

# Innovative Learning Approaches for Medical Students: A Comparative Analysis of Hybrid Learning vs Conventional Lectures

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Submitted: 26 April 2025; Final Revision: 8 December 2025; Accepted: 29 December 2025

## ABSTRACT

**Introduction:** With the rapid progress of technology, learning approaches have increasingly moved online, including the method for learning electrocardiography (ECG). ECG interpretation is a core skill for physicians, especially in emergency settings. Massive Open Online Courses (MOOCs) provide a flexible and complementary learning method that complements traditional classroom instruction. This study aims to evaluate the effectiveness of MOOCs as a complementary learning method and compare that with conventional learning in enhancing ECG knowledge among second-year preclinical students.

**Methods:** A prospective cross-sectional study with consecutive sampling was conducted to recruit participants. They were divided into a control group (conventional lectures) and an intervention group (using MOOC as a complementary method). All participants are required to complete pre-test and post-test questionnaires, as well as evaluations after each module. This study compared learning gain scores between traditional and hybrid learning methods.

**Results:** Of the 258 participants registered, 160 students completed the learning modules, including the post-test. The majority of participants were female, all under 25 years old, and had been in medical education for 1.5 to 2 years. Overall, the gain score achieved was 2.03 for traditional and 2.75 for hybrid. While the topics of electrolyte imbalance and heart enlargement showed increasing scores, arrhythmia and ECG in ischemia and infarction showed lower scores for the hybrid method. Not all registered participants completed the course; the main factor motivating participants to complete the course was gaining knowledge (80.00%).

**Conclusion:** Hybrid ECG learning using online media, such as video lectures and mini-quizzes, improves interpretation skills more effectively than traditional methods by boosting engagement and knowledge retention. To further enhance learning, integrating artificial intelligence-driven reminders and monitoring can improve completion rates, and continuous updates to the curriculum are necessary to strengthen medical students' ECG competence.

**Keywords:** ECG learning media; Massive Open Online Course; MOOC; Hybrid learning; Learning experience

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**BACKGROUND**

Cardiovascular disease is the leading cause of death in the world. In Indonesia, heart disease is the second leading cause of death. Therefore, the ability to detect heart abnormalities quickly and accurately is an essential skill that healthcare workers, especially general practitioners, need to master. One of the required competencies is electrocardiography (ECG).<sup>1,2</sup>

ECG is often used to assess patients with cardiac signs and symptoms. ECG may be a basic but vital instrument for recognizing both cardiac and non-cardiac crises. In emergency settings, ECGs have a major impact on clinical decision-making by changing how diagnoses are made, treatment strategies, and patient management.<sup>3</sup> Recent guidelines emphasize its role in the rapid detection of life-threatening cardiac events, such as acute coronary syndrome and arrhythmias.<sup>4,5</sup>

A precise interpretation of the ECG is needed to take appropriate action steps for the patient. The total results of ECG recordings can reach hundreds of millions every year.<sup>6</sup> This situation causes many variations in results and is often a challenge for general practitioners to interpret.<sup>7</sup> Data in the United States shows that every year, there are about ten million cases of ECG misinterpretation that cause ten thousand deaths.<sup>8</sup> One of the factors that affects the low ability to interpret ECG is the lack of confidence that arises due to the lack of exposure to ECG during medical school. This reality poses a problem for the future because a basic understanding and repeated practice in analyzing ECG variations are necessary.<sup>9,10</sup>

Conventional learning methods, such as reading books, attending lectures, and participating in discussions, as well as complex and impractical teaching and learning methods, pose challenges in the ECG learning process. In line with the growing use of electronic media for medical education, the approach of blended learning or e-learning can be implemented. Technology can be utilized as a medium for learning ECG, providing a solution to overcome existing obstacles.<sup>9</sup>

The use of educational applications as a means of learning ECG can increase learning effectiveness.<sup>2</sup>

This learning method not only increases the level of student understanding but also increases student participation and interaction with teachers.<sup>11</sup> Another method that utilizes technology in learning is the Massive Open Online Course (MOOC). The MOOC is an open online learning course that can be accessed freely through the website. MOOCs also sustainably support medical learning, making them a potential solution to the challenges of ECG learning for general practitioners.<sup>12</sup> In a MOOC test for nursing students in China, it was found that students prefer conventional learning integrated with MOOCs over ordinary traditional classes, with the main advantages of flexible learning time and improved independent learning skills.<sup>13</sup>

Therefore, this study aims to determine the effectiveness of MOOC as a complementary learning method and compare it with conventional learning in improving ECG understanding for second-year preclinical students at the Faculty of Medicine, Public Health, and Nursing, Universitas Gadjah Mada. This research is expected to provide benefits in using ECG learning MOOCs integrated with the educational curriculum to monitor the medical students' ECG interpretation competency in the future.

**METHOD**

This study utilized the MOOC-based learning method for ECG interpretation, employing a pretest and post-test design to assess its effectiveness. The research was conducted in April and May 2024 among second-year preclinical medicine students at the Faculty of Medicine, Public Health, and Nursing (FMHPN), Universitas Gadjah Mada (UGM), Yogyakarta, Indonesia. Consecutive sampling techniques were carried out to select research subjects. The inclusion criteria used are 1) signed informed consent, 2) participated in the pretest and post-test, 3) underwent all learning on the website, and 4) filled out the final evaluation for the MOOC group. Subjects who are not present at the time of the pre-test or post-test were excluded from the research.

In this study, participants were divided into two groups: a control group and an interventional group. In the control group, subjects studied ECG

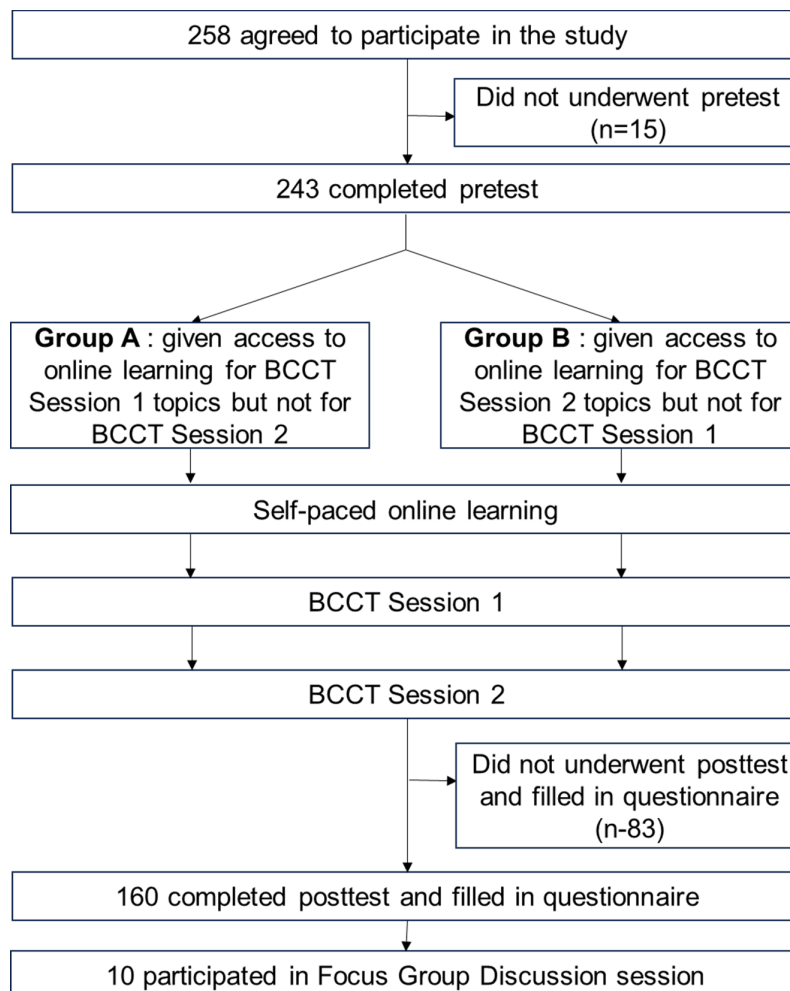
from conventional public lectures. In the MOOC intervention group, subjects were asked to study ECG using the MOOC ECG developed by the Department of Cardiology and Vascular Medicine, FMHPN UGM. Before and after the learning took place, all subjects were asked to complete pre-test and post-test questionnaires. The pre-test and post-test questionnaires consist of 10 ECG interpretation questions. The ECG material used in both groups included patterns of basic ECG material, arrhythmias, conduction disorders, heart chamber enlargement, and electrolyte balance disorders. For the interventional group, MOOC consists of basic and abnormal ECG material modules, quizzes or practice questions at the end of each model, and evaluation questions after completing all modules.

This study compared the gains between traditional and hybrid learning methods. The data will be

analyzed using IBM SPSS 25\*. The T-test was conducted to assess the difference between the pre-test and post-test results. This research has been approved by the Medical and Health Research Ethics Committee (MHREC), Faculty of Medicine, Public Health and Nursing, Universitas Gadjah Mada (Ref. No: KE/FK/1221/EC/2024).

### RESULTS

A total of 258 individuals registered for the online ECG course, and 243 completed the pre-test. They were then divided into two groups. Group A was given access to online learning for BCCT Session 1 topics but not for Session 2. Group B was given access to online learning for BCCT Session 2 topics but not for BCCT Session 1. A total of 160 completed post-test and filled-in questionnaires. Ten participants were involved in the Focus Group Discussion session.



**Figure 1. Flow Chart of Study Participants**

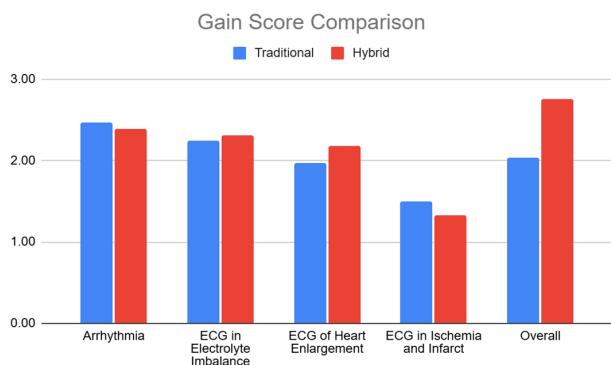
Of the 160 participants, there was a notable predominance of females, with a gender ratio of 112 females to 48 males (Table 1). The participants' ages ranged from 18 to 22, with the majority being 18 years old (40.63%) or 19 years old (42.5%). On average, they had been in medical education for 1.84 years, with the duration ranging from 1.5 to 2 years. When it came to resources for learning ECG, most participants (65%) primarily used lectures, followed by YouTube videos (19.38%) and textbooks (18.75%). Additionally, a large portion (94.38%) had previously self-studied ECG, with 81.25% focusing on interpretation and 13.13% on electrophysiology.

**Table 1. Subject Demographic Data**

Characteristic	Frequency	Percentage
<b>Gender</b>		
Male	48	30%
Female	112	70%
<b>Age (years)</b>		
18	65	40.63%
19	68	42.5%
20	17	10.63%
21	9	5.63%
22	1	0.63%
<b>Duration of Medical School (years)</b>		
1.5	50	31.25%
2	110	68.75%
<b>Source of ECG Learning</b>		
Lecture	104	65%
Youtube Videos	31	19.38%
Textbook	30	18.75%
Website	8	5%
Tiktok	1	0.63%
<b>Prior Self-studied ECG Topics</b>		
Basic concept	151	94.38%
Electrophysiology	21	13.13%
Interpretation	130	81.25%
None	9	5.63%
<b>Most Frequent Gadget Use</b>		
Laptop	89	55.63%
Mobile phone	55	34.38%
Tablet	20	12.5%
Computer	5	3.13%

Characteristic	Frequency	Percentage
<b>Most Frequent Browser Use</b>		
Chrome	78	48.75%
Firefox	50	31.25%
Safari	41	25.63%
Microsoft Edge	2	1.25%
<b>Most Frequent Access Time</b>		
Morning 07.00-10.00	9	5.63%
Afternoon 10.01-15.00	44	27.5%
Evening 15.01-19.00	31	19.38%
Night >19.00	50	31.25%
Randomly	26	16.25%
<b>Most Frequent Access Day</b>		
Weekday	81	50.63%
Weekend	57	35.63%
Weekday and/or weekend	22	13.75%
<b>Most Useful Feature</b>		
Video Lectures	125	78.13%
Mini Quizzes	20	12.5%
Learning Module PDFs	15	9.38%

The majority of participants use laptops to complete the course (55.63%). The most commonly used browser is Chrome, used by 78 participants (48.75%). Most participants access the course at night, with 50 participants (31.25%), followed closely by those who access it in the afternoon, primarily during college hours (27.5%). Among the three available features, video lectures are the most popular, used by 125 participants (78.13%).



**Figure 2. The Gain Score Comparison between the Traditional and Hybrid Learning Methods**

A total of 160 participants successfully completed the learning modules and the post-test. We observed

the comparison between the traditional and hybrid learning methods. Overall, the gain score achieved was 2.03 for traditional and 2.75 for hybrid. The score in the ECG for electrolyte imbalance was 2.25 for the traditional and 2.31 for the hybrid approach. The ECG of heart enlargement had a value of 1.98 for the traditional method and 2.18 for the hybrid method. While most topics had increasing scores, arrhythmia and ECG in ischemia and infarction had lower scores for the hybrid method. Arrhythmia had a rate of 2.46 for the traditional method and 2.39 for the hybrid method; meanwhile, ischemia and infarct had rates of 1.50 for the traditional method and 1.33 for the hybrid method.

**Tabel 2. Factors that Driven Participants to Complete the Course**

Reason	Number of participants	Percentage
Knowledge	130	80.00%
Interesting Features	44	27.5%
Video Lectures	30	18.75%
Mini Quizzes	10	6.25%
Modules	4	2.5%
Free access	11	6.88%

Not all participants who registered for the course were able to complete it. The main factor motivating participants to finish the course was the desire to gain knowledge, cited by 130 participants (80.00%). The interesting features offered by the MOOC were mentioned by 44 participants (27.5%) as the reason they finished the learning. Additionally, 11 participants (6.88%) completed the course due to the free access provided.

## DISCUSSION

Cardiovascular problems are among the major causes of health concerns worldwide. In most countries, mortality-related ischemic heart disease increased significantly after the COVID-19 period compared to the previous period.<sup>14</sup> Electrocardiography is one of the main keys to diagnosing heart problems. The doctor must be competent in interpreting heart abnormalities using an ECG to improve patient outcomes.<sup>15</sup>

Interpreting ECGs can be a barrier in managing patients without good capability and experience. Many factors, such as limited ECG concept comprehension and difficulty analyzing the ECG due to infrequent reading of it, can exacerbate the barrier.<sup>16</sup> Therefore, ECG interpretation competence should be sharpened during the medical student phase. Web-based ECG programs are currently the preferred learning media over textual books because of their flexibility, various sources, and visually appealing.<sup>17</sup>

A total of 160 participants (62.02%) of the 258 had completed the course. The differences between registered and completed participants can be obtained from the self-paced online learning method. Participants' commitment to completing the course is essential to understanding the study results more effectively. Periodic reminders, live discussions, and showing appreciation, such as a leaderboard and reward points or prizes during the course, are necessary to increase participants' activity and loyalty.<sup>18</sup>

A study by Inoa et al.<sup>19</sup> proved that periodic task reminders and monitoring can enhance participants' commitment during hybrid interprofessional learning for graduate students at a public university in the northeastern United States. Although the participants received reminders in this research, they were given weekly reminders, and monitoring was not conducted on a daily basis.

Learning websites that utilize artificial intelligence to assist with task and time planning can enhance students' self-regulated learning.<sup>20</sup> Hence, this research application should be further developed with artificial intelligence features to maximize participants' course completion.

The assessment results show that participants who received hybrid learning achieved an overall gain score higher than the conventional group. This shows how learning media can enhance participants' study effectiveness. This finding was also supported by Table 1, which shows that the participants primarily used videos, such as those on YouTube, as their self-study learning source after the lecture materials. Table 4 also shows that interesting features of the website, such as video lectures and mini quizzes,

become factors that drive participants to complete the course, in addition to knowledge intention. These findings align with the research conducted by El-Sabagh et al.,<sup>21</sup> which highlights that adaptive online learning models can significantly help students reach their learning goals.

Aside from its learning benefits, the website-based ECG course also offers an inexpensive option. As virtual learning media grow, their ability to assist the learning outcomes is projected to increase.<sup>22</sup> Subsequently, the development of this website research on hybrid learning should be maintained and innovated again to enhance students' ECG interpretation effectiveness during the class courses.

**CONCLUSION**

Hybrid ECG learning, incorporating online media through lecture courses, can enhance ECG interpretation competence compared to conventional learning. The study found that virtual learning media, such as video lectures and mini quizzes, offer advantages over conventional learning methods by engaging participants, enhancing knowledge retention, and improving learning effectiveness. Periodic reminders and monitoring, integrated with artificial intelligence, are needed to increase participants' completion rates in application innovation. That development should also be continuously integrated into the educational curriculum to enhance medical students' competence in ECG interpretation.

**ACKNOWLEDGEMENT**

The authors would like to express gratitude for the facilitation provided by the Clinical Skills Laboratory, Faculty of Medicine, Public Health, and Nursing, Gadjah Mada University. This study also received support from Royhan Rozqie, MD, PhD, and Anastasia Evi Handayaningsih, MD, PhD, as coordinators of the Basic Clinical Competencies Training for 2nd-year medical students.

**COMPETING INTEREST**

The authors declare that there are no competing interests related to the study.

**DECLARATION OF INTEREST**

The authors declare that they have no competing interests related to this study.

**FUNDING**

This study was fully funded by the Hibah DAMAS Penelitian Skema Mahasiswa S1-Dosen, Faculty of Medicine, Public Health, and Nursing, Universitas Gadjah Mada, 2025.

**AUTHORS' CONTRIBUTION**

*Dyah Samti Mayasari* – coordinating the research process, developing research proposal, publication manuscript.

*Bidhari Hafizhah* – funding management, collecting data, data analysis, publication manuscript.

*Hafidz Abdullah* – collecting data, data analysis, and publication manuscript.

*Shofuro Hasana* – collecting data and data analysis.

*Saski Yasmin Alfina* – data analysis and publication manuscript.

*Vita Arfiana Nurul Fatimah* – data analysis and publication manuscript.

*Hana Maryam Solikhah* – collecting data.

*Orisativa Kokasih* – collecting data.

*Putrika Prastuti Ratna Gharini* – developing research proposal, data analysis, publication manuscript.

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