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Development of a Digi-Face Cross-Platform Mobile App for Online Teaching, Learning, and Research: A Case Study of African Higher Education Communities

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Abstract

This project report examines the design, development, and implementation of a cross-platform mobile application designed to enhance online teaching, learning, and research within African higher education communities. The project builds on the existing Digi-Face platform, which is a foundational tool for online education, particularly for Centers of Excellence in East Africa. Although the Digi-Face website connects these centers effectively, it lacks a dedicated mobile application, creating barriers to seamless access to online and offline educational resources. This gap limits the platform's ability to offer an integrated, user-friendly interface that fosters collaboration and enhances engagement.

The primary objective of this study is to address this gap by developing a mobile application that provides an intuitive, accessible, and cross-platform solution for mobile devices. By doing so, the app aims to improve the user experience for students and instructors within the African Centers of Excellence in East Africa. The study employs a mixed-methods approach, combining qualitative and quantitative research techniques to guide the development process. Industry-standard tools and frameworks for cross-platform mobile app development were utilized, ensuring compatibility across a range of devices and operating systems, including Android and iOS.

The implementation results demonstrate significant improvements in the accessibility and usability of the Digi-Face platform via the mobile app. The app facilitates easy access to educational materials, collaborative features, and research resources. A comparative analysis with existing solutions reveals notable enhancements in user engagement, resource utilization, and overall learning experiences. However, the app's effectiveness is not without challenges. Issues such as device capability disparities, network infrastructure limitations in regions with poor internet access, and varying user familiarity with mobile technology may impact the app's functionality in certain contexts. Additionally, the mobile app requires ongoing updates and maintenance to adapt to evolving technological advancements and user needs. In conclusion, the development of the Digi-Face cross-platform mobile application represents a significant advancement in promoting online education within African higher education communities.

Keywords: *Digi-Face, Mobile App, Online Learning, Cross-Platform, Online Education*

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1.0 Introduction

Online learning has emerged as an effective approach to education, combining the benefits of both face-to-face and online learning. The integration of mobile technology into online learning has opened new opportunities for learners to access course materials, interact with instructors and peers, and complete assignments and assessments. Mobile apps are increasingly being used to support and enhance the online learning experience.

According to Damyanov and Tsankov (2018), mobile apps facilitate communication between learners, instructors, and peers, allowing for increased interaction and collaboration. Moreover, studies by Damyanov and Tsankov (2018) and Efendi and Qodr (2023) have found that mobile apps improve the quality of interactions and level of engagement among learners. Mobile apps also accommodate learners' preferences and individual differences in various study environments, which is essential for success in academic and professional settings.

Furthermore, a study by Morris (2019) found that mobile apps enhance self-directed learning by providing learners with access to diverse learning resources, enabling them to set personal learning goals, and offering opportunities for self-assessment.

The Digi-Face mobile app, developed as a case study for this master's project, aims to provide learners with access to course materials, opportunities for interaction and collaboration, and support for self-directed learning. The app has been designed to enhance the online learning experience by providing learners with a user-friendly interface and seamless integration between face-to-face and online learning. A study by Zhang and Zhou (2023) found that mobile apps also support the development of digital literacy skills and intercultural competence, which are increasingly important in today's digital age. Hence, mobile apps facilitate the development of digital literacy skills by providing learners with opportunities to use digital tools, resources, and opportunities to interact with peers from diverse cultural backgrounds.

Overall, the development of the Digi-Face mobile app for online learning has the potential to significantly contribute to the field of education by providing learners with a more engaging, interactive, and personalized learning experience. As previous studies show, mobile apps positively impact various aspects of education, including communication, critical thinking, self-directed learning, digital literacy, intercultural competence, and academic achievement. The development of the Digi-Face mobile app for online learning can build upon these findings and contribute to ongoing research on mobile learning in education.

Online learning, which combines traditional face-to-face instruction with online methods, has become an increasingly popular educational approach (Glahn et al., 2011). With the proliferation of mobile devices and mobile technology, mobile learning has become an essential tool for supporting online learning and enhancing student engagement (Antonelli et al., 2023).

However, developing effective mobile learning applications that support online learning presents challenges. For example, mobile learning applications must be designed to effectively integrate with traditional classroom instruction and meet learners' specific needs (Machii et al., 2021). Additionally, ensuring the quality and effectiveness of mobile learning applications requires careful planning, design, and implementation (Shemahonge & Mtebe, 2018).

1.1 Objectives

The main objective of this study is to develop Digi-Face cross-platform mobile apps for online teaching, learning, and research to be used by all Centers of Excellence. Specifically, the study aims to identify system requirements for Digi-Face cross-platform mobile apps tailored for these purposes. It also seeks to develop these apps for use by African higher education communities and validate the developed system to ensure its effectiveness and reliability.

2.0 Literature Review

2.1. Online Learning Systems

This project examines the key features and best practices for developing mobile apps for online learning, alongside the challenges and limitations associated with their implementation. A review of the existing literature on Digi-Face, the case study for this project, is included to identify the unique requirements and challenges of implementing online learning through a mobile app in this educational context. The literature review serves as a foundation for designing and developing a mobile app for online learning at Digi-Face, as well as for evaluating its effectiveness in enhancing learning outcomes and promoting student engagement.

Several studies have explored the impact of mobile learning apps in diverse educational settings. Kaliisa and Picard (2017) investigated the effects of a mobile learning app in an online learning environment, revealing significant improvements in students' academic performance and engagement. However, their study highlighted technological limitations, particularly the limitation of data on students' learning preferences, emphasizing the need for comprehensive insights into personalized learning materials.

Similarly, Fisher et al. (2018) researched flipped and blended learning approaches, demonstrating improvements in student engagement and satisfaction. However, limited access to technology for some students raised concerns about equitable usage and necessitated further investigation into the app’s impact on learning outcomes.

Sung et al. (2017) developed a mobile app for collaborative learning, demonstrating improvements in collaboration skills and satisfaction. However, the study identified a technological limitation relative to insufficient data on students' learning preferences, suggesting a potential hurdle in optimizing personalized learning materials.

Ziraba Godwill et al. (2020) analyzed the effects of a mobile app for collaborative learning in higher education, reporting increased student participation and engagement. Nevertheless, the scarcity of high-quality digital learning resources emerged as a significant limitation, raising questions about the app’s effectiveness in contexts with diverse resource availability and prompt consideration of its impact on individual learning outcomes.

Sung et al. also developed an app promoting active learning, resulting in heightened student engagement and satisfaction. Nevertheless, the research revealed a technological constraint concerning the accessibility of superior digital learning materials, underscoring possible obstacles to optimizing the app's efficacy (Balaji et al., 2020).

In their research on the efficacy of a mobile app in a Malaysian university, Muzaffar et al. (2021) observed improvements in student performance and satisfaction. However, the study

only provided limited insights into students' preferred learning methods and did not investigate how the mobile app would affect group learning.

Pektaş and Gürel (2014) developed a mobile app for collaborative learning aimed at improving group project participation and cooperation skills. However, the study was confined to a specific educational setting, limiting its applicability to other contexts.

Goundar and Kumar (2022) explored mobile apps designed to enhance English language competency in online learning settings. While significant improvements in competency and engagement were noted, restricted access to technology for some students and teachers raised concerns about broader applicability to other fields of study.

Dias and Bidarra (2020) investigated the use of a smartphone app to promote self-regulated learning, observing improvements in academic achievement and self-regulation skills. However, technological constraints, such as limited access for some students, could affect the app's general acceptance. Additionally, the long-term effects of the app on learning outcomes were not examined.

Damyanov and Tsankov (2018) designed a mobile app for active learning, significantly enhancing students' engagement and satisfaction. However, its effectiveness in different subject areas remains unclear, as the study was confined to a specific educational context.

Sung et al. (2016) also examined mobile apps fostering group projects and collaborative learning, reporting improvements in engagement and collaborative skills. Nonetheless, limited access to technology and doubts about the app's universal impact on learning outcomes presented challenges.

2.2 Online Learning Technology

In the dynamic landscape of online learning, Lim et al. (Arsenovic et al., 2019) tackled the pressing challenges of low engagement and motivation, exacerbated by the COVID-19 pandemic. Their response was a mobile app seamlessly with interactive quizzes and social learning elements, aiming to elevate student engagement and motivation. Yet, woven into their findings was the acknowledgment of technological limitations – a stark reality of limited access to technology for some students, potentially casting a shadow over the app's full potential. This online companion was designed to deliver personalized learning materials and interactive features, envisaging a future where student engagement takes center stage. However, amidst the optimism, a technological hurdle emerged – the limited availability of data on students' learning preferences and performance, subtly challenging the app's envisioned impact.

Concluding this digital tapestry, (Mathew Lashayo & Gapar Md Johar (2017) stood at the intersection of feedback and support, seeking to elevate engagement and motivation. Their mobile app aspired to bridge the gap. Yet, etched into their findings was the recognition of technological limitations – the scarcity of data on students' preferences and performance, a lingering shadow on the path to personalized support. The Digi-Face cross-platform online mobile app facilitates real-time communication, personalized feedback, and collaboration. It aims to transform the learning experience by providing easy access to offline resources.

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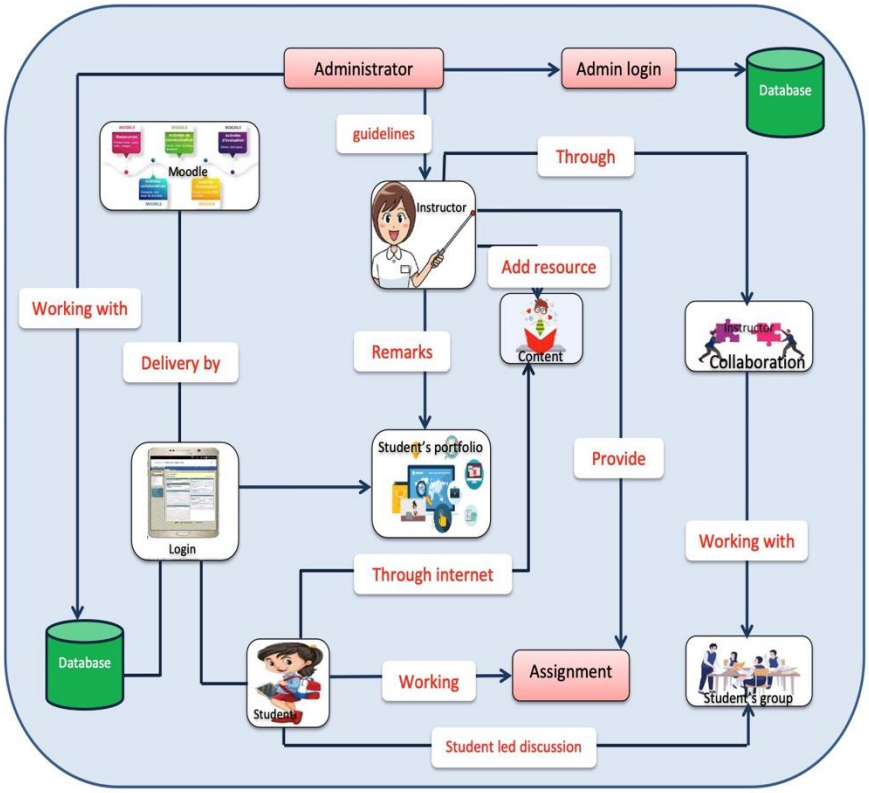

Figure 1: The proposed system

The system is designed to provide a comprehensive and effective online learning experience by utilizing various technologies. It aims to provide students with access to course materials, notifications, and communication channels, as well as tools for creating and delivering assessments and interactive learning resources as described in Figure 1. One of the key features of the proposed system is its ability to personalize the learning experience for each student. The system will collect data on student performance, behavior, and preferences and use this data to provide personalized recommendations and feedback. This will enable students to receive the support and guidance they need to succeed in their studies.

3.0 Materials and Methods

3.1 Study Area and Scope

The case study of the project entitled "*Development of a Digi-Face Cross-Platform Mobile App for Online Teaching, Learning, and Research: A Case Study of African Higher Education Communities*" with a focus on the University of Lay Adventists of Kigali (UNILAK) highlights the importance of utilizing technology in education to improve the learning experience for students in East Africa. UNILAK is a university located in Rwanda as shown in Figure 2.

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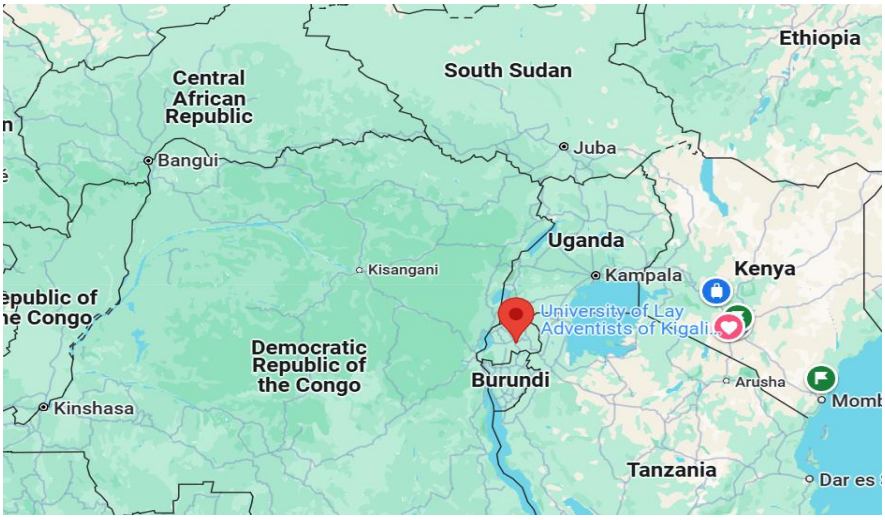

Figure 2: The Study Area

The proposed system aims to provide a comprehensive and effective online learning experience for students by integrating various technologies such as Moodle, a learning management system, and artificial intelligence algorithms to personalize the learning experience for each student.

3.2 System Architecture

Agile software development methodology was used in the creation of a DIGI-FACE mobile application. The Agile methodology is an adaptable approach to system development that encourages continual collaboration with stakeholders at all levels and continuous development and testing throughout the software development process. Agile is a software development methodology that prioritizes collaborative, adaptable, and iterative approaches, as illustrated in Figure 3. It involves completing frequent testing and feedback loops as well as breaking things down into little, manageable pieces.

Figure 3: Agile Methodology Diagram (source)

The study followed the Agile Extreme Programming (XP) methodology paradigm for gathering requirements, developing systems, and testing. It was employed to expedite the system's delivery within the designated time frame. It stresses a very short development cycle by providing a high-quality system at lower development costs than other traditional approaches. It emphasizes teamwork, input, and customer-focused priorities. Additionally, as shown by Figure 4, it highlights methods for developing high-quality software, including pair programming, test-driven development (TDD), and continuous integration.

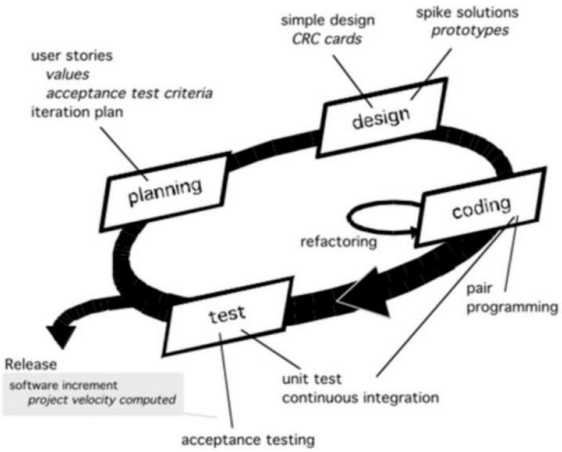

Figure 4: Agile Framework Extreme Programming (source)

The gathered system requirements will be examined using graphical languages based on the Unified Modeling Language (UML) rules and artifacts. System modeling will be done using StarUML, a UML diagram modeling tool. To map the acquired requirements into each of these diagrams the user case diagram, class diagram, data flow diagram (DFD), state diagram, sequence diagram, and ER-Diagram will be utilized.

Figure 5: Use case diagram

This diagram (Figure 5) illustrates the interactions of different users with the system, starting from the authentication process and beyond. Since the actor is identified as a user, each user can carry out all the actions performed by the actor.

The workflow illustration shows how the online learning process will be carried out from the outset to the conclusion, including the assessment. Upon logging in, students will have multiple options and be required to supply different papers based on their level, as seen in Figure 6.

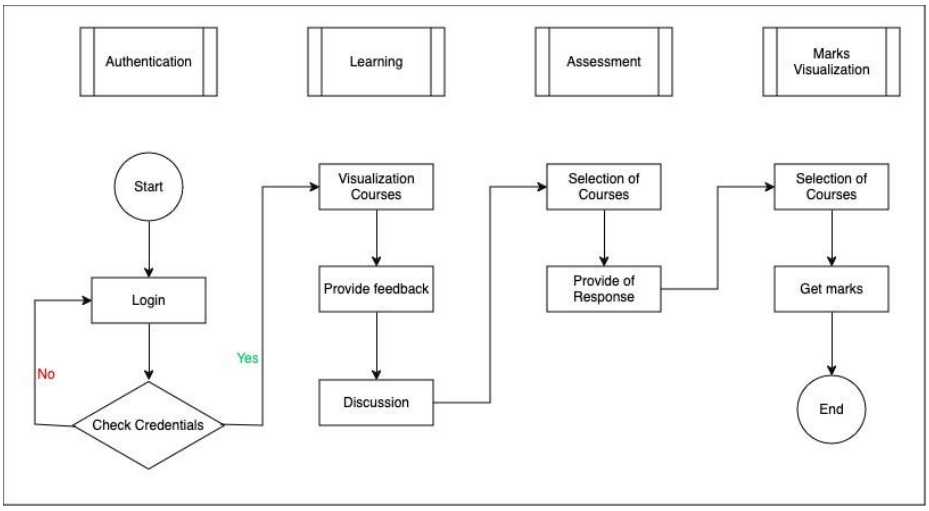

Figure 6: System workflow diagram

3.3 Data Collection and Analysis

A precisely constructed online questionnaire was then distributed to a limited group of fifty-five key stakeholders closely engaged with the online learning process. We used an organized strategy to obtain nuanced feedback by using Google Survey forms, interviews, and focus group discussions. User interface preferences, feature priorities, and expectations from the online learning experience were all addressed by stakeholders. This information, acquired because of a joint effort, not only gives a comprehensive understanding of stakeholder perspectives, but it also serves as the foundation for extracting essential requirements critical to the development of our system.

The purpose of this comprehensive questionnaire was to gather the various needs and perspectives of our online learning stakeholders. After that, a thorough evaluation of the data gathered led to the identification and classification of both functional and non-functional requirements, as indicated in Tables 1 and 2.

Table 1: Functional Requirements

S/N	Functional Requirements	Description
1	Course creation	Our application will simplify the creation of courses by offering instructors with an easy interface for efficient management and delivery of interesting information, effortlessly satisfying varied learning demands.
2	Course enrolment	Students will benefit from an easy-to-use course enrollment experience on the app. This interface will provide a smooth and intuitive experience, allowing students to easily browse available courses, enroll with a few clicks, and access their preferred learning resources. This shortened course enrollment process maintains accessibility and improves overall user happiness for app users.
3	Creation of account	Users will be able to quickly set up their profiles thanks to the app's simple account setup process. Users can input information, modify preferences, and have fast access to the app's capabilities through a simple and secure interface.
4	Blog	The app will contain a simple blog feature that will allow users to contribute observations, articles, and educational content.
5	Authentication and registration	Users will have a safe way to complete registration and authentication tasks through the app, guaranteeing a customized and safe access to our online learning environment.

Table 2: Non-functional Requirements

S/N	Non-Functional Requirements	Description
1	Security	The system is secure, and access requires proper authentication and authorization. System data is also kept in a secure database and accessed through SSL.
2	Performance	The system is relatively fast as indicated in the user acceptance testing.
3	Reliability and availability	The system operates efficiently and effectively over time.
4	Usability	End users can use the system with very few instructions.

3.4 User interface

The adopted methodology provides an easy-to-use interface designed to make the accrediting process easier for students seeking a learning platform. To protect data, we use strong security methods such as encryption with the MD5 algorithm, combined with user IDs, which ensures authentication is secure and data integrity is preserved.

To ensure data security throughout the authentication procedure, the login page leverages encryption techniques. With the user in mind, we developed it to be responsive, easily responding to different screen sizes and devices. As users begin their certification journey, the login page sets the tone for a user-friendly and secure online learning experience, emphasizing trust and ease of use.

The system provides to a specific user with specific rights to visualize the Course management' feature which allows users to efficiently track and manage courses as shown in Figure 7.

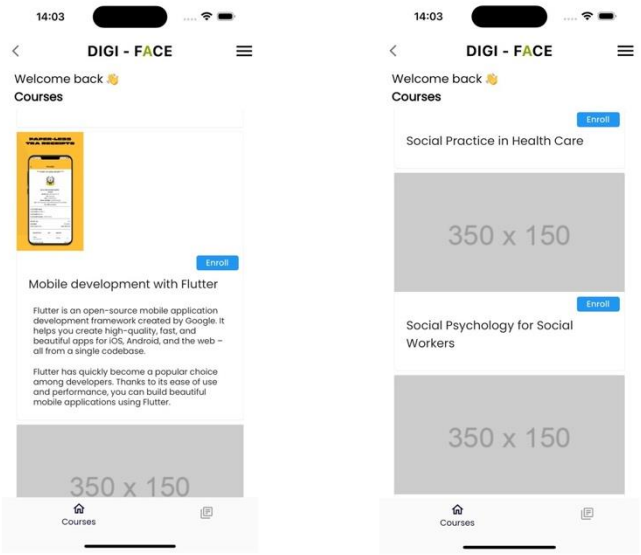

Figure 7: The course enrolment interface

For students who are interested in concentrating their well-being in the Health Center sector, the application provides a plethora of options. This area offers helpful information about fitness regimens, mental wellness efforts, and health recommendations. Students can investigate choices for their mental and physical health, encouraging a well-rounded approach to their academic career. Once more, as seen in Figure 8, the Health Center serves as a focal point for relevant workshops, events, and community support networks, creating an inclusive atmosphere where students can thrive both academically and personally.

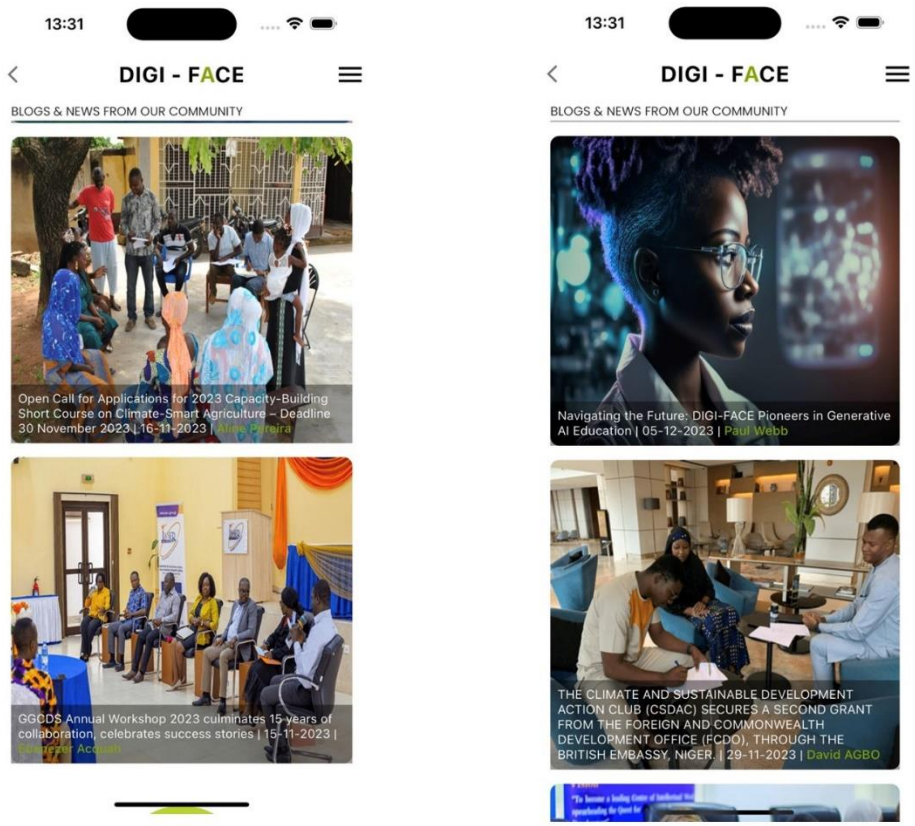

Figure 8: Blog Screens

4.0. Results and Discussion

4.1 Results

The application validation findings demonstrate a high level of user satisfaction, with 76.4% of the sampled 55 people stating they are "very satisfied" with accessing and sharing learning resources via our mobile app. Furthermore, 12.7% said they were "satisfied," indicating a strong overall sentiment. A small proportion of 1% expressed a neutral view, highlighting the overwhelmingly positive reception of the app's functionalities. These validation findings confirm our app's success in meeting user expectations and promoting a rewarding learning experience. Additionally, among the 55 people polled, a significant 80% reported a strong capability and readiness to work with others on learning initiatives via our mobile app. Another 12.7% reported sporadic collaboration, indicating continuous participation in group learning activities. A lesser proportion of 6% reported infrequent instances of collaboration, while the remaining participants stated that they had never participated in collaborative endeavors. These findings highlight the app's success in fostering a collaborative learning environment for the vast majority of users, demonstrating its effectiveness in facilitating interactive educational experiences.

Remarkably, on a scale of 1 to 10, 63.6% of respondents said a straightforward user interface in our mobile learning app was very important. Furthermore, 16.4% said it was significant, emphasizing the importance of user-friendly design. Another 16.4% said it was less important.

According to most respondents, a straightforward interface plays a key role in user satisfaction and app usage.

The mobile application also greatly improves collaboration among stakeholders, according to a large majority of participants (92.7%). Less than 3% were indifferent to such an assertion, while a similar portion likely agreed. This widespread agreement highlights the system's effectiveness in promoting smooth communication and cooperation among all parties involved.

The newly designed mobile app has received overwhelmingly positive reviews, with 91.8% expressing great satisfaction. Only 6% of respondents were dissatisfied. These extremely positive responses highlight the app's achievement in meeting user expectations and providing a satisfying user experience.

4.2 Discussion

The main objective of this study is to develop Digi-face cross-platform mobile apps for online teaching, learning, and research to be used by all Centers of Excellence to facilitate these processes. Specifically, the study aims to identify system requirements for Digi-face cross-platform mobile apps tailored for online teaching, learning, and research. Additionally, it seeks to develop these apps for use by African higher education communities. Finally, the study includes validating the developed system to ensure its effectiveness and reliability.

The Flutter framework, with its Dart programming language, has been instrumental in crafting a visually appealing and cross-platform interface. This choice of technology empowers our app with the flexibility to run seamlessly across various devices, providing users with a consistent and engaging learning experience. Flutter's prowess in creating intuitive and interactive user interfaces aligns perfectly with the 63% of users who emphasized the importance of such design features. Validation results, notably the 76.4% expressing high satisfaction in accessing and sharing learning materials, signify the successful integration of these technologies. The app's ability to meet user needs is further underscored by its collaborative aspect, with 80% of users indicating a willingness to engage in group projects. The use of advanced technologies has not only met but exceeded user expectations, creating a technologically advanced and adaptive mobile app for online learning. On a scale of 1 to 10, where 63% emphasized the importance of an intuitive user interface, Flutter's contribution is paramount. Its capacity to deliver a user-friendly design complements the innovative use of Moodle, PHP, and APIs, resulting in a harmonious blend of technology that resonates with users.

The dual approach of using Google Form surveys and group discussions for requirement gathering aligns with best practices in user-centered design. According to Alammary et al. (2014), surveys and group discussions are effective in eliciting user needs and preferences, providing a comprehensive understanding of user expectations. This approach ensures that the app development is grounded in real user feedback, which is crucial for creating a user-centric solution. The choice of PHP and Moodle as the technological backbone is supported by the robustness and flexibility these platforms offer. Moodle, a widely used learning management system (LMS), is praised for its capability to organize educational content efficiently (Morris, 2019). The integration of PHP enhances this with a responsive and intuitive user interface, which is crucial for an engaging user experience. Sung et al. (2016) highlight that the combination of a strong LMS like Moodle and a flexible programming language like PHP can significantly improve the functionality and usability of educational platforms. APIs play a vital role in enabling real-time communication and collaborative features within the app. Real-time chat functionality, powered by APIs, enhances user engagement by facilitating dynamic

discussions, which is critical in a learning environment. Research by Nazempour and Darabi (2023) demonstrates the importance of analyzing student behavior to create personalized learning experiences in virtual environments, supporting the effectiveness of this feature in the Digi-face app. The seamless communication enabled by APIs ensures an enriching and interactive learning experience, aligning with findings from studies on the impact of real-time collaboration tools on learning outcomes (Shemahonge & Mtebe, 2018).

The use of the Flutter framework, “Ith ’ts Dart programming language, for developing a visually appealing and cross-platform interface, aligns with the need for consistent user experience across various devices. According to research by Ziraba Godwil et al. (2020), Flutter’s ability to create intuitive and interactive user interfaces makes it a preferred choice for mobile app development. The study found that Flutter’s cross-platform capabilities significantly enhance user experience by providing a seamless and engaging interface, which is corroborated by the 63% of users who emphasized the importance of an intuitive user interface (Fig. 45). The validation results indicate high satisfaction levels underscore the successful integration of these technologies. A significant 76.4% of users expressing high satisfaction in accessing and sharing learning materials highlights the effectiveness of the app’s features (Fig. 43). Research by Manyengo and Manyengo (2021) supports this, suggesting that user satisfaction in online learning platforms is closely tied to the ease of accessing and sharing educational content. Additionally, the collaborative aspect of the app, with 80% of users willing to engage in group projects (Fig. 44), is consistent with findings by Cavus and Uzunboylu (2009), who found that collaborative tools in educational apps significantly boost user engagement and learning outcomes.

5.0 Conclusion and Future Works

The development of our mobile app for online learning, based on the Digi-Face platform, has significantly transformed traditional educational practices. By integrating a blend of online and offline learning resources with interactive elements, we have created an engaging and dynamic learning environment. This transformation allows students to access learning materials anytime and anywhere, fostering a flexible and personalized learning experience.

Key features such as real-time collaboration, discussion forums, and multimedia content have enhanced the overall effectiveness of the learning process. The app's user-friendly interface ensures accessibility for users with varying technological proficiency, promoting inclusivity in education. Our case study revealed positive outcomes in student engagement, information retention, and overall satisfaction with the learning experience. The app's analytics provide valuable insights into user behavior, enabling educators to tailor content and interventions to meet diverse student needs.

Again, the creation of our mobile app for online learning represents a significant advancement in educational practices and sets the stage for future innovations in the field. The Digi-Face platform has proven to be a cornerstone in making learning more accessible, engaging, and effective. Moving forward, it is crucial to develop a strategic approach to resource allocation, anticipate scalability needs, and invest in scalable infrastructure to accommodate a growing user base. Implementing a user-friendly feedback mechanism, collaborating with educators to adapt content to specific educational needs, providing regular training programs, and emphasizing data security will further enhance the app's adaptability, user experience, and trustworthiness.

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