Developing a student attendance app using QR codes: educational and practical considerations

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Abstract: Recording student attendance in educational institutions is a tedious, manual process that is both time-consuming and error prone. We have developed an app to capture student attendance. During each class session, the students will point their device at a unique QR Code displayed on the teacher's projector. Each student's attendance will be recorded immediately on the learning-management system. The app has been developed for both Apple and Android platforms to enable attendance capture in all classroom settings; a module added to a home-grown learning-management system enables display of the appropriate QR Code for each class session. We conclude that it is possible to develop an app that records student attendance using QR codes and institutional information systems. Implemented efficiently, student attendance can be recorded accurately and effectively, saving class time. Overall user satisfaction with the system was high, demonstrating that information technology can positively drive and support change in medical education.

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1 Introduction

Accumulating evidence shows that classroom attendance is a strong predictor of academic performance (Marburger, 2006; Chen and Lin, 2008; Eisen et al., 2015; Alghamdi et al., 2016; Credé et al., 2010; Deane and Murphy, 2013). In fact, academic success is a function of many factors, including cognitive and non-cognitive determinants, such as positive study habits, attitudes, study skills, and cognitive abilities (Credé and Kuncel, 2008). In fact, students, faculty members, and educational researchers have questioned the importance of physical class attendance (Kauffman et al., 2018), supporting their arguments by citing growing levels of absenteeism, ranging from 18.5% (Marburger, 2006) to as high as 70% (Moore et al., 2008).

In addition, students (as adults) should have the autonomy to choose their preferred instructional methods, educational activities, and other provisions relevant to their own academic progress. Some authors have expressed additional doubts about the fast-growing use of educational technologies and the availability of commercial resources, which have recently been adopted by both students and educational institutions, particularly in the medical field (Kauffman et al., 2018). These voices have questioned the common practice of establishing policies to enforce mandatory attendance (Hyde and Flournoy, 1986; St. Clair, 1999).

Despites these doubts, attendance has been shown to benefit students, irrespective of the mode of instruction. This is true even in lecture courses, where students play a relatively passive role. Indeed, one metanalysis review found a link between lecture-based instruction and increased knowledge, as well as interpersonal and, surprisingly, psychomotor skills among students (Arthur et al., 2003). A recent study with thousands of subjects has suggested that attendance is more positively associated with class grades than with any other known predictors, including high-school GPA, SAT scores, student characteristics, and study habits (Credé et al., 2010). Furthermore, failure rates are significantly reduced by class attendance, at a level as high as 70% (Kooker, 1976). Reducing failure rates has many implications and benefits for both students and their educational institutions; for students, it increases the likelihood of graduation and timely employment, while for universities and colleges, it increases revenue and social accountability. Class attendance influences student performance and grades for many reasons. It offers students the chance to obtain knowledge that may not appear in textbooks or hand-outs, as well as providing opportunities for repeated contact with the content through lectures, assignments, and demonstrations. It aids retention of knowledge and helps students obtain high grades through a system of distributed practice and overlearning (Cull, 2000; Donovan and Radosevich, 1999; Cepeda et al., 2006; Peladeau et al., 2003).

Historically, medicine has been taught using an apprenticeship model, through which students are physically connected with their trainers through full attendance, observation, and assistance with daily activities; this lasts until trainees are trusted to work independently. Clinical skills – in particular, psychomotor skills, such as those used to carry out procedures – require demonstration and practice under observation; these require physical attendance. For this reason, most medical schools make it mandatory for students to attend clinical skills sessions. One study found a strong relationship between attendance and clinical performance in summative assessments. Attendance is also considered a sign of punctuality, a key attribute of professional behaviour. Medical students with poor attendance have been found to develop higher rates of absenteeism

later, during professional practice (Papadakis et al., 2005). Another study used class attendance as a sensitive measure of professionalism (Al Rumayyan et al., 2016).

Academic success can be theoretically explained by Self-Regulated-Learning (SRL) theory (Sandars and Cleary, 2011). According to this theory, students define their own goals and select appropriate strategies to realise them. In addition, their behaviour is modified to optimise both learning and performance. According to this theory, classroom attendance serves as an indicator of engagement, explaining variations in student performance (Salamonson et al., 2009). In a Dutch study, the voluntary classroom participation of first-year medical students showed a significant positive association with motivation, measured in terms of self-efficacy and learning strategies, using the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich et al., 1991), modified on the basis of SRL theory.

The above discussions highlight the importance of attendance in enhancing both theoretical and empirical academic performance. Given these data, it is valid to ask why educational institutions are failing to monitor attendance. One reason may be that taking attendance is time-consuming, especially as the number of student's increases. It is often very difficult to obtain accurate and timely attendance data. However, recent advances in information technology have made it relatively easy and more cost-effective to monitor attendance.

In most universities, recording student attendance is a tedious process, in which the teacher must ask students to sign an attendance sheet for each session and then enter the names of absent students into the system. This process is time consuming and error prone. We therefore set out to find a way of automating this process to keep more accurate records of student attendance, while also enhancing faculty satisfaction.

Although several apps have been developed to record student attendance, all require the teacher to enter student information, check that students attend each class, and record their presence or absence in the system (Trabelsi and Shuaib, 2011; Namrata et al., 2016; Vishwakarma, 2016).

2   Methods

The present study set out to develop an app (for both Android and iPhones) that students could download for free from Google Play or Apple App stores. Each student would enter his or her Student ID and use only that device to capture class attendance. In each teaching location, a computer with a pre-defined webpage would be visible to all students and connected to a learning-management system that contained the timetable for all classes with location information. A QR Code would appear on this webpage at precisely the start of class and disappear when the class ended. The teacher would click a shortcut on the desktop, causing the session title to appear on the page. He or she would check the session name and click the Display Code for the session. A QR Code would appear for 60 seconds, giving students enough time to capture their attendance. The QR Code simply encodes any chosen information. In this case, it would contain the following information in encrypted form: Session ID, Location ID, Date and Time (to the second). The page would refresh every 5 seconds, completely changing the QR Code each time. Whenever the teacher asked them to do so, students could click the Capture Attendance button on their apps and point their devices' cameras towards the displayed QR Code; their attendance would be automatically recorded in the learning-management system in

a matter of seconds. The teacher could ask students to do this at any time during class – or even several times (for example, at the beginning and end of the session). The teacher would thus initiate this process by clicking a shortcut on a desktop or browser to display the QR Code.

3 Results

3.1 App development

This project involved the development of two apps, one for Android and the other for iPhone devices. The apps look exactly the same and work in the same way. We also developed a webpage for teachers and a system for recording attendance by receiving data from the app and entering it into the learning-management system.

3.2 App implementation

We chose the College of Medicine and Health Sciences (CMHS), United Arab Emirates University (UAEU), as an appropriate setting to implement this app. The main advantage of this setting was the in-house-built learning-management system, the Curriculum Management System (CMS). The College controlled this system, agreed to build the server-side pages needed for the project, and also agreed to pilot the project.

Figure 1 Session QR Code projected from the teacher's computer


3.3 Website description (teacher-side)

CMHS IT will ensure that each teaching location in the College has a teacher's computer with a projector, which contains a desktop shortcut (or a shortcut in each browser). This shortcut will open a browser with session information and a 'Display Code' button, which will display the QR Code on the page. When the teacher wishes to take attendance,

he or she will simply click on this shortcut, check that the session title is correct, click on the 'Display Code' button, and instruct the students to 'record their attendance'. This website will only work on the teacher's computer. If the class is not in session (based on the class schedule in the CMS) a message will appear, stating that no session has been found in the CMS for this location at this time. When the class is in session, the session information will appear with a 'Display Code' button. When the teacher clicks on the 'Display Code for This Session' button, the QR Code will appear for 60 seconds (see Figure 1).

The teacher should ask students to record their attendance 5–10 minutes into the session and again during the session – whenever it seems necessary (for example, near the end of the session).

Figure 2   The student enters his or her Student ID to authorise the device to use the app.
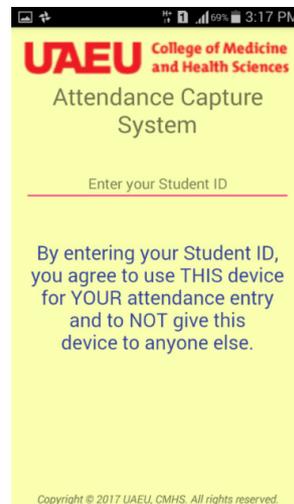

3.4   App description (student-side) (Steps 1–4 are carried out only once)

1   The student searches for 'CMHS' on Google Play or the App Store.

2   The student downloads the app and enters his or her Student ID (see Figure 2).

3   The student will receive a confirmation message explaining that he or she must use this authorised phone only to register attendance and may not give the phone to anyone else (see Figure 3).

4   If the student tries to install the app on another phone and enters the same student ID, he or she will receive a message stating that another phone is already authorised for this student ID. If the student wants to use the new phone instead, he or she should contact Medical Education.

5   When the teacher displays the QR Code and instructs the students to 'take attendance', the student will click on the 'Capture Attendance' button and point the device's camera towards the displayed QR Code; his or her attendance will be recorded on the CMS in a matter of seconds (see Figure 4).

The student must agree (click 'OK') when asked whether the app is allowed to access the phone camera. The student must have an active Wi-Fi connection on his or her device to capture attendance.

6   If the student is in the wrong class, he or she will receive an 'Attendance NOT Recorded' message.

Figure 3   Device authorised, enabling the student to record attendance
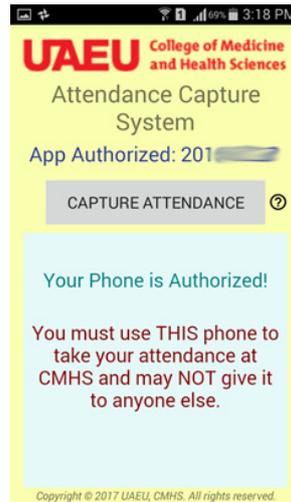
Figure 4   Message confirming that attendance has been recorded

3.5   *Implementation quantitative analysis*

The system was used for the full 2017/2018 academic year in the College MD program. During this time, 550 students received a total of 133,000 attendance posts: an average of 244 posts per student; this figure correlates with the expected number of sessions in each year of the program.

3.6   *Students and faculty satisfaction survey*

Institutional Review Board approval was obtained to carry out this survey, using anonymous participant data (approval number: ERS_2017_5549). The satisfaction survey was conducted after the pilot period in 2017 and after the app had been used for the full academic year in 2018. The response rates for students were 47% and 28%, respectively; for faculty members, they were 19% and 24%, respectively. Student participants were well distributed by year in the program. Table 1 shows the percentage of participants who chose 'Agree' or 'Strongly Agree' in response to selected survey questions. Table 2 shows the percentage of times specific situations occurred, as estimated by participants.

Table 1   Percentage of participants who chose 'agree' or 'strongly agree' in response to selected questions

Survey question	*First survey 2017 (after piloting app)*	*Second survey 2018 (after one year of use)*
1 It is easy and quick to download and install the app.	85%	90%
2 Teachers remember to display the Attendance Code in each session.	11%	29%
3 The process of capturing attendance using the app is quick and simple.	59%	84%
4 When necessary, it is reasonable to continue to have paper attendance sheets available for those students who have trouble taking attendance using the app.	87%	88%
5 Recording attendance by signing attendance sheets is a better method.	58%	14%
6 Overall, I am satisfied with the attendance capture app, as it is a good way of capturing student attendance.	29%	71%
7 It is necessary to record student attendance at lectures.	26%	35%
8 It is necessary to record student attendance at course covering clinical skills, practical sessions, PBL, and bedside teaching.	50%	53%

Table 2 The percentage of time these situations occurred, as estimated by participants

Situation	First survey 2017 (after piloting the app)	Second survey 2018 (after one year of use)
1 Teachers forget to display the Attendance Code and need to be reminded by students.	70%	62%
2 Teachers display the Attendance Code too EARLY in the session (right at the start of the session).	35%	28%
3 Teachers display the Attendance Code too LATE in the session (right at the end of the session).	42%	57%
4 The Attendance Code does NOT display correctly.	23%	12%
5 For some reason, my phone fails to capture attendance using the app.	33%	18%
6 I cannot record attendance using the app because of Wi-Fi issues.	Not asked	37%
7 I forget to bring my phone with me to the College.	21%	8%
8 My phone battery is not charged when I need it to record my attendance.	32%	15%

4 Discussion

As in most medical schools, we applied a mandatory attendance policy for lectures and small-group learning activities across the curriculum. All students must attend 85% of sessions to be eligible to take the final examination. The attendance app was piloted for three months at the end of the 2016/2017 academic year at the College of Medicine and Health Sciences, United Arab Emirates University; it has been the standard method of taking attendance since the 2017/2018 academic year.

Our student-satisfaction survey showed that 50% of the students surveyed in 2017 and 53% in 2018 agreed or strongly agreed that taking attendance was necessary for small-group learning activities, such as clinical skills, practical sessions, PBL, and bedside teaching. By contrast, 26% of students during the pilot phase and 35% one year later agreed or strongly agreed that taking attendance was necessary for lectures.

Evidence indicates that medical educators are increasingly emphasising the importance of students' self-efficacy, self-directed learning, and empowerment, which enable them to take responsibility for decisions related to their learning (Harvey et al., 2003; Nothnagle et al., 2010). However, some medical schools do require students to attend specific learning sessions, such as small-group classes, rather than lectures. This is prudent since, in small-group learning, chronically absent students can have an impact on their classmates' performance of Gottfried (2019). Other considerations militating against compulsory lecture attendance include the provision of recorded lectures or video streaming; these can negatively affect student lecture attendance (Traphagan et al., 2010;

Bridge et al., 2009). In 2018, 84% of students agreed or strongly agreed that the process of recording their attendance for all learning modalities using the app was quick and simple, indicating that this process is easy to use.

Our attendance system has been enthusiastically accepted by College administrators, faculty members, and students. As a result, absenteeism is closely monitored and crosschecked, with students receiving warnings at 5%, 10%, and 15% non-attendance from the Assistant Dean for Student Affairs and the Medical Education Department. We see this as a means of supporting students' understanding of what is expected of them and tackling the attrition caused by unsuccessful attendance (Taylor, 2005). Overall, the study data show that, as students and faculty members become more familiar with using the attendance-capturing app, they become increasingly satisfied with and accepting of its use. The satisfaction-survey data reveal an increasingly favourable response, from 2017 to 2018, to the resolution of situational encounters associated with the app, including issues related to Wi-Fi, phone batteries, the attendance-code display, and other matters. Interestingly, however, in 2017 and 2018, a consistently high percentage of students (87% and 88%, respectively) agreed or strongly agreed that 'When necessary, it is reasonable to continue to have paper attendance sheets available for those students who have trouble taking attendance using the app'. Although this indicates an understandable desire for a 'backup' mechanism, this response appears to diminish as the system becomes institutionally embedded; user experiences become more positive and reach higher levels of receptivity to adopting the technology. According to Rogers (2003), the adoption and diffusion of technological innovation is a process that takes time, confidence building, and compatibility with the beliefs and existing values of individuals and the institution as a whole.

Research has shown that students are more likely to attend classes when attendance is made mandatory (Marburger, 2006; Hartinett, 2008). As Hartinett (2008) suggests, organisational structures and values either support or undermine values and beliefs within an institution's mission. A South African study has found that some faculty members enforce attendance rules while others do not; 'because of this inconsistency, students "play" the system' (Scheckle, 2014). We believe that effectively monitoring attendance and acting against non-attendance is a signal that the institution cares about helping students succeed and is therefore important. However, attendance data must be accurate, up-to-date, and useable (Bowen et al., 2005). Researchers have shown, for example, that in order to achieve high levels of protection, efficiency, and reliable implementation, it is necessary to have e-attendance systems that provide reliable solutions to the problems of student impersonation, firewall elimination, and the need to detect intrusions (Trabelsi and Shuaib, 2011).

Some studies have been sceptical about the strength of the link between lecture attendance and subsequent academic performance (Eisen et al., 2015; Van Walbeek, 2004). In this regard, researchers have suggested that contemporary features of higher education, such as flexible approaches to engagement, an emphasis on student-centred, self-directed learning, and enhanced access to information and information technology are reducing the emphasis on lecture attendance, making non-attendance seem unproblematic (Moore et al., 2008). However, regardless of the discipline or mode of instruction, other studies have indicated that class attendance has a positive and significant effect on exam performance (Chen and Lin, 2008). In the field of medicine, Bamuhair et al. (2016) found that Saudi medical students' lecture attendance was

correlated to performance but not to other learning modalities; another Saudi study used the average of lost class hours and students' average academic performance to show that student absenteeism had a negative impact on academic performance (Alghamdi et al., 2016).

Indeed, it is well understood that individual academic achievement is linked to various cognitive and non-cognitive factors. Intuitively, one would expect attendance and the habit of punctuality associated with it to demonstrate non-cognitive attributes, such as professionalism, conscientiousness, diligence, and achievement motivation; these, in turn, mediate performance by influencing behaviours that support the understanding and retention of the material to be learned. In medicine, the presence of these attributes is very important in professional careers. Fitness to practice considerations often involves descriptions of unprofessional behaviour or a lack of professionalism. Indeed, studies have shown an association between unprofessional behaviour in training and subsequent disciplinary action in later clinical practice (van de Camp et al., 2004; Papadakis et al., 2004, 2005).

We believe that attendance monitoring, at both the individual and institutional level, represents an important component of professional behaviour and quality assurance; it is as important an indicator of successful medical school outcomes as other key quality indicators. However, despite the emphasis placed on professionalism in medicine, some medical education leaders seem to lack enthusiasm for robust policies and procedures that cultivate and monitor all aspects of professional behaviour, including attendance (Stern, 2006; Veloski and Hojat, 2006). Equally significant, it is important to recognise the reasons for low student motivation to attend class, to monitor attendance, and to take a stand on student non-attendance. On-going analyses of the way this app is used may throw light on these considerations.

Future internal research, a review of the attendance literature, and technological advances in the field, including clickers, audience-response systems, swipe cards, and the use of effective and secure biometrics-based systems, will not only shed further light on the reliability, utility, acceptability, and educational impact of the technologies being used to monitor attendance in our setting and elsewhere, but will also inform the on-going debate about the importance of medical-school class attendance; it may thereby have important practical policy implications. In the meantime, the literature suggests that attendance is linked to academic performance; this should at least provide medical educators with the evidence they need to persuade students that is in their best interest to attend classes. Other specific questions worthy of future exploration include the reasons for student non-attendance and the extent to which students are being selective in their attendance. Examining these questions may help us to identify various motivational aspects of student attendance in order to formulate better policies while optimising educational and professional outcomes.

Although this analysis of user satisfaction in a single institution has produced favourable results, the findings may not be sufficiently generalisable. However, this study does provide an example of the process, development, and use of an attendance app, based on educational and practical principles. Other medical schools could apply a similar approach to student attendance taking.

5   Conclusions

In keeping with institutional policies on student attendance, this study has shown that it is possible to develop an app to take student attendance using QR Codes and the institution's student information system. Implemented efficiently, such an app can save a great deal of class time and record student attendance for every session accurately and effectively. Overall user satisfaction in using the system was high. Information technology can positively drive and support change in medical education.

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