an application was developed to monitor the health status of patients with heart problems, taking into account 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 provide data and graphs of user interactions. In conclusion, the research shows the accuracy of the application in providing advice and predictions in sensitive areas such as healthcare.

Regarding the use of NoSQL databases (non-relational databases), Alvarez, et al., (2020) present 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 viable results in the meter reading market in Brazil. On the other hand, Weng et al., (2021) propose 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 and providing students with more active control over their health information data.

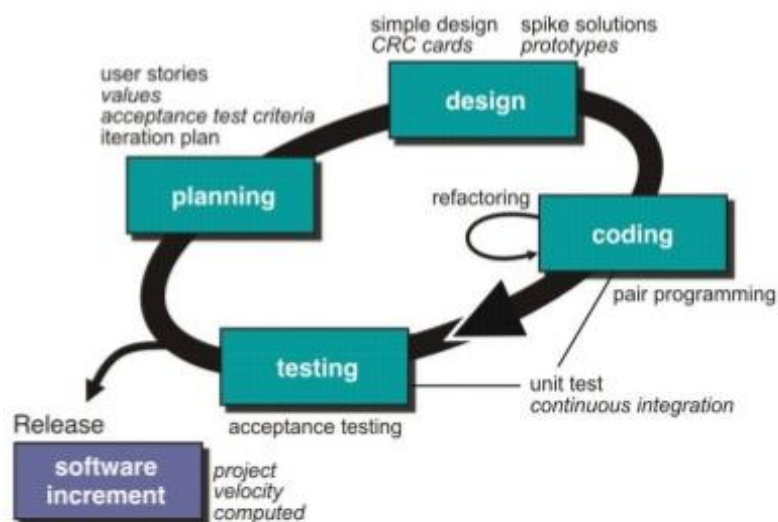
### 1.1. Purpose of study

The primary goal of the study is to use cutting-edge technologies like cloud computing and machine learning to streamline and enhance the process of tracking attendance and monitoring during learning sessions.

## 2. Methods and Materials

The Extreme Programming (XP) methodology is used, consisting of the following phases (Reyes & Marin, 2021): Planning, Design, Coding, Testing, and Deployment, as shown 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 a customer-centric, adaptable, communicative, high-quality, and efficient process. These characteristics are essential for the success of a project of this nature, which has a direct impact on academic management and the experience 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 (Khawas & Shah, 2018), Android is the development platform, and the XP methodology to manage the development of the proposal.

**Figure 1**  
*Phases of the XP methodology*



Source: Pressman (2010), cited by Reyes & Marin, (2021).

## 2.1 Procedure

### 2.1.1. Phase 1: Planning

According to Katrilla et al., (2022), it is important to select the prioritized functions that will be developed first so that the application can be implemented gradually and meet the primary needs of the users. In the operation of the application developed in (Katrilla & Dewa, 2022), two types of data are taken (Primary data and secondary data). In this research, the primary and secondary data are related to student attendance (See Table 1).

**Table 1**

*Student attendance data, adapted from*

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

Source: Katrilla et al., (2022)

In this context, the first thing defined in this phase were 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 (Reyna et al., 2021).

**Table 2**

*User story*

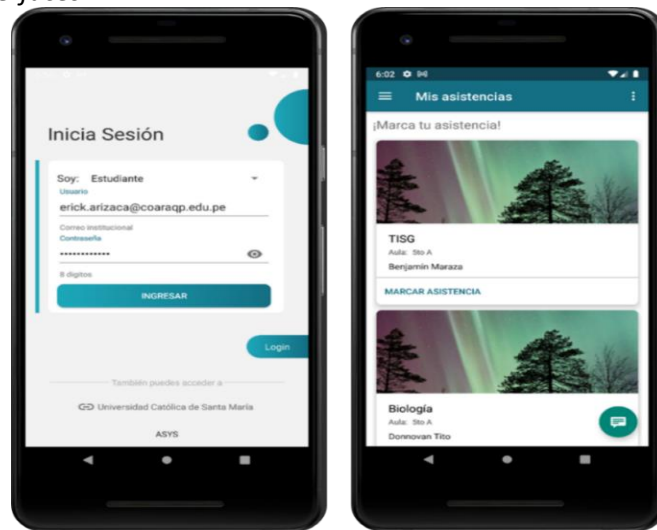
User Story 01	
Number: 1	Name: Access to the application
User: Teacher, Student	Assigned Iteration: 1
Business Priority: High (High / Medium / Low)	Estimated Points: 2
Development Risk: Medium (High / Medium / Low)	Actual Points: 2
Description: Users of the application will have a unique username and password with which they can log in	
Observations: Only users who are registered in the application will have access to its functionalities.	

### 2.1.2. Phase 2: Design

In this phase, all the application mockups were developed for end users to interact with. While in other methodologies, deliverables such as sequence diagrams are usually developed, in this case, the client-server model was chosen (Reyna, et al., 2021). Below, Figure 2 shows the main interfaces of the mobile application.

- **Students**
  - Screen for user login.
  - Screen to view the list of students' courses and their corresponding 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.

**Figure 2**  
*Mobile Application Interfaces*



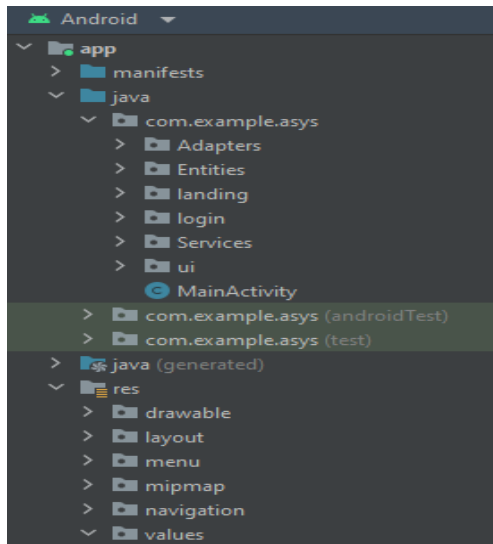
### 2.1.3. Phase 03: Coding

#### 2.1.3.1. Implementation of the Model-View-View-Model Design Pattern

In this phase, the application's functionalities began to be coded, for which the Model-View-View-Model (MVVM) design pattern was used, as it allows the implementation of much more robust Android applications and aligns with the development methodology used (Khairat et al., 2022); for development in Android Studio. See Figure 3.

**Figure 3**  
*MVVM Pattern of the Application*

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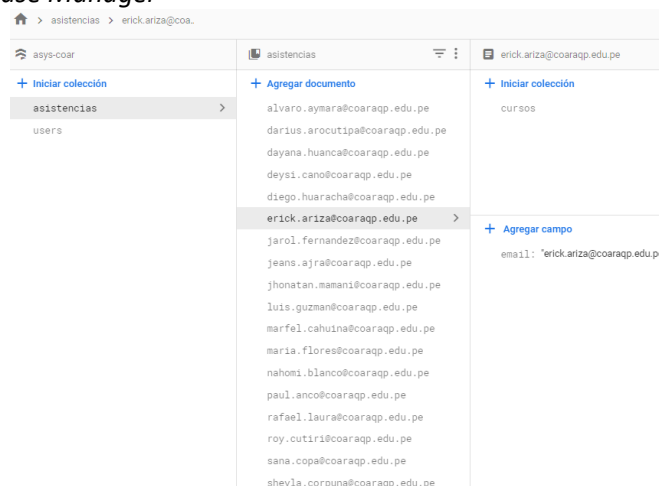


Where the model layer translates all the data and delivers it to the ViewModel, the ViewModel layer connects to the database or external APIs, and the view layer presents the data, which can be invoked through commands.

## 2.2. Use of Firebase as a Database Manager

Firestore was used as a database manager due to its advantages, such as cloud storage and rapid scalability it offers, as well as its data analytics add-on for generating reports on application demand from users. See Figure 4.

**Figure 4**  
*Firestore as a Database Manager*



In Figure 4, you can observe the database implemented in Firestore, where you can see the code of the courses and their corresponding fields, such as 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 low-resource record that contains fields with assigned values (Firestore, 2022), for example, the "email" field. On the other hand, there are collections. Documents are stored in collections, which are simply

containers of documents (Firebase, 2022). For example, in illustration 5, there is a collection called "attendances," within which there is a set of documents that can also store collections, such as the "courses" collection, which stores the courses in which each student is enrolled.

**Figure 5**  
*Courses Collection Cloud Firestore*

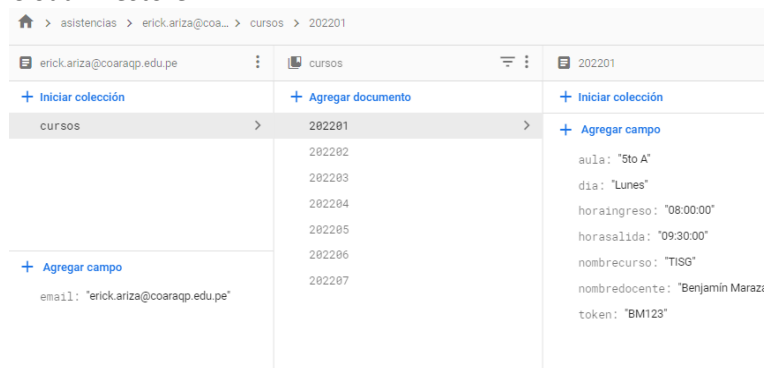


Figure 5 shows the "courses" collection, which stores the courses in which the student is enrolled. Each subject is uniquely identified by the subject code.

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

### 2.3. Data Model

The attributes that handle the main functionalities of the mobile application were collected from students and their corresponding courses, which are shown 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	The day when the student has classes	day	String
Entry time	Time of entry to classes	entry time	String
Exit time	Time of exit from classes	exit time	String
Course name	Name of the course	course name	String
Teacher name	Name of the teacher who teaches the course	teacher name	String
Token	The token generated to validate attendance registration	token	String

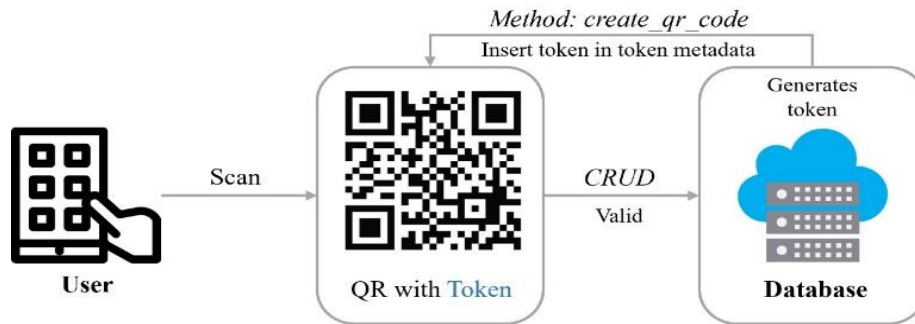
## 2.4 Implementation of Machine Learning

### 2.4.1. QR Code Scanner



To implement the attendance registration functionality through QR codes, we utilized the Firebase Machine Learning kit (Firebase, 2022) to validate students' attendance records. Figure 6 illustrates the architecture used for QR code validation in the application.

**Figure 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.

#### 2.4.2. Automatic Responses

To generate automatic responses to user inquiries, such as obtaining instructions on how to use the application or how to mark attendance (Ranoliya et al., 2017), we utilized the BrainShop.ai Machine Learning kit, which 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 (Chung et al., 2019). Figure 7 displays the knowledge base in BrainShop.ai used to generate automatic responses.

**Figure 7**  
*BrainShop.ai Knowledge Base*

ASYS: Cells

Training Cells Nerves Codes Discovery Logs Settings

Id	Input	Output	Context
273725	Donde queda el colegio	Teodoro Valcarcel 300, Arequipa 04007	.
273724	Como marco mi asistencia	Hola username! Para marcar tu asistencia, debes seguir los siguientes pasos: 1. Ubícate en el curso que te pertenece marcar tu asistencia. 2. Si te encuentras en el horario para marcar tu asistencia, haz click sobre 'MARCAR ASISTENCIA'. 3. Recuerda que para registrar tu asistencia debes estar matriculado en los cursos correspondientes al semestre que te corresponde. Recuerda que siempre puedes ponerte en contacto con nosotros 'uD83D'uDE42.	.
273723	Hi	Hola. ¿En que podemos ayudarte?	.
272193	Como marco mi asistencia	Puedes marcar tu asistencia en la pantalla de "Mis asistencias"	.
272192	Hola	Es un gusto saber de tí!	.
272191	Hola	¿En que podemos ayudarte?	hola

Figure 8 illustrates the training phase of the Machine Learning model's knowledge base. This model takes as input a character string that will serve as the foundation for user queries. Additionally, for

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training purposes, an output containing the text that the model will generate in response to user queries is provided.

**Figure 8**  
*Training of the Machine Learning model's knowledge base*

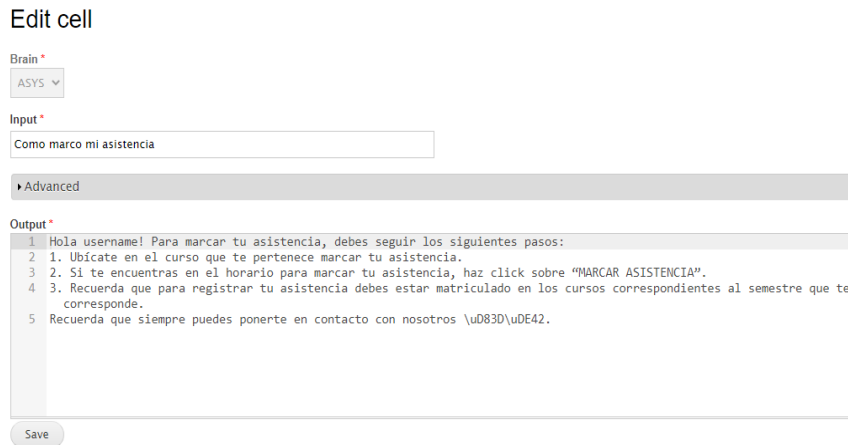
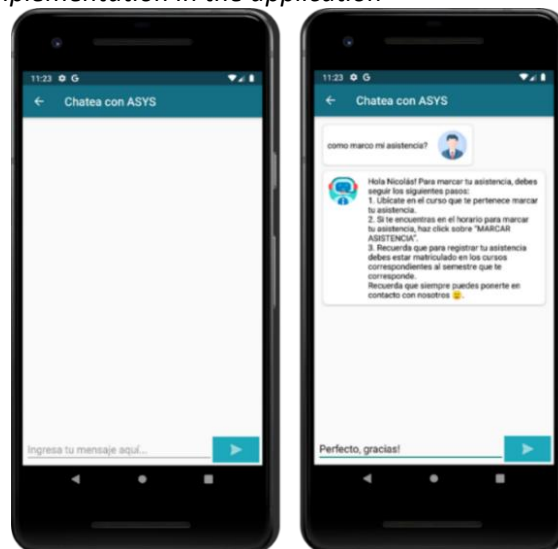


Figure 9 displays the implementation of the Chatbot in the application.

**Figure 9**  
*Result of the Chatbot implementation in the application*



## 2.5 Results of the Coding Phase

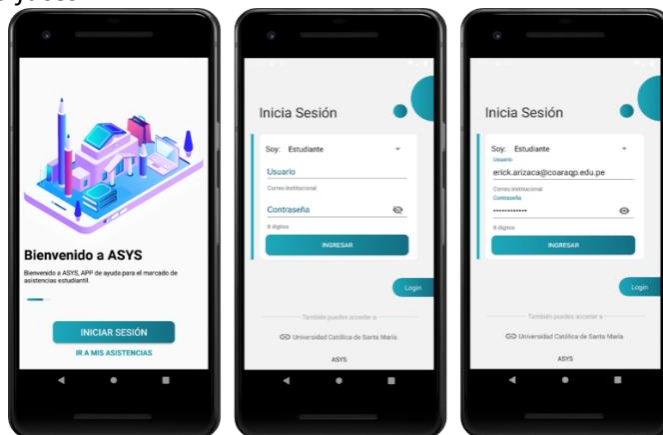
Next, the main screens of the resulting application based on the user stories from the planning phase (Phase 01 of the XP methodology) are shown. It is worth noting that these results come after the testing phase (Phase 04 of the XP methodology).

### 2.5.1. User Story 01: Access to the Application

Caytairo-Silva, N.E., Maraza-Quispe, B., Pena-Alejandro, J.M., Castro-Gutierrez, E. & Rosas-Paredes, K. (2024). Toward optimized attendance management in education: A machine learning and cloud computing approach. *Contemporary Educational Researches Journal*. 14(1), 28-46. <https://doi.org/10.18844/cej.v14i1.9340>

Figure 10 shows the interfaces for accessing the application, including welcome screens and a screen for logging in based on roles (Student - Teacher).

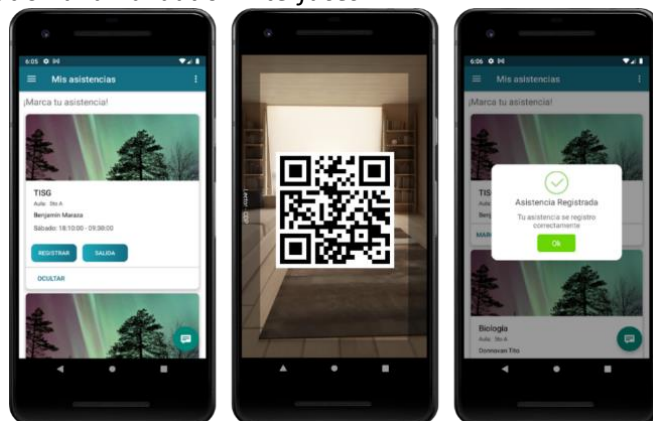
**Figure 10**  
*Application Access Interfaces*



### 2.5.2. User Story 02 and 03: Attendance Registration and QR Code Attendance Validation

Figure 11 shows the list of courses in which the student is enrolled. When the student clicks on the "REGISTER" button, a new activity is started, enabling the camera to scan the QR code (which has a registered token). If the QR code is verified with the token from the database, the student's attendance is recorded correctly.

**Figure 11**  
*Attendance Registration and Validation Interfaces*



### 2.5.3. User Story 04: Attendance Control

Figure 12 shows the interfaces for how attendance control is carried out by teachers, following these steps:

- Log into the application with the role of "Teacher" (only accesses with this role are recognized).
- Navigate to the corresponding course and click on "DOWNLOAD ATTENDANCE RECORD," which generates and downloads a CSV spreadsheet for teachers. Illustration 13 shows an example of attendance control performed by a teacher.

**Figure 12**  
Screen to Download Student Attendance Report

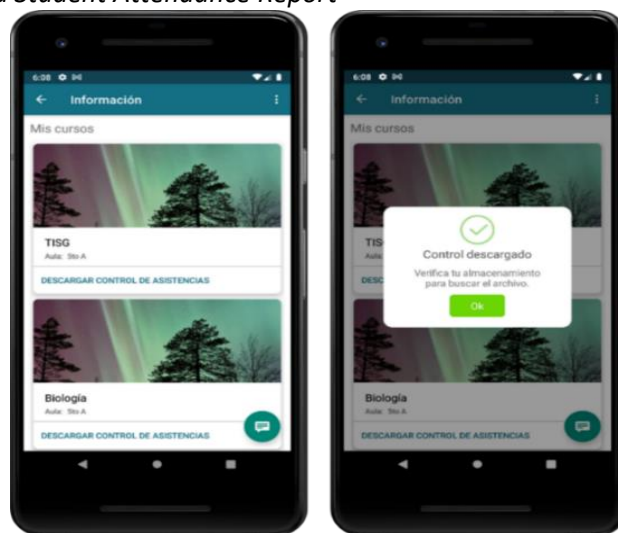


Figure 13 displays the attendance control file. The record includes the date, entry time, and exit time recorded by the student. The record corresponds to the "Mobile Technologies - Practical Group 1" course, scheduled for "Tuesday 15:00 - 17:00."

**Figure 13**  
Attendance Control File "Mobile Technologies - Practice Group 1"

G29	A	B	C	D	E	F	G	H	I	J	K
1	alumno:.....										
2	erick.ariza@coaraqp.edu.pe;2/05/2022;"14:55;2/05/2022";"16:58;9/05/2022";"14:59;9/05/2022";"16:56;16/05/2022";"15:00;16/05/2022";"17:04;23/05/2022";"15:00;23/05/2022";16:55										
3	jeans.ajra@coaraqp.edu.pe;2/05/2022;"14:56;2/05/2022";"17:01;9/05/2022";"15:00;9/05/2022";"16:59;16/05/2022";"14:58;16/05/2022";"17:00;23/05/2022";"14:56;23/05/2022";16:59										
4	paul.anco@coaraqp.edu.pe;2/05/2022;"14:58;2/05/2022";"17:04;9/05/2022";"14:57;9/05/2022";"17:02;16/05/2022";"14:59;16/05/2022";"17:03;23/05/2022";"15:04;23/05/2022";17:03										
5	darius.arocutipa@coaraqp.edu.pe;2/05/2022;"14:59;2/05/2022";"16:57;9/05/2022";"15:00;9/05/2022";"16:58;16/05/2022";"15:04;16/05/2022";"17:03;23/05/2022";"15:03;23/05/2022";16:57										
6	alvaro.aymara@coaraqp.edu.pe;2/05/2022;"15:00;2/05/2022";"17:00;9/05/2022";"14:58;9/05/2022";"16:58;16/05/2022";"14:56;16/05/2022";"16:59;23/05/2022";"14:58;23/05/2022";16:58										
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8	marfel.cahuina@coaraqp.edu.pe;2/05/2022;"15:03;2/05/2022";"16:56;9/05/2022";"14:58;9/05/2022";"17:03;16/05/2022";"15:00;16/05/2022";"17:04;23/05/2022";"14:58;23/05/2022";16:57										
9	deysi.cano@coaraqp.edu.pe;2/05/2022;"14:56;2/05/2022";"16:59;9/05/2022";"15:00;9/05/2022";"16:59;16/05/2022";"14:56;16/05/2022";"16:57;23/05/2022";"15:04;23/05/2022";17:02										
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13	jarol.fernandez@coaraqp.edu.pe;2/05/2022;"14:57;2/05/2022";"17:01;9/05/2022";"15:04;9/05/2022";"17:03;16/05/2022";"15:55;16/05/2022";"16:59;23/05/2022";"14:57;23/05/2022";17:04										
14	maria.flores@coaraqp.edu.pe;2/05/2022;"15:01;2/05/2022";"17:04;9/05/2022";"15:02;9/05/2022";"16:57;16/05/2022";"15:03;16/05/2022";"16:57;23/05/2022";"14:59;23/05/2022";17:01										
15	luis.guzman@coaraqp.edu.pe;2/05/2022;"15:02;2/05/2022";"16:57;9/05/2022";"15:03;9/05/2022";"17:01;16/05/2022";"14:57;16/05/2022";"17:02;23/05/2022";"15:55;23/05/2022";17:00										
16	dayana.huanca@coaraqp.edu.pe;2/05/2022;"15:04;2/05/2022";"17:00;9/05/2022";"15:04;9/05/2022";"16:55;16/05/2022";"15:02;16/05/2022";"17:01;23/05/2022";"15:00;23/05/2022";17:00										
17	diego.huaracha@coaraqp.edu.pe;2/05/2022;"15:55;2/05/2022";"17:03;9/05/2022";"15:03;9/05/2022";"17:00;16/05/2022";"15:01;16/05/2022";"16:58;23/05/2022";"14:56;23/05/2022";17:01										
18	rafael.laura@coaraqp.edu.pe;2/05/2022;"15:00;2/05/2022";"16:56;9/05/2022";"14:56;9/05/2022";"17:01;16/05/2022";"14:58;16/05/2022";"16:56;23/05/2022";"15:03;23/05/2022";16:56										
19	jhonatan.mamani@coaraqp.edu.pe;2/05/2022;"14:58;2/05/2022";"16:59;9/05/2022";"14:55;9/05/2022";"16:57;16/05/2022";"15:01;16/05/2022";"16:58;23/05/2022";"14:55;23/05/2022";16:59										

## 2.6 Phase 04: Testing

When using the XP methodology, it is recommended to use unit tests and acceptance tests (Gutierrez et al., 2022). 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 the case of our project, each module will be tested to ensure that appropriate values are entered, it guides the client to correct activities and maintains the integrity and security of the data provided by students and teachers. Finally, customer satisfaction will be verified through surveys and scheduled presentations of the final product to determine if all requirements and end-user expectations have been met. Table 5 shows the implemented functional tests.

**Table 5**  
*Functional tests*

Identifier	Functional Requirement	Detected Errors or Failures	Improved (YES/NO)
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 various questions to validate and assess user satisfaction with the use of the application. Below, Table 6 shows the criteria taken into account for the survey development.

**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 Collect 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 functions 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.

## 2.7 Phase 05: Launch

For the application launch, the following steps were followed:

- Generate the application's APK.
- Distribute the application installer within the institutional group to teachers and students.
- 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.

## 2.8 Participants

Information was collected from 100 high school students and teachers during the first academic semester of 2022 over one month.

## 2.9. Data collection instrument

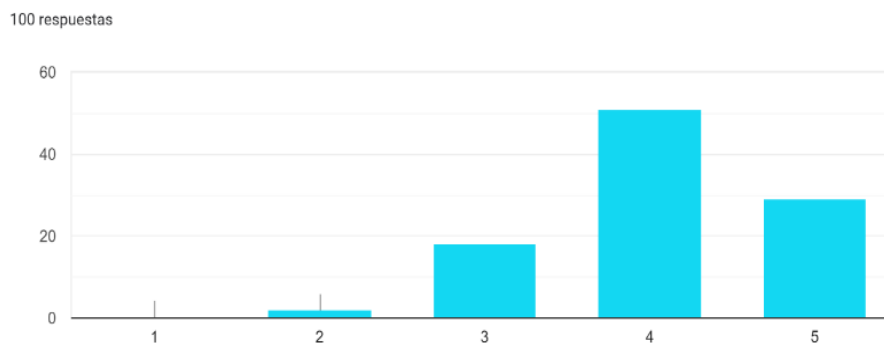
This study collected data from the participants with a survey. To fulfill ethical requirements, permission was sought from the right authorities before proceeding with the survey.

## 3. Results

The general results of the conducted surveys are shown below in Figure 14.

**Figure 14**

*Level of user satisfaction with the mobile application*



According to Figure 14, 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.

### 3.1 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 use of the application to others. The responses to this question are shown below. The results are displayed in Table 7.

**Table 7**

### Application acceptance criteria

Criteria	Results	Fulfillment Level (%)
<b>Functionality 100%</b>	The system meets the necessary functionalities for the proper registration and control of student attendance.	100%
<b>Operability</b>	The system integrates seamlessly with the database manager for subsequent functionalities implemented in the application	100%
<b>Satisfaction</b>	The results obtained in section IV indicate the level of satisfaction that both teachers and students have with the use of the application.	98% (What is your level of satisfaction?).
<b>Acceptance</b>	The "ASYS" application fulfills the registration and control of student attendance.	92.9% (Would you recommend the use of the application for attendance registration and control to others?)

Source: adapted from Padilla (2020)

Table 7 shows that, based on the acceptance criteria, 100% is achieved in the functionality and operability criteria, indicating that these criteria have been fully met. On the other hand, in the satisfaction and acceptance criteria, 98% and 92.9% were obtained, respectively, which, according to (Padilla et al., 2020), represent a significant percentage compared to the resulting difference (2% and 7.1%, respectively).

## 4. Discussion

When comparing the results regarding the functionality of similar proposals, we can highlight similarities and differences, which are mentioned below:

**Attendance Automation:** Similar to other studies (Firebase 2022 & Gutiérrez et al., 2022) the current research 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, improving the efficiency of the process.

**Use of Advanced Technology:** The current research, like some previous studies (Firebase 2022 & Gutiérrez et al., 2022), utilizes advanced technologies such as Machine Learning and Cloud Computing to enhance attendance registration. This reflects a trend towards integrating cutting-edge technology into educational management.

**Interaction with Teachers and Students:** Some previous studies (Gutiérrez et al., 2022) emphasize the importance of interaction between teachers and students in the attendance registration process. In the current research, both teachers and students are considered when designing the user interface and evaluating the acceptance of the application.

**Facial Recognition Focus:** Unlike other studies (Gutiérrez et al., 2022), the current research does not rely on facial recognition as a key element for attendance control. Instead, QR code technology is used to validate student attendance.

**Development Methodology:** While some previous studies (Firebase 2022, & Instituto Nacional de Estadística e Informática 2021), mention the use of specific methodologies like XP (Extreme

Programming) in application development, the current research does not focus on methodological details, placing a greater emphasis on technological implementation.

**Application Context:** Each previous study addresses the attendance registration problem in specific educational contexts, such as universities (Firebase 2022) virtual institutions, or even in the oil and gas industry (Katrilia et al., 2022) In contrast, the current research focuses on the broader context of educational institutions.

In summary, the current research aligns with the trend of using advanced technology to automate attendance registration in educational environments. While it shares similarities with previous studies, it also presents distinctive features, such as the use of QR codes and a broader focus on the educational context as a whole. These differences and similarities provide a solid foundation for assessing the impact and effectiveness of the proposed solution compared to prior research.

## 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 allowed for 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 execution of the mobile application has demonstrated positive results in implementing Firebase services, such as Cloud Firestore and Firebase Authentication, in 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 application has incorporated Machine Learning techniques to provide automatic responses to user queries. This has proven particularly useful when users have questions about using the application, improving user experience and support efficiency.
- The use of Firebase's Machine Learning kit to validate attendance through tokens stored in the database has proven to be an effective measure to ensure accuracy in attendance registration.

## 6. Recommendation for future work

In future work, the use of other ML techniques such as image recognition and geolocation for student attendance registration is proposed.

**Improving Control:** Enhance the control by allowing teachers to select which types of data they want to retrieve from the database, such as dates or students. Additionally, improve the visualization of control data, as it currently only downloads in a date and time format when the student registered



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their attendance (Entry/Exit). Furthermore, scaling the database to a relational database schema is considered, which can work in conjunction with the institution's current database.

**Enhance Application Security:** Since data is an important asset for an organization, improving application security at a much higher level is proposed. Implement the application for iOS operating systems. Improve the UI/UX design of the application.

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