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Integration of Adaptive Game-Based Learning Approach in Learning Mathematics Subject for Primary School

Sung Sheau Hui¹, Dayang N. A. Jawawi² & Nurul N. Jamal³

Faculty of Computing

Universiti Teknologi Malaysia

81310 UTM Johor Bahru, Johor, Malaysia

Email: hui1998@graduate.utm.my¹; dayang@utm.my²; nnazihah27@graduate.utm.my³

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Abstract—Mathematics is useful in everyday life particularly in solving problems. Teaching or having a good understanding in mathematics is challenging as students having different kinds of learning preferences including personalities, interests, learning abilities and needs. This study presents how an adaptive game-based learning can help in improving students' learning mathematic experience while helping them develop an interest in learning mathematic subjects. Adaptive game-based learning provides entertainment and better engagement of the students in learning as most students love to play games during their free time. To evaluate the usefulness of adaptive game-based learning approach towards the students' mathematic learning, an experimental study with 20 primary school students and 1 teacher from SJK(C) Pui Chi was conducted through an integrated application called ALearn. The finding shows most of the students gave positive feedback and agreed that the adaptive game-based learning approach is very helpful and useful in enhancing their learning particularly in mathematics subject.

Keywords—Mathematic Subject, Adaptive Game-based learning, Primary School Students

I. INTRODUCTION

Mathematics is used in everyday life. Every single moment of life requires knowledge of mathematics. No matter where the person is, they will use mathematics skills to solve problems. For instance, mathematics can help the student tell the time, do calculations, spend money, and have better problem-solving skills. So, mathematics is a vital part of the learning for students in early childhood education. More attention should be paid to students in early education, where mathematics will have significant opportunities and options for shaping their future.

However, teaching mathematics is challenging. This is because every student is different. Students have different personalities, interests, learning abilities, and needs. In the past, the teachers used the teaching-centered approach where the teacher was actively engaged in teaching the students. However, this practice has been proven to harm those students with higher or lower abilities. Most teachers now would find a way to distinguish and satisfy every student based on their needs. It is beneficial to the students, but it comes at a cost to the teacher. It is a time-consuming and challenging mission. It is hard to monitor students' learning and engage the students in activities. The major challenges in teaching mathematics are the students' lack of relevant prerequisites, trouble understanding concepts quickly, and a large number of students in the classroom [1].

A certified personal tutor can help a student understand complex concepts particularly in mathematics by tutoring them. The tutor will adjust the lesson flow to accommodate the student's problems and doubts and modify activities at the moment. Imagine that this tutor was always around, ready to assist students anywhere, anytime, and in any situation. Tutoring as an example is referred to as an adaptive learning experience. However, a single tutor can only effectively handle the exact needs of one or two learners at a time. The more students there are, the less a tutor will use their teaching skills to ensure that every student progresses.

Nowadays, adaptive learning technology make this situation become a reality. Adaptive learning aims to provide the best possible learning experience for each student. Therefore, adaptive learning can be defined as an educational technology that offers personalized learning paths to each

student according to their learning abilities and understanding [2]. Besides, game-based learning is a form of gameplay with specific learning objectives. In general, game-based learning aims to strike a balance between subject matter and gameplay. Game-based learning is also an active learning method that can facilitate and encourage student learning motivation. Therefore, with the help of game-based learning in the adaptive system, it will enhance the student's learning motivation. Tsai, Lo and Chen [3] concluded that the adaptive game increases learners' motivation and satisfaction more than the adaptive learning content.

Integrating adaptive game-based learning approach in learning mathematics is believed to improve students' learning experience and attract the student's interest in learning particularly for mathematics subject. Adaptive game-based learning can improve students' learning experiences compared to non-adaptive game-based learning [4]. Also, the adaptive version of each game was more engaging and entertaining to the students than the non-adaptive one. Further, it would help students customize the mathematics learning paths according to each student's understanding and needs. Lastly, it would help to save time for the students in learning mathematics. Thus, there seems to be a great initiative to integrate the adaptive game-based learning approach for learning mathematics. This study proposes to develop an integrated adaptive game-based learning approach into a learning application called Alearn.

II. RELATED WORK

Game-based learning can be defined as "learning that is facilitated by the use of a game" [5]. It is an effective learning tool that can improve student motivation and learning experiences. Game-based learning refers to programs that use video and computer game characteristics to generate engaging and immersive learning experiences for specific learning goals, activities, and experiences [6]. According to Marc Prensky, game-based learning is a more engaging and exciting platform than traditional text-based learning, allowing learners to improve their learning performance. People must create educational games that contain learning content that has been taught in the classroom. The student will spend more time studying in exciting environments, and they will gain experience and learn by conquering hurdles to achieve a winning state [7].

Numerous adaptive game-based learning approach have been designed and integrated into application particularly for mathematics subject, including Doodle Maths [8], Prodigy Math Game [9] and JumpStart Academy Math [10]. Doodle Maths integrated adaptive game-based learning approach to help students from age 4 to 14 to build confidence by tailoring the learning to their strengths and weaknesses. Prodigy Math games integrated game-based learning to drive the students' learning outcomes for math particularly for 6 to 14 year old students. JumpStart Academy Math also provides adaptive math application with game-based learning approach to provide interesting games and individualized activities [11,12]. However, the curriculum delivered through these three applications require a different level of understanding. In

addition, curricula also followed a particular region standard including UK, US, Canadian and Australian.

Even so, there are many valuable features are available that can be used to drive the adaptive game-based learning approach. Few key elements such as uniqueness and immediate feedback, need to be considered to have a better integration of adaptive game-based learning approach as the elements are essential to encourage the students to keep learning [7].

III. EXPERIMENTAL DESIGN

In this study, the adaptive game-based learning approach is integrated into Alearn application to achieve the goal of study. Fig. 1 shows the use case of Alearn application, while Fig. 2 shows the architecture of Alearn application.

Alearn application has only two users, which are students and teacher. All the users need to register an account before starting the learning. The teachers can only manage the class and view the students' learning progress. Meanwhile, for the students, their task is only to go through the learning based on the recommended mathematic topics and view the badges that they have earned during the learning process.

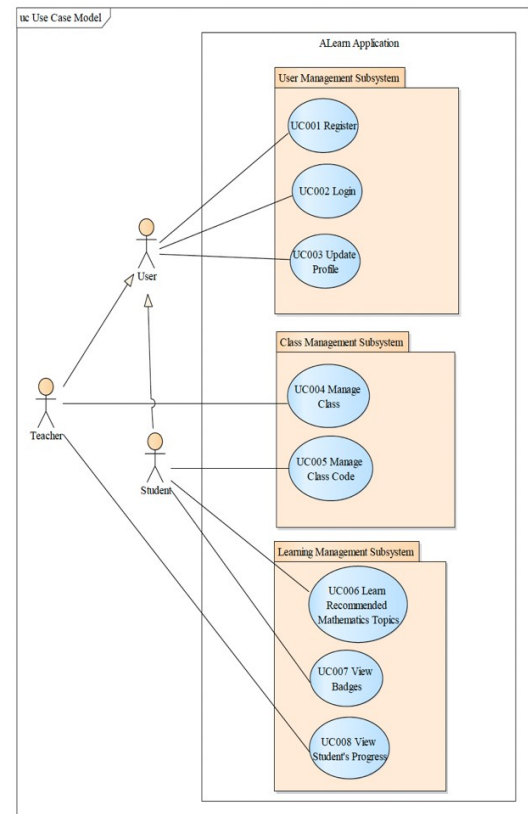


Fig. 1. Use Case of Alearn Application

Through Alearn application, the students begin by receiving the mathematics exercise. The students need to complete the first exercise to alert the decision tree to evaluate their knowledge according to their performance with the exercise taken. With the help of adaptive game-based learning approach (decision tree

technique), the Alearn application will then personalize the next exercise set following the learning path of the students.

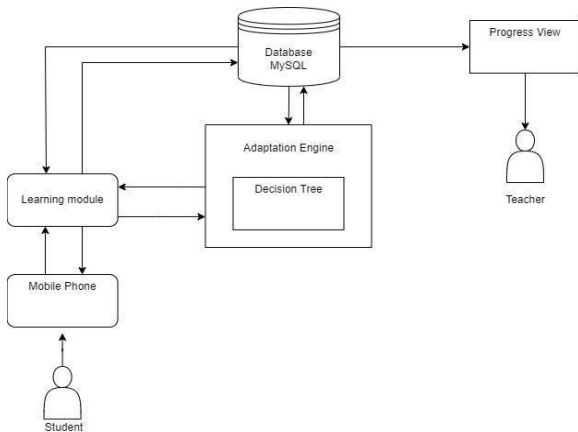


Fig. 2. System Architecture of Alearn Application shows the integration of game-based learning approach.

Fig. 2 shows an example one of the mathematic exercise learning recommended for them. Each exercise provides five questions, and each question has four options to select. The recommendation of the exercise is based on the level of understanding of the students such as easy, medium or hard. The level of understanding is rated based on the achievement result and the time iteration taken by the students for one set.

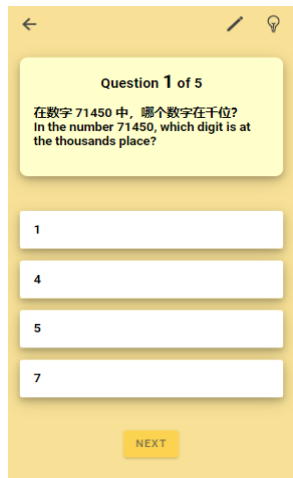


Fig. 3. Interface for student's view

For instance, if a student scores four or more true questions per set, they will progress to the next level of difficulty, excluding the students who are already on the high level, which is hard level. Meanwhile, if the score is less than four true questions per set, the application will track the number of iterations taken by the students; if fewer than two, the application will remain at the same level of difficulty. Meanwhile, if the number of iterations is higher than two, the application will reset the count and offer exercises at one lower

level of difficulty except for easy level, which remains unchanged. Fig 3 shows the decision tree of adaptive game-based learning approach.

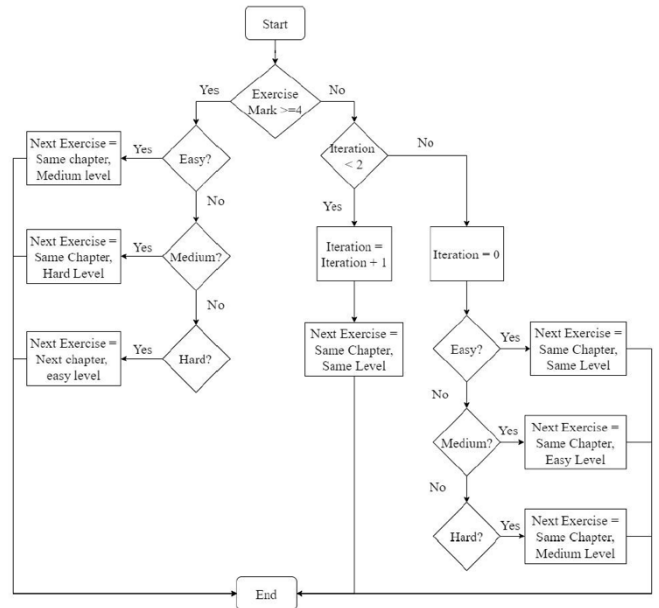


Fig. 4. Decision Tree of Adaptive Algorithm

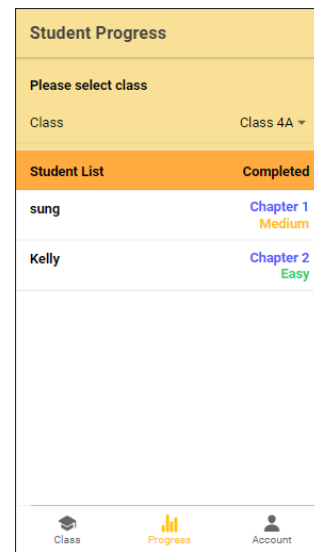


Fig. 5. Interface for teacher's view

Figure 5 shows the other interface that can only be viewed by the teachers. Teachers can view the students' learning progress. It allows the teachers to diagnose and plan the journey of the students in mathematic learning.

IV. RESULT AND DISCUSSION

In measuring the usefulness and helpfulness of the adaptive game-based learning approach integrated in Alearn application, two different kinds of measurement are taken which are:

- a) *Usability testing by completing task* : to test the usefulness of the Alearn application.
- b) *Feedback by using Questionnaires* : to test the helpfulness of the adaptive game-based learning approach towards their learning.

Usability testing involves evaluation of the application’s usability towards the targeted audience. It is typically used to observe the users while the users try to complete the tasks given. Table 1 shows the list of tasks for the students and teachers.

TABLE 1. TASK LIST FOR TEACHERS IN ALEARN APPLICATION FOR USABILITY TESTING

<i>Audience</i>	<i>Task List</i>
Teachers	1 Please register a new account. 2 Please login to the application 3 Please update the user information such as nickname and email address. 4 Please update the account password. 5 Please create a class. 6 Please share the class code with the student. 7 Please update the class information such as the class name. 8 Please view the student’s learning progress. 9 Please delete the class
Students	1 Please register a new account. 2 Please login to the application 3 Please update the user information such as nickname and email address. 4 Please update the account password. 5 Please play the quiz. 6 Please view the badges earned through the quiz. 7 Please insert the class code shared by the teacher. 8 Please delete the class code.

After completing the task, the audience (students and teacher) is needed to give feedback toward the usefulness and helpfulness of the adaptive game-based learning approach integrated through Alearn application via questionnaires wherein a five-point Likert scale is employed, ranging from 5 (signifying “Very Useful”, “Very Helpful”, and “Very Reliable”) to 1 (indicating “Very use-Unfriendly”, “Very Unhelpful,” and “Very Unreliable”). Table 2 shows the percentage of positive feedback by the audience.

TABLE 2. FEEDBACK (%) OF THE STUDENTS AND TEACHERS

Result of Questionnaire (%)		
<i>Reliability of Alearn Application</i>	<i>Helpfulness of game-based learning approach in enhancing students’ understanding in mathematics</i>	<i>User-friendliness of Alearn Application (usefulness)</i>
90.5	90.4	95.2

Based on Table 2, it is shown that more than 90% of students and teacher give positive feedback towards the reliability and user-friendliness of Alearn application and they agreed that the game-based learning approach helps them in enhancing their understanding in mathematics. This demonstrates a positive vote of confidence in ease of use and robustness towards the

integration of adaptive game-based learning approach in Alearn application.

V. CONCLUSION

The integration of adaptive game-based learning approach appears to be a valuable resource in enhancing students’ understanding in mathematics based on the highly positive response (above 90%) from both students and teacher. However, there still exists a thread of validity during this study. The case study used in this study is only focused on the first four chapters of the Malaysia Mathematics textbook for Standard Four (SJKC) and the Alearn application only provides five questions only per exercise due to technical constraints.

In addition, there are few future improvements that can be taken into account including covering all the mathematics for Malaysia standard and increasing the choice of questions to be able to interpret the students’ understanding level more precisely. Despite that, the integration of adaptive game-based learning approach in learning mathematics subjects can be highlighted as a potential approach to contribute positively to the field of educational technology and pedagogy.

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