The Online Attendance System Models for Educational Institutions

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Abstract. Global COVID-19 pandemic embraces educational institutions to adaptatively implement long-distance learning. Needless to say, there are difficulties and limitations during the process. Besides the learning process, the attendance system plays an indispensable role, notably in Indonesian education. Currently, lecturers need to do extra workload to perform attendance checks to prevent cheating (proxy attendance). An attendance system can be used to help lecturers focus on academic deliverance. The attendance system should focus on user as part of the ecosystem by adhere good user interface to produces good user experiences. The system must reduce lecturer workload and be easy to implement and use. In this paper, we introduce three online attendance system models that adhere to those criteria. Our models have been tested with an actual working prototype that follows interaction design principles. Finally, the end product has undergone an evaluation process based on heuristic usability principles to ensure the models are feasible to be implemented and applied to educational institutions.

Keywords: online attendances system, heuristic, usability, models

INTRODUCTION

The global spread of COVID-19 forces the education system, including the higher system such as universities, to adapt into distance-learning methods, also known as learning from home (LFH). Students and lecturers conduct classes virtually using Zoom, Google Meet, and other virtual meeting settings. In Indonesia, student attendance is mandatory; it is one factor of determining their outcomes. Therefore, even in the LFH setting, student attendance must be conducted as well. There are numerous studies on such attendance systems using techniques such as voice recognition, fingerprint, face recognition, location-based (GPS), RFID, NFC, Bluetooth Low Energy (BLE), and barcode. In general, we can categorize these techniques as biometric-based and non-biometric-based authentication. Jain et al.[1] specified biometric recognition systems such as face, fingerprint, palm print, retina, voice, etc.

Voice recognition is usually used to understand what humans speak, but it can also be used to identify who is speaking[2]. Shah et al. proposed such an attendance system using voice recognition which yielded 80% accuracy. Another voice recognition-based attendance system was developed by Kumar et al.[3], comparing isolation and continuous text model, however the accuracy was pretty low, 62.67% and 53.6% respectively. Other work by Soewito et al. [4] compared the efficacy of fingerprint and voice recognition attendance system, with 5.88% false negative rate for voice recognition system. The sentence used for voice identification can be explored, as a study revealed that using students' names may be tricky to recognize, with only 46.15% accuracy[5]. Noisy environments can also lower the accuracy of voice recognition, as explored by Nidhyananthan et al. to create an attendance system using voice recognition that was capable of working in a multi-speaker and noisy environment[6]. With COVID-19 restrictions in place, voice recognition systems should be able to recognize muffled voices due to masks. To enforce physical distancing, centralized voice recognition stations must be set up properly with all health regulations considered.

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Like voice, fingerprint is unique per person, so it can be used to identify someone. There are many studies regarding fingerprint attendance systems[7–9] with great accuracy. However, due to the COVID-19 concerns, a fingerprint machine must be sanitized after each use, resulting in long queues. To minimize the risk of spreading COVID-19, a touchless fingerprint system may be examined, which uses a camera instead of a dedicated fingerprint sensor[10,11]. With the rise of Android smartphones that have fingerprint sensors, Android systems may also be developed as alternatives in fingerprint-based attendance systems[12,13].

As computers become more capable of doing complex calculations at astonishing speed, face recognition is more widely recognized as a method of identification, which is then may be used on systems such as attendance systems. Many works have been proposed on face recognition-based attendance systems[14–17]. One system used real-time video processing[18] with up to 82% accuracy, reducing the skipping class rate by 13%. An Android-based attendance system[19] was developed using face recognition as well with the accuracy up to 97.29% using linear discriminant analysis, which only took 0.000096s for the identification. The system used QR-codes for teachers to open the class, which were then scanned by students to start the attendance process. There are challenges for face recognition systems[18], such as environmental conditions (e.g. lighting in room, blurry or out-of-focus camera) and students' facial accessories (e.g. make-ups, hats or hoodies, glasses, etc.) which may reduce the accuracy of face recognition. Therefore, other methods of verification may be used to increase the accuracy of identification. Due to COVID-19 health regulations, it is currently not advised to set up a face recognition booth for students to scan their face one by one, as this will create long queues and is against the physical distancing regulation. Masks will also reduce or even hinder the face recognition system. A multi-face recognition system may be considered, however a study by Raghuwanhi and Swami reported lower accuracy in analyzing multiple faces at once[20]. Another issue to be addressed is the usage of face masks, which may hinder the face recognition system to be able to recognize individuals. Opening masks to perform face recognition, albeit temporarily, is dangerous, however this is subject to our personal opinion and should be addressed in future research for concrete and solid findings of this statement.

In some cases, non-biometric options for identifying students can be used to develop attendance systems. One alternative is to use RFID cards[21–23]. Students tap their student ID cards into an RFID reader, then the system will record the student ID and time of reading as data considered for the attendance. This system was also being used in our campus, University of Surabaya, limited in the Faculty of Engineering, during the pre-COVID era from 2018. The disadvantage of using this system is that students may forget to bring their ID cards, and sometimes the RFID reader fails to read some cards, thus a backup mechanism should be also integrated into the attendance system. Another disadvantage that should be taken into account is that students may easily trick this system by bringing their friends' cards. As NFC technology is becoming more common in cards and smartphones, it can also be used to create alternative attendance systems[24–26]. Students may sometimes forget to bring their student cards, but they usually bring their smartphones along with them to classes. This behavior can be utilized for NFC-based attendance systems where students can either tap their student card or their smartphone. A study by Shen et al. [25] even showed improvement in students' attitude towards computer science since the application of such systems directly shows students one of many beneficial applications of computer science in daily life. Nevertheless, this system is also prone to proxy attendance, so Jacob et al.[27] implemented a one-time password (OTP) to complement the NFC attendance system.

Both RFID and NFC attendance systems may still create a long queue for students to tap their cards or smartphones, so this is not ideal during COVID-19 pandemic era. Contactless devices, such as BLE beacons, GPS in smartphones, and barcodes can be used as attendance systems while still conforming to physical distancing regulations. Past studies have explored possibilities in BLE attendance systems. Bae and Cho[28] suggested a BLE attendance system using Bluetooth 4.0 which required no actions from students and professors. When they entered the lecture hall, the smartphone app automatically connected to a beacon and then checked if the attendance was valid. However, another study by Huang et al.[29] found that the student adoption rate to this system was pretty low at 38%, due to some misconceptions in students (a common one is leaving Bluetooth on may drain smartphone battery quickly). When they added a second method, which required active student action, the adoption rate increased to 80%.

As QR codes are becoming increasingly common in every day's life, we can take advantage of cameras in students' smartphones to log their attendance in classes. Such studies have been conducted in the past[30–32]. To prevent cheating, there are some measurements that can be taken. For example, Hermanto et al.[33] uses International Mobile Equipment Identity (IMEI) of each students' smartphone to validate the attendance request, so students cannot use other smartphones which are not registered under his/her identity. Ayop et al.[34] uses GPS to check the location of each student when she requests for attendance. A different approach to keep students' attendance rate and engagement was explored by Xiao et al[35], which used gamification techniques to display QR codes multiple times during class, rewarding students with a small portion of class participation points.

To prevent proxy attendance, e.g., when a student is not physically present in the classroom but is able to log a valid attendance, geofencing technique should be considered. Geofencing means that the system only considers an attendance to be valid in some specific geolocations, for example in a classroom. Some methods aforementioned before may be used as geofencing methods, such as using BLE. An example of BLE as geofencing can be observed in the work of Noguchi et al.[36]. Their primary attendance system is a card-based one; students may scan their ID card either on the teacher's scanning terminal device or their personal Android smartphone. The BLE is used to prevent students who are not in the classroom physically to log attendance, by transmitting a unique sequence of numbers required for a proper attendance. Another common geofencing technique is using a smartphone's GPS[34]. By checking the students' current position during logging, this eliminates the chance of sharing the QR code by other means (such as instant messaging or emails) and scanning the QR code anywhere but in the classroom for a valid attendance.

As COVID-19 might not be over anytime soon (at least at the time of writing), universities may continue to conduct online or hybrid learnings. This circumstance raises the need for an online attendance system focusing on the user as part of the design ecosystem. This user-centered, driven approach has been standardized as a general solution for developing a reliable system [37]. Furthermore, the system must adhere good user interface and eventually deliver good user experiences for both students and lecturers [38]. Based on these considerations, in this paper, we propose some attendance system models that are heuristically acceptable in terms of usability that may be implemented in universities as online systems. Moreover, the proposed models may also be used or adapted in offline settings while still conforming with COVID-19 health regulations such as physical distancing.

METHODOLOGY

As stated before, an online attendance system should be able to prevent cheating (proxy attendance). The system should help with the administrative processes of an educational institution, reducing the lecturers' workload of having to perform attendance checks (either at the beginning, during, or at the end of a class), increasing the available time and focus to deliver the knowledge to the participants. Because numerous people with various IT backgrounds and capabilities will use this system, it should be accessible to everyone, while still maintaining or even increasing the efficiency of already-established attendance systems. Due to some time constraints an educational institution may impose on, the system should be relatively easy to implement. With these factors in mind, we proposed three attendance models with different approaches and benefits.

The first model is called the Automatic QR Attendances Model. As the name suggested, this model doesn't require lecture involvement. Instead, participant actions are needed. First, participants sign into the web system, and the system automatically checks for an ongoing schedule or a class which is about to start in 15 minutes for that particular participant. The system then periodically generates a unique QR code per participant with 10 seconds intervals. Participants then use the supporting app to scan the QR codes, and it is validated back by the system. Finally, the results are triggered back to the participant app as feedback with two types of status. First, the participant is deemed late if the recorded attendance time is more significant than the class late policy. Secondly, the participant is considered to be on time if the recorded attendance time is within the time limit of the late policy. The advantages of this Automatic QR code are zero involvement of the lecturer; therefore, the lecture should be more focusing on the learning process rather than doing manual attendance. Moreover, changing QR codes periodically and the requirements to use both supporting apps and web systems make it harder for cheaters to expose the system or conduct proxy attendance. Figure 1 shows the Business Process Model Notation (BPMN) diagram that explains the process flow of the model.

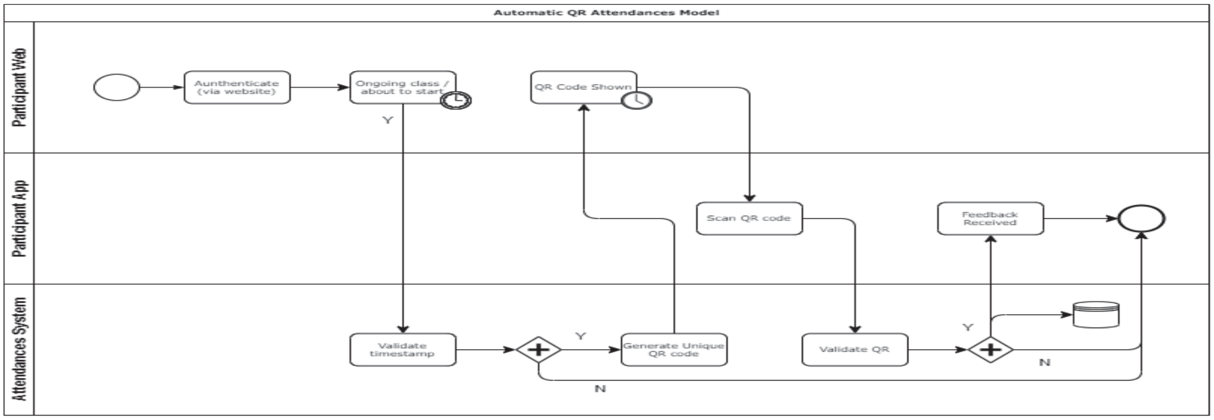


FIGURE 1. BPMN Diagram of Automatic QR Attendance Model BPMN

The first model assumes that the class schedule policy embraces the general procedure. Therefore, the lecturer doesn't have control over the attendance time range. However, it means that participants can record their attendance late, even after the class has been conducted. On the second model, we introduce the lecturer's involvement over when the class allows the attendees. The model is called the Manual QR Attendance model. As its name implies, it embraces the manual action that the lecturer must perform to open or close the class, allowing participants to attend the course. It requires the lecturer to authenticate into the web system and then start the class as allocated. Hereafter, the system validates the timestamp and periodically generates new unique QR codes with intervals of 10 seconds. Next, the lecturer displays the QR codes on the screen through the online conference system (e.g., Zoom or Google Meet). Participants then scan the QR codes shown by the lecturer using the supporting app. This code is only valid within a limited 10 second period. Beyond that, the participant must scan the new QR code. Finally, the system receives the requested task, validates the code, and then returns the result as feedback to the participant's app. The benefit of this second model is lecturers have control over when they should open the class. Therefore, this should decrease or prevent the problem of students late attending. Moreover, on the participant side, they are simply required to use the supporting app. Figure 2 shows the BPMN diagram that explains the process flow of the model.

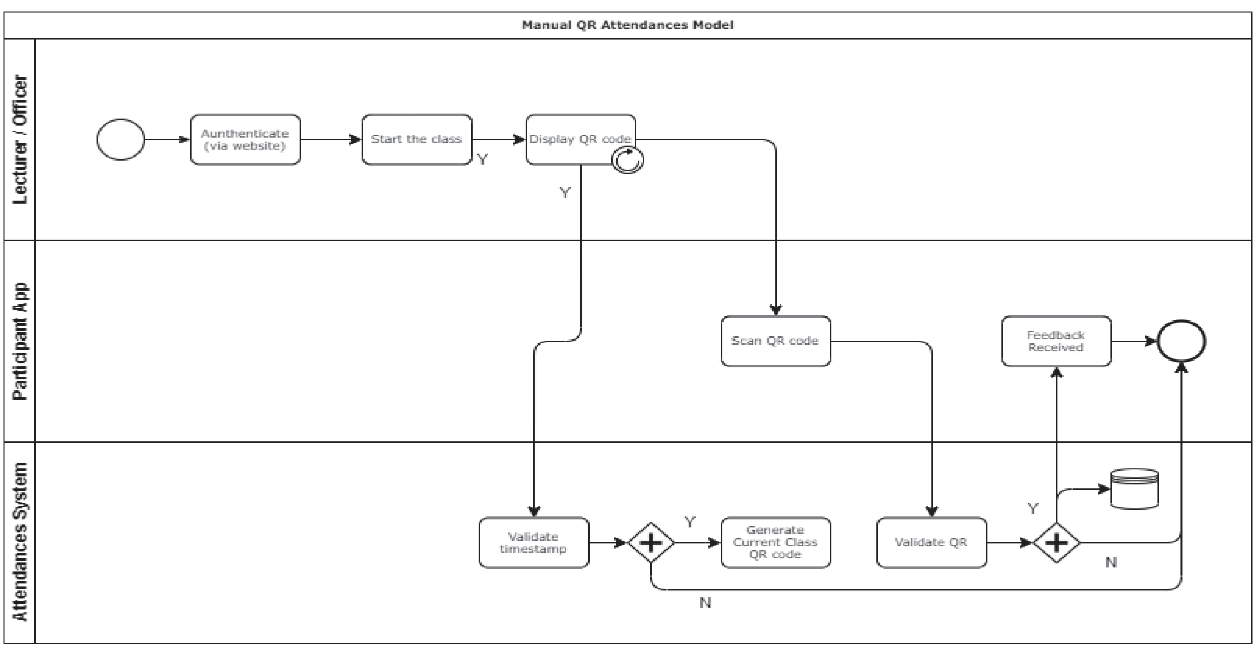


FIGURE 2. Manual QR Attendance Model BPMN

Two previous models require the participant to use app and camera permission to scan the QR codes. This may impose a problem, because it really depends on the smartphone's camera hardware to record the attendance. Other factors, such as the angle of the smartphone when scanning the QR code, the distance between smartphone and QR code, as well as the brightness of the device displaying the QR code, can affect the scanning capability[34]. With great variance in smartphone's camera hardware, we must make sure that the QR code can be scanned by as many participants as possible. Therefore, in this third model, we introduce a simpler attendance system, without needing access to camera devices, but should still be reliable and prevent cheaters from proxy the attendances. The third model is called the Authenticator Attendances Model. This model uses the token-based password to authenticate user credentials. This has been proved to be more secure compared to text-based passwords. However, the user must spend more time establishing authentication since it requires two devices to work[39].

In this model, the participant needs to access both the supporting app and web system. It begins with participants authenticating themselves into the web system. Next, the system will validate the current ongoing class and enable the attend button. This button starts the authenticator mechanism. The participant must enter the correct authenticator codes that are shown via the supporting app into the web system. These codes are always periodically refreshed every 10 seconds and consist of 10 alphanumeric characters. If the authenticator is valid, then the attendance data is recorded. The authenticator code is uniquely constructed for each individual participant and should be linked with the app. Figure 3 shows the BPMN diagram that explains the process flow of the model.

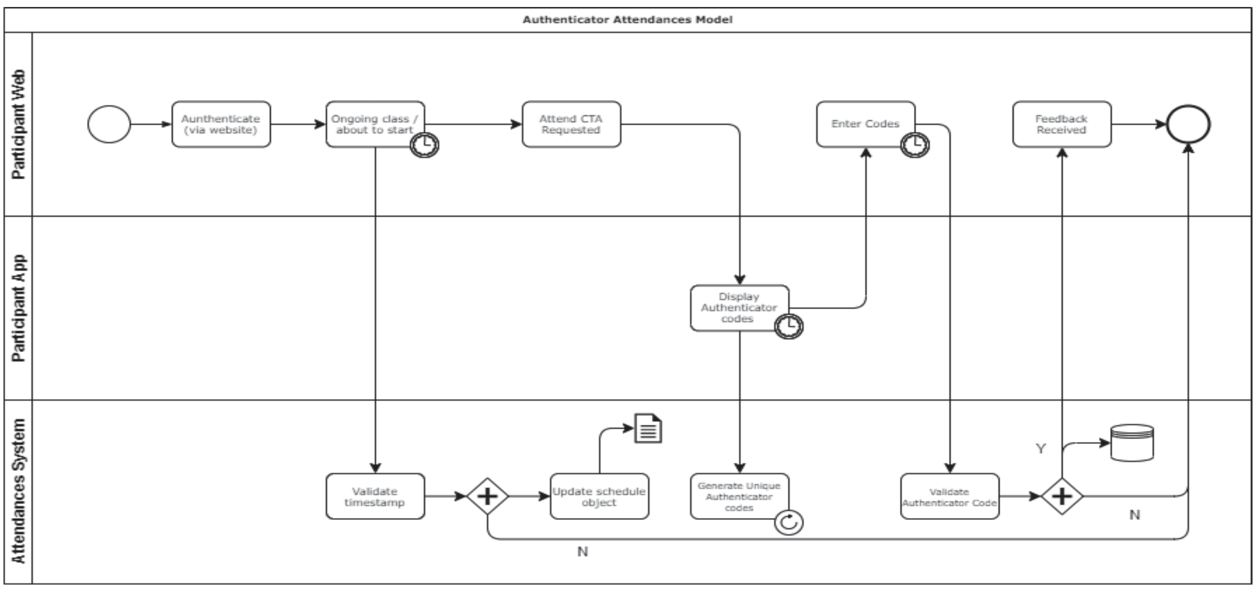


FIGURE 3. Authenticator Attendance Model BPMN

RESULT & DISCUSSION

The models involve three categories of users: the participant, lecturer, and admin/officer. Therefore, we also adapt the Interaction Design (IxD) framework that emphasizes the human factor when designing the interactive product and services[40]. In IxD, five dimensions need to be considered to develop a holistic form of end product or service. Those dimensions are: (1) Words, which encompass the amount of tangible information absorbed by users; (2) Visual Representations, that aid user interaction in the form of typography, visual elements, and other esthetical elements; (3) Physical objects, which in this case are the users' smartphones that interact with the model; (4) The Time that is related with event propagation or time delay on specific process; and (5) the Behavior that perceive how the user interacts with the product. The IxD framework commonly introduces certain steps such as designing, prototyping, and implementation to ensure the end product produces a relevant result to the model's goals.

We develop a native Android app to validate our models heuristically. Additionally, the web-based system with multiple user access has been designed to test out whether it fits our model's intended goals. Figure 4 (a) shows a screenshot from the participant's app that clearly informs the current or upcoming class. An adaptive interaction offers the intended interactivity based on several factors: time and attendance types. For instance, in Fig. 4 (a), there is instruction for the participant to access the web system to trigger the QR codes (first model). In Fig. 4 (b), the system requires the participant to scan the lecturer's QR code (second model). In Fig. 4 (c), the system instructs the participant to input authenticator code into the web system. All those forms of interactivity lead to a single purpose: to record the class attendances; they only appear during the current class' timeframe. All those feedback and attendance reports are accessible easily within a single menu on the app. Figure 4 (d) shows the most recent attendance report that highlights the status.

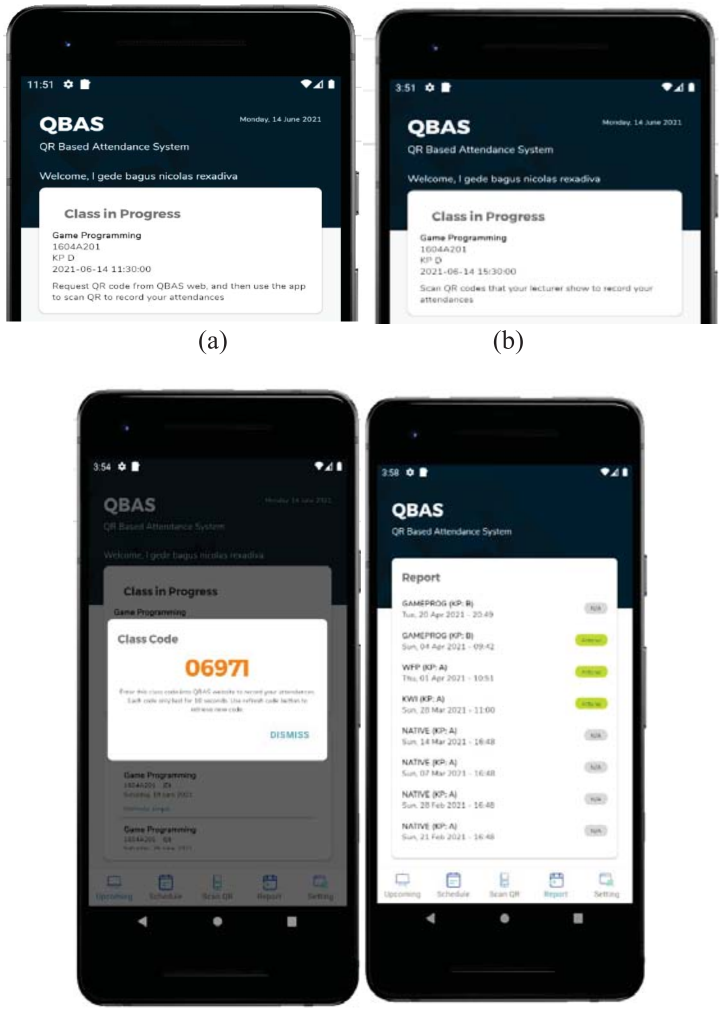
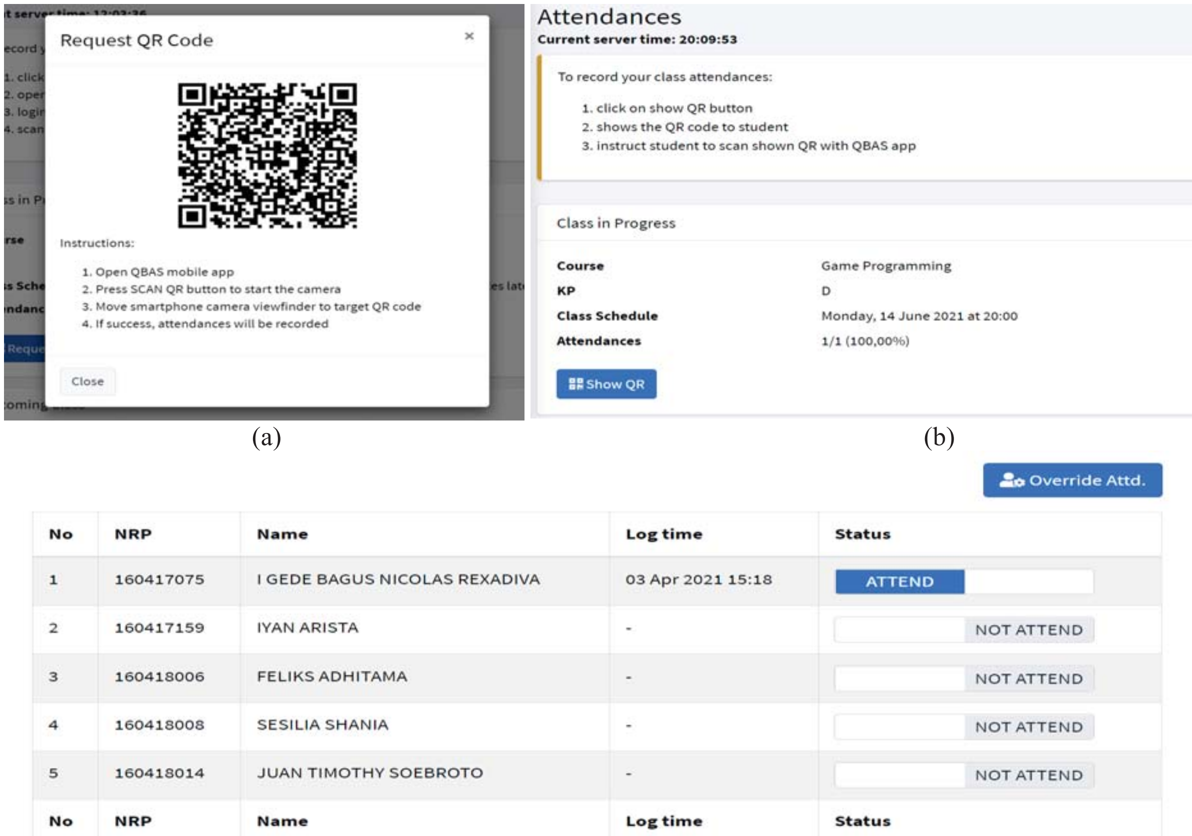


FIGURE 4. (a) adaptive screen interaction for automatic QR model; (b) adaptive screen interaction for manual QR mode; (c) authenticator code model displaying unique code; (d) feedback and attendances report accessible from application menu

We also developed a web-based system that works as part of the same ecosystem with native apps. The CodeIgniter framework was used to provide quick and reliable implementation of the models. The web-based system allows multiple user access: participant, administrator, and lecturer. It involves managing master data, participant enrollment, and other configurations mainly handled by the administrator. However, these administrative tasks are not necessarily an essential part and are excluded from the models since they are usually handled by the university system. The lecturers use the web system to open the class and display QR codes to the participants. Essential data and status are displayed on the lecturer's dashboard screen as shown on Fig. 5 (b). Extra features, as in Fig. 5 (c), let the lecturer override student attendances manually. On the automatic QR models, the web system is used by the participants to display QR-codes for themselves, which are to be scanned using the app, as shown in Fig. 5 (a).



(c)

FIGURE 5. (a) QR code that needs to be scanned on participant side; (b) informative information on lecturer dashboard; (c) manually override participant attendances

We conduct the heuristic usability evaluation to evaluate the usefulness of our model. This application is used mainly for participants that frequently interact with the model. The purpose is to help participants record their presence during the online course. Heuristic evaluation should evaluate 10 principles in UI to improve good UX[41]. We use this type of evaluation mainly because our end products of the attendances models are users (human). Hence, it requires a proper fundamental framework to evaluate the user satisfaction rate of the products.

Conducting heuristic evaluation requires two evaluators to improve the accuracy of the perception method during the assessment. Minimum number of evaluators used does not reflect on the result significantly as long as the methods and scenario laid out clearly[42]. At first, we decided to set a value for each principle that shows essential factors because our focus is to introduce a proper model for the attendance system and how to implement it. Weighting the heuristic importance toward the end product goals have been proved effectively focusing team effort on product development[43]. The essential factors should guide other researchers to build an attendance system based on our models. VS principle is the most essential factor that must be considered in these models. The reasons are participants should be well informed regarding the current time, currently attend status, and all other important stuff. We consider that the MW principle is closely related to participant experiences when offline attendance systems were applied. Therefore, we conclude that this principle should be accommodated in the end product.

Heuristic evaluation is all about finding the positive experiences that evaluators feel and noting down negative findings for further investigations. Table 1 shows the relationship between how many findings on each principle compared to the essential factors. Three positive findings on VS principles stated that participants have been able to perceive the information provided on the app or web system. That information is when the upcoming class started, the attendance status, and how many minutes the lateness are during ongoing courses. The negative findings found on UC principle are related to how evaluators feel that the products are too strict and have virtually nothing left to do. The product is only being used when class is about to start. The HD principle stated that evaluators cannot find necessary help documentation, except for small instructions on smartphones, that are difficult to read. These negative findings are all on lesser essential factors. However, those should be taken into consideration for future improvements. The conclusion is that high-impact essential factors should yield more positive findings and suppress negative findings. These ensure the user experiences on the end product: in this case, how well users perform while recording their attendances.

TABLE 1. Heuristic Evaluation of the end product during walkthrough scenario of each model

Heuristic Elements	Essentials Factors	Positive Findings	Negative Finding
Visibility of System Status (VS)	0.2	3	-
Match between system and real world (MW)	0.05	-	-
User control and freedom (UC)	0.05	-	1
Consistency and standards (CS)	0.15	2	-
Error prevention (EP)	0.15	1	-
Recognition rather than recall (RR)	0.1	1	-
Flexibility and efficiency of use (FE)	0.05	1	-
Aesthetic and minimalist design (AE)	0.1	1	-
Help users recognize, diagnose, and (HU) recover from errors	0.1	1	-
Help and documentation (HD)	0.05	-	1

CONCLUSION

We introduced three models for online attendance systems for education institutions. Automatic and manual QR models both offer zero involvement for the lecturer to conduct the attendances. The authenticator model provides a control for the lecturers to start or dismiss classes manually, maintaining the reliability and accuracy of attendances. All model goals are set to reduce administration difficulties during online courses. All models we developed also adhere easily to use, implement, reliable, efficient, and accessible. Working prototypes of the end products follow all principles of heuristic usability evaluation as a guideline to develop good user experiences.

However, based only on this approach, we cannot derive the solid conclusion that these models supposedly can prevent participants from cheating their attendances (proxy attendances). Our works have not been tested in the real world, in this case, in the university environment. Further research should conduct extensive empirical studies to gain a more detailed evaluation of each model's usage, usefulness, and feasibilities. Additionally, these models should be compared with other models that have the same principle and plans. Finally, the investigation should be carried out even more whether the models should be reliable enough in different circumstances and environments and enhance the system to prevent proxy attendances. These have been our following goals throughout the research roadmap.

In future works, hybrid courses would likely be implemented due to decreasing of COVID-19 impact. This means the online attendance model should be improved to support hybrid classes that may record the attendances for both participants who join the course from home and others that are physically present in class.

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InCITE 2021 receives very kind supports from world class scholars to be our international reviewers or international scientific committees. This will guarantee the presence of high quality papers from our reviewing process as the accepted papers will undergo rigorous review. Thus, the conference organizers would like to express their gratitude to the following scholars who will serve as the international scientific committees.

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Preface: International Conference on Informatics, Technology, and Engineering 2021 (InCITE 2021)

Welcome to the 3rd biannual International Conference on Informatics, Technology, and Engineering 2021 (InCITE 2021). This year, InCITE is organized from Surabaya, Indonesia and researchers from around the world discuss current challenges and technological solutions via an online platform on August 25-26, 2021.

InCITE 2021 presents "Leveraging Smart Engineering" as its central theme. In response to several world challenges, such as sustainable development, global convergence of information and communications technologies, along with smart systems as opportunities as well as challenges in developments for better industries, it is considered important to discover innovative approaches from science and engineering perspectives. Innovation suggests the introduction of novelty to create better solutions. Innovation in engineering and science requires contributions from multidisciplinary sectors, involving industries, practitioners, researchers, and academics.

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WELCOME FROM InCITE 2021 STEERING COMMITTEE

It is a great pleasure to welcome all of you to the 3rd Bi-Annual International Conference on Informatics, Technology, and Engineering 2021 (InCITE 2021) held by the Faculty of Engineering, University of Surabaya (UBAYA). The first and second InCITE have been successfully held in Bali, Indonesia in 2017 and 2019. Hence, now we are delighted to host the third InCITE through online media due to the Covid-19 pandemic situation.

There are 37 papers that have been selected to be presented in InCITE 2021. The papers were written by experts not only from Indonesia, but also from different parts of the world. The main theme of this conference is Leveraging Smart Engineering in response to the current and future Industrial Revolution 4.0 that should be handled by every country in the world. We hope through this conference, all participants will be able to know each other and interact to develop future collaboration.

We would like to express our sincere gratitude to the Keynote speakers, International Scientific Committee, Steering Committee, and Organizing Committee for their huge efforts to make this conference successful.

Thank you all for your support and attendance at InCITE 2021. Please enjoy the conference!

Asst. Prof. Doddy Sutrisna, Ph.D.
Steering Committee

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WELCOME FROM InCITE 2021 ORGANIZING COMMITTEE

Welcome to InCITE 2021! The third bi-annual international conference on engineering domain conducted by the Faculty of Engineering, The University of Surabaya (UBAYA). Due to the COVID-19 pandemic, InCITE 2021 is held as an online conference. Online conference opens the opportunity for many researchers around the globe to share their findings and learn from other global researchers with less restrictions.

InCITE 2021 invites three keynote speakers, well reputable global researchers in their research domain from Australia and Taiwan. Following each keynote session are two presentation sessions run in parallel.

This year, we received 66 papers submitted by researchers from four distinct countries (i.e., first author's country of origin): Indonesia, Australia, Taiwan, and Kazakhstan.

We employed a double-blind review to ensure a high standard and a minimum level of bias in the reviewing processes. This resulted in 56% of the submissions were accepted and will be published to the AIP Conference Proceedings.

Authors of all accepted papers are to disseminate their findings during InCITE 2021 conference between 25 to 26 of August 2021. This presents a great opportunity for everyone, including the researchers, to discuss and further improve current achievements.

We thank all keynote speakers, presenters, and reviewers/scientific committees for the generous supports. We thank the University of Surabaya, the Faculty of Engineering UBAYA, and all InCITE 2021 committees that enable InCITE 2021.

We wish you a very pleasant and rich conference experience in InCITE 2021 and look forward to seeing you again on InCITE 2023! Thank you.

Yours sincerely,
Asst. Prof. Dr. Jimmy
InCITE 2021 Organizing Committee

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