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PAPER

KKA Attendance Pro: Web-Based Smart Attendance with AI Facial Recognition and Multi-Layer Verification

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ABSTRACT

Student attendance management that still requires lecturers to manually mark attendance status in the existing system can cause various issues, including data entry errors, a time-consuming report preparation process and the risk of proxy attendance. In certain circumstances, student signatures on attendance sheets are also used as supporting records. To address these issues, KKA Attendance Pro was developed as a web-based smart attendance system for use at Arau Community College, Perlis. This system integrates layered authentication that includes artificial intelligence-based facial recognition, device biometric authentication via WebAuthn and location authentication using GPS Geo-Fencing. This system is also equipped with an Emotion Analytics module to record students' facial expression patterns during the check-in process, a sick leave certificate scanning module using Optical Character Recognition technology, an administrator dashboard, automatic report generation and absence warning letters. System development was carried out iteratively based on Agile principles through four phases. Technical testing and user testing were conducted for two weeks involving 30 students. The test results showed a facial recognition accuracy of 94.3%, a GPS verification success rate of 97.8% and a System Usability Scale score of 81.5 out of 100. During the test period, no proxy attendance incidents were recorded. These findings indicate that KKA Attendance Pro has the potential to improve the efficiency, security and regularity of student attendance management.

KEYWORDS

Smart Attendance System; AI Facial Recognition; WebAuthn; GPS Geo-Fencing; Emotion Analytics; Community Colleges

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1. INTRODUCTION

Student attendance management is an important element in the administration of educational institutions. The process of recording student attendance at Arau Community College, Perlis, still requires lecturers to manually mark attendance status in the existing system. In certain circumstances, student signatures on attendance sheets are also used as supporting records. Although this method allows attendance records to be stored, the data entry process still relies on manual actions by lecturers. This situation can increase the management workload, take time and cause record entry errors. The use of manual signatures can also open up the possibility of proxy attendance, which is when attendance records are made on behalf of absent students. This situation can affect the accuracy of records and the integrity of student attendance management. The rapid development of biometric technology and artificial intelligence (AI) opens up opportunities to improve the student attendance management process. Previous studies have shown that the method of manually recording attendance is at risk of record falsification, data inaccuracy and longer time consumption. Therefore, a web-based attendance system with facial recognition and location verification can help improve the student attendance management process [1]. Meanwhile, the use of Progressive Web App (PWA) allows web-based applications to provide a user experience that is close to mobile applications without the need to download from the app store [3].

In the context of existing management, the use of digital systems does not necessarily eliminate the reliance on manual processes if the attendance status still needs to be marked one by one by the lecturer. The process can be more challenging when involving a large number of students, multiple class sessions and the need to provide records for monitoring purposes. In addition, the signature record on the attendance sheet cannot automatically verify that the student who signed the record was actually at the class location at the designated time. This situation shows that system improvements should not only focus on digital data storage, but also need to include more structured identity, location and time verification.

Accordingly, the development of a more comprehensive attendance system needs to consider two main aspects, namely ease of use and record integrity. A system that is too complex can burden users, while a system that is too simple may not be sufficient to reduce the risk of proxy attendance. A layered authentication approach provides space to balance both needs by combining biometric technology, location verification and data management in one platform. Such a design

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also allows attendance records to be used not only for documentation purposes, but also supports the monitoring and follow-up process by the administration.

KKA Attendance Pro was developed to improve the existing attendance management process through a more systematic and integrated approach. This system reduces the reliance on the manual attendance marking process by lecturers by allowing students to record attendance through a layered authentication process. The three main layers used are AI-based facial recognition, device biometric authentication via WebAuthn and location authentication using GPS Geo-Fencing. Attendance records are only accepted after the student's identity and location have been successfully verified. This approach helps to improve the integrity of attendance records and reduce the risk of proxy attendance. The use of facial biometrics in digital systems is also supported by the development of modern facial recognition research [7]-[9].

An additional uniqueness of KKA Attendance Pro is the integration of the Emotion Analytics module which uses the AI Face-API.js model to identify students' facial expression patterns during the attendance check-in process. The data recorded through this module can be used as an early indicator to help lecturers and administrators monitor student expression patterns in a more structured manner. However, the information should be interpreted as supporting data and not as a psychological diagnosis because facial expression analysis can be influenced by lighting factors, camera angles and individual context [10], [11], [19].

The objectives of KKA Attendance Pro innovation are to Develop a systematic, secure and efficient web-based student attendance system to improve the process of recording student attendance at Arau Community College. Integrate layered authentication methods that include AI-based facial recognition, device biometric authentication via WebAuthn and location authentication using GPS Geo-Fencing to reduce the risk of proxy attendance. Develop an Emotion Analytics module using the AI Face-API.js model to identify student facial expression patterns during the attendance check-in process as an early indicator for student well-being monitoring. Provide an integrated attendance management module that includes centralized attendance records, report generation, data analysis, sick leave certificate management and automatic generation of absence warning letters.

The main contribution of this innovation is the development of a web-based student attendance system that combines three layers of authentication, namely GPS Geo-Fencing, AI-based facial recognition and device biometric authentication via WebAuthn. This system is also equipped with support modules to assist in more structured management of student attendance and monitoring.

2. METHOD

2.1 System Development Framework

The development of KKA Attendance Pro uses an iterative approach based on Agile principles to enable system improvements to be implemented in stages according to user needs and the results of functional testing [4]. The development process is divided into four phases over a period of eight weeks. The first phase involves problem analysis, user needs identification and workflow planning. The second phase focuses on the development of the web interface and administrator dashboard. The third phase includes GPS Geo-Fencing integration, AI-based facial recognition and device biometric authentication via WebAuthn. The fourth phase involves the development of support modules, functional testing and system improvements. The development flow is shown in Figure 1.

Figure 1. KKA Attendance Pro System Development Flow

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2.2 System Architecture

KKA Attendance Pro is developed using a web-based architecture consisting of three main layers, namely the user interface layer, the application logic layer and the data storage layer. The interface layer allows students to record attendance and submit sick leave certificates, while administrators use the dashboard to manage schedules, records, reports, analytics and warning letters. The application logic layer handles AI-based facial recognition, device biometric authentication via WebAuthn and GPS Geo-Fencing. WebAuthn uses public key-based credentials via an authenticator on the user's device [5], while the Geolocation API obtains the device's location with user permission [6]. Firebase Firestore is used as a cloud database and LocalStorage supports temporary storage. The relationship between the layers is shown in Figure 2.

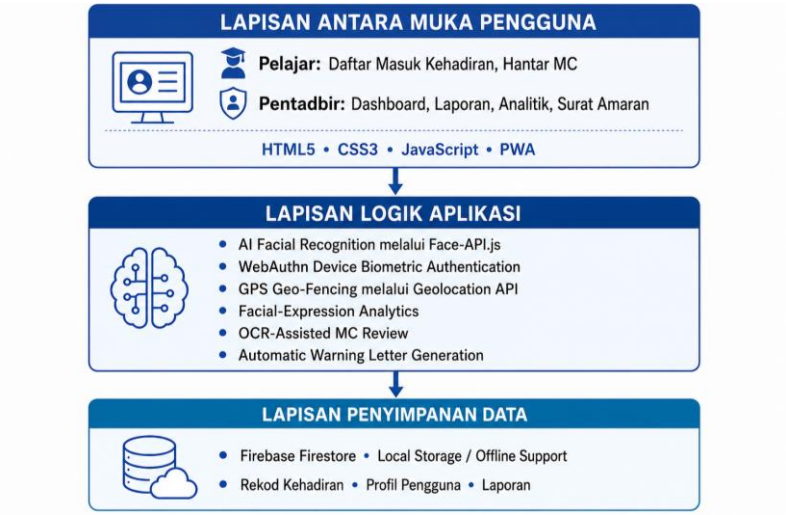

Figure 2. The Overall Architecture of the KKA Attendance Pro System

2.3 Technology Used

The technologies in KKA Attendance Pro were selected based on the need to develop a responsive, secure and accessible web-based system across multiple devices. HTML5, CSS3 and JavaScript ES6+ are used to build the interface, while Progressive Web App provides a user experience that closely resembles a mobile application [3]. Face-API.js supports face recognition and facial expression patterns. WebAuthn is used for device biometric authentication, Geolocation API for GPS Geo-Fencing and Firebase Firestore for centralized data storage. LocalStorage supports temporary storage, while Optical Character Recognition helps extract text from sick leave certificates [12]. A summary of the technologies is shown in Table 1.

Table 1. Technology Used in KKA Attendance Pro

Technology	Functions in the System
HTML5, CSS3 dan JavaScript ES6+	Building a responsive web-based system interface
Progressive Web App (PWA)	Allows the system to be accessed via a web browser with an application-like user experience
Face-API.js	Supports facial recognition and analysis of students' facial expression patterns
WebAuthn	Perform biometric device authentication using a compatible authenticator
Geolocation API	Obtaining device location for GPS Geo-Fencing process
Firebase Firestore	Centrally store and synchronize system data
LocalStorage / Offline Storage	Supports temporary storage when Internet connection is interrupted
Optical Character Recognition (OCR)	Extract text from sick leave certificates to aid administrative review

2.4 System Modules

KKA Attendance Pro consists of five main modules. The Attendance Verification Module handles location, facial and device biometric verification sequentially. The Sick Leave Certificate Management Module allows students to upload supporting documents and uses OCR to assist with administrative review [12]. The Admin Panel Module provides schedule management, student profiles, attendance logs, reports and document export. The Emotion Analytics Module identifies facial expression patterns as an early indicator of student monitoring, but the analysis results need to be interpreted with caution as they can be influenced by lighting, facial position and individual context [10]. The Automatic Warning Letter Module generates letters when absences exceed a set limit. A summary of the module functions is shown in Table 2.

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Table 2. KKA Attendance Pro Main Module

Modul	Main Functions
Attendance Verification Module	Record student attendance via facial verification, device biometrics and location
Sick Leave Certificate Management Module	Allows students to upload MC documents for administrative review with the help of OCR
Admin Panel Module	Manage schedules, student profiles, attendance logs, reports and document exports
Emotion Analytics Module	Identifying facial expression patterns during the check-in process as an early indicator of student monitoring
Automatic Warning Letter Module	Generate warning letters when student absences exceed the set limit

2.5 Layered Attendance Verification Flow

The attendance process begins when a student selects a name and class schedule. The system obtains the device location via the Geolocation API and compares it to the designated GPS Geo-Fencing area. If the location is not allowed, the check-in process is rejected. If the location is accepted, the system performs AI-based facial recognition and requests biometric authentication of the device via WebAuthn. Attendance records are only saved after all three layers of authentication are successfully completed. The system also records facial expression patterns to support the Emotion Analytics module. The flow is shown in Figure 3.

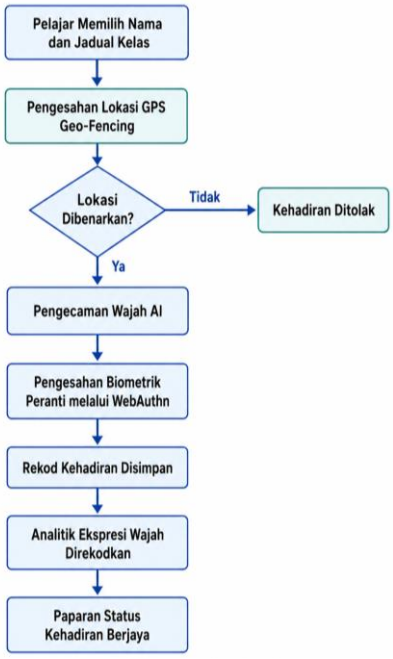

Figure 3. Layered Attendance Verification Flow

2.6 Testing and Evaluation Methods

KKA Attendance Pro testing was conducted through technical and user testing. Technical testing included GPS Geo-Fencing, AI-based facial recognition, device biometric authentication via WebAuthn, OCR for sick leave certificates and system response time. Facial testing involved registered users and mismatched faces to obtain accuracy rates, False Rejection Rate (FRR) and False Acceptance Rate (FAR). GPS Geo-Fencing was tested through attempted check-ins inside and outside the permitted area. WebAuthn was tested using compatible devices and OCR was tested using uploaded documents. The technical testing components are shown in Table 3.

Table 3. System Technical Testing Components

Component	Testing Method	Evaluation Metrics
AI-Based Facial Recognition	Attempts to use a registered user's face and a non-matching face	Accuracy rate, FRR and FAR
GPS Geo-Fencing	Check-in attempts inside and outside the permitted area	Location verification success rate
WebAuthn Biometric Device	Authentication attempt using a compatible device	Verification success rate

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Component	Testing Method	Evaluation Metrics
AI-Based OCR for MC Scans	Upload sick leave certificate document	Document reading accuracy
System Response Time	Measurement of processing time during system use	Average response time

The user testing involved 30 students for two weeks. The level of usability was assessed using the System Usability Scale (SUS), a ten-item instrument with a five-point Likert scale that produces a score between 0 and 100 [14]. The interpretation of the scores refers to the rating scale [15]. Feedback on the Emotion Analytics module was also recorded. The system also recorded facial expression patterns for categorical distribution analysis. The relationship between negative expression patterns and academic performance was analyzed using Pearson correlation. The analysis method is shown in Table 4.

Table 4. User Testing Methods and Data Analysis

Evaluation Aspects	Method	Data Analyzed
System Usability	SUS questionnaire after system use	Overall SUS score
Acceptance of the Emotional Analytics Module	User feedback	Percentage of positive responses
Attendance Process Efficiency	Comparison of manual process times and digital systems	Average time per class
Record Accuracy	Comparison of record error rates	Percentage of data entry errors
Proxy Presence	Comparison of incidents before and during the use of the system	Number of recorded cases
Facial Expression Patterns	Two-week Emotional Analytics Record	Distribution of expression categories
Relationship with Academic Performance	Pearson correlation test	Correlation values and significance levels

3. RESULT AND DISCUSSION

3.1 Technical Testing Results

Technical testing showed that KKA Attendance Pro achieved satisfactory performance across all key modules. AI-based facial recognition testing recorded an accuracy rate of 94.3%, with a False Rejection Rate (FRR) of 5.7% and a False Acceptance Rate (FAR) of 0.2%. The FRR value indicates that a small proportion of attempts by legitimate users are not accepted by the system, while the FAR value refers to the acceptance rate of authentication attempts that should not be accepted. The very low FAR rate indicates that the risk of false acceptance is low within the scope of the testing that has been conducted. However, additional testing in various lighting conditions, facial angles and usage environments is still important to assess the robustness of the system more comprehensively. A summary of the technical testing results is shown in Table 5.

Table 5. Summary of KKA Attendance Pro System Technical Testing Results

Testing Components	Metric	Results
AI-Based Facial Recognition	Accuracy rate	94.3%
AI-Based Facial Recognition	*False Rejection Rate* (FRR)	5.7%
AI-Based Facial Recognition	*False Acceptance Rate* (FAR)	0.2%
GPS Geo-Fencing	Verification success rate	97.8%
WebAuthn Biometric Device	Verification success rate	98.5%
AI-Based OCR for MC Scans	Document reading accuracy	91.2%
System response time	Average	< 2,500 ms

GPS Geo-Fencing authentication achieved a success rate of 97.8%. Location authentication failures mainly occurred when users were inside buildings or areas with physical barriers, which affected the reception of location signals. Previous studies have shown that GPS performance in buildings depends on environmental conditions and wall and roof materials that affect signal reception [13]. Biometric device authentication via WebAuthn achieved a success rate of 98.5%. The AI OCR module for sick leave certificate scanning recorded a document reading accuracy of 91.2%. In addition, the average system response time was less than 2,500 milliseconds, indicating that the system was able to provide feedback in a period that is suitable for daily use.

The facial recognition results should be interpreted in conjunction with the FRR and FAR values, as both metrics provide a more detailed picture of the system's performance. The FRR value of 5.7% indicates that there were a small number of valid user attempts that were not accepted on the initial attempt. This could be due to changes in lighting, facial position, or camera image quality during the authentication process. On the other hand, the FAR of 0.2% indicates that the rate of false face acceptance is low within the scope of testing. This finding is important because reducing the risk of false acceptance is directly related to the system's goal of reducing proxy attendance. However, further testing is still

needed to evaluate the system's performance in a wider range of environments, including low lighting, the use of cameras with different specifications, and changes in facial angles.

The performance of GPS Geo-Fencing, WebAuthn, and OCR also indicates that the system is capable of supporting a comprehensive attendance workflow. The WebAuthn success rate of 98.5% indicates that device biometric authentication can be performed well when the user is using a compatible device. For GPS Geo-Fencing, the success rate of 97.8% indicates that the user's location can be verified in most attempts, although the location accuracy can be affected by the physical environment. The document reading accuracy of the OCR module of 91.2% indicates that the function is suitable for use in assisting the initial review process of sick leave certificates. However, the final review still needs to be done by the administrator because OCR functions as a support tool and not a document validation mechanism. A response time of less than 2,500 milliseconds also indicates that users do not have to wait too long to complete the verification process.

3.2 User Testing Results

User testing involved 30 student respondents who used KKA Attendance Pro for two weeks. Usability assessment was carried out using the System Usability Scale (SUS) instrument. The analysis results showed that the system obtained a SUS score of 81.5 out of 100. Based on the evaluation scale [15], the score was in the "Excellent" category. This finding shows that the system interface is easy to understand and can be used well by respondents even though the system integrates several layers of authentication. The structured usage process allows students to go through the steps of GPS Geo-Fencing, facial recognition and device biometric authentication sequentially without affecting the overall user experience. User feedback also showed positive acceptance of the Emotion Analytics module. A total of 86.7% of respondents stated that they felt more attentive when the system recorded facial expression patterns during the check-in process. This finding shows that the module has the potential to support early student monitoring. However, the information produced should be used as supporting data and not as a clinical assessment or psychological diagnosis.

The SUS score of 81.5% also shows that the integration of several technologies does not affect the overall usability of the system. Although the sign-in process involves several steps, the sequential order of confirmations helps users understand the actions to be taken. This finding is important because a system that has good security features but is difficult to use has the potential to cause users to revert to manual methods. In the context of KKA Attendance Pro, the balance between security and ease of use is one of the factors that supports user acceptance. Respondents' feedback on the Emotion Analytics module also showed that students were able to accept the use of the additional functionality when its purpose was clearly explained. However, the actual implementation needs to be accompanied by data usage guidelines so that facial expression records are not interpreted out of context.

3.3 Comparison with Manual Attendance System

A comparison between KKA Attendance Pro and manual attendance methods showed improvements in time management efficiency, record accuracy and proxy attendance control. The time required to record attendance for a class involving 25 students was reduced from an average of 8.3 minutes using the manual method to 2.1 minutes using KKA Attendance Pro. The 74.7% reduction indicates that the system can speed up the process of recording student attendance.

The incidence of proxy attendance also decreased from an average of 3.2 cases per month to zero cases during the testing period, equivalent to a 100% reduction. The decrease is related to the use of layered authentication that includes location, face and device biometrics. However, these findings need to be interpreted based on the two-week testing period. Implementation over a longer period is still needed to continuously evaluate the effectiveness of the system.

In terms of data accuracy, the record entry error rate decreased from 4.8% for the manual method to 0.3% after the use of the new system. The report generation process that previously required between two to three hours manually can be completed in less than 30 seconds through the Excel and PDF export functions. A summary of the comparison between the two methods is shown in Table 6.

Table 6. Comparison of Manual Attendance System and KKA Attendance Pro

Comparative Aspects	Manual Attendance System	KKA Attendance Pro	Change
Time to record attendance for 25 students	8.3 minutes	2.1 minutes	Decreased 74.7%
Proxy presence incident	3.2 case of a month	0 cases throughout the testing period	Reduced by 100% during the testing period
Record entry error rate	4.8%	0.3%	Decreased by 4.5 percentage points
Report generation time	2–3 hours	Less than 30 seconds	Faster

The comparison shows that the impact of the system is not limited to the student check-in process. The reduction in time to record attendance allows lecturers to start teaching sessions more quickly, while centralized record keeping reduces the need to check attendance sheets separately. Generating reports in less than 30 seconds also benefits administrators when records are needed for monitoring, documentation or follow-up. From a data integrity perspective, layered authentication helps ensure that attendance records are not just a record of names, but are linked to the identity and

location of the user. While the reduction in proxy attendance incidents during the testing period is a positive finding, the results need to be re-evaluated through a longer implementation. Using the system over several semesters will provide a stronger picture of the stability of performance and changes in user behavior.

3.4 Analysis of the Emotion Analytics Module

The Emotion Analytics Module recorded the facial expression patterns of students during the attendance check-in process. During the two-week testing period, a total of 630 attendance records were processed. Of these, 71.4% of the records were categorized as "Happy/Calm", 22.2% as "Neutral/Tired" and 6.4% as "Depressed/Sad/Angry". The breakdown of the data is shown in Table 7. The usability evaluation of the facial expression recognition system was also discussed in a previous study [11].

Table 7. Distribution of Students' Facial Expression Patterns

Facial Expression Pattern Category	Percentage
Happy / Calm	71.4%
Neutral / Tired	22.2%
Depressed / Sad / Angry	6.4%
Total	100.0%

The data provides an initial picture of the facial expression patterns recorded during the check-in process. Correlation analysis showed a moderate inverse relationship between negative expression patterns and students' academic performance ($r = -0.43$, $p < 0.05$). This finding indicates that an increase in negative expression records is associated with a decrease in academic performance in the study sample. However, the correlation does not prove a cause and effect relationship. The Emotion Analytics Module should not be considered a psychological diagnostic tool. On the contrary, this module can be used as an initial indicator to help lecturers or relevant parties identify patterns that require further observation. The distribution of facial expression patterns shows that the majority of records are in the Happy or Calm category. However, the existence of records in the Neutral or Tired and Stressed, Sad or Angry categories still deserves attention as supporting information. The data cannot be used alone to draw conclusions about a student's emotional state because facial expressions are dynamic and influenced by various factors. The main value of this module lies in its ability to identify recurring patterns that may require further observation. If negative expression patterns consistently emerge in conjunction with attendance issues or declining academic performance, lecturers may consider appropriate follow-up actions. This approach positions the Emotion Analytics module as an early support mechanism rather than a determinative or diagnostic tool. The use of facial expression data also requires clear ethical considerations and data governance. Students should be informed about the purpose of data collection, how the information will be used, and who is allowed to access the records. Access to Emotion Analytics data should ideally be limited to those relevant to student monitoring. In addition, the system should avoid labeling students based on a single facial expression record. Controlled data storage and careful interpretation are essential to ensure that this module is used to support student welfare without compromising their privacy.

3.5 Integrated Attendance Management Module Results

KKA Attendance Pro also provides an integrated attendance management module to help administrators manage student information in a more organized manner. Confirmed attendance records are stored centrally and can be monitored through the administrator dashboard. This system allows administrators to check attendance logs, manage student profiles and generate reports based on the stored records. The document export function also facilitates the preparation of reports in Excel and PDF formats. In addition, the sick leave certificate management module allows supporting documents to be uploaded and reviewed with the help of OCR technology. The system also automatically generates warning letters when student absences exceed the set limit. The integration of these functions helps reduce dependence on manual management processes and increases the efficiency of handling attendance records.

From an operational point of view, the integration of several functions in one platform helps reduce the need to manage records through separate channels. Administrators can refer to attendance records, review supporting documents and generate warning letters through the same system. This approach simplifies the audit trail process because student-related records can be reviewed in a more organized manner. The document export function also helps when data needs to be used for the preparation of reports or administrative actions. However, the effectiveness of this module still depends on the accuracy of the system configuration, database maintenance and regular monitoring of user access.

3.6 Discussion Summary

Overall, the test results show that KKA Attendance Pro can function as a more comprehensive student attendance management system compared to manual methods. GPS Geo-Fencing integration, AI-based facial recognition and device biometric authentication via WebAuthn form a layered authentication process that can improve the integrity of attendance records. Additional modules such as AI OCR, Emotion Analytics, report export and automatic warning letters also increase the practical value of the system to the administration. Although the initial findings show positive performance, testing over a longer period and involving a larger group of users is still recommended to continuously evaluate the reliability of the system.

Although the initial results show good performance, several limitations need to be taken into account. The two-week testing period is still too limited to reflect the long-term use of the system. In addition, the testing involved 30 students from the same institutional context. Further testing could involve a larger group of users, different academic sessions and devices with more diverse specifications. Such evaluation is important to determine the stability of the system, the accuracy of the modules and the level of user acceptance when the system is used more widely.

4. CONCLUSION

KKA Attendance Pro has been successfully developed and evaluated as a comprehensive web-based biometric attendance system for use at Arau Community College, Perlis. The system integrates AI-based facial recognition, device biometric authentication via WebAuthn and GPS Geo-Fencing into an integrated attendance management platform. The test results showed that the system achieved a facial recognition accuracy of 94.3% and a GPS authentication success rate of 97.8%. During the test period, no proxy attendance incidents were recorded after the system was used. The System Usability Scale (SUS) score of 81.5 out of 100 also showed that the system has a very good level of usability and is easy to use by users. The main uniqueness of this innovation is the integration of the Emotion Analytics module which allows the system to record students' facial expression patterns during the check-in process as an early indicator for monitoring student well-being. Although there are several limitations such as the dependence on GPS signal accuracy, appropriate lighting for facial recognition and the requirement for devices that support WebAuthn, this innovation shows good potential to improve student attendance management in a more systematic, secure and efficient manner. Future improvements can be implemented through integration with the college's existing Student Information Management System (SMP), expansion of testing to a larger user group, and the use of more detailed AI models to improve facial expression pattern analysis.

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