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Mobile ECG App Integration and ECG Interpretation Offline Workshop for Healthcare Professionals

Putrika Prastuti Ratna Gharini[1,3*], Rizki Amalia Gumilang[1,2], Bidhari Hafizhah[1], Hana Maryam Sholikhah[1], Vita Arfiana Nurul Fatimah[2], Shofuro Hasana[2], Orisativa Kokasih[2]

[1]Department of Cardiology and Vascular Medicine, Faculty of Medicine, Public Health, and Nursing, Gadjah Mada University, Yogyakarta, Indonesia
[2]Faculty of Medicine, Public Health, and Nursing, Gadjah Mada University, Yogyakarta, Indonesia
[3]Dr. Sardjito General Hospital, Yogyakarta, Indonesia

Email: pgharini@ugm.ac.id (corresponding author)

Abstrak Electrocardiogram (ECG) plays a major role in diagnosing cardiovascular disease (CVD). Despite the escalating CVD rates, medical professionals exhibit suboptimal ECG interpretation skills due to inadequate training and declining competencies over time. Conventional teaching methods have proven ineffective. The Mobile ECG application was developed in 2022, employing online learning to enhance ECG interpretation. While previous studies demonstrated its effectiveness, this study aims to evaluate its impact in a one-day timeframe ECG offline workshop setting. An observational study was done using a Mobile ECG application in combination with an offline workshop. Participants were recruited using consecutive sampling. The included participants needed to meet the criteria: 1) registered as participants in one of the Jogja Cardiology Update Workshop, 2) agreed to participate in this study. Participants were assigned to a 2-hour offline workshop. Pre- and post-test analysis and System Usability Scale (SUS) questionnaire were used to evaluate the study. A total of 28 participants analyzed in the study with the majority of participants (89.7%) were general practitioners. The study showed a significant result based on the mean scores of pre- and post-tests were 29.29 ± 15.62 and 48.21 ± 16.79 (p-value < 0.05), respectively. According to the SUS score, this study demonstrated good usability (73.19, SD 15.45). The evaluation showed participants were satisfied, but suggested improvements, including offline access, teaching videos, and a discussion forum are further needed. Mobile ECG application is favorable to be a complementary learning media in ECG interpretation offline workshop to improve interpretation skills for healthcare professionals.

Keywords: *mobile ECG application; ECG workshop; ECG learning media; healthcare professionals; System Usability Scale*

INTRODUCTION

Cardiovascular disease (CVD) dominates 30% of deaths globally. In Indonesia, CVD remains the leading cause of illness and death, accounting for one-third of all fatal cases (Balitbangkes, 2018). According to Indonesia's basic health research (Riskesdas) conducted in 2013 and 2018, the prevalence of CVD has been on the rise, increasing from 0.5% in 2013 to 1.5% in 2018. This means that in 2018, approximately 15 out of every 1,000 Indonesians were affected by CVD (Nurwahyuni, 2023). Most CVDs can be detected early by a simple examination called electrocardiography (ECG) (Torres-Cisneros *et al.,* 2019). ECG, the most commonly used diagnostic test in cardiology, is employed as the simplest, most cost-effective, and widely accessible method used to assess the heart (Antiperovitch *et al.,* 2018). Therefore, basic ECG interpretation is an important skill for medical professionals. Lack of competence and confidence among doctors potentially leads to diagnostic inaccuracies in its interpretation, resulting in investigation and treatment delays (Baral *et al.,* 2020; Pollard *et al.,* 2021).

A study involving medical interns in several medical colleges showed unsatisfactory performance in ECG interpretation, despite their completion of advanced cardiac life support courses. Most of the participants attributed their challenges to inadequate training in college, including practical case-based training (Al Mousa *et al.,* 2023). A study in Iran, consisting of medical staff and students, showed that the participants' level of ECG interpretation competency was low. Despite the fact that they had already taken courses on ECG interpretation in their first years of work and study, one of the reasons is the "declining skills" of their practice in the long run after periods of "non-use" (Amini *et al.,* 2022). One of the challenges in learning ECG is the impractical traditional teaching methods (textbooks, lectures, and discussions). Studies have shown that those strategies are ineffective in developing critical thinking skills required in higher education, especially in medicine (Alamrani *et al.,* 2018; Joseph*,* Fenton, & Winchester, 2022). Nowadays, the use of electronic media as a learning method in medicine is increasing exponentially. Mobile ECG learning methods may be beneficial in assisting medical students and clinicians to practice skills, including ECG interpretation (Pollard *et al.,* 2021).

In 2022, a team from Gadjah Mada University created an ECG learning application named Mobile ECG to be the solution to this problem. Mobile ECG facilitates web-based learning, which comprehends basic ECG module topics (normal ECG, basic arrhythmia, cardiac chamber enlargement, ischemia and infarction, electrolyte and drug-induced ECG changes), difficulty-based quizzes levels, and a gallery of real ECG cases. This application has been tested several times for use (Gumilang *et al.,* 2021)

Pilot study showed that Massive Open Online Course ECG learning significantly improved subjects ECG interpretation skills required in clinical settings. A study to investigate the implementation of Mobile ECG application in an online learning environment as a supporting device had been done and significantly improved subjects in ECG interpretation (Gumilang *et al.,* 2021). However, a study to examine the implementation of Mobile ECG application in an offline learning setting had not been conducted. Thus, this study aimed to evaluate the application of Mobile ECG learning designed to improve ECG interpretation in a one-day ECG workshop setting.

METHOD

This study was an observational study conducted using a mobile-based application in combination with an offline workshop. The study population were the participants of ECG Interpretation Offline Workshop in Yogyakarta 2023. The inclusion criteria were, 1) GP participants, 2) Doctor of Medicine (MD) as their latest educational background, and 3) agreed to participate in the study from start to end. The exclusion criteria were, 1) other than GPs, and 2) not willing to participate in the study. The quantitative and qualitative data were taken prospectively using a questionnaire. The subjects were recruited using consecutive sampling.

Subjects were assigned to do a 10-minutes pretest before the workshop started. It consisted of 10 questions about ECG findings and interpretation (Table 1). Subjects were then asked to access Mobile ECG during a 2-hour offline workshop. The workshop consisted of three theoretical sessions with three cardiologists as the speakers. During the workshop, participants engaged in a learning environment in which they experienced the integration of Mobile ECG using smartphones or tablets and two-way discussion with the speakers.

After the workshop, subjects completed the post-test and completed the System Usability Scale (SUS) questionnaire. It consists of 10 items that rate the usability of Mobile ECG on a 5-point scale (1: strongly disagree to 5: strongly agree). The data obtained were computerized using SPSS version 25 and analyzed using univariate and bivariate. The Shapiro-Wilk normality test was used to test the distribution of the data.

This study was approved by The Medical and Health Research Ethics Committee (MHREC) Faculty of Medicine, Public Health and Nursing Universitas Gadjah Mada - Dr. Sardjito General Hospital (KE/1722/11/2023). Before collecting the data, the subjects were given the written informed consent.

Table 1. Items of SUS Questionnaire

Number	Item
1	*I think that I would like to use this system*
2	*I think the system complicated to use*
3	*I thought the system was easy to use*
4	*I think that I would need the support of a technical person to be able to use this system*
5	*I found the various functions in the system were well integrated*
6	*I thought there was too much inconsistency in this system*
7	*I would imagine that most people would learn to use this system very quickly*
8	*I found the system very cumbersome to use*
9	*I felt very confident using the system*
10	*I needed to learn a lot of things before I could get going with this system*

FINDINGS AND DISCUSSION

A total of 23 subjects participated in the study, with 7 male subjects and 16 female subjects. The characteristics of the participants are stated in Table 2. The mean age was 29.48 (± 4.97) years old.

Table 2. Baseline characteristics of subjects

Characteristic	*n*	Value
Age (in years; mean)	23	29.48 ± 4.97
Sex, n (%) Male Female	 7 16	 30.43 69.57

Our pilot study, investigating the impact and usability of Mobile ECG application in medical students and GP in a one-week timeframe showed that GP predominantly made up the study. This tendency could be linked to a difficult transition from academia to clinical practice, motivating them to prepare thoroughly for the demands of real-world medical settings. GPs or any other healthcare professionals, have the responsibility to treat and look after the patients while simultaneously improving competence in daily clinical activities. Unlike during preclinical years, the availability of time for learning and training as

well as the urge to receive feedback is limited. Hence, they need a practical and applicable two-way ECG learning approach.

Table 3. Analysis of pre-test and post-test scores

	Pretest	Post-test	p-value
Mean ± SD	27.83 ± 17.83	44.35 ± 19.96	0.018
Median	20	50	
Range	0-60	0-80	

The mean scores of pre- and post-tests were 27.83±17.83 and 44.35±19.96, respectively (Table 3). The median scores of pre- and post-test were 20 and 50, respectively. All participants showed an increase in their post-test compared to pre-test scores, except 5 that demonstrated a reduction in results. Still, this study showed a significant result (p-value < 0.05).

Our study might align with a study by Bojsen *et al.* (2015) with different target population and longer duration, evaluating the effect of 5 hours interactive ECG learning among the medical students. The study had its 5-minute introduction, 40-minute pre-test, 3 hours and 25 minutes of web-based tutorial developed by cardiologists, and 40-minute post-test session which showed a significant result with overall mean test score 52.7 (SD 16.8) in the pre-test and 68.4 (SD 12.3) in the post-test (p-value < 0.001).

The workshop consisted of three theoretical sessions with three cardiologists as the speakers. During the workshop, participants engaged in a learning environment in which they experienced the integration of Mobile ECG using smartphones or tablets and two-way discussion with the speakers.

Our particioants engaged in a blended learning setting, which led to noticeable improvement, as shown by the significant results. This finding is supported by a study conducted by Viljoen *et al*. (2020) that examined the effectiveness of blended learning (utilization of web apps to facilitate ECG interpretation with immediate feedback from lecturers) and conventional lecture-based teaching. The results stated a significant score result for blended learning compared to conventional teaching. Blended method showed a 2.4-fold increase in the mean test scores (31.0% ± 13.2% in the pre-test to 75.3 ± 16.2% in the post-test, p-value < 0.001). Meanwhile, conventional teaching method was observed with a 1.6-fold improvement in the mean test scores (31.2 ± 11.5% in the pre-test to 50.3 ± 17.1% in the post-test, p-value < 0.001).

Another study by Bazrgar *et al.* (2023) also assessed the effectiveness of 20 hours of online, offline, and blended methods (10-hour online and 10-hour offline session) in residents and interns' ECG learning. The results showed that the blended method was favored by participants with the mean total exam score

(7.20 ± 1.89, p-value 0.017). Offline (5.97 ± 2.33) and online teaching methods (6.07 ± 2.07) had similar efficacy (p-value 0.819).

Table 4. SUS study score

Evaluation	Result
SUS Study Score	73.48
Median	80
Standard Deviation	16.77
Adjective	Good
Quartile	3rd

In this study, the overall SUS study score was 73.48 with a standard deviation (SD) of 16.77, representing good usability (Table 4). The score was considered higher compared to our previous study which investigated the use of mobile apps in an online ECG learning method as complementary device and demonstrated marginally acceptable results with the SUS score 67.5 (SD 15.16). Despite its good usability, this study still needs further improvement. The absence of data on any additional courses or training undertaken by participants before engaging with the mobile apps and attending the workshop raises questions about potential contributors to their ECG interpretation skills.

Figure 1. User Satisfaction Evaluation of Learning ECG with Mobile ECG

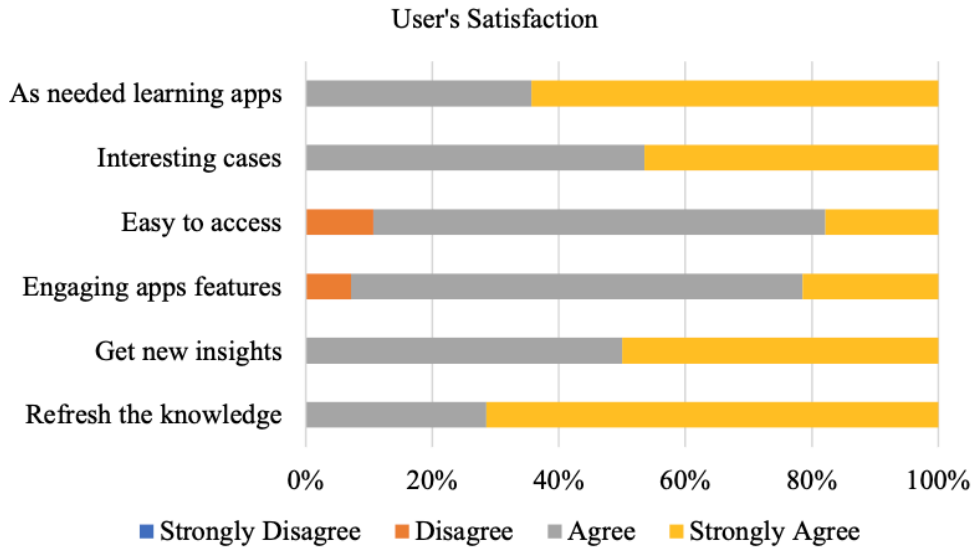

Figure 1. User's satisfaction

User satisfaction evaluation was shown in Figure 1. A few participants did not agree that Mobile ECG apps had easy access and engaging features. They noted issues, including features requiring internet connections, no teaching

videos, and no discussion forum. Additionally, some suggested a more diverse color palette for the interface.

Despite some concerns, many participants acknowledged this mobile app's effectiveness in refreshing, practicing, and gaining new insights into ECG interpretation materials. They mentioned that the materials were written in an easily understandable language, complemented by direct explanations from the speaker during the workshop. For more in-depth study, participants have the flexibility to select particular materials based on their individual needs. The option to revisit and review content at their own pace offers a more adaptable and convenient approach, fostering improved retention of the materials.

Incorporating more quizzes and online consultation features was recommended by the subjects. Furthermore, they expressed a desire for this app to be widely used by healthcare professionals, especially general physicians and nurses, knowing the significant benefits offered.

This study had certain limitations. Study participants were limited to a single workshop, resulting in a relatively small sample size. The limited time sessions might affect the comprehensiveness of data collection. Additionally, evaluation on how students had interacted with the online material was beyond the scope of our study.

CONCLUSION

The application of Mobile ECG learning in a one-day time-frame ECG offline workshop significantly improved the ECG interpretation of healthcare professionals based on pre- and post-test score measurement. The overall SUS study score was interpreted as good usability. Participants also expressed satisfaction with the contents despite a few noted feedback points.

RECOMMENDATION

Further large-scale study, including a large number of participants, is recommended to collect data to verify the effectiveness of the application of Mobile ECG in offline workshop settings as a complementary learning method in improving participants' ECG interpretation skills. Assessing participants' retention of ECG competence also needs to be done weeks or months after the intervention.

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