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Evaluation of Hybrid Classroom Implementation in Room A101

Ilham Alifudin[1,*], Hery Irwan[2]
[1,2]Department of Industrial Engineering, Universitas Riau Kepulauan Batam, Indonesia

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ABSTRACT

The rapid development of information and communication technology (ICT) has accelerated the adoption of blended learning in higher education, combining traditional classroom instruction with online participation. To support this approach, universities require hybrid classroom systems that allow synchronous interaction between on-site and remote students. This study presents the design and implementation of a hybrid classroom in Room A101 using affordable and easily accessible devices. The system was built with a webcam connected to a mini PC and monitor, a wireless clip-on microphone integrated with the lecturer's laptop, a projector supported by an HDMI switcher, and a stable internet connection. Implementation followed five stages: needs analysis, system design, installation, workflow, and evaluation. Technical testing covered video, audio, speaker performance, and internet stability, while user surveys captured perceptions of effectiveness. Results showed the system delivered acceptable 720p video, clear audio, and stable connectivity. Survey feedback indicated satisfaction levels of 82% for video, 88% for audio, 75% for speaker performance, and 84% overall. These findings confirm that low-cost hybrid classroom solutions can enhance flexibility, inclusivity, and accessibility in higher education, while remaining practical and replicable in similar institutional contexts.

Corresponding Author:

Ilham Alifudin,
Department of Industrial Engineering,
Universitas Riau Kepulauan,
99 Pahlawan Street, Bukit Tempayan, Batu Aji District, Batam City 29425, Riau Islands Province, Indonesia,
Email: * ilhamalif0610@gmail.com

1. INTRODUCTION

The rapid advancement of information and communication technology (ICT) has significantly shaped the transformation of higher education. One of its most notable outcomes is the emergence of blended learning, which integrates face-to-face instruction with online participation. This model gained increasing importance during and after the COVID-19 pandemic, when universities were required to adopt remote teaching and later sought more sustainable approaches to flexible learning. Blended learning is now recognized as a promising model because it addresses diverse student needs, promotes inclusivity, and ensures continuity of learning beyond physical classrooms [1], [2].

Despite these benefits, the practical adoption of blended learning is often hindered by limited facilities. Conventional classrooms generally do not provide adequate support for remote participants, which can result in reduced engagement and inequities between on-site and online learners [3], [4]. Hybrid classroom were developed to address this challenge by combining classroom-based teaching with digital platforms that enable synchronous interaction. Prior studies have highlighted the importance of reliable audio-visual systems, stable internet connectivity, and ergonomic classroom design in ensuring effective hybrid learning experiences [5], [6]. This shows that the adoption of technology in learning environments is not only a necessity but also a strategic effort to improve the quality of education [7].

However, many reported implementations rely on high-end technologies and institutional-scale investments, such as professional cameras, advanced sound systems, or automated boards. While effective, these solutions are often too costly for institutions with limited budgets. This creates a gap in research and practice concerning the development of low-cost, replicable hybrid classroom models that remain pedagogically effective [8], [9]. In Indonesia, this challenge is particularly relevant, as many universities require accessible and sustainable solutions that can be implemented without extensive renovations or large financial investment [6].

In a global context, the implementation of hybrid learning models has been widely recognized as a strategic response to the challenges of modern education [1], [2], [3], [10], [11]. Reports from international organizations such as UNESCO and OECD emphasize that flexible learning environments combining online and offline modes are increasingly essential for ensuring inclusivity, resilience, and adaptability in higher education systems [7], [12]. In many countries, hybrid learning is no longer perceived merely as an emergency response during the COVID-19 pandemic, but as a long-term approach to educational transformation [4], [6], [13].

In Indonesia, the urgency for adopting hybrid class models is further driven by disparities in digital infrastructure, variations in lecturer readiness, and differences in institutional policies [5], [13], [14]. Universities in major urban areas often demonstrate stronger capabilities in terms of facilities and resources, while smaller institutions still face challenges in providing adequate technical support [15], [16]. These gaps highlight the importance of studies that not only present a technical design for hybrid classes but also contextualize the implementation within local needs and constraints. Furthermore, research on hybrid learning in Indonesia can contribute to bridging the global discourse with regional realities, ensuring that the benefits of innovation in education are distributed equitably across diverse higher education environments.

This study seeks to address that gap by presenting the implementation of a hybrid classroom in Room A101. The system was designed using affordable and widely available equipment, including a webcam, mini PC with monitor, wireless clip-on microphone, lecturer's laptop, HDMI switcher, projector, and stable internet connection. The novelty of this project lies in balancing cost-effectiveness with functional reliability, while ensuring ease of replication in similar contexts. In addition to describing the system design and setup, this study evaluates its technical performance and user satisfaction, offering practical insights for institutions aiming to expand blended learning opportunities in higher education [9], [17].

2. RESEARCH METHOD

This study employed an implementation-based approach to develop and evaluate a hybrid classroom in Room A101. The methodology consisted of five main stages: needs analysis, system design, implementation, testing, and evaluation [5].

2.1. Needs Analysis

The first phase focused on determining the needs of both lecturers and students for hybrid learning. This analysis addressed technical requirements, including video resolution, audio clarity, internet reliability, and ease of use, alongside pedagogical considerations, particularly the ability to support blended learning [1], [18]. The physical condition of Room A101 was also assessed to determine optimal placement of devices, considering ergonomics and usability aspects as highlighted in related design studies [6], [19].

2.2. System Design

Based on the analysis, a low-cost hybrid classroom system was designed using accessible and affordable equipment [12], [14]. The system architecture is shown in Figure 1, while the detailed device specifications are summarized in Table 1.

Figure 1 illustrates the workflow of the hybrid classroom system, from input devices (webcam, microphone, and laptop) to processing (mini PC and HDMI switcher) and output devices (projector and speakers). This diagram clarifies the signal flow and interaction between hardware and software components.

The system design emphasized cost efficiency while maintaining functionality, making it suitable as a model for replication in other classrooms [3], [20].

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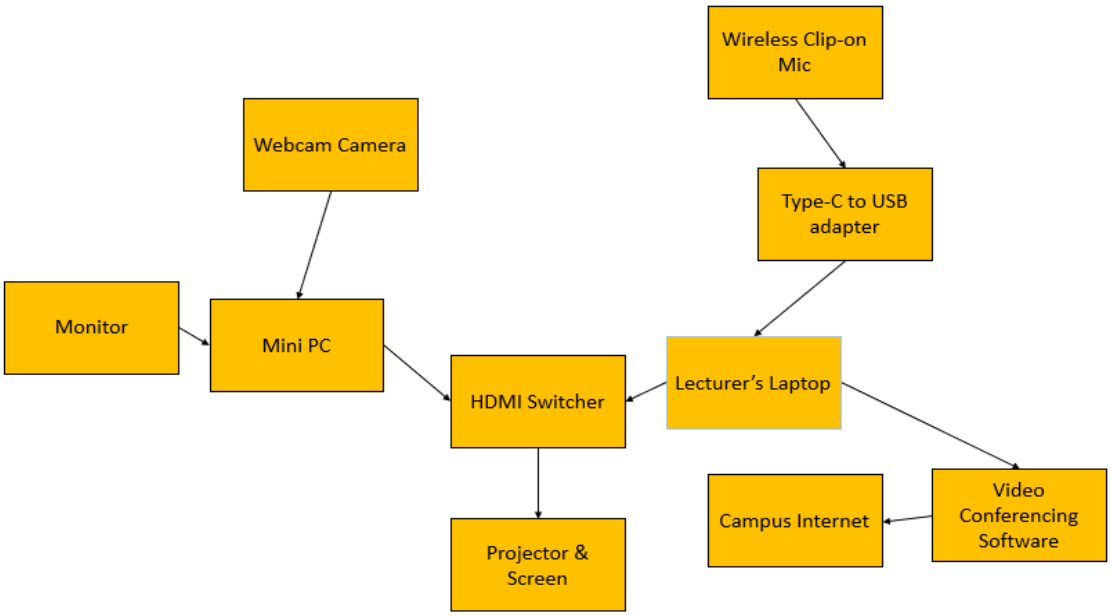

Figure 1. Hybrid Classroom System Diagram in Room A101

Table 1. Specification of Hybrid Classroom Equipment in Room A101

Device	Function
Webcam Camera	Captures classroom video activities to be displayed to online students.
Mini PC	Processes video input from the webcam and displays it on the monitor.
Monitor	Displays the webcam feed in the classroom
Wireless Clip-on Microphone (Type-C)	Captures the lecturer's voice clearly for online participants.
Type-C to USB Adapter	Connects the clip-on microphone to the lecturer's laptop.
Lecturer's Laptop	Serves as the main device to run video conferencing software and connect other equipment.
HDMI Switcher (1in-2out)	Allows the projector to switch between the lecturer's laptop or mini PC display as needed.
Projector & Screen	Displays online participants and learning materials to offline students.
Video Conferencing Software	Main communication platform between online and offline students (Zoom/Google Meet).
Campus Internet	Provides real-time connectivity to support online interaction.

2.3. Implementation

The implementation phase consisted of device setup and configuration. Each step was carried out to ensure integration and minimize technical issues during operation [4], [21].

1. Positioning the webcam to capture both the lecturer and classroom activities.
2. Connecting the webcam to the mini PC and monitor for real-time video display.
3. Setting up the wireless clip-on microphone and configuring it on the lecturer's laptop.
4. Connecting the lecturer's laptop to the projector for displaying online participants and teaching materials.
5. Integrating the HDMI switcher to connect the projector, enabling flexible switching between the lecturer's laptop screen and the mini PC display.
6. Conducting initial testing to verify functionality

Figure 2. Classroom Condition Before Hybrid System Implementation

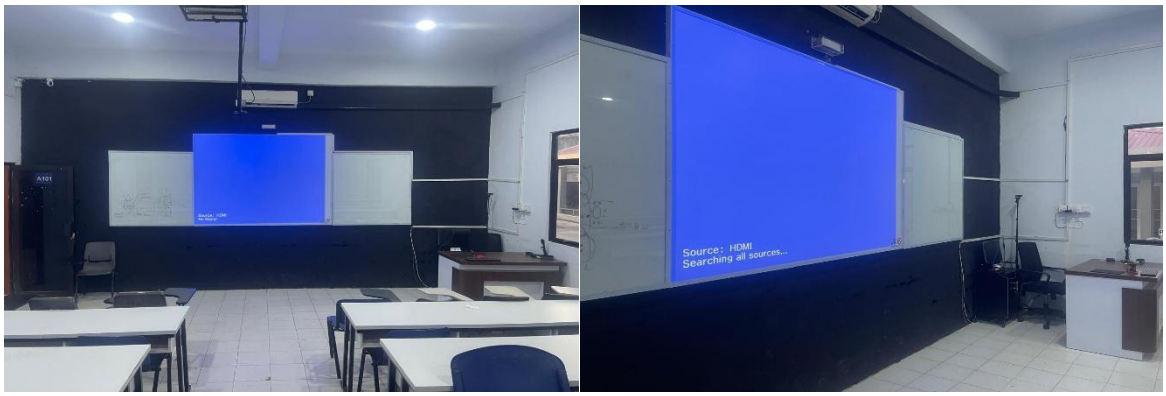

Figure 3. Classroom Condition After Hybrid System Implementation

2.4. Testing and Evaluation

The hybrid classroom system was evaluated through technical testing and user feedback. Technical testing measured video quality, audio clarity, and internet performance, while user surveys assessed the extent to which the hybrid classroom supported blended learning [2], [13].

1. Video quality from the webcam displayed via the mini PC and monitor.
2. Audio clarity transmitted through the wireless clip-on microphone.
3. Internet stability during synchronous sessions.

2.5. System Workflow

The workflow was divided into preparation, execution, and evaluation phases to ensure smooth adoption of the hybrid classroom system, a structure consistent with blended learning implementation models [22].

1. Preparation Stage – At this stage, the devices were assembled and configured before class sessions. The webcam was positioned to cover both the lecturer and the classroom, the clip-on microphone was paired with the lecturer's laptop through the adapter, and the HDMI switcher was set up to ensure the projector could alternate between laptop and mini PC outputs. A trial run was also conducted to test internet connectivity, audio clarity, and video quality.
2. Execution Stage – During the class, the lecturer used the system to deliver lectures simultaneously to offline and online students. The projector displayed online participants and learning materials, while the webcam transmitted classroom activities in real time. The wireless microphone ensured that the lecturer's voice was clearly audible to online participants. The lecturer could switch projector sources as needed, using either the laptop for slides or the mini PC for video display.
3. Evaluation Stage – After class, surveys were distributed to both students and lecturers to assess user experience. Technical logs such as latency, audio feedback, and connection stability were recorded. These data formed the basis for the performance analysis and user feedback evaluation presented in Section 3.

This workflow illustrates that the hybrid classroom implementation did not only involve hardware configuration but also operational procedures to ensure smooth and sustainable use in routine teaching.

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2.6. Survey Instrument

To evaluate the effectiveness of the hybrid class implementation in Room A101, a structured survey was designed and distributed to students who participated both online and offline. The main purpose of the survey was to capture students' perceptions regarding the quality of the learning experience, with a particular focus on technical performance and pedagogical aspects [5], [18].

The survey instrument was developed based on indicators that are commonly used in evaluating hybrid or blended learning environments, namely video quality, audio quality, interaction quality, internet connectivity, learning engagement, and overall satisfaction [11], [18], [20], [21]. Each indicator was represented by a survey question formulated in simple and clear language to ensure that all participants could understand and respond accurately.

A 5-point Likert scale was employed for all items, allowing respondents to rate their experiences from negative to positive. For indicators related to technical aspects such as video, audio, and connectivity, the scale ranged from 1 = Very Poor to 5 = Excellent. For indicators related to learning engagement and satisfaction, the scale ranged from 1 = Very Low/Very Dissatisfied to 5 = Very High/Very Satisfied. The details of the indicators and corresponding survey questions are presented in Table 2.

Table 2. Survey Instrument for Hybrid Classroom Evaluation

Indicator	Survey Question	Scale (1–5)
Video Quality	The clarity and stability of the video during hybrid class sessions.	1 = Very Poor → 5 = Excellent
Audio Quality	The clarity and audibility of sound from lecturers and students.	1 = Very Poor → 5 = Excellent
Interaction Quality	The ability of students to interact effectively (both online and offline).	1 = Very Poor → 5 = Excellent
Connectivity	The stability of the internet connection during hybrid sessions.	1 = Very Poor → 5 = Excellent
Learning Engagement	The extent to which hybrid learning motivates and engages students.	1 = Very Low → 5 = Very High
Overall Satisfaction	The overall satisfaction of students with the hybrid learning experience.	1 = Very Dissatisfied → 5 = Very Satisfied

3. RESULT AND ANALYSIS

3.1. System Implementation

The hybrid classroom in Room A101 was implemented successfully using low-cost and accessible devices [14]. The system consisted of a webcam camera connected to a mini PC and monitor to capture and display classroom activities for online participants, a wireless clip-on microphone connected to the lecturer's laptop to ensure clear audio transmission, the laptop's built-in speakers to receive audio from online participants, and a projector for displaying online participants and teaching materials in the classroom. The system required minimal modifications to the physical layout of the room, making it a cost-effective and replicable solution [9], [12].

3.2. System Testing

Testing results showed that the system functioned as intended. The webcam delivered acceptable video quality, the wireless clip-on microphone ensured clear audio for online students, and the internet connection provided stable performance [1], [8]. The technical performance of the hybrid classroom was evaluated in terms of video quality, audio clarity, speaker performance, and internet stability, as presented in Table 3.

Table 3. Technical Testing Results

Aspect	Result	Notes
Video quality	720p, stable	Clear but could be sharper
Audio quality	Clear voice with clip-on mic	Adequate for online students
Speaker performance	Good for ≤20 students	Needs external speakers for bigger class
Internet stability	Latency < 100 ms	Stable during sessions

1. Video quality: The webcam provided stable video at 720p resolution, enabling online students to follow the lecture clearly.
2. Audio Quality (Lecturer to Online): The wireless clip-on microphone significantly improved clarity compared to the laptop's built-in microphone, ensuring that the lecturer's voice was transmitted effectively.
3. Audio quality (online to offline): The laptop's built-in speakers were sufficient for small to medium class sizes, although external speakers may be needed for larger classrooms.

4. Internet stability: With an average latency under 100 ms, online participants reported minimal lag and uninterrupted sessions.

These findings indicate that the system enabled synchronous participation, supporting blended learning effectively [18], [21].

3.3. User Feedback

User feedback was collected through questionnaires distributed to 30 students and 5 lecturers who participated in the trials. User satisfaction with video, audio, speaker performance, and overall experience is presented in Figure 4.

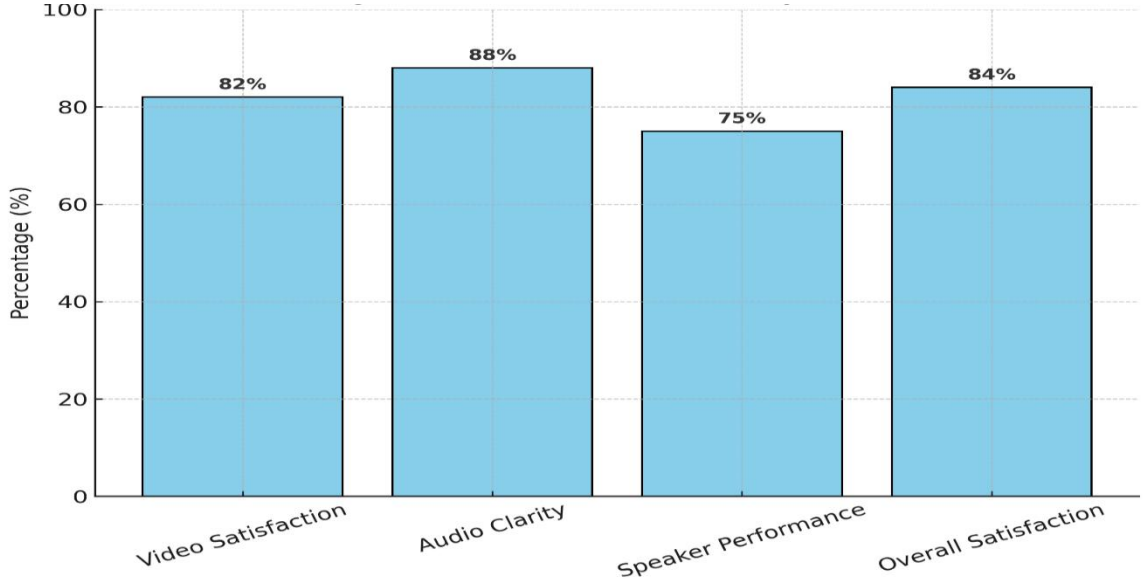

Figure 4. User Satisfaction Survey Results

1. 82% of students rated the webcam video quality as satisfactory.
2. 88% of online participants stated that the lecturer's voice was clear when using the wireless clip-on microphone.
3. 75% of offline participants found the laptop speakers adequate, though some suggested the use of additional audio equipment.
4. Overall satisfaction reached 84%, with most respondents highlighting increased flexibility and accessibility in attending lectures.

Survey results revealed high levels of satisfaction among participants. Students highlighted increased flexibility and accessibility, while lecturers noted improved engagement with both offline and online students [3], [4]. Overall satisfaction reached 84%, consistent with previous studies on hybrid and blended learning environments [2], [13], [20], as well as ergonomic design approaches that emphasize user comfort and efficiency [14].

The comparison in Figure 5 highlights several interesting patterns. Offline students generally reported slightly higher satisfaction across all indicators compared to online students [2], [8]. The gap is most pronounced in audio quality and connectivity, where offline participants benefit from the direct classroom setting without dependence on internet stability [10]. Meanwhile, online students still face occasional disruptions in sound clarity and connection reliability. However, in terms of engagement and overall satisfaction, both groups showed relatively similar results, indicating that the hybrid class model successfully balanced participation and learning motivation [10]. These findings suggest that further improvements should focus on optimizing the online experience, particularly in audio and connectivity aspects, to achieve parity with the offline setting.

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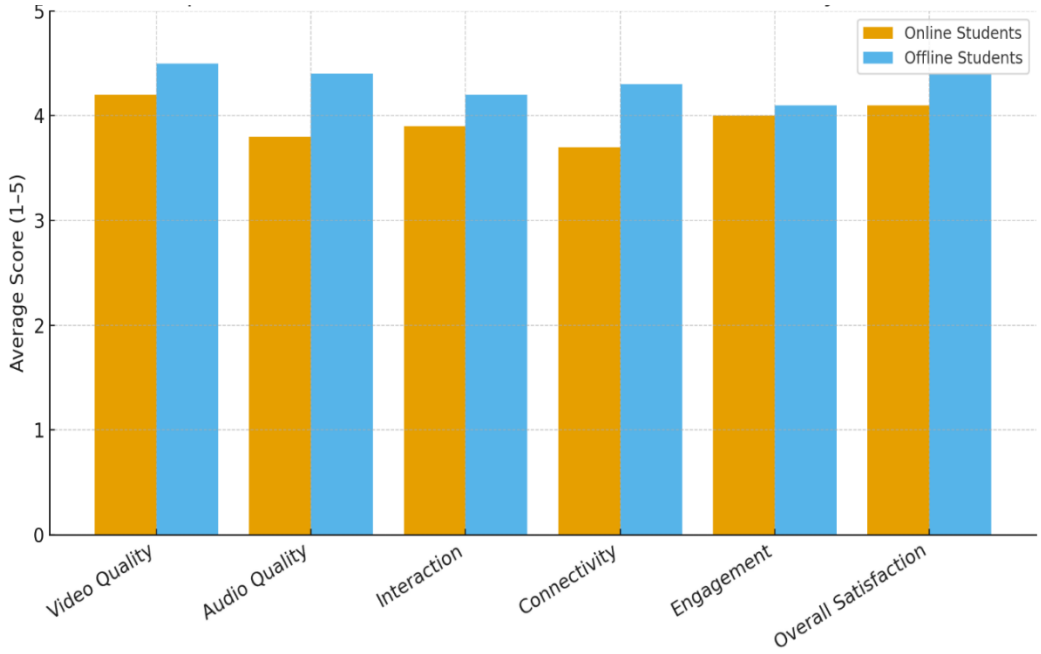

Figure 5 Comparison of Online and Offline Student Satisfaction in Hybrid Classroom

3.4. Discussion

The implementation of a hybrid classroom in Room A101 demonstrates that effective blended learning can be supported using affordable and accessible devices. The technical tests confirmed that the system provided acceptable video quality through the webcam, clear audio transmission with the wireless clip-on microphone, and stable internet connectivity for synchronous sessions. These results indicate that the basic requirements for hybrid classroom operation can be met without the need for high-cost infrastructure [8], [9], [14].

In addition to the technical aspects, user feedback highlighted increased flexibility and accessibility for students. Online participants were able to follow lectures in real time, while offline students could interact with their peers remotely. The overall satisfaction rate of 84% suggests that the system not only met technical standards but also supported the pedagogical goals of blended learning [3], [4]. These findings are consistent with previous studies that emphasize the role of accessibility, flexibility, and user satisfaction as critical success factors in blended learning environments [1], [18], [21].

A notable aspect of this implementation is its replicability. By using low-cost and readily available equipment, the system can be easily adopted in other classrooms within the institution. This contrasts with many hybrid classroom models that rely on advanced, high-cost technologies, making them less feasible for widespread adoption in resource-limited settings [2], [9]. The results of this study contribute to the growing body of literature showing that cost-effective solutions can deliver comparable benefits in terms of learning outcomes and student engagement [13], [20].

Moreover, ergonomic considerations play a role in ensuring long-term usability of the system. As emphasized by Rahmadani and Yuamita [14], design approaches that account for user comfort and efficiency are crucial to prevent fatigue and increase adoption. In the context of Room A101, the positioning of the webcam, the portability of the wireless clip-on microphone, and the simplicity of device integration were factors that minimized disruption for lecturers and students. These ergonomic elements strengthen the practicality of the implementation, ensuring that the system remains functional and sustainable in routine academic use.

Despite the positive results, several limitations were identified. The laptop’s built-in speakers were sufficient for small to medium-sized classes but inadequate for larger groups. Additional audio equipment would enhance the distribution of sound in bigger classrooms. Furthermore, while the webcam quality was acceptable, higher-resolution devices could improve the experience for online participants. Future implementations should also include standardized guidelines and training for lecturers to optimize system usage, reduce setup errors, and improve consistency of operation [20], [21].

Overall, this study reinforces the idea that hybrid classrooms, when designed with cost-efficiency, replicability, and ergonomic considerations, can effectively support blended learning in higher education [14], [21]. It provides a scalable model that addresses the challenges of accessibility and flexibility, while also ensuring sustainability for institutions with limited resources.

Another significant point is the sustainability of hybrid learning practices. Beyond the technical performance, the long-term success of hybrid class implementation relies on continuous maintenance, lecturer training, and institutional support [6], [16]. For instance, the use of a mini PC connected to the webcam allows for flexibility in classroom recording and streaming, but also introduces new demands for technical staff to manage software and troubleshoot potential issues. Ensuring the sustainability of such systems requires both human resource development and financial planning from the institution [21].

3.5. Pedagogical Impact

Beyond technical performance, the implementation of the hybrid class in Room A101 also influenced the teaching and learning process from a pedagogical perspective. Lecturers reported that the system allowed them to maintain active interaction with both onsite and remote students simultaneously. This interaction included delivering lectures, answering questions, and facilitating discussions, which helped online students feel more engaged compared to passive streaming methods. Continuous evaluation of system and device quality is therefore essential to ensure consistent service delivery in hybrid classroom learning [16].

Students also noted that the hybrid environment provided greater flexibility in attending classes. Those who were unable to be physically present due to illness, distance, or scheduling conflicts could still participate in real time. This inclusivity helped reduce learning gaps between groups of students. Offline students similarly benefited, as they were exposed to digital learning practices and gained experience collaborating with peers joining remotely.

In terms of learning outcomes, the system encouraged more active participation. Online students could interact through chat and voice, while offline students could continue direct face-to-face discussions. This blended interaction fostered a more student-centered approach, these results align with prior studies showing that blended learning enhances student engagement and accessibility [10], [11], [20].

However, the pedagogical benefits were not without challenges. Some lecturers felt the need for additional training to manage interactions across two modes simultaneously. Likewise, occasional audio or video issues disrupted the flow of communication, requiring quick adjustments during class. Despite these challenges, the overall perception was that hybrid classroom has the potential to support more inclusive and flexible learning environments in higher education.

3.6. Limitations

Although the hybrid classroom system in Room A101 was successfully implemented, several limitations were identified. Such technical constraints are similar to challenges documented in other hybrid learning environments [17].

First, the reliance on the built-in laptop speakers limited sound distribution in larger classrooms, potentially affecting the learning experience of offline students seated further from the device. Second, the webcam resolution, while adequate for small groups, may not provide sufficient clarity in larger or more dynamic classroom settings. Third, the system required manual configuration of the HDMI switcher and microphone, which could be challenging for lecturers unfamiliar with the equipment.

3.7. Implications

The implementation of the hybrid classroom in Room A101 provides several important implications for higher education.

First, the project demonstrates that blended learning can be effectively supported even in institutions with limited financial resources. By using accessible devices such as webcams, clip-on microphones, and HDMI switchers, universities can create hybrid classrooms without investing in expensive infrastructure [9], [14]. This opens opportunities for smaller institutions to adopt hybrid learning as part of their regular teaching practice.

Second, the system provides greater flexibility for lecturers and students. Lecturers can seamlessly switch between different display sources using the HDMI switcher, while students can choose whether to attend offline or online without losing access to real-time interaction. This flexibility reflects the growing demand for learning environments that accommodate diverse student needs [1], [18].

Third, the findings highlight the importance of ergonomic and user-friendly design in educational technology implementation. As noted in local ergonomic research [19], user comfort and efficiency play a critical role in ensuring adoption and sustainability. The positioning of devices, simplicity of the microphone system, and minimal room modifications made the implementation practical for daily academic use.

Finally, the study provides a replicable model that other classrooms can adopt. By documenting the system architecture, specifications, and workflow, this research offers a practical reference for institutions aiming to integrate hybrid learning into their curriculum.

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3.8. Future Research Directions

While this study demonstrates the feasibility of implementing a hybrid classroom with affordable and readily available devices, future research should expand on several areas to strengthen both the technical and pedagogical aspects of hybrid learning.

First, future studies could explore the integration of advanced technologies such as high-definition cameras with automatic tracking, beamforming microphones, or external speaker systems. These upgrades would enhance the overall quality of interaction without significantly increasing complexity for users.

Second, future research may explore the integration of AI and analytics to enhance hybrid classroom effectiveness, as highlighted in recent literature [7]. AI-based systems could automatically manage camera angles, monitor student participation, and provide real-time feedback on engagement levels. Learning analytics could also track patterns of attendance and interaction, offering valuable insights for lecturers to adapt teaching strategies.

Third, future work should examine hybrid learning from a broader pedagogical perspective, including long-term impacts on student achievement, motivation, and inclusivity. Comparative studies between fully online, face-to-face, and hybrid models could provide empirical evidence on the strengths and weaknesses of each approach.

Lastly, scaling hybrid classrooms across multiple rooms or faculties may present new challenges related to management, training, and infrastructure. Research in this area could help universities design institutional policies, technical guidelines, and capacity-building programs to ensure sustainable adoption of hybrid learning at a larger scale.

4. CONCLUSION

This study demonstrated the implementation of a hybrid classroom in Room A101 by integrating low-cost and readily available technology to support blended learning. The system combined a webcam, mini PC with monitor, projector, HDMI switcher, wireless clip-on microphone, and stable internet connection, enabling simultaneous participation of on-site and online students.

Technical testing confirmed that the setup provided reliable performance, with acceptable 720p video quality, clear audio transmission, and stable internet connectivity. User surveys further indicated positive responses, with satisfaction levels reaching 82% for video, 88% for audio, 75% for speaker performance, and 84% overall. These results suggest that affordable hybrid classroom solutions can effectively meet the demands of blended learning without requiring expensive infrastructure.

Nevertheless, the system has limitations, such as limited speaker coverage and modest webcam resolution. Addressing these challenges in future implementations could involve upgrading audiovisual equipment, providing standardized procedures, and offering lecturer training.

Overall, this project offers a practical and replicable model for institutions with constrained resources. By enhancing accessibility, inclusivity, and flexibility, hybrid classroom can serve as a sustainable approach to advancing blended learning in higher education.

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