

Development and Evaluation of a Hybrid Mobile-Learning App Using Design Science Research (DSR) Framework

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Abstract: This paper details the development and evaluation of a hybrid mobile-learning application designed through design science research (DSR) to address educational software challenges in accessibility, flexibility, and cost-effectiveness, especially during the COVID-19 pandemic in one of the schools in the Philippines. Following the DSR framework, the study encompasses four phases: problem explication, design and development, demonstration and implementation, and learning experience assessment. Through literature reviews and stakeholder surveys, the mobile-learning app aims to enhance distance learning, focusing on science education in Philippine schools. An agile-kanban method facilitated app development. Comprehensive evaluations by experts, users, developers, and researchers highlight the app's effectiveness in diverse educational settings. Implemented in a Grade-7 class at Occidental Mindoro State College (OMSC) resulted to highly satisfactory feedback. While the app's accessibility, appeal, cost-effectiveness, and pedagogical efficacy are noted, challenges such as optimization and technical complexities are still evident. These findings suggest that the developed app and similar hybrid mobile-learning apps can provide scalable, cost-effective solutions for improving education in remote and disadvantaged areas, narrowing the digital gap.

Keywords: Design Science Research, Hybrid-learning application, mobile-learning approach

1. Introduction

Amidst these challenges, mobile devices emerged as ubiquitous tools for instructional delivery, with cell phones surpassing traditional amenities like toilets in Filipino households (APIS, 2017). This pervasive mobile penetration among diverse socioeconomic groups opened avenues for mobile learning (m-learning), enabling learners to access educational content anytime and anywhere (Keskin & Metcalf, 2011). M-learning not only supports self-paced and lifelong learning but also promotes ubiquitous access to educational resources, transcending physical constraints.

Despite the promise of mobile technologies, the effective integration of these tools into educational frameworks remains a critical area of research and development. Hybrid mobile-learning applications have emerged as a promising solution to bridge the digital divide, combining the strengths of native and web applications to deliver seamless learning experiences across multiple platforms (Paul et al., 2015; Miller et al., 2015). However, rigorous methodologies are essential to evaluate their efficacy and address pertinent challenges in accessibility, scalability, and pedagogical effectiveness.

On this note, this paper employs the Design Science Research (DSR) framework to develop and evaluate a hybrid mobile-learning modular app (MoLMA), named Knowbel, designed specifically to address the underlying concern of science education in Philippine schools. By leveraging DSR's iterative approach of problem identification, artifact development, and evaluation, this study aims to contribute practical insights into overcoming educational software limitations exacerbated by the COVID-19 pandemic. Through a comprehensive evaluation involving stakeholders and end-users, MoLMA-Knowbel seeks to demonstrate its potential as a scalable educational tool for remote and underserved communities.

2. Review of Related Studies

2.1 Hybrid Mobile Apps

Hybrid applications are essentially online apps wrapped in a native app shell. Once downloaded from an app store and installed locally, the shell may connect to whatever capabilities the mobile platform gives through an embedded browser in the app content (Dimi, 2017). Hybrid mobile apps, which effectively combine the functionality of native applications with the broad accessibility of web applications, have been pivotal in educational contexts, particularly during the COVID-19 pandemic (Paul et al., 2015). Utilizing web technologies such as HTML, CSS, and JavaScript within a native framework, these apps enable educational content to be accessed across multiple platforms while leveraging device-specific features, thus enhancing user interaction and multimedia engagement (Miller et al., 2015). The key advantage of this hybrid approach is its ability to deliver timely educational materials and notifications, enhancing the learning experience by utilizing the portability and ubiquity of mobile devices. (Mulatu et al., 2018). Furthermore, during a period marked by significant isolation, these applications supported not only the continuity of learning but also addressed the psychological and educational needs of students, maintaining engagement and interaction through accessible educational resources (Rangel-de Lazaro & Duarte, 2020). This capability underscores the critical role of hybrid apps in bridging the digital divide and enhancing educational delivery during global crises.

2.2 Mobile Learning

Mobile learning, or m-learning, leverages mobile technology to facilitate accessible and flexible education. M-learning's characteristics include ubiquity, contextuality, and personalization, supporting learners in various environments, including traditional and non-traditional settings (Ally, 2009). A significant study by Ebarido and Suarez (2023) highlights the transition to m-learning in medical education, where cognitive, affective, and social needs influence the adoption of m-learning. Their research, conducted during emergency remote teaching due to COVID-19, underscores how m-learning platforms not only continue educational processes but also meet psychological needs, thus enhancing students' attitudes towards and adoption of m-learning.

2.3 Design Science Research (DSR)

The Design Science Research (DSR) framework, as outlined by Johannesson and Perjons (2014), is a systematic approach to developing solutions to real-life problems. According to Hevner et al. (2004), DSR involves designing artifacts to address observed problems, evaluating those designs, making research contributions, and communicating the results to the scientific community. Unlike theoretical or purely methodological frameworks, DSR starts with identifying a need for change or improvement, addressing gaps or undesirable situations. This study applied the DSR framework to design a mobile-learning modular app (MoLMA) for high school science education. The DSR process, known for its practical relevance in educational technology, consists of five key activities: explicating the problem, outlining and defining the artifact's requirements, designing and developing the artifact, demonstrating the artifact, and evaluating its performance.

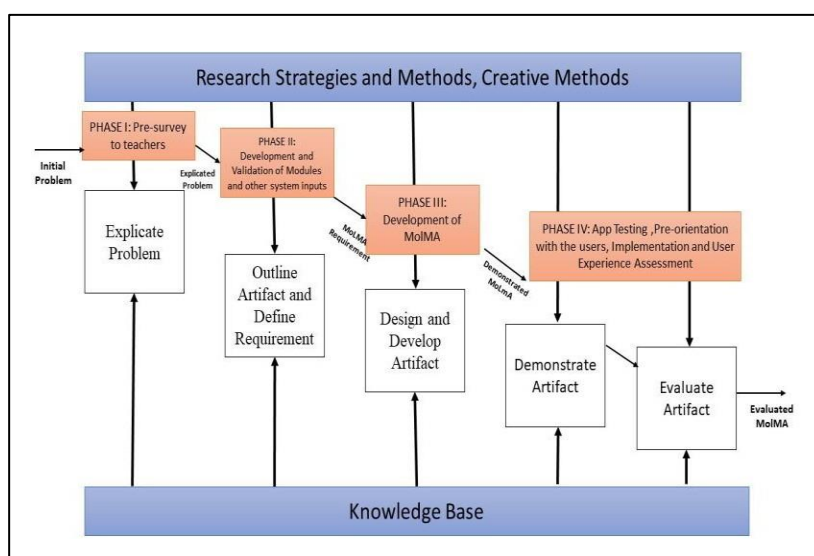


Figure 1. Research Paradigm using DSR

3. Methodology

3.1 Phase I: Pre-assessment Readiness Checklist

Before implementing the study, an assessment was conducted to evaluate the readiness of the grade 7 science teachers in Occidental Mindoro State College-Basic Education in the conduct of distance learning. This was based on DepEd Order No. 13 s. 2020, which outlines a Readiness Assessment Checklist for Learning Delivery Modalities in the Learning Continuity Plan for Private Schools. The checklist aimed to evaluate the following key areas: (1) Availability of a learning platform and support systems, (2) Availability of content and assessment materials, (3) Readiness of teachers and students for distance learning, (3) accessibility of ICT resources, (4) Readiness of parents to support learning at home. The checklist consisted of 12 questions answerable by Yes or No, with an additional column for narrative explanations to provide more context for each response. The science department head completed this assessment, which informed the study by ensuring that the school was adequately prepared to engage with the mobile-learning app.

3.2 Phase II and III: App Development Procedure

The Agile Kanban method was employed to manage the development of the app. Tasks were visualized through a Kanban board, with each stage of development monitored closely to ensure timely progress. The app was developed using Vue.js for the front-end and AWS Lambda for the back-end, leveraging the flexibility of Single Page Application (SPA) architecture and cloud-based services.

The app serves three user roles: students, teachers, and administrators. Each user interface was designed to

cater to the unique needs of these groups: (1) Students: Access lessons, complete quizzes, and view grades. (2) Teachers: Upload instructional materials, create assessments, and monitor student progress. (3) Administrators: Manage system updates, user enrollment, and teacher assignments.

The app is hosted on Amazon Web Services (AWS) with a Singapore data center for fast access in Southeast Asia. Student logins are managed by CloudFront for quick access to stored content, while lesson materials are kept in Amazon S3. User actions, like quizzes, are processed by AWS Lambda and stored in DynamoDB. Teachers and administrators use Amazon API Gateway to update content and manage users. The app is designed for efficient data handling and a smooth user experience. It requires Android 1.4 or higher with 2GB memory and 4GB storage, using Vue.js for the front-end and AWS Lambda and DynamoDB for scalable back-end performance.

3.4 Phase IV: Pilot Testing, Implementation and Feedback

The mobile-learning modular app (MoLMA) was introduced to Grade 7 science teachers and students through a structured deployment process, where teachers provided their information

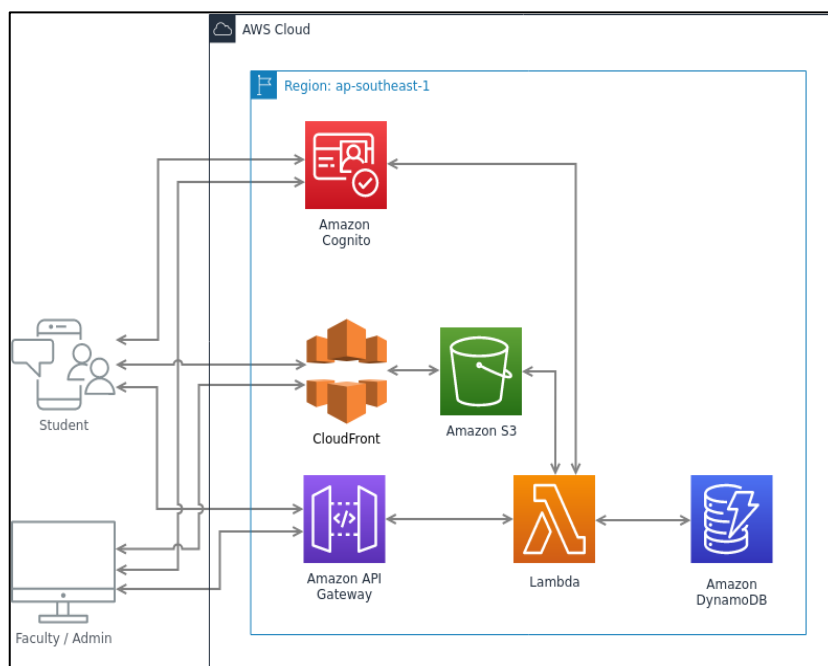


Figure 2. System Architectural Framework

and students received personalized credentials to access the app. An orientation session via Zoom familiarized participants with the app, and students used it for three weeks to learn Grade 7 Biology at their own pace. Weekly Google Meet sessions were held for students to ask questions and clarify concepts, while teacher observers and the researcher gathered feedback on the app's use.

At the end of the pilot test, teachers completed a validation form, and the app was evaluated using a modified survey aligned with ISO 9126 and ISO 20510 standards. Data collection included pre- and post-use surveys, teacher interviews, and classroom observations. Quantitative data was analyzed to assess user satisfaction and performance, while qualitative data was thematically coded to address usability, reliability, and educational effectiveness. The insights from this feedback were used to refine the app and identify areas for improvement.

4. Results and Discussion

4.1 Features and End-user Interface of the Developed App

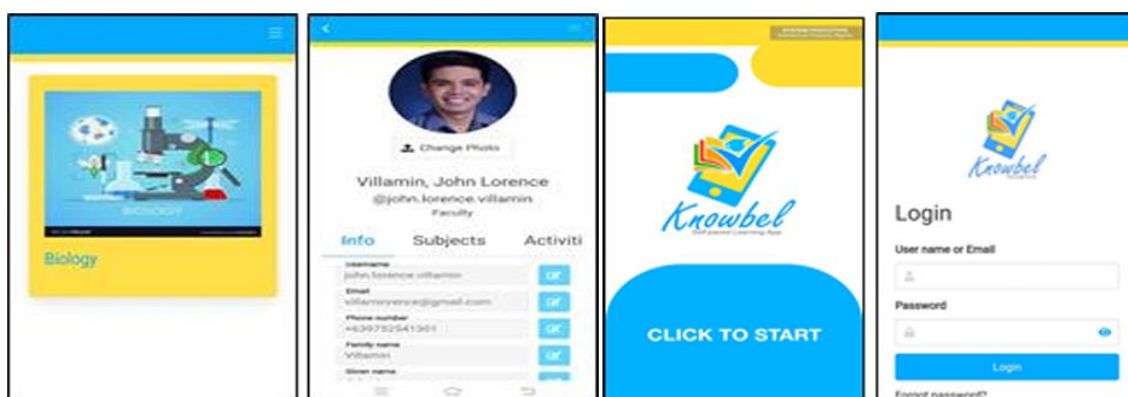


Figure 3. App Features and User Interface

During development, the researchers identified three major features of the app: content, technical, and aesthetics. The app offers pre-lab activities, guide questions, lesson materials, and assessments for flexible, self-paced learning at school or home. Key technical features include login, navigation, video embedding, score tabulation, and offline functionality for both Android and iOS devices. Its minimalistic, mobile-friendly design ensures easy navigation, data privacy, and accessibility across devices, making it suitable for areas with limited internet connectivity. The app's multimedia elements and real-time feedback enhance teacher-student interaction and engagement.

During the feedbacks analysis, the app's offline capabilities and flexible design make it especially beneficial in resource-limited environments, promoting equitable access to education. By supporting self-paced learning and integrating multimedia, it fosters a dynamic learning experience, helping students in remote areas stay engaged and improving learning outcome

4.2. Evaluation Summary of the Developed App

The app was pilot tested in a span of three weeks to one of the grade-7 classes of the target school, the teachers' observation and assessment were collected and statistically analyzed. The tables below prevail the result of these evaluation

Table 1. Application Overall Evaluation Results

Criteria	Average	Interpretation
A. Functionality	4.75	Highly Satisfactory
B. Reliability	4.35	Satisfactory
C. Usability	4.75	Highly Satisfactory
D. Efficiency	4.84	Highly Satisfactory
E. Effectiveness	4.72	Highly Satisfactory
Final rating	4.68	Highly Satisfactory

The app was pilot tested over three weeks with Grade 7 students, with feedback collected from teachers, an IT specialist, and the school's Science coordinator. The evaluation assessed five key areas: functionality, reliability, usability, efficiency, and effectiveness. The overall functionality score was 4.75, indicating that the app performed its tasks well, had robust security measures, and interacted seamlessly with its environment. However, the app's reliability scored 4.30, highlighting occasional bugs and the need for better error management. Usability scored 4.75, showing that the app was easy to navigate and well-received by users. Efficiency was the highest-rated category, with a score of 4.84, noting the app's flexibility, responsiveness across devices, and offline capabilities. The final overall rating was 4.68, signifying that users were highly satisfied with the app's performance. Feedback suggested areas for improvement, including extending essay character limits, adding more detailed registration instructions, and addressing occasional system freezing.

The high scores in functionality, usability, and efficiency reflect the app's potential to significantly enhance distance learning, particularly in resource-limited settings. The ability to operate offline and adapt to various devices ensures that it can serve students in areas with limited internet access, promoting equitable education. Its ease of use makes it accessible to both teachers and students, while the ability to provide real-time feedback through quizzes supports continuous learning. The suggestions for improvement also highlight the app's flexibility to evolve, making it an effective tool for engaging students and improving learning outcomes in a digital classroom setting.

4.3 App Limitations and Potential Improvements

The app performed well overall, but reliability issues, such as occasional bugs and system freezes, were noted, especially when handling large multimedia files or during high-traffic periods. To improve stability, future versions shall focus on enhancing fault tolerance and scalability. Additional improvements based on user feedback include increasing the essay character limit, simplifying the registration process, and allowing more diverse file attachments. These enhancements will make the app more reliable and user-friendly, especially in resource-limited environments, ensuring smoother access to educational content and promoting better student engagement and learning outcomes.

5. Conclusion

The development and evaluation of the hybrid mobile-learning app, using the Agile-Kanban approach and the Design Science Research (DSR) framework, demonstrated its effectiveness in enhancing student engagement and learning outcomes, particularly in science education. The app's user-friendly design, offline functionality, and adaptability to different devices made it a practical and accessible tool for students in resource-limited environments. High scores in functionality, usability, and efficiency indicate that the app successfully supports self-paced and flexible learning, while providing teachers with the tools to deliver content and assess student progress in real-time. However, the app's reliability, particularly in handling large multimedia files and high-traffic periods, revealed some limitations. Future improvements focusing on fault tolerance, scalability, and system stability are essential to ensure smoother performance. Feedback from users also highlighted the need for expanded functionality, including greater essay length, easier registration processes, and more diverse file attachment options. The app's potential to bridge the digital divide and support equitable education, especially for students with limited internet access, was a significant outcome of this research. Moving forward, integrating this app into the secondary science curriculum in the Philippines could further enhance remote learning and contribute to reducing educational inequities. Continued research and development in hybrid mobile learning will be critical in addressing technical challenges and expanding its application in diverse educational settings.

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