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AR-OOP: Augmented Reality-based Mobile Learning Application for Learning Object-Oriented Programming

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Abstract : Nowadays, Object-Oriented Programming (OOP) is vital for modern software development. Practically, learning and understanding concepts of Object-Oriented Programming (OOP) is always difficult to students, especially the novices, and even for educators who teach the concepts, because these concepts are usually abstract and hard to image. Over the years, there have been various methods to support learning of these concepts including through mobile applications. Practically, mobile learning applications benefit users as they able to engage the course content and allow students to progress at their own pace. Additionally, with the emerging of Augmented Reality (AR), it allows the concepts of OOP can be visualized in a graphical way which enables novice learners to understand the fundamentals and relationship of objects clearly and thus understand the concepts at a first glance. Thus, this project proposes a mobile learning application that utilizing AR, namely AR-OOP to support novice in learning basic concepts of OOP. The AR-OOP consists of features such as View Notes, Do Quick Practice and Quiz, Learn OOP topics via AR Tutorial as well as view history of attempted quizzes. As of to access the functions of Do Quiz, AR Tutorial and View History, a user needs to register and login successfully. The AR Tutorial comprises three topics which are inheritance, polymorphism and encapsulation. The learning contents of these topics are presented in AR that provides an immersive digital experience in which digital objects are placed on top of real-world objects of environments. For example, in the inheritance topic, the hierarchical class diagrams are linked with their respective instances or objects to show how their relationships and interaction can be seen clearly supported with a feature to superimpose digital media atop physical objects. As to prove a validity of the AR-OOP, an evaluation was conducted to measure its usability, satisfaction, user interface and performance. The results have shown that most of the respondents provide very positive responses in all the measurements parameters. Generally, the AR-OOP is able to provide an immersive hybrid learning environment that allows the novice learners to tune into the concepts of OOP via interactive visualization.

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Keywords: Augmented Reality (AR), Learning Programming, Object-Oriented Programming, Mobile Application

1. Introduction

Object-Oriented Programming (OOP) has become a fundamental part of most software development. OOP offers several advantages in terms of modularity for easier troubleshooting, reuse of codes through inheritance, flexibility through polymorphism, and effective problem solving [1]. Instead of breaking down large problems into sub-problems and solving them in separate units of code by using the top-down approach of traditional structured programming in languages like Visual Basic, OOP provides a whole new way of solving problems as the objects were self-contained instances of a class.

Teaching programming and modeling by means of Object-Oriented concepts has become a common content of introductory programming course (s) for Computer Science or Information Technology related disciplines. Learning OOP is indicated as more difficult than coming to grips with other programming paradigms [2]. Existing research has shown that there are lots of problems faced by educators when teaching OOP to undergraduate students. Students, especially novice learners find it abstract and very difficult to understand OO concepts like classes, constructor invocation, overloaded constructors, friend functions and other object-oriented concepts [3,4]. Also, it has been shown by a study that students perceived as most difficult in learning OOP, understanding what is happening when executing a program, misunderstanding of memory operations, difficulty in developing and understanding how the program solve the certain problems [5]. In fact, these are the consequences of ineffective teaching pedagogy in OOP, poor programming planning and complexities in the available teaching and learning tools in OOP.

Augmented Reality (AR) supplementing current pedagogical materials by simply augmenting more contextual experiences and superimposing virtual objects into real scenes so that users have the illusion that virtual objects are part of the real scene. The immersion and interaction features offered by AR may encourage students to engage in learning activities and may improve student motivation to learn [6]. AR provides highly interactive experiences and can generate authentic learner activity, interactivity, and a high level of realism [6]. Motivation is important in promoting and sustaining self-regulated learning, which often results in improved academic performance [7]. Therefore, this study proposes a mobile learning application that utilizes AR, namely AR-OOP to support novices in learning basic concepts of OOP (see **Figure 1**). Basically, AR-OOP covers four basic concepts of OOP including inheritance, polymorphism, abstraction and encapsulation. It is designed to provide an immersive learning environment so that novice learners are more interested and engaged in learning as well as to fully grasp and understand the concepts of OOP with the central motivation of visualization learning.

The rest of this paper has the functionalities of AR-OOP in Section 2, evaluation and results of AR-OOP in Section 3, and conclusion in the last section.

2. AR-OOP Fuctionalities

The AR-OOP consist of seven (7) functions include Register New Account, Login, View Notes, Attempt Quick Practice, Do Quiz, Learn AR Tutorial, and View History. The flow of processes involved in AR-OOP is shown in **Figure 2**. Starting from **Figures 3 to 10**, they show all interfaces of these functions. As of to access the function of Do Quiz, Learn AR Tutorial and View History, a user has to register an account and login successfully.

Figure 1: AR-OOP application with AR files

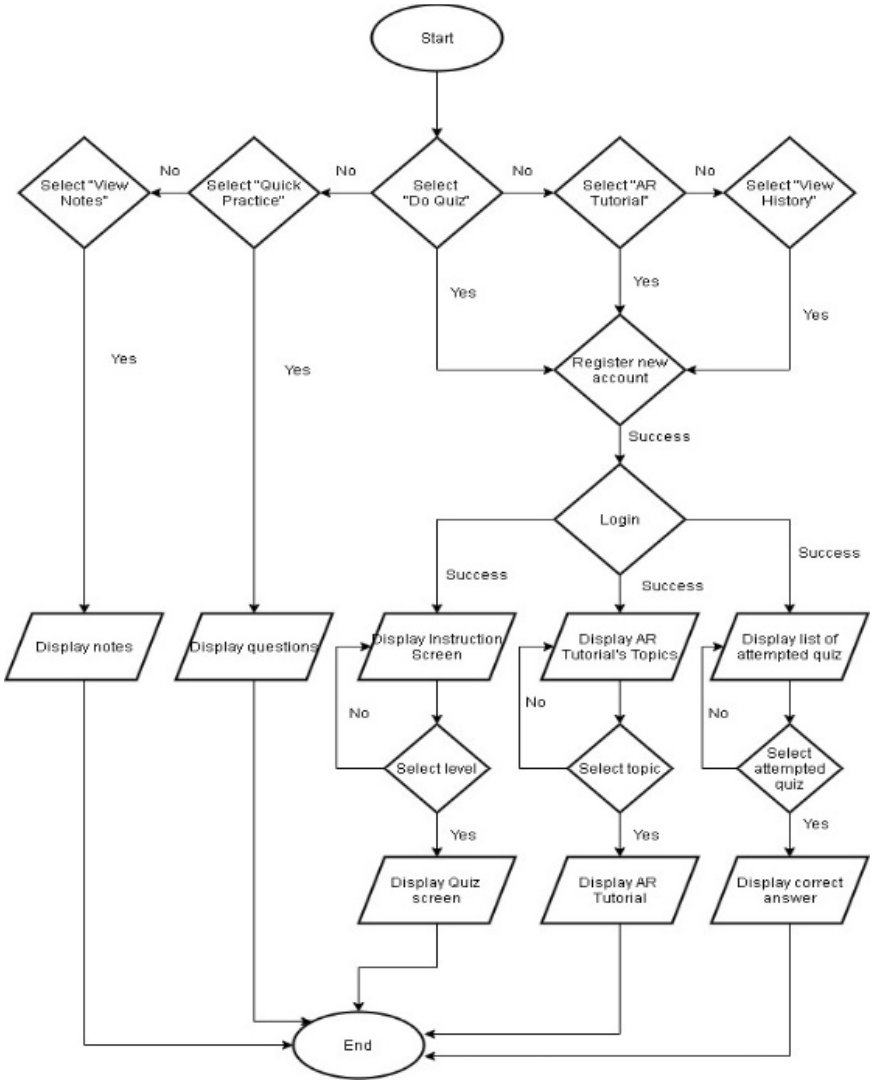

Figure 2: Flow of Processes involved in AR-OOP

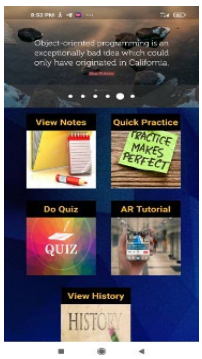

Figure 3: Main Screen of AR-OOP application

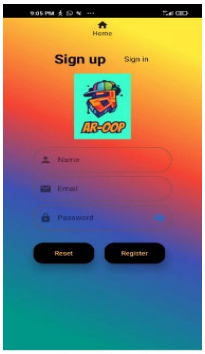

Figure 4: Register Screen of AR-OOP application

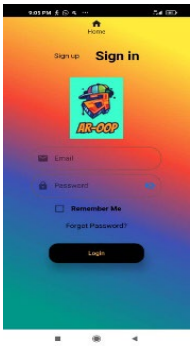

Figure 5: Login Screen of AR-OOP application

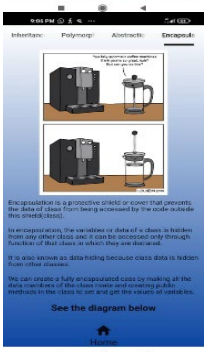

Figure 6: The encapsulation topic of View Notes of AR-OOP application

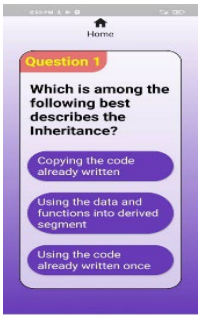

Figure 7: The Attempt Quick Practice Screen of AR-OOP application

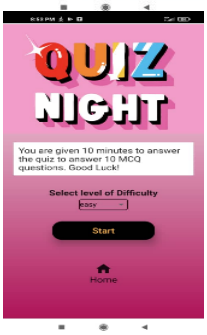

Figure 8: The Instruction Screen of Do Quiz of AR-OOP application

Figure 9: The AR tutorial for Polymorphism concept of Learn AR Tutorial of AR-OOP application

Figure 10: The View History Screen of AR-OOP application

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3. Results and Discussion

An evaluation was conducted on AR-OOP that measured usability, user interface, user satisfaction, and performance. It involved 30 respondents that consisted of 2 instructors, 5 outsiders, and 23 undergraduate students. The respondents were recruited through online chat (WhatsApp) and some of them were voluntaried to participate. The instrument used for the evaluation was a questionnaire. The questionnaire consisted of six (6) sections (Demography of Respondent, Usability, User Interface Evaluation, User Satisfaction Evaluation, Performance, and Recommendation).

The overall results have shown that the majority of the respondents provided a very positive response on the AR-OOP. The usability, user interface, user satisfaction and performance have achieved the average of 92%, 90%, 90.83% and 90% respectively. The results of evaluation are depicted from

Figures 11 to 13. From **Figure 11**, it shows that the 50% of the respondents agreed and 40% of them responded as strongly agreed based on the user interface evaluation of AR-OOP. However, it is depicted that 10% of the respondents think that the user interface still can be improved further. Regarding the user satisfaction evaluation of AR-OOP, from **Figure 12** its shows 50% and 40.83% of the respondents responded to agreed and strongly agreed respectively. Additionally, in terms of its performance (good loading and response time), Figure 13 shows that 55% and 35% of the respondents chose agreed and strongly agreed respectively. However, 4 (or about 13.33%) out of 30 respondents commented that the loading time is not stable and still can be improved further.

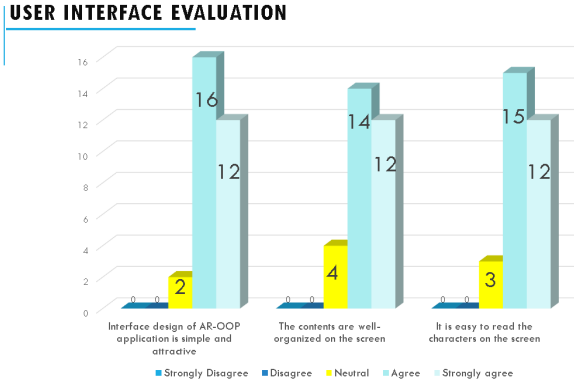

Figure 11: Analysis result on user interface evaluation

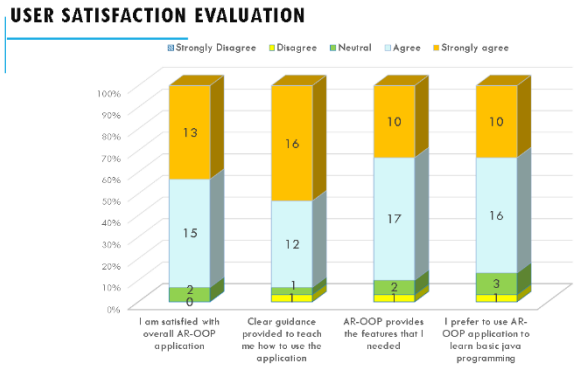

Figure 12: Analysis result on user satisfaction evaluation

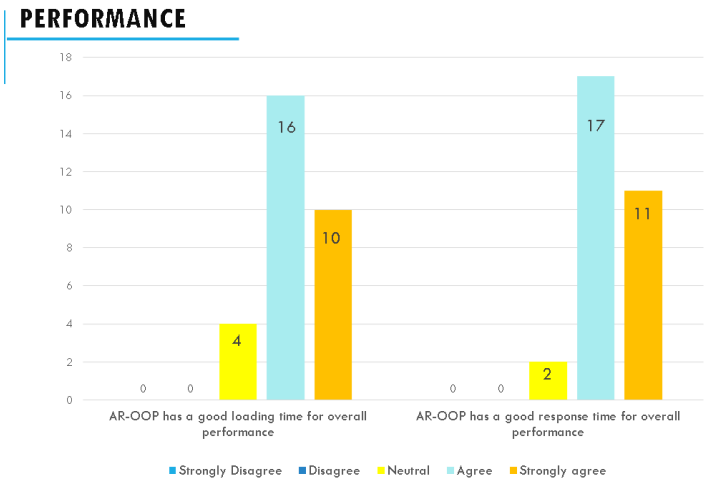

Figure 13: Analysis result on performance evaluation

4. Conclusion

In this study, an Android mobile application that utilizing the technology of AR was developed to provide an immersive learning environment for novice learners to learn the basic concepts of OOP via the interactive visualization. The usability, user interface, user satisfaction and performance of the developed application have been successfully demonstrated. However, based on the responses of some respondents, they suggested that the user interface and performance still can be improved further. As for future works, the AR-OOP can be extended by covering others basic concepts of Java programming such as user-defined classes, GUI, exception handling etc. and AR-OOP can be transformed as a web-based application particularly to resolve the performance issue related to AR learning tutorials.

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