# AN AUGMENTED REALITY COLORING MOBILE APPLICATION TO IMPROVE CHILDREN'S ENGAGEMENT AND CONCENTRATION IN ENGLISH ALPHABET LEARNING

Siok Yee Tan, Liu Xin Yi

Fakulti Teknologi dan Sains Maklumat, Universiti Kebangsaan Malaysia
43600 UKM Bangi, Selangor Malaysia.

Esther@ukm.edu.my,P110977@ukm.edu.my

## ABSTRACT

*This project is a research paper on the application of AR alphabet learning. With the development of technology and society, AR functions are becoming more and more mature. As a result, many AR applications have been designed as the market changes. The beneficiary population of this project is children, who, due to their young age, are not very attentive and engaged in using educational applications with AR technology. Although AR features can bring novel and interesting experiences to children, how to improve the application of AR technology and increase children's attention and engagement when using AR educational apps for learning has become the main topic of this project.*

*Therefore, this project was developed based on ADDIE's application development model by developing an augmented reality coloring mobile application with the goal of improving children's engagement and attention in learning the English alphabet.*

*First, the project obtained data on the functional requirements for the project development through a questionnaire survey of 66 participants, and designed a prototype after analyzing the required functionality of the application. The development process involved the use of software such as Unity 3D, Easy AR, 3DMAX and Blender. During the implementation and evaluation phase, children's attention and engagement were assessed by conducting usability tests with 39 parents or teachers. Based on the good results obtained in the usability testing, it was shown that the application meets the current usability specifications. Next, in the attention and engagement assessment. The results obtained also performed well, indicating that children were able to maintain good attention and engagement levels while using the application developed in this project.*

*In conclusion, this project combines the novelty and fun of AR features to bring a unique learning experience to children. In addition, it can improve children's attention and engagement. It enriches the development scope of AR children's educational applications and provides references and suggestions for the development of other AR children's educational applications.*

**Keyword:** Android, Early Childhood Education, Augmented Reality, Concentration , Engagement, UKM, Usability Testing

## I. INTRODUCTION

With the development of technology, the cost of AR technology is gradually decreasing and more and more users are becoming familiar with interactive computers and mobile applications. Therefore, the development of classroom applications using AR technology is a topic of interest

because it affects the quality and effectiveness of current early childhood education (Gerasimova, 2019).

Due to the increasing importance of early childhood education in the current social context, many scholars in the field of computing hope to improve the current issues of early childhood education through new AR technologies. However, in their study, Tzima et al. (2019) summarized the problems of AR technology in educational applications through questionnaires and analysis, where the prominent problems are the inability of students to maintain their attention and stay engaged for a long time due to 3D information overload and high content repetition.

For the integration of AR technology with coloring games, Mokhtar et al. (2018) noted in their study that traditional coloring games are a natural activity that keeps children's attention for a long time and allows them to practice and express creativity through interesting content and high frequency of interaction. It has become a major challenge for teachers and parents to combine traditional coloring games with AR technology to gain children's attention to these creative activities.

Secondly, Pan et al. (2021) argued that traditional coloring games can provide more opportunities for children to exercise their creativity and rich coloring content can engage children in creative coloring repeatedly; therefore, how to apply AR technology to coloring games and how to engage children in coloring practices through the combination of traditional coloring games and AR technology is a key issue.

In the process of using AR technology to teach English alphabet, how to properly use AR coloring technology to improve children's attention and participation through games is an important issue and research gap based on the current research context. Therefore in order to respond to these issues. This project aims to improve current preschool technology for children by developing AR coloring applications to improve children's attention span and increase their engagement. This research has important implications for improving current early childhood education and developing AR technology-based methods for teaching English to children.

## II. LITERATURE REVIEW

### *A. The Basic Principle Of Ar Technology*

Augmented Reality(AR) is a technology that superimposes virtual information on the real world. It extends human perception by adding computer-generated visual, auditory, or other sensory information to the real world. AR technology can be traced back as far as the 1960s, when it was

invented by artists Ivan Surridge and Ashtberg (Gerasimova, 2019). However, it was the rise of the mobile Internet and smartphones in the late 1990s and early 2000s that really brought AR to widespread attention and promotion. Since then, AR technology has been widely used in various fields such as education, entertainment, and healthcare (Gerasimova, 2019).

AR technology uses technologies such as cameras, sensors, computer processing and display devices to combine virtual information with realistic scenes, enabling users to see virtual objects that interact with the actual environment for the purpose of enhancing the user experience, improving productivity and solving problems.The theoretical technologies of AR technology include computer vision technologies, sensor technologies, image processing technologies, 3D modeling technologies, the human-computer interaction technology and data storage and processing technology. The continuous development and innovation of these technologies provide a broader space and development prospect for the application of AR technology (Ceuterick, 2021).

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*B. Application Of Ar Technology In The Field Of Education*

In their study, Hsu, (2019) explored the cognitive load, flow states, foreign language learning anxiety, and learning outcomes of students who used AR educational games to assist language learning based on self-directed and task-based learning approaches. The authors provided evidence from previous studies to support their claims and also conducted their own experiments to test their hypotheses. Results showed that students using either the self-directed learning or task-based AR educational game systems had similar and higher learning outcomes, although students using the self-directed learning system showed higher mobility experiences.

Yip et al., (2019) argue that traditional teaching methods are often ineffective for teaching 3D concepts because students may lose interest or miss lessons. AR technology, on the other hand, can be used to provide students with immediate and relevant information, such as videos and 3D images, to facilitate their processing skills and increase their motivation and level of understanding. The results of the test conducted by the authors showed that those students who watched AR videos received higher scores in understanding weaving movements than those who were only given handouts.

Teo et al., (2022) explored the role of teacher immediacy in the AR game-assisted flipped classroom for Asian students' comprehension of English for Medical Purposes (EMP). Second, the authors highlight the potential of AR game-assisted exercises in instantiating real-life scenarios for authentic teacher-student communication and student professional comprehension. This article provides insight into the role of teachers in AR game-assisted flipped classrooms for Asian students' EMP understanding.

Che Dalim et al., (2020) conducted a user study with 120 children from six kindergartens in Malaysia to evaluate the effectiveness of using AR versus non-AR tools for English language instruction and to find out whether combining voice input with AR prompts facilitated non-English speaking children's learning of English names for colors, shapes, and spatial relationships. Results showed encouraging results by using both technologies to create a new instructional strategy that not only increased knowledge gains and enjoyment, but also made certain tasks faster and easier for young children compared to traditional strategies.

Koparan et al., (2023) provide a comprehensive overview of the potential benefits of using augmented reality (AR) technology in mathematics education. The authors provide evidence from various studies demonstrating how AR can be used to increase student engagement and understanding of mathematical concepts. And they propose the development of an AR material for mathematics instruction and use interviews with experts and teachers to explore the effectiveness of such AR materials in developing mathematical skills related to spatial geometry.

### *C. Literature Related To Children'S Concentration And Engagement*

For children, the duration of high concentration varies depending on age, the nature of the task, and individual differences. It is generally accepted that children aged 3 to 4 years concentrate for approximately 8 to 12 minutes, children aged 5 to 6 years concentrate for approximately 10 to 15 minutes, and children aged 7 to 8 years concentrate for approximately 12 to 20 minutes (Can Cappellen et al., 2019). Concentration is not just a single length of time, but also takes into account multiple aspects such as the child's level of focus, duration, and engagement with the task (Can Cappellen et al., 2019). The assessment phase of this project will refer to the study of children's concentration by Can Cappellen et al, (2019).

Slattery et al. (2022) critically evaluated three popular sustained attention training methods, namely cognitive attention training, meditation, and physical activity, to improve sustained attention in children and adolescents. In their study, the authors concluded that cognitive attention training did

not reliably improve sustained attention, whereas physical activity and meditation showed greater potential for improving sustained attention.

For children, high engagement is typically demonstrated by their active participation in an activity or task, showing strong interest and commitment. Among others, initiative, persistence, cooperation, independence and emotional expression are the hallmarks of high engagement (Kucirkova & Kamola, 2022). It is important to note that each child is different and some children may show higher levels of engagement, while others may need more support and guidance to achieve high engagement (Kucirkova & Kamola, 2022). The evaluation phase of this project will refer to Kucirkova & Kamola's child engagement study, (2022).

Soininen et al.'s study, (2023) examined the correlation between teacher-child interaction, teacher work engagement, and children's social competence in first grade classrooms. Results showed that high-quality instructional support was associated with more pro-social behavior and less antisocial behavior in the classroom. In turn, pro-social behaviors were associated with higher quality emotional and instructional support and higher classroom work engagement.

## III. RESEARCH MODEL

This project is based on the ADDIE development model, a systematic model for developing training and education programs that includes five main phases. It includes analysis, design, development, implementation, and evaluation (Bamrara, 2018).

First, this project will investigate the needs of the application after completing the basic needs survey. By analyzing the results of the harvesting, a paper prototype of the application will be designed and then a prototype of the application will be developed. The application prototype will be given to the user for evaluation, and when the evaluation result is good. The development of the mobile application will continue and users will be sought for testing. If the prototype of the application is not well evaluated, then the prototype of the application will be modified until the proposed project is well evaluated. Finally, the application will be implemented and evaluated, which is to determine if the developed project meets the development goals.

### *A. REQUEST FOR INFORMATION*

According to the results of the proposed application demand survey, most of the respondents' families are aware of the early childhood education APP, and 77.27% of them are willing to accept and use the English alphabet of ARAPP. Therefore, the app development for this project has a high

willingness to use. Secondly, most respondents are not willing to let their children use the English alphabet in the AR app independently, and 63.64% of them think their children do not have the ability to use the English alphabet in the AR app independently. Finally, most respondents think the AR English alphabet app has a good interface and is easy to use, and they think the biggest advantage of AR technology in English alphabet learning is that it can attract children and make them understand the content faster.

Based on the above analysis, the application design of this project should focus on graphics and ease of operation. The application design should focus on graphics and ease of operation. It should also allow some children and parents to work together, so it should provide easy operation and family interaction. Secondly, it should focus on user needs and develop instructional content that is easier for children to understand. Among them, good interface and interaction are very important in the application development. And it should ensure that the application of AR technology will not affect children's eyesight, which is also a point of concern for most respondents. The UI design should use cartoon buttons and design style, and the text content should be written and formatted in more standardized English. Finally the design of the application should be between 2-3 color combinations, too many color combinations are not accepted by users.

*B. Interface Design*

According to the previous demand survey. In UI design, the color should be controlled to about three, so the main colors in UI design are red, yellow and gray. Adobe ux was used in the design of the UI prototype, and the development and functional implementation of the UI was carried out in Unity 3D. In the UI design of this application, the main functions such as scene switching, pop-up window, and exit from the application are provided.


*Figure 1 UI design of the proposed application*

*C. Development*

In this project, the AR function is implemented from the use of Easy AR plugin in Unity 3D. Easy AR supports multi-language and multi-platform development, and the programming language is mainly C#. By registering on the official Easy AR website and creating a project, you will be able to obtain the license key for the AR functionality. In fact, the Easy AR plugin provides the ability to add computer vision functionality, allowing users to recognize pictures and objects or to reconstruct environmental content in the real world. easy AR plugin is a client-side library that can be statically integrated into your application. It is available in the Easy AR SDK and supports both iOS and Android platforms. Therefore, using Easy AR plugin can be a good way to implement AR-related app design and production in Unity 3D platform. This project involves the 3D models of 26 English letters and 5 3D models in order to implement the AR coloring function. Among them, the basic 3D models are modeled by Blender. Secondly, in the AR coloring function, it is necessary to UV unfold the 3D models and design the UV material that meets the AR coloring function.

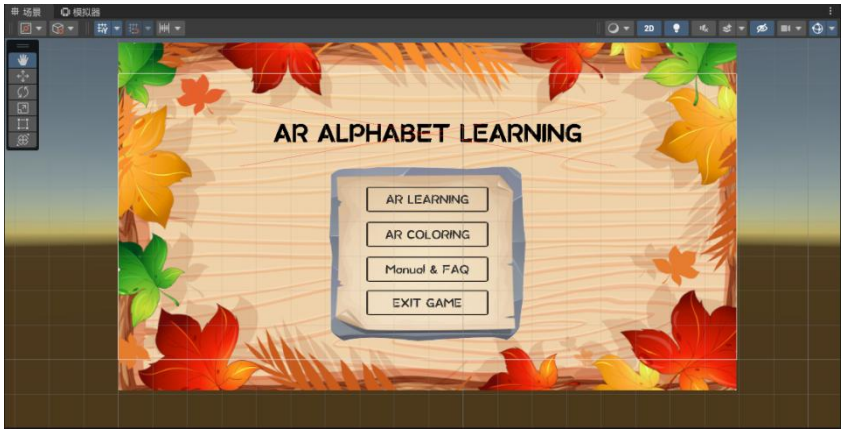


*Figure 2 Main interface of the proposed application*

*D. Usability Testing*

For this testing, 39 testers associated with the program were identified as parents of children or teachers of students. A functional test of the application and a usability questionnaire were also conducted, and test results and testers' feedback were recorded as testers performed the test and answered the questionnaire. In the usability questionnaire, testers were asked to respond to a 5-point Likert scale designed questionnaire. The tests and surveys were conducted with the knowledge and consent of the testers, and the testers' information was kept anonymous during the tests and in the post-survey sample analysis. Thus, the tests and surveys were conducted with the permission and

privacy of the users. In the usability test involving 39 testers, testers' use of and feedback on the AR coloring learning application was recorded for further analysis after the functional test.

In the questionnaire design, the questionnaire was divided into 8 main sections. section A is the basic information of the respondents, section B is the application consistency survey, section C is the application ease of use survey, section D is the application effectiveness survey, section E is the application satisfaction survey, section F is the child attention survey, section G is the child engagement survey, and section H is the user feedback and suggestions.

The six main sections, B, C, D, E, F, and G, are subjective measurement type questions with a five-point Likert scale design, while the last section, H, is descriptive open-ended questions. In the scale questions, SD stands for strongly disagree, D stands for disagree, N stands for normal, A stands for agree, and SA stands for strongly agree.

## IV. RESULTS & DISCUSSION

*Table 1 Basic Information Survey Results*

| Item | Option | Frequency | Percentage |
|---|---|---|---|
| 1. Are you a parent or a teacher? | Parent | 18 | 46.15% |
| | Teacher | 21 | 53.85% |
| 2. What is the gender of your children/Student? | Male | 23 | 58.97% |
| | Female | 16 | 41.03% |
| 3. What is your children/Student's age? | 3-5 | 20 | 51.28% |
| | 6-8 | 19 | 48.72% |
| 4. Has your children/Student used an AR alphabet learning app before? | Yes | 32 | 82.05% |
| | No | 7 | 17.95% |
| 5. Has your children/Student used an AR coloring learning app before? | Yes | 36 | 92.31% |
| | No | 3 | 7.69% |

First, regarding the basic information of the testers in Part A, 46.15 of the users who took this test were the parents of their children and 53.85% were the teachers of their students. Secondly, the male/female ratio of their children/students were 58.97% for boys and 41.03% for girls. And most of the children/students in the test were between 3 and 8 years old. And among the parents/teachers who participated in the test, 82.05% of them they had used AR self-learning learning software, and 92.31% of them had used AR coloring teaching software. This indicates that most of them have experience in using AR applications, so they were able to provide effective feedback on this test and evaluation.

*Table 2 Descriptive analysis results*

| Item | Sample size | Minimum value | Maximum value | Average value | Standard deviation |
|---|---|---|---|---|---|
| 6.The font style in APP， is consistent. | 39 | 3 | 5 | 4.41 | 4.410±0.715 |
| 7.The style of the buttons in the APP is consistent. | 39 | 4 | 5 | 4.385 | 4.385±0.493 |
| 8.The background music style in APP is the same. | 39 | 2 | 5 | 4.282 | 4.282±0.605 |
| 9.AR alphabet learning in 3D model style， is consistent. | 39 | 2 | 5 | 4.333 | 4.333±0.662 |
| 10.The style of coloring cards in AR coloring games is consistent. | 39 | 3 | 5 | 4.308 | 4.308±0.731 |
| 11.APP is not complicated and I can use it skillfully. | 39 | 3 | 5 | 3.821 | 3.821±0.756 |
| 12.The overall functional design of the APP meets my usage habits | 39 | 3 | 5 | 4.436 | 4.436±0.552 |
| 13.I don’t need extra help in using the app. | 39 | 3 | 5 | 4.205 | 4.205±0.695 |
| 14.I can understand the function names， the meaning of the function modules and the operating instructions very well. | 39 | 3 | 5 | 4.282 | 4.282±0.686 |
| 15.I can easily do AR coloring and find exactly the features I need. | 39 | 3 | 5 | 4.385 | 4.385±0.590 |
| 16.For me， APP using 3D as a method to implement teaching is effective | 39 | 4 | 5 | 4.769 | 4.769±0.427 |
| 17.For me， the app is effective in using AR as a way to implement teaching | 39 | 3 | 5 | 4.308 | 4.308±0.863 |
| 18.For me， the overall teaching function of the app is effective | 39 | 3 | 5 | 4.641 | 4.641±0.628 |
| 19.For me， the teaching of the app can meet my need to learn the English alphabet | 39 | 3 | 5 | 4.308 | 4.308±0.731 |
| 20.I was able to get the knowledge of the alphabet I needed from the app | 39 | 3 | 5 | 4.308 | 4.308±0.766 |
| 21.The way the information is presented in the APP is clear and satisfying to me. | 39 | 3 | 5 | 4.462 | 4.462±0.643 |
| 22.The interface design of APP (font，color， layout， etc.) is to my satisfaction | 39 | 2 | 5 | 4.256 | 4.256±0.785 |
| 23.The amount of information taught in the APP is reasonable， not too much or too little. | 39 | 3 | 5 | 4.41 | 4.410±0.677 |
| 24.The overall system failure rate of APP is relatively low. | 39 | 3 | 5 | 4.385 | 4.385±0.711 |
| 25.APP overall use feeling is more satisfactory | 39 | 3 | 5 | 4.385 | 4.385±0.673 |
| 26.Your children/Student is able to maintain attention while using the proposed AR Coloring App. | 39 | 3 | 5 | 4.41 | 4.410±0.637 |
| 27.Your child/student will be able to stay focused for long periods of time while learning with the proposed AR coloring App. | 39 | 3 | 5 | 4.385 | 4.385±0.673 |
| 28.Your children/Student is not easily distracted and interrupted while using the proposed AR Coloring App. | 39 | 3 | 5 | 4.564 | 4.564±0.641 |

| | | | | | |
|---|---|---|---|---|---|
| 29.Your children/Student is able to concentrate on learning tasks when using the proposed AR Coloring App. | 39 | 3 | 5 | 4.333 | 4.333±0.530 |
| 30.Your children/Student is not bored or tired when using the proposed AR Coloring App. | 39 | 3 | 5 | 4.179 | 4.179±0.756 |
| 31.Your children/Student is happy to be involved when using the proposed AR Coloring App | 39 | 4 | 5 | 4.462 | 4.462±0.505 |
| 32.Your children/Student will actively request to use the proposed AR Coloring App. | 39 | 3 | 5 | 4.154 | 4.154±0.630 |
| 33.Your child/student is willing to spend more time learning with the proposed AR coloring App. | 39 | 3 | 5 | 4.513 | 4.513±0.601 |
| 34.Your children/Student is willing to actively explore the teaching and game content of the proposed AR Coloring App. | 39 | 3 | 5 | 4.59 | 4.590±0.549 |
| 35.Your children/Student is willing to share his or her experiences and feelings about using the proposed AR Coloring App. | 39 | 3 | 5 | 4.41 | 4.410±0.637 |

While 90.2% of the testers in the analysis of Part F and Part G showed positive results when testing the attention span of children/students while using the proposed AR coloring app, especially in the responses to question 27, testers generally believed that their children/students were able to achieve prolonged attention spans of 12 minutes or more while using the app. Thus, the proposed app scored highly on the child/student's attention test, indicating that the child/student was able to maintain a high level of attention through the proposed app.

Secondly, in questions 31 to 35 in Section G, these five questions tested children's initiative, persistence, cooperation, independence, and emotional expression. 94.3% of the testers showed positive results in testing children/students' engagement when using the proposed AR coloring app, and the proposed app achieved good results in testing children/students' engagement. indicating that children/students were able to maintain a high level of engagement through the proposed app.

## V. CONCLUSION

The basic functions required for this application have been developed. The main features include AR alphabet learning and AR coloring functions. The AR alphabet learning function of this application showed teaching effectiveness in the test. Secondly, good results were obtained in the children's attention and engagement tests. Therefore, this project found that the combination of the AR coloring game and the AR alphabet teaching application did improve children's attention and engagement in using the proposed application. Therefore, the purpose of this application has been achieved, and it can effectively improve children's attention and engagement in teaching English

using AR. This application is suitable for children to learn English alphabet and entertaining coloring games.

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