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THE DEVELOPMENT OF A MOBILE APPLICATION ISMIND FOR FORMATIVE STUDENTS' ASSESSMENT

Abstract. Nowadays, mobile learning utilizing mobile applications has become widely adopted due to its flexibility and the numerous benefits it offers. However, the availability of mobile apps in education especially for assessment is limited and still an emerging topic despite the affirmation of its positive impact on students' learning outcomes and motivation. The complexity of the mobile application development process, which includes requirement elicitation, modeling, designing, developing, testing, and evaluating, could be a contributing factor to this issue. This study aimed to propose a guideline for designing and developing an educational mobile application through the development of an application named IsMind that focuses on formative assessment. Evolutionary Prototyping, a methodology under the agile approach of Software Development Life Cycle (SDLC) was deployed to meet the educational application requirement by integrating content, pedagogy, and technology aspects to provide better teaching and learning material. The activities within each phase of evolutionary prototyping including the models, tools, techniques, and deliverables were discussed extensively. The analysis and design phase were done using an object-oriented approach with appropriate models (diagrams) to present the functional requirement of the mobile application. Various CASE tools which accelerated the development process in various stages of software development were explained.UMLet software was employed to create a use case diagram, activity diagram, and sequence diagram. The user interface design, which followed The Eight Golden Rules of Interface, was developed utilizing Marvel software. Adobe Photoshop CS6, Adobe Illustrator CS6, Unity 3D, and Microsoft Visual Studio Code (C#) were utilized in the development process. The mobile application provides a variety of question types, such as Drag And Drop, Multiple Choice, Numbering, True And False, Matching, and Puzzle. The evaluation of IsMind indicated its appropriateness as an interactive teaching and learning media for assessment. The proposed steps for constructing this assessment educational mobile app. The proposed methodology consists of the details of phases, various activities within each phase, techniques, models, and tools for each activity as well as deliverables of each phase offer a helpful guideline for anyone interested in developing a similar application.

Keywords: software development; SDLC; mobile learning; mobile application; assessment.

1. INTRODUCTION

With the exploding popularity of smartphones and tablets, mobile application development is becoming a more popular medium for software creation. A lot of mobile applications have been developed for mobile learning, which is not restricted by internet access, specific timing, or classroom environment. The use of apps for learning has sparked a significant debate among

education scholars and practitioners [1]. [2] asserts that mobile learning has become widespread and is now a necessity in today's society. It is considered an important tool to be considered in both formal and informal learning contexts. They also emphasize that mobile learning can positively impact students' learning and motivation by extending the learning space, facilitating collaboration, and enhancing interaction with course content. [3] stated that research generally indicates that mobile learning contributes to student retention and satisfaction with learning content. They also claim that research has demonstrated a positive impact on students' learning outcomes and motivation through the use of mobile-based assessment systems.

Research on mobile-based assessment has confirmed that these applications have a positive impact on students' learning outcomes and motivation [3], [4]. However, research on mobile-based assessment systems is still an emerging topic in the field of mobile learning. Assessment plays an important role in the teaching and learning process and is closely interconnected with learning outcomes. Typically, teachers allocate 5 to 10 minutes of each lesson to complete the assessment process. As teachers and students work towards achieving curriculum outcomes, assessment plays a constant role in informing instruction, guiding students' next steps, and monitoring progress and achievement [5], [6]. Thus, appropriate teaching aids are critical in achieving learning outcomes.

[1] assert that although the adoption of digital tablets by schools has become widespread, researchers repeatedly draw attention to the lack of evidence-based app development needed to support the multitude of learning apps available. This dearth is a result of the absence of educational researchers involved in the development, design, and classroom implementation of tablet apps. They argue that researchers, teachers, and developers need to collaborate and adopt appropriate methodologies to radically improve the design of apps used by young students for learning. This implies the need for a suitable methodology for developing a quality mobile application. In the development of mobile applications, a thorough understanding of the subject matter is required, making requirements engineering a crucial stage. [43] asserts that developing mobile applications is a challenging task, as novice mobile programmers will often sketch the user interface before coding when given a task. Poor domain understanding is one issue that arises from rapid prototyping and trial and error.

[44] researched the causes of failure in Information Technology (IT) projects and classified them into 12 categories, including software development methodology. Based on past research, he claims that some methodologies, such as Agile and DevOps, may be better at tackling failure issues than others, and that development technique is always inappropriate for the project. It was also influenced by the lack of reviews at the end of each step and shoddy development processes. Furthermore, while scale and complexity are easily overcome, consider dividing a project down into manageable sub-components. Furthermore, design management issues might generate significant problems later in a project.

The main errors in innovation failure are in planning and design, execution, and market orientation[45]. In failed projects, together with team characteristics, core conditions are represented by project complexity and uncertainty, while environmental characteristics play a dual role. [46] claims that no systematic methodology has been applied to software project development will lead to project failure. [47] emphasizes ~~on~~ the importance of having the right stakeholders according to the project's purpose and scope.

Against the backdrop of the issues highlighted above, this article proposed a software development methodology with a complete set of phases, activities, models, tools and techniques to develop a mobile application. It discusses the process of developing a mobile application for assessing the Islamic Study Year 3 subject known as *IsMind*, using a systematic approach. This research provides a guideline through evolutionary prototyping for designing, developing, and evaluating the mobile application, with a specific focus on assessment. The selection of this software development methodology is crucial as employing appropriate software methodology reduces the likelihood of a software failure according to previous research.

2. LITERATURE REVIEW

Mobile Learning (M-learning) can be defined as the subset of 'e-learning', while 'e-learning' is the subset of distance learning. It is a type of distance education that focuses on learning across various contexts and utilizing mobile devices. [7] define M-learning as the ability to use mobile devices to support teaching and learning. The importance of M-Learning becomes evident in situations where traditional classes cannot be conducted. This situation is currently being faced by people all over the world where most schools and educational institutions are closed due to the Covid-19 pandemic [8]. In such circumstances, the use of M-learning is critical to ensure the learning process can be continued without exposing individuals to unnecessary risks. Learning in a classroom setting can be modified by utilising a smartphone, which is more convenient since it can be done anywhere and at any time [41]. The use of mobile applications for educational purposes has garnered significant interest among academics.

Mobile technology is essential for the successful implementation of M-learning, with mobile applications being one of the key technologies. Mobile technologies have been found to elicit positive responses from students in terms of their engagement in mobile activities and how these activities can enhance their performance [9], [10]. Furthermore, [11] affirms that mobile learning represents a way to address several educational problems. In addition, [12] assets the technological advancements and the widespread popularity of mobile devices have opened up new avenues for communication, education, and collaboration. Compared to traditional teaching methods, education through mobile devices offers numerous advantages, including flexibility, collaboration, motivation, accessibility, and portability [13]. [14] suggests that teachers and educational institutions should promote M-learning as a more natural and effective educational platform for the generation of "digital natives".

[42] discussed the primary goals of incorporating mobile technologies into the educational process, which include increasing the effectiveness of learning materials by students; creating opportunities for students to receive continuous education; and introducing formative assessment (analysis of own mistakes, self-assessment) which ultimately will improve educational quality. The authors also highlighted the advantages of mobile applications that allow the student to choose the level of difficulty, administer tests, and automatically assess the user's knowledge level. This accelerates the evolution of learning outcomes and enables teachers and students to monitor progress, facilitating the quick identification and resolution of academic issues while raising educational standards.

There are two types of assessment: formative and summative. Formative assessment is conducted to monitor student progress [15]. This formative assessment can take the form of homework, quizzes, exercises, projects, or online assessments. [16] highlights the importance of formative assessment, which includes benefits such as enhancing student learning, improving teaching methods, fostering healthy competition among pupils, and reducing the learning gap when compared to standard curriculum content with the standard content. In addition, [17] affirms that assessment plays an important role in helping teachers gauge the attainment of teaching and learning objectives, categorizing students, and providing feedback on the effectiveness of teaching methods.

Furthermore, [18] emphasized that formative assessment encourages students to learn independently and receive ongoing feedback from teachers. The use of mobile learning through mobile applications installed on mobile devices effectively promotes independent learning through online assessment. This approach caters to the needs of the Alpha and Z generations, who are more inclined to use mobile devices in various aspects of their lives [19]. These generations, born from 1995 to 2009 (Z generation) and from 2010 onwards (Alpha generation), are currently enrolled in primary schools within the Malaysian education system. Therefore, utilizing mobile applications for teaching and learning processes is a commendable and effective approach.

A study conducted by [20] investigated the use of mobile learning in K-12 education and found that science was the most frequently researched subject, accounting for 53% of the research. The study suggests that M-learning can support both science and non-science courses based on empirical evidence. In addition, the study summarizes that elementary schools were the most frequently examined setting, constituting 56% of the studies. Therefore, there is great potential for implementing mobile learning in the subject of Islamic Studies, which is offered to all students in Malaysian primary schools from Year One to Year Six.

Numerous efforts have been made by Islamic countries to design and implement Islamic Education and its philosophy in alignment with the demands and challenges of the 21st century. [19] and [21] have compiled a list of 158 suitable websites for use in Islamic Education. However, it's worth noting that many of these websites are not fully functional and merely provide information without any interactive elements. Furthermore, mobile applications focusing on assessment are very limited, especially for the Islamic Study subject of Year Three in Malaysian primary schools. Hence, a more attractive, appealing, and effective mobile application is needed for the assessment of Islamic Study subject. However, as emphasized by [22], the development process of an effective mobile application is neither easy nor quick; it requires detailed and systematic planning. [23] points out that mobile application development is a multidisciplinary field that encompasses knowledge in such areas as software development, human-machine interaction, web programming, IT security, network interaction, artificial intelligence, and machine learning. Furthermore, [24] stated that professional mobile application development requires proficiency in object-oriented analysis and programming.

3. METHODOLOGY

An appropriate software methodology, which is a variation of the Software Development Life Cycle (SDLC), is crucial as a guideline for implementing any software project [26]. Determining methodology is the key to mobile application development, particularly in a cross-platform environment where multiple efforts may be ongoing simultaneously [27]. Based on a review, it has been concluded that the Agile approach is considered the best fit for mobile applications in many studies. In addition, [28] states that the Agile approach is seen as a natural fit for mobile application development. The Agile methodology helps to limit idea failures, gives users the ability to test mobile apps, and provides feedback simultaneously [29]. Moreover, [25] asserts that agile methodologies represent a philosophy of using organizational models based on collaboration between people and shared values that seek to achieve customer satisfaction through short and fast iterations from which deliverables can be obtained through which you can have a view of the progress of developments from the first phase.

Agile methodology is based on an incremental, iterative approach and is open to changing requirements and there is no in-depth planning at the beginning of the project. Within the Agile approach, there are several methodologies ~~or~~ normally known as the software process model in the software engineering area, which is a variation of SDLC. Among them are Scrum, Prototyping, Rapid Application Development (RAD), and eXtreme Programming (XP) [30].

Evolutionary prototyping is a type of Agile model that was deployed in the development of the *IsMind* app. Figure 1 illustrates the diagram of evolutionary prototyping methodology while Table 1 shows the phases in this methodology together with the activities within each phase and the artifacts involved such as documentation and deliverables of the early model of the working system.

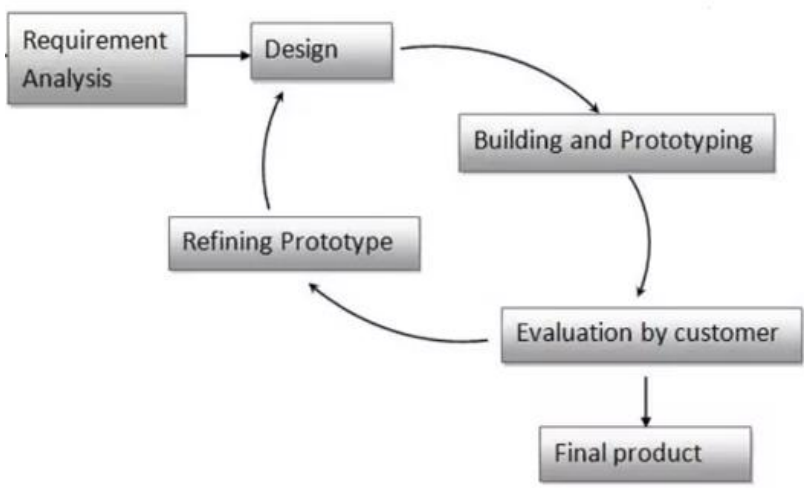

Figure 1: Prototyping methodology

Table 1.

The details of the prototyping methodology

Phase	**Activity**	**Techniques/ models/ tools**	**Deliverable/ Artifact**
Requirement Analysis	– Elicit requirements rapidly from the stakeholders to investigate the requirements of the app. – Analyze the gathered requirements via modeling.	Techniques: -Interview -Document review (Standard curriculum) -Literature review Tools: UMLet Software Models: -Use case diagram -Activity diagram	Software Requirement Specification (SRS) (Functional and non-functional requirements)
Design	– Design the architecture of the application. – Design interface (menu/sub menu/instruction/types of questions).	Models: -Sequence diagram/ collaboration diagram Tools: - UMLet -Marvel/ Proto	Software Design Document (SDD) Mockup of the user interface
Building and prototyping	– Develop the prototype of the application. – Develop the user interface components. – Construct the processing logic (coding). – Conduct unit testing, integration testing, and system testing.	Tools: Prototype- Adobe Photoshop CS6 and Adobe Illustrator CS6 Unity 3D Microsoft Visual Studio Code (C#)	Software Testing Plan (STP) A mobile application prototype
Evaluation by customer	– Present the prototype to the client for an initial evaluation. – The aim is to get feedback and find out the strengths and weaknesses of the prototype. – Measure the quality of the application.	Techniques: -Interview -Test plan	Comments and suggestions from the client

Refining Prototype	– Identify defects and resolve bugs to ensure the functionalities of the mobile apps are correct and complete. – Refine the prototype according to the user's feedback and suggestions.	Tools: -Adobe CS6 and -Adobe Illustrator CS6 -Unity 3D -Microsoft Visual Studio	The refined mobile application prototype
Final Product Deployment	– Deploy the developed mobile application to be used by users if there is no modification from the feedback phase. – If there is any suggestion for modification, the amendment will be made accordingly in the next iteration.		A working mobile application

Requirement Analysis

Requirement analysis is the first and the most important phase in mobile application development, regardless of what software process a developer chooses. The two important activities in this phase are requirement gathering and requirement modeling. Numerous requirements-gathering techniques can be used to elicit users' requirements. The purpose of requirement gathering is to understand the problem that arises from the needs of stakeholders and transform it into requirements to define and design the related solution. After gathering all the requirements, they need to be analyzed via modeling. As reinforced by [31], requirements analysis is the process of determining user expectations for a new software or information system.

Software engineers can utilize a myriad of elicitation techniques to capture relevant information to specify requirements [31]. In this study, the techniques which were utilized were document review, interview, and literature review. The combination of requirement-gathering techniques should be applied in triangulation for efficient and successful requirement specification.

The Curriculum Standard Document or *Dokumen Standard Kurikulum Pelajaran (DSKP)* of Islamic Study Year 3 was scrutinized in this first phase. The DSKP is a standard document that needs to be followed by all teachers in planning their teaching. It was obtained from the Malaysian Ministry of Education portal. Besides, the textbook and activity book of Islamic Study Year Three were reviewed to investigate various aspects of Islamic Study content and questions. It was found that this subject is divided into four sections namely *Ibadah, Sirah, Akidah,* and *Al Quran*. It was also identified that *Jawi* writing was used for textbooks and activity books for this subject. However, most of the available mobile applications in the market for *Pendidikan Islam* are in Malay or English. Hence, the *IsMind* app is developed using *Jawi* writing to make it parallel with the current syllabus and resources.

The result from the literature review shows that the currently available mobile application in the market for Islamic Study is a general one, not specific to the level of learner's knowledge in school, and is to be used by students of all ages. This is in line with the finding by [23] that most teaching aids available online are very general and do not help teachers teach Islamic Education based on a prescribed syllabus. Therefore, a DSKP is used as the main reference in constructing the content of the *IsMind* app.

Requirement modeling was performed after all the requirements were acquired. Various diagrams can be used to model the requirement based on two main approaches, either a structured approach or an object-oriented approach. Based on [32], essentially these approaches use two different sets of diagrams with different notations to model a system, which is presented to

different stakeholders, such as users who will know the specific requirements for the system being modeled and programmers who will construct the relevant codes for the system based on the system design

Two main diagrams within the object-oriented approach were used to model the requirement of the *IsMind* app in this phase. A use case diagram was used to model the functional aspect of the system while an activity diagram shows the flow of activities within the mobile application. Generally, all main functions are included in the use case diagram which also shows the boundary of this application. Figure 2 illustrates the use case diagram for the *IsMind* app which has four main functions namely choose a topic, answer a question, click 'Home', and click 'Quit' functions.

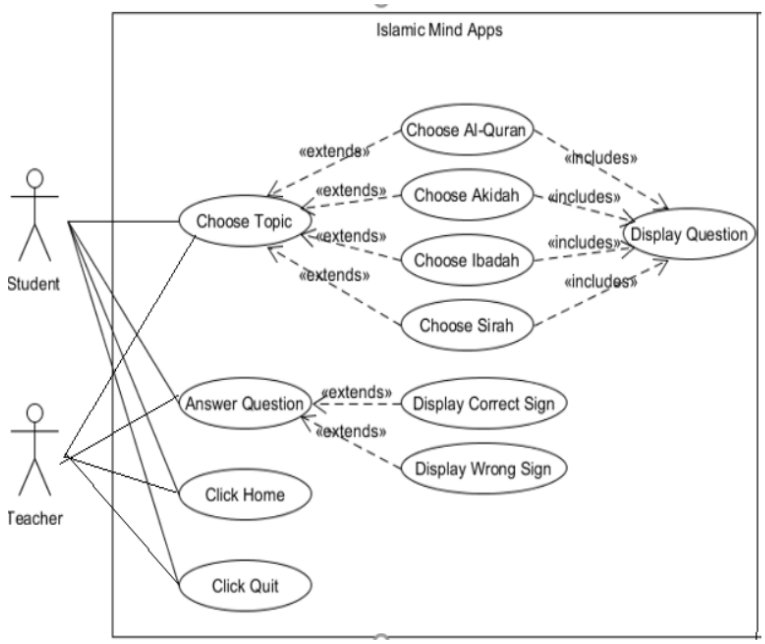

Figure 2: Use case diagram of the IsMind app

'Choose Topic' has four extended use cases which means there are some options for the user when using this 'Choose Topic' function. They can choose any section of the Islamic study contents, *Al-Quran, Akidah, Ibadah,* and *Sirah* which is implied by the four extended use cases. Each of these four extended use cases has an included use case which is 'Display Question'. In other words, the 'include' use case indicates that it needs to be used by the main use case. Questions for the assessment of the selected section will be displayed for the respective areas. There are several types of assessment approaches in the *IsMind* app to make the learning activity more fun and interactive when answering the questions. The types of questions namely multiple choice, numbering, matching, true or false, drag and drop, and puzzle activity are described as shown in Table 2.

Table 2

Types of questions and its description

Type	Description
Multiple Choice	This type of question is used for several topics namely *Al Quran, Akidah,* and *Sirah*. There are five questions of multiple choice in the *Al-Quran* and *Sirah* topics. The *Akidah* topic contains three multiple-choice questions. Multiple choice questions can be useful for formative assessment and to stimulate students' active and self-managed learning.

Numbering	The numbering approach is used in the *Al-Quran* topics. The student needs to insert a number to arrange the piece of *An-Nas*'s surah in a correct sequence. There are six questions of numbering because *An-Nas*'s surah has six verses.
Matching	The student needs to match the other Arabic names of *Al-Quran* to their meaning correctly. If they match wrongly, the wrong Arabic name will be bounced to its original position.
True and False	The student needs to choose either the *True* or *False* button to answer the question. There are five questions of this type in the *Akidah* topic.
Drag and Drop	Drag and drop approach is used in the *Ibadah* topic which contains nine questions. The students can drag the choice of answers given and drop it into the answer box. If it is dropped wrongly, the answer will be bounced to its original position.
Puzzle	The picture puzzle is used in the *Sirah* topic. This approach is interesting because it is a game. The student needs to arrange the picture to its correct position to construct an image of *Gua Hira'*.

The system will prompt feedback on whether the answer is correct or wrong, implied by the use of extended use cases which is an option. The student can click the home button if they want to go back to the main menu while answering the question. On the other hand, the students need to click the Quit button in the main menu to exit from this app.

Figure 3 shows an activity diagram that illustrates the navigation flow of the *IsMind* app from the beginning until the end. The Swimlane activity diagram differentiates the function of the application based on the actor.

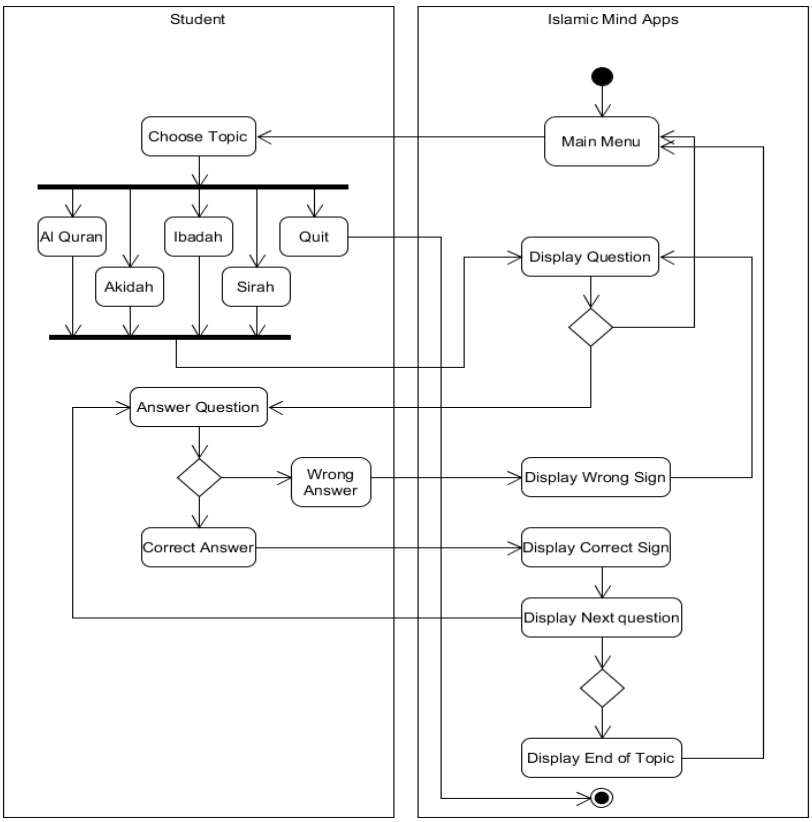

Figure 3: Activity diagram of an IsMind apps

Design

For an application to be usable by individuals, it will need to be designed such that the individual's needs, preferences, and context of usage are taken into serious consideration [33]. Therefore, they affirm that the mobile app needs to be designed keeping in mind design guidelines that can help in evoking affective responses with regards to their quality perception towards the mobile app.

Developing software without an architecture or design pattern can be compared to building a house without a blueprint. The architecture used for the *IsMind* app development is the Model-View-Controller (MVC). The MVC architecture is a very popular approach for the development of a mobile application that separates the components of the user interface (View), core data (Model), and functionality as well as response to user inputs (Controller). The Model is a part of the framework to store the data of the application such as database, text data, and files that usually represent the business logic and data.

The view level represents the graphical user interface of the application which is responsible for displaying data and transforming the Model into a visual representation. The *IsMind* app has meaningful instruction, various buttons and labels, text boxes, and other controls to let the user interacts with the *IsMind* app. The controller acts as an intermediary between view components and model components which retrieve inputs from *View*, work with *Model* and return View. The blank space is provided in which the user needs to enter the number, check the button to user check the answer and the app shows the feedback answer referring to *View* components. Furthermore, the Controller refers to the C# code that acts as a checker to check the input of the answer that the user fills in the blank space provided. From a user perspective, the user interface is the main aspect that needs to be designed and implemented. User interfaces are the access points where users interact with designs. This could be the control buttons or the visual layout of interfaces. This design must not only be attractive to potential users but must also be functional and created with users in mind. User interface brings together concepts from interaction design, visual design, and information architecture.

Figure 4 to Figure 10 show some interfaces of the designed application. The main objective of user interface design is to create a user-friendly design that is easy to learn and use. This user interface design was based on The Eight Golden Rules of Interface Design by [34]. Among them are striving for consistency, seeking universal usability, offering informative feedback, permitting easy reversal of actions, keeping users in control, and reducing short-term memory load. The main user interface is shown in Figure 4.

Figure 4: Main menu for the IsMind app

There are four (4) buttons that represent the four sections of Islamic Education content, namely *Ibadah, Akidah, Sirah,* and *Al Quran*. Soft and bright colors were used in the screen background to help users focus more on the displayed information. Additionally, the use of soft colors makes it comfortable for the users while viewing the phone screen. Furthermore, colorful

font manages to attract users' attention. Besides, the chosen font type is important to be readable. *Jawi* font was used in the *IsMind* app to help students in improving their *Jawi* reading skills and it is parallel with the DSKP and government initiatives.

Figure 5 shows different types of questions that exist in the *IsMind* app. The variety of these types of questions can avoid the monotonousness of presenting the question. The six types of questions are multiple-choice, numbering, true and false, matching, drag and drop, and puzzle. The background of the screen remains unchanged for the benefit of consistency.

Figure 5: Examples of six types of questions in the IsMind app

The sequence diagram is important to reflect the details of each function within the software, which is included in the Software Design Document (SDD). Various modeling tools can be considered and here UMLet was used to construct various diagrams including the sequence diagram. Marvel software is used for the mockup of the user interface.

Building and prototyping

The development of a mobile application using prototyping methodology is reflected by the third phase, building, and prototyping. In this phase, the prototype of the application and the user interface components need to be developed using the user interface principles that have been designed in the previous phase. The processing logic must be constructed using the software and programming tools and they need to be compatible with each other. Afterward, the three types of testing, unit testing, integration testing, and system testing need to be carried out in sequence.

The choice of hardware and software is crucial to avoid any possibility that would interrupt the development process. The hardware used can operate well with the chosen software to make the development of the apps. Unity 3D is the main software used for the development of this mobile application, especially in the production of animation. It has been used to develop the scene whereby all the background, buttons, *Jawi* writing, and correct and wrong signs were constructed. All the images were saved as sprites in Unity 3D while all the other characters were animated to add interactive values to the *IsMind* app.

Graphics and images are crucial in mobile applications as they contribute to the outlook of the apps. Among the software used to develop these components are Adobe Photoshop CS6 and Adobe Illustrator CS 6 which were used to produce the graphics and edit the images for the menu buttons and navigation as well as the icons in this mobile app.

Microsoft Visual Studio Code was used to write the back end of the apps using C# due to its compatibility to work well with Unity 3D. It was used to implement the coding to program functionalities of the mobile application in Unity. The processing logic (controller of MVC architecture) has been written using C#. Figure 6 shows the Unity 3D environment.

Figure 6: The Unity 3D environment to develop the IsMind app

4. EVALUATION RESULT

Evaluation of the developed mobile apps was done mainly to assess whether the app meets users' requirements. Functionality refers to the task that the *IsMind* app should support as an assessment instrument in teaching and learning. Hence, the app's functionalities play a valuable role in user evaluation [35]. Functional testing is to validate that each component of the application is working as expected.

A qualitative study was adopted involving six teachers who teach Islamic Study subject in primary schools intending to get feedback, find out the strengths and weaknesses of the prototype, and make improvements in the following phase, refining prototyping. Comments and suggestions were collected from the respondents.

The teachers were given the *IsMind* app to be installed and used for a week. After that period, they were interviewed to check their acceptance of the *IsMind* app. Generally, all respondents found the *IsMind* app interesting to be used as a medium for teaching and learning due to the various types of questions offered by the app.

The interview questions were divided into three criteria which are the user interface, content, and accessibility. Several aspects of the user interface design that were evaluated are the font type, font size, font color, background theme, and consistency of the button. All respondents agreed that the *IsMind* app has a suitable font type and size. The font is easy to read and attractive to users. The respondents liked the various colors used in the application; the background colors, the fonts, and the button as they were used in harmony. The combination of colors makes the interface of the *IsMind* app look attractive. The use of bright colors is suitable for kids. The users also mentioned the attractiveness of the background used, the garden which is claimed very nice and beautiful.

Despite the positive response to the user interface, two of the respondents commented on the inconsistency of the button. Consistency is crucial in providing a quality experience to the users

in both design and content. They do not agree with the inconsistency in the display position of the Home and Next buttons when a user moves to the next assessment. It also happened to the background display of the apps when moving from the previous assessment to the next assessment.

All users agreed that the contents of the question are in line with the subject of Islamic Study for Year Three students as well as following the *Dokumen Standard Kurikulum dan Pentaksiran* (DSKP) set by the Malaysian Education Ministry. All users also agreed that this app uses a very good approach as it diversifies the activities to answer questions. Despite that, they stated the way to answer the question needed to be added such as making the students color the correct answer and use their voice to answer the question.

One of the six respondents mentioned that the questions in this app are difficult as the topics covered in the app are among the difficult topics. As an example, the question to arrange pieces of *Al-Quran'*s verses required the student to have a strong memory. Furthermore, half of the respondents said this app has very clear instructions because they can understand well how to answer the questions.

Matching and puzzle question is claimed interesting because it is very similar to playing games. It is very good because it has an edutainment aspect. [36] affirms that the edutainment strategy is beneficial for all types of learning and when it comes to kids, leisure has more role than academics.

Five respondents were satisfied with the function of questions and answers for multiple choice, numbering, and the drag-and-drop approach. According to one respondent, the approach is good and fun to attract the students but the feedback answer for the wrong answer is too fast. The students might be unaware of the wrong feedback answer. Therefore, this needs to be improved. However, two respondents disagreed with the drag and drop function, mentioning that there is a lag while doing the *Ibadah* assessment. The home and exit functions work fine because they did the right function to back home and exit the apps.

Refining prototype and Deployment

In the refining prototype phase, all the defects and errors were fixed. Besides, all the comments and suggestions were considered in improving the functional aspects of the apps. Besides, the non-functional requirements which reflect the quality were also important.

The refining cycle continues until all the stakeholders agree with all the features the IsMind app offers. This phase will not be over until all the requirements specified by the user are met. Once the user is satisfied with the developed prototype, a final system is expanded to the final version of the system based on the approved final prototype.

5. FUTURE WORKS AND RECOMMENDATION

The respondents highlighted some issues and made some recommendations for the application to be improved in the future. The motivation element should be added to the *IsMind* app to encourage students to use the application positively, with intrinsic or extrinsic motivation. Here, extrinsic motivators such as offering learners rewards they consider desirable extrinsic motivation. The question level should have low, medium, and high levels because students' cognitive levels are different.

Considering how theory underpins learning activities is important to ensure appropriate pedagogical practice. This is especially important when adopting emerging technologies, such as mobile technology, to ensure that the learning, not the tool, is the driver of the activity [37]. Various learning theories should be considered in developing this app, such as constructivism, behaviorism, and cognitivism. In addition, Bloom's Taxonomy is also important in determining the level of questions and different types of questions.

A cognitive load is a load that involves a person's intellectual activity such as thinking, reasoning, or remembering [38]. Extraneous cognitive load must be reduced so that the total cognitive load imposed on the students will not exceed their cognitive capacity [39]. Instead, the germane cognitive load which is useful in the learning process is more needed to help in understanding the course [40]. The Constructivism Learning Theory guides the application design to focus on constructing cognitive experience. The Constructivism Learning Theory and Cognitive Load Theory help in designing and developing better educational software.

6. CONCLUSION

Students can swiftly and conveniently use learning resources anytime, anywhere with the use of mobile technology, which also provides additional functionality for Islamic study beyond what is already available. Learning Islamic Study by using the *IsMind* app is more interactive and fun because it provides a lot of assessment approaches rather than answering the assessment using an exercise book. The primary reference document, DSKP, provides the specific guidelines, objectives, and learning outcomes established by the Malaysian Ministry of Education. It also outlines the information and skills that students should be able to acquire at each grade level. The mobile app is built to comply with the national curriculum and the authorities' defined requirements for education.

This article explored the suitable methodology for mobile application development projects via evolutionary prototyping. It is to ensure the project will be completed on time, within the allocated budget, and ultimately deliver a quality mobile application that satisfies users and meets requirements. Various factors to be considered in methodology selection are the complexity of the project, certainty of the requirement, familiarity with the development technology, allocated budget, time given, defined scope, risk that could happen, and expertise of the developer.

An assessment-specific mobile application requires a variety of skills and knowledge, from requirement investigation to establishing the app's architecture, which includes the user interface, components, and database. Anyone planning to design a mobile app can use the specified prototyping methodology by adhering to the suggested process using CASE tools. The thorough guidance in this article including strategy in each phase will accelerate the process of developing such an application. The use of the Jawi typeface within the application manages to aid pupils in honing their Jawi reading abilities and is in line with government efforts, killing two birds with a stone. Hence, students can improve their reading skills in *Jawi* while using this app, making the assessment process more enjoyable and interactive.

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РОЗРОБЛЕННЯ МОБІЛЬНОГО ДОДАТКА ISMIND ДЛЯ ФОРМУВАЛЬНОГО ОЦІНЮВАННЯ УЧНІВ

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Анотація. Сьогодні мобільне навчання з використанням мобільних додатків набуло широкого поширення завдяки своїй гнучкості та численним перевагам. Однак доступність мобільних додатків в освіті, особливо для оцінювання, є обмеженою і все ще залишається новою темою, незважаючи на підтвердження їх позитивного впливу на результати навчання та мотивацію студентів. Складність процесу розробки мобільних додатків, який містить визначення вимог, моделювання, проєктування, розробку, тестування та оцінювання, може бути одним з факторів, що сприяють вирішенню цієї проблеми. Це дослідження мало на меті запропонувати рекомендації щодо проєктування та розробки освітніх мобільних додатків на прикладі розробки додатка IsMind, який фокусується на формуючому оцінюванні. Еволюційне прототипування, методологія в межах гнучкого підходу життєвого циклу розробки програмного забезпечення (SDLC), було застосовано для відповідності додатка освітнім вимогам шляхом інтеграції аспектів контенту, педагогіки та технологій для забезпечення кращого викладання та вивчення матеріалу. Кожний етап еволюційного прототипування, зокрема моделі, інструменти, методи та результати, детально обговорювався. Фаза аналізу та проєктування була виконана з використанням об'єктно-орієнтованого підходу з відповідними моделями (діаграмами) для представлення функціональних вимог до мобільного додатка. Надані пояснення різних CASE-інструментів, які прискорили процес розробки програмного забезпечення на різних його етапах. Програмне забезпечення UMLet було використано для створення діаграми варіантів використання, діаграми діяльності та діаграми послідовності. Дизайн інтерфейсу користувача, який відповідав *Восьми золотим правилам інтерфейсу*, був розроблений за допомогою програмного забезпечення Marvel. Під час розробки використовувались Adobe Photoshop CS6, Adobe Illustrator CS6, Unity 3D та Microsoft Visual Studio Code (C#). Мобільний додаток пропонує різноманітні типи питань, як-от: перетягування, множинний вибір, нумерація, правильно/неправильно, на відповідність та головоломки. Апробація IsMind показала його придатність як інтерактивного засобу оцінювання під час викладання та навчання. Описано кроки для створення цього освітнього мобільного додатка для оцінювання. Запропонована методологія складається з детального опису кожного етапу, видів діяльності в його межах, методів, моделей та інструментів, а також корисних рекомендацій для тих, хто зацікавлений у розробці подібного додатка.

Ключові слова: розробка програмного забезпечення; SDLC; мобільне навчання; мобільний додаток; оцінювання.