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Design and Assessment of a Mobile Cloud Learning Platform for the Classroom: Examining the Efficiency of Blended Learning in Post-COVID Science Education

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Abstract: The COVID-19 pandemic has brought forth numerous educational obstacles but has also created opportunities for progress and innovation. In the aftermath of the pandemic, education is expected to place greater emphasis on technology, and one promising solution in this regard is the utilization of mobile cloud learning technologies. These technologies offer various advantages, including flexibility, customization, and cost-effectiveness, potentially revolutionizing the learning process. This paper details the creation and advancement of a self-contained mobile learning platform designed for teaching science by integrating mobile cloud learning technology. The objective was to assess the effectiveness of this blended approach, which combines traditional teaching methods with technology. The evaluation encompassed lesson delivery, organization, classroom atmosphere, enrichment, and accessibility. The results demonstrated that the blended approach complemented conventional teaching techniques. The instant feedback provided by the technology proved beneficial in monitoring students' progress in real-time and intervening promptly when necessary. However, the study highlights the importance of addressing limitations and challenges in implementing this approach to fully maximize its benefits. Valuable insights are provided regarding the key factors to consider when designing and implementing blended learning in the classroom, contributing to the ongoing discourse surrounding the future of education in a post-COVID world.

Keywords: Mobile Learning, Delay Tolerant Networks, Blended Learning

1. Introduction

The COVID-19 pandemic has significantly reshaped the educational landscape, highlighting both challenges and opportunities for innovation. As schools transition to post-COVID education, there is a growing emphasis on integrating technology, including mobile cloud learning technologies, which have the potential to transform educational practices (Bashir et al., 2021; Crioll-C et al., 2021). The advancements in technology and data processing are paving the way for more personalized learning experiences, allowing educational institutions to better tailor instruction to individual students' needs and interests. Furthermore, the pandemic has underscored the importance of digital literacy and resilience, prompting curriculum adjustments to address these new priorities (Haleem et al., 2022).

Mobile cloud learning technologies are increasingly popular due to their ability to facilitate learning anytime and anywhere through cloud computing and mobile devices. These technologies offer benefits over traditional classroom-based methods, such as increased flexibility, personalization, and cost-effectiveness (Peimani & Kamalipour, 2021; Raghunathan, Singh & Sharma, 2022). Various mobile cloud learning solutions, including mobile apps, cloud-based learning management systems, and virtual classrooms, have proven valuable during the COVID-19 pandemic by enabling remote education (Singh, Steele

& Singh, 2021). This has demonstrated the potential for mobile cloud technologies to provide flexible, accessible, and personalized learning experiences (Winter et al., 2021).

Looking ahead, technological advancements are expected to lead to even more innovative mobile cloud learning solutions. Recent developments include mobile learning cloud networks that offer open educational resources without requiring an internet connection, combining mobile devices and cloud computing for personalized and cost-effective education (Villanueva et al., 2021). Other innovations, such as portable asynchronous learning platforms, have been designed for socially distanced learning during pandemics or post-disaster scenarios, allowing students to access educational content via portable devices (Villanueva et al., 2022a; Villanueva et al., 2022b).

Mobile learning continues to benefit from cloud computing, allowing students to access educational resources flexibly. Studies emphasize the importance of designing pedagogically sound and technologically feasible mobile learning systems to ensure accessibility for diverse student populations (Wang, Chen & Khan, 2014; Heng & Zhong, 2016). Blended learning models, such as the Enriched-Virtual Blended Learning Model, further enhance educational outcomes by integrating in-person and remote learning (Staker & Horn, 2012). Research indicates that such models improve student performance and engagement, illustrating the value of incorporating technology into traditional educational environments (Vijayakumar, Tamilarasan, & Harshini, 2020).

The paper addresses both aspects of technology: as a teaching strategy and as a learning tool. As a teaching strategy, mobile cloud technologies support educators by enabling blended learning environments that mix in-person and remote instruction, enhancing flexibility and responsiveness in teaching. As a learning tool, these technologies offer students the ability to access educational resources anytime and anywhere, fostering personalized and self-directed learning. By integrating mobile cloud technologies, the paper highlights improvements in both teaching practices and student learning experiences, making education more adaptable and effective.

2. Materials and Methods

2.1 Research Setting

To demonstrate how a portable cloud network is used, a demonstration was held. The researcher worked in tandem with a science teacher in Grade 9 at Kaong National High School located in Cavite, Philippines. Using the 7E's instructional paradigm, they chose a topic on the respiratory system and collaborated to create a lesson plan based on Open Educational Resources (O.E.R.).

Thirty teachers participated in the demonstration class. The researcher took advantage of the timing of the annual teacher's evaluation of the participating school. The school head agreed with the set-up to demonstrate a class using the proposed technology. The cooperating teacher is the primary facilitator of the lesson. At the same time, the researcher serves as a technical assistant responsible for the teachers' orientation and addressing technical problems.

2.2 Technology Set-up

The portable server (Figure 1), built around a Raspberry Pi 4B, was selected for its affordability, low energy consumption, and portability. It features 4GB of RAM, a Gigabit Ethernet port, and dual-band 2.4GHz and 5GHz Wi-Fi. The Raspberry Pi OS runs on a 1TB SSD and is powered by two 3500 mAh rechargeable batteries, enhancing its portability. The server is equipped with a TP-Link Archer T3U Mini Wireless adapter and a TP-Link Archer C24 dual-band Wi-Fi router, providing flexibility as an independent content distribution system. Devices can connect via 2.4 GHz or 5 GHz through the router or mesh Wi-Fi system, and the server supports both battery and mains power, ensuring constant access to files and applications.

Kolibri, an LMS designed for offline learning, was installed on the Raspberry Pi to create a mobile education solution for areas with limited internet or power access. This setup offers a cost-effective, portable, and low-maintenance method for delivering educational content. Students can access materials on the device using any Wi-Fi-enabled device, such as smartphones, tablets, or laptops. The Kolibri interface is user-friendly, making it easy for both students and teachers to navigate and manage educational content effectively.

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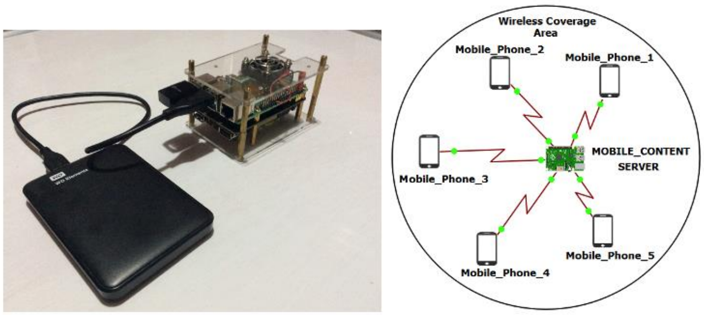

Figure 1. The Portable Mobile Cloud Network Prototype and Network Diagram

2.3 Teaching Demonstration

The teaching demonstration utilized a portable mobile cloud and Kolibri’s Coach and Learn features in a classroom setting. Teachers received a 30-minute orientation on Kolibri and the portable network, with varying levels of familiarity with the platform. The portable network, linked to a classroom monitor via HDMI, used a Raspberry Pi server to display the lesson's PowerPoint and video. The session began with an 8-item pretest on Kolibri’s Learn tab, followed by immediate feedback and discussion of answers. During the "Engage" phase, a video and guided discussion were conducted, and in the "Explore" phase, teachers accessed three Kolibri resources: a flexbook on Respiratory System Organs, a video on "Meet the Lungs," and another flexbook on the breathing process, each with practice items. The demo teacher monitored and addressed issues, discussing frequently missed questions before concluding the phase.

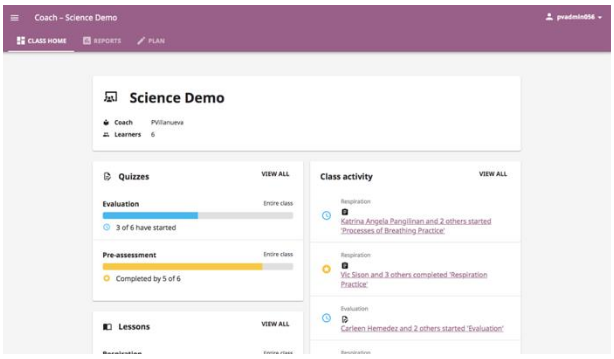

Figure 2. Science Demo Class Progress Summary

The class continued with a brief discussion using the preloaded PowerPoint presentation, followed by a video that teachers accessed individually, leading to increased noise due to the absence of earphones. In the "Elaborate" phase, participants accessed two additional resources: a flexbook on Respiratory System Diseases with a 12-item practice and another on Respiratory System Health with a 10-item practice. At the end of the class, teachers took a 10-item exam covering material from the pretest and practice exercises, with randomized questions generated by Kolibri. Immediate feedback was provided on incorrect answers and overall scores, and the monitor displayed both class performance and individual results. During the "Extend" phase, teachers were given additional COVID-19 resources accessible through the Channels page on the site.

2.4 Measures

The researcher conducted a simulated network activity to assess the initial performance of a mobile cloud network, measuring capacity throughput, network speed, and received signal strength. The test involved assessing the 2.4 and 5 GHz connection throughput and sampling bandwidth for 60 seconds. Baseline data on network performance were collected through throughput testing and received signal level (RSL) measurements within the room.

Additionally, the Classroom Environment Evaluation Scale (CEES) (Yang & Huang, 2015) was employed to assess teachers' perceptions of the blended learning approach and classroom technology. The physical aspect of the CEES, consisting of five dimensions—Showing, Manageable, Accessible, Tracking, and Enhancement—was used to evaluate the technology-rich classroom environment. Each dimension was rated on a five-point Likert scale, from 1 ("Almost Never") to 5 ("Almost Always").

3. Results and Discussion

3.1 Network Performance

During deployment, we monitored network performance and data transfer rates as we gradually increased the number of users. Starting with five users, we added five more users at each subsequent test until reaching thirty users. The results showed a clear decline in network performance, with both throughput and data transfer rates decreasing as more users joined.

For both the 2.4 GHz and 5 GHz bands, performance metrics dropped significantly with higher user counts. Initially, the 2.4 GHz band had a throughput of 10.65 Mbps and a data transfer rate of 2.17 Mb with five users, while the 5 GHz band showed better performance with 18.81 Mbps and 2.24 Mb. By the time the user count reached thirty, the 2.4 GHz band’s throughput fell to 2.06 Mbps and data transfer to 0.42 Mb, whereas the 5 GHz band’s throughput and data transfer rates decreased to 3.11 Mbps and 0.38 Mb, respectively. The most significant drop occurred when increasing from five to ten users, with performance metrics halving. Although performance continued to decline, it stabilized around fifteen users, indicating that while network efficiency diminishes, it can still support a substantial number of users with relatively consistent throughput.

3.2 Technology-rich Classroom Environment Evaluation

The scale utilized in the study's sample had a moderate level of internal consistency, as indicated by the CEES-Physical's Cronbach alpha estimate of 0.61. However, this interpretation should be taken cautiously since the sample has only 30 participants. Moreover, all the subdimensions' indicators in the physical aspect of a technology-rich classroom can be interpreted as "Often," leading to an assumption that the participants have uniformly observed the indicators on the scale.

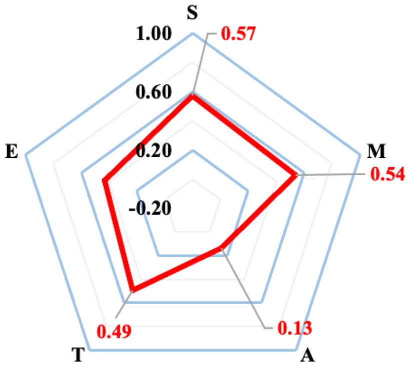

*Figure 3***.** Status of Physical Classroom Environment

The subscales' mean values were compared to the overall CEES-Physical score (M = 3.95, SD 0.37) to evaluate the status of each indicator (Figure 3). Yang & Huang's (2015) CEES validation categorizes subdimension status as poor (0–0.4), normal (0.4–0.8), or optimal (0.8–1). The findings show that the subscales of Showing, Manageable, Tracking, and Enhancement fall within the normal range. This suggests that teachers' positive attitudes toward technology and their openness to innovation (Khalisang et al., 2021) may have positively influenced their adoption of new classroom technologies.

These results align with previous studies on cloud-based learning applications. Utami et al. (2022) emphasize that the adoption of technology is not significantly influenced by its perceived ease of use but by its demonstrated utility. Therefore, simply mandating the use of technology without ensuring that teachers fully understand its benefits may not lead to widespread adoption. To overcome this, schools should create supportive learning environments and provide regular training sessions to enhance teachers' proficiency with cloud services and digital tools.

On the other hand, the Accessible subdimension was rated poorly, likely due to technical challenges experienced during the demonstration, such as device compatibility issues, Wi-Fi connectivity problems, and long loading times. Many of the participating teachers were in their 40s and 50s, a factor that may have influenced these results. Research by O'banon & Thomas (2014) suggests that older teachers are less likely to own smartphones and show less enthusiasm for mobile technology, which could explain the lower accessibility scores observed in this study.

4. Conclusions

The study demonstrated a classroom-based mobile cloud network prototype for face-to-face classes, evaluated using a classroom environment assessment tool designed for technology-rich settings. The evaluation revealed that while aspects like presentation, management, conduciveness, and enrichment were rated as normal, the access parameter was rated poorly due to technical issues and teachers' unfamiliarity with the technology.

The findings indicated that teachers found the blended approach useful for supplementing traditional methods, particularly valuing the real-time feedback for assessing student mastery and enabling immediate interventions. However, challenges were noted, including diverse student backgrounds and varying technical and pedagogical skills among teachers. The study suggests a longitudinal study design to assess the long-term effectiveness of the mobile cloud learning platform, providing a comprehensive understanding of its impact on student learning outcomes over time. The overall results emphasize the potential of blended learning to enhance traditional teaching methods while addressing implementation challenges to maximize its benefits.

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