Interactive AR Textbook Application For 3M Orang Asli Students in Primary School

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ARTICLE INFO	ABSTRACT
	The impact of technological advancement on the education system, particularly the need for innovation in its use in teaching and learning, is significant. However, the disclosure of a previous study found that a total of 269,332 primary school students across the country were not able to master the basic 3M skills of reading, counting, and writing. Therefore, this study aims to develop an Interactive AR textbook to learn the vowels a, e, è, i, o, and u. Evaluation of the effectiveness of using Interactive AR Textbooks, especially from the design point of view and to user experience and cognitive style in the context of Orang Asli education in the State of Perak. This study uses design-based research (DBR) as design research, which is divided into four phases: Phase I (analysis), Phase II (development), Phase III (evaluation), and Phase IV (documentation). Six experts were selected to verify the application. It was tested for usability and student performance on 62 first-year students among Orang Asli students in the State of Perak. The results revealed that the Interactive AR Textbook can be used to learn vowels a, e, è, i, o, and u based on expert agreement in terms of usability (99%), ease of use (98%), ease of learning (96%), and motivation (100%). Results show that Interactive AR Textbooks can increase motivation for learning Malay vowels, making them beneficial for grade 1 students, teachers, and schools. This application enables the creation of a realistic, authentic, engaging, and entertaining learning environment. This study also acknowledges the limitations and future recommendations of this study.

1. Introduction

Revolution 4.0 education necessitates inventive, competitive, and progressive supplies. In the current educational landscape, the digitization of education is a front-and-centre concern taken in [1,2]. Developing digitally literate students to meet the demands of the digital age and to enable educators and educational leaders to integrate digital technology into the educational ecosystem is a critical objective of the Malaysian Ministry of Education's Digital Education Policy (DPD), which this application helps to realise the research posits [3]. Prior research has supported this point of view

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the instructional and learning capabilities of both students and instructors are enhanced by technological instruments [4]. Moreover, the advancement of the educational system and curriculum is significantly influenced by technological instruments as evidenced by the study [5]. Digital media, including instructional videos, desktop textbooks, augmented reality, virtual reality, and mobile applications, are among the many technological tools that can be implemented in the classroom taken in [6]. Consequently, a comprehensive implementation of this innovation and adaptation trend is highly feasible from the previous study [7].

Academics and educators are placing increasing emphasis on the integration of technological advancements, particularly augmented reality (AR), into learning and facilitation activities (PdPc), as they recognise the significance and advantages of technology in education as stated in the study [8], [9]. Determining the efficacy of augmented reality interactive books in the context of education for Orang Asli people in the state of Perak is thus the objective of this study, with a particular focus on their design, user experience, and cognitive style.

Reading is an activity that contributes to the expansion of one's knowledge. This opinion is supported by this study [10,11]. Rashid [12] discovered a deficiency in comprehension and reading mastery abilities among 161 rural primary school students in Negeri Sembilan, Pahang, and Sarawak, who were in grades 4 and 5 in line with the opinion of the study [12]. Consequently, primary school reading performance continues to endure obstacles. These students fail to comprehend the text's facts and sentence meaning (minimum = 3.24; average = 3.40; standard deviation = 0.71), respectively (sp = 0.60) [13]. Students in Year 1 and a limited number of those in Levels 4 and 5 of primary school continue to grapple with reading fluency, comprehension, and text recognition. The findings of the research revealed [14-16].

The research objectives for this study can be referred to as follows:

1. To identify What are the needs of Interactive AR Textbook for learning vowels a, e, è, i, o, and u from the Bahasa Melayu textbook (KSSR) Grade 1?

2. To develop an engaging Interactive AR Textbook prototype application for vowels a, e, è, i, o, and u look like?

3. To evaluate the usability of the Interactive AR Textbook Prototype Application in terms of content, elements, design, and ease of understanding based on the user's perspective?

4. To find the motivation effect of the Interactive AR Textbook prototype application for 3M skills on students' performance in learning the vowels a, e, è, i, o, and u.

Enhancing students' literacy proficiency is the rationale behind the investigation into the application of augmented reality (AR) technology in the creation of Bahasa Melayu (KSSR) Grade 1 textbooks. Year 1 KSSR primary school students from the Orang Asli 3M community predominantly depend on Malay language textbooks for instructional and reading materials that are specific to the Malay language curriculum. We selected primary school students from the Orang Asli community as our subject matter experts due to our conviction that this phase is crucial for cultivating students' enthusiasm for reading, particularly in relation to acquiring knowledge from diverse academic fields, and for reinforcing their proficiency with 3M. In the current textbook, Orang Asli students are afforded the chance to develop a more profound understanding and acquire expertise in every subject. Regarding the extent to which students' literacy comprehension can be enhanced through its use and reference, how does the textbook impact this ability? A review of the relevant literature indicates that these textbook merits a multifaceted analysis [13].

2. Literature Review

2.1 Technology in Education

Technology applications have become integrated with traditional approaches in the delivery of educational activities. For instance, Indiran *et al.*, [17] identified the difficulty of utilising WhatsApp to teach primary school children in rural Malaysia to read texts at any time and in any location [17]. Through the use of the WhatsApp mobile application, reading instruction and study are facilitated. Consequently, the utilisation of interactive augmented reality textbooks is highly feasible. Early identification of readers at risk averts the onset of illiteracy. Mahyuddin *et al.*, [18] suggests early education for detection and prevention. The findings evaluated 168 first-graders. Learning to evaluate classmates with lower intellectual prowess can be challenging. taken from previous studies, despite the importance of reading in education, 33.8% of first graders lack this skill [18]. Failure to take prompt action and maintain control could potentially exacerbate this situation [4]. Literacy is impacted by mathematical and linguistic obstacles. Primary school students obtain the majority of their reading and learning materials from Malay textbooks. What is the impact of textbooks on students' utility and reliance on them to enhance their literacy skills? Prior studies have recommended approaching this textbook from multiple perspectives as shown in Figure 1 below are taken in [19,20].

Fig. 1. Yuk Mewarnai is an application specifically developed for young children and their teachers. It enables them to (a) capture images of images they wish to color (b) engage in colouring activities that inspire the user's imagination

Interactive AR textbooks enhance the reading comprehension of first-year students in comparison to traditional textbooks as stated in the study [21]. AR is utilised in the classroom to educate students on (PDPC) are taken from previous studies [22,23]. Alpha learners exhibit a preference for interactive materials that incorporate characters, sounds, and motion [1]. Reading, writing, and arithmetic in elementary schools are not enhanced by augmented reality textbooks, in line with the opinion of the study [24,25]. The correlation between young children's intellectual development and the intimate relationship they have with their physical and digital environments through book use is crucial [20]. The study conducted by Saxena et al., also investigated digital cameras, iPads, laptops, desktops, touch displays, audio recorders, YouTube links, and e-books [26]. Students Orang Asli in their first year of elementary school were evaluated in order to ascertain the effects of interactive AR textbooks on reading, writing, and numeracy. They will be more engaged and motivated by augmented reality (AR) interactive textbooks; therefore, the selection of appropriate character designs for the information in these textbooks is crucial. There are numerous

effects of video projection of two-dimensional figures [27]. AR cat symbols, alphabets, and audio will be integrated into interactive textbooks to simulate reading and writing tasks from Malay textbooks [1]. By utilising AR in this learning activity, by means of Figure 2 and 3, students will improve their memory, originality, cognitive ability, inquire, and investigate. The research posits, in addition to art, English, mathematics, and the Quran are also taught using AR technology are taken in [28-30].

Fig. 2. Augmented reality application development by Dreamz Abadi

Fig. 3. Internet prevalence and cheap mobile and handheld devices changed education [31]

2.2 Augmented Reality-AR

Augmented reality (AR) gained significant traction during the 1960s and 1970s due to its establishment by companies in the 1930s for training and visualisation purposes are taken in [32], [33]. Tom Caudell, a researcher at Boeing, coined the phrase "augmented reality" in the 1990s. AR has expanded into disciplines such as education, consistent with the findings of the study [34]. AR can enhance education by combining elements of the virtual and physical worlds to engage and instruct students [35]. Interactive learning, collaboration, and three-dimensional modelling are all promoted by AR in education. The number of studies examining the efficacy and usability of education is expanding globally [36]. Innovative and engaging educational solutions through the prototype development of augmented reality teaching instruments Prototype effects have resulted from modifications in development methodologies in line with the opinion of the study [37].
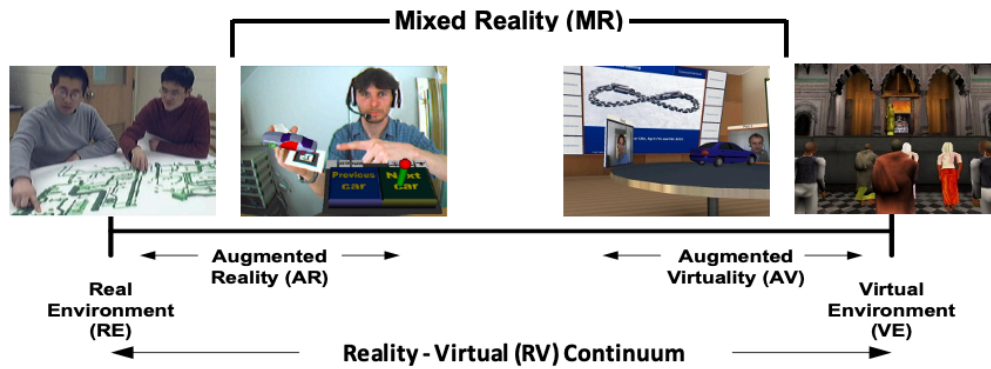
Fig. 4. Virtual continuum – A taxonomic view of Mixed Reality by Milgram

Compiling data from the physical environment with data generated by a computer, augmented reality (AR) is a computer system such as an opinion this study [38,39] in accordance with the illustration presented in Figure 4. An increasing number of studies have been undertaken to track the evolution of augmented reality (AR) in this particular domain as interest in its implementation in the classroom grows globally are taken in [40]. Innovative and dynamic pedagogical approaches that actively engage students in their own education are fostered by the implementation of technology in the classroom [41]. Through fundamentally altering the educational process itself, augmented reality possesses the capacity to transform the education system as it presently exists.

2.3 Augmented Reality in Education

Augmented reality (AR) superimposes sensory input generated by a computer onto live images or video. AR has the capacity to revolutionise education by imbuing teachings with greater relevance and engagement for students. This opinion is supported by this study [42-44]. The are examples of augmented reality applications in the classroom, mentalizing challenging concepts and Augmented reality (AR) has the capability to generate visual representations of complex ideas that are unsuitable for traditional instructional approaches [45-47]. Students can investigate chemical and biological subjects, including molecular structure and physiology, by employing augmented reality (AR) are extracted from previous research [48-50]. The study argues, augmented reality (AR) has the potential to generate life like simulations that offer students beneficial training in a secure setting token [51].

Students are able to simulate a variety of real-world scenarios, including engineering design and surgery, by utilising augmented reality. Augmented reality has the potential to convert conventional textbooks into interactive learning aids, such as an opinion [52]. By means of page scanning in a textbook, for instance, students may acquire a three-dimensional representation of the subject matter that they are engrossed in. Students can experience virtual field excursions to locations they would not otherwise be able to visit by utilising augmented reality [53]. Students can travel to distant planets and ancient ruins through the use of augmented reality. Encouraging students to utilise augmented reality in the classroom can boost their engagement and motivation [54].

Students can engage in a variety of subject-specific educational activities using augmented reality (AR). AR has the capacity to revolutionise education by imbuing teachings with greater student interest and engagement [55]. By means of page scanning in a textbook, for instance, students may acquire a three-dimensional representation of the subject matter that they are engrossed in [56]. Students can experience virtual field excursions to locations they would not otherwise be able to visit

by utilising augmented reality [57]. This opinion is supported by this study, students can travel to distant planets and ancient ruins through the use of augmented reality [58].

Previous studies have supported this view, the implementation of augmented reality in the classroom has the potential to enhance student engagement and motivation are taken in [59]. Students can engage in a variety of subject-specific educational activities using augmented reality (AR). AR has the capacity to revolutionise education by imbuing teachings with greater student interest and engagement [60]. By means of page scanning in a textbook, for instance, students may acquire a three-dimensional representation of the subject matter that they are engrossed in [61]. In light of Figure 5, Students can experience virtual field excursions to locations they would not otherwise be able to visit by utilising augmented reality. Students can travel to distant planets and ancient ruins through the use of augmented reality as stated in the study [62,63].
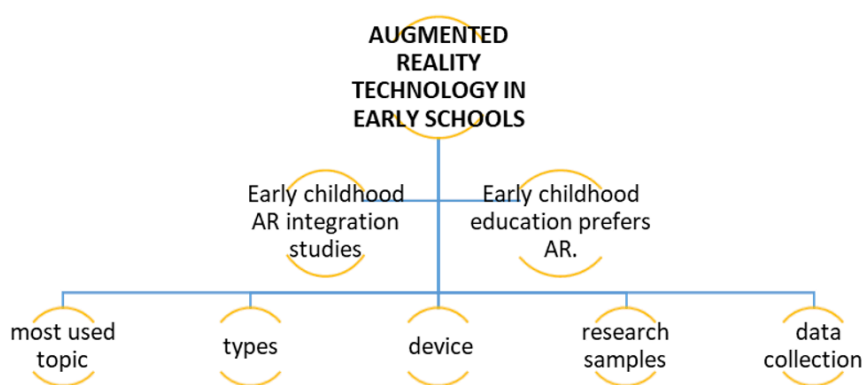

Fig. 5. Augmented reality technology in early childhood AR integration topic study [63]

2.4 Interactive AR Textbook

Interactive AR Textbook is a teaching assistance application (ABM) that integrates augmented reality technology (AR) with printed textbooks. This programme facilitates interactive teaching and learning sessions between students and the Bahasa Melayu Grade 1 textbook (KSSR). During the learning session, the Interactive AR Textbook will serve as a teaching aid (ABM) for the Malay language, guiding the listening and speaking activities of year 1 students' vocal a, e, è, i, o, and u. The Interactive AR Textbook's material focuses on listening to words, phrases, and sentences that contain vowel letters. The Interactive AR Textbook presents visual, audio, and animation of vocal content a, e, è, i, o, and u in accordance with the KSSR syllabus. Students are asked to practice with the Interactive AR Textbook app.

The Interactive AR Textbook application's content comprises the preparation of images, text paths, and vowels a, e, è, i, o, and u across the six pages, as well as video files, animations, and virtual page links. When a smartphone or tablet is scanned with the app's scanner and trigger, extra 2D or 3D layers are displayed. The dynamic AR Textbook enhances and prioritises the use of existing textbooks by transforming them into an interesting and dynamic learning experience in line with the opinion of the study [36,64-66]. This application has assisted and solved the problem of kids with poor mastery of the 3M (reading, writing, and counting) as stated in the study [25,67,68].

Education that is pertinent is crucial for young people. They hold digital learning in high regard, contributing to its development. Text revision is necessary to increase student engagement. Mechanical engineers at Ruse University are reportedly developing an interactive augmented reality textbook concerning advanced tools for blended learning [25]. The utilisation of augmented reality

elevates prose. Mobile devices owned by students facilitate three-dimensional exploration and access to course materials. AR education is integrated into textbooks, taken from previous studies [8,69]. Photographs of textbooks may be utilised by the application to generate item models. Text-graphical "electronic books" are readable on a flat-screen computer or other electronic device. Augmented reality (AR) technology has the potential to produce effective learning aids that augment the visual content of academic textbooks, as stated by Kravtsov *et al.*, [22]. This stimulates children's intellectual capacity and resourcefulness [70]. Figure 6 illustrates, AR-based electronic learning aids are intuitive, engaging, and efficacious for secondary school educators. Apply these digital resources to your studies, both in the classroom and at home. Using AR texts, mother-tongue education is current.
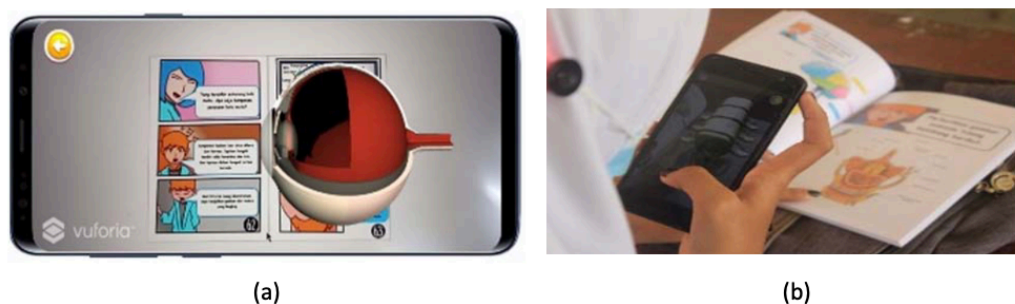

(a)   (b)

Fig. 6. AR with 3D organ graphics (a) Textbook tracker view (b) Students scan instructional content with a mobile phone [71]

The purpose of this research was to determine how Malay language augmented reality books were utilised by primary educators. Damopolii *et al.*, [71] asserts that a significant proportion of augmented reality novels comprise content necessary for natural cognition. It aids the fields of environmental science and education are taken in [71]. Younger readers are assisted in their journey of self-discovery through experiential and knowledge-based education, which involves engagement in group and outdoor activities portrayed in literature. In their article, Polyzou *et al.*, [1] examine kindergartens that utilise both interactive augmented reality and conventional texts. AR and paper textbooks pose challenges for young students. AR touchscreen gestures designed for young children are not appropriate for children who have limited fine motor skills. The inclusion of interactive books enhances the appeal of AR books. Adhering to established norms, extracted from previous research [1,25,72].

Proficient ability is evident in the interpretation of diverse forms of semiotics, encompassing visual, written, and oral multimedia children's books, moving parts, sound, and portents, among others [24]. According to Saforrudin *et al.*, [24], Malay educators held the textbook in high regard, despite the fact that it required some modifications. Instructors should revise Malay texts for educational objectives. As asserted by Zamri *et al.*, [73] a mere 3.4% of Malay educators possess the knowledge that integrating augmented reality (AR) into curricula represents an exceptional approach to augmenting pedagogy [73]. They asserted that augmented reality could be beneficial to education, specifically Malay courses. Augmented reality will serve as an advanced, captivating, and productive educational tool in line with the opinion of the study [74,75].

3. Methodology
3.1 Research Design

Methodology serves as the foundational component of a research investigation. To acquire its findings, each research study employs a distinct methodology. As outlined in the cited sources [76], [77], the researcher employed the Design-Based Research (DBR) methodology. "Engineering research," "formative evaluation," and "development research" are subsets of "design research" that are further classified under this overarching term. At times, scholars in the learning sciences implement designer-based research (DBR), a methodology that has its roots in the field of education. Responses to issues (also referred to as "interventions") are executed during the initial phase of the DBR procedure [78].

Figure 7 illustrates, using design-based research (DBR), the researcher gathered data with the participation and education of Orang Asli students through the implementation of augmented reality (AR) experiences. Researchers identified and resolved any challenges that students might encounter when utilising augmented reality experiences by employing DBR [77]. DBR may be employed by researchers to generate evidence-based recommendations regarding the implementation of augmented reality (AR) interactive textbooks in the classroom. Phase I (analysis), Phase II (development), Phase III (evaluation), and Phase IV (documentation) comprise the design research model utilised in this study, which is design-based research (DBR). A.D.D.I.E. models, Design-Based Research (DBR), and the animation production process can be utilised by educators, researchers, and animators in concert to produce augmented reality (AR) interactive textbooks that are both captivating and efficacious, as evidenced by the study [76].
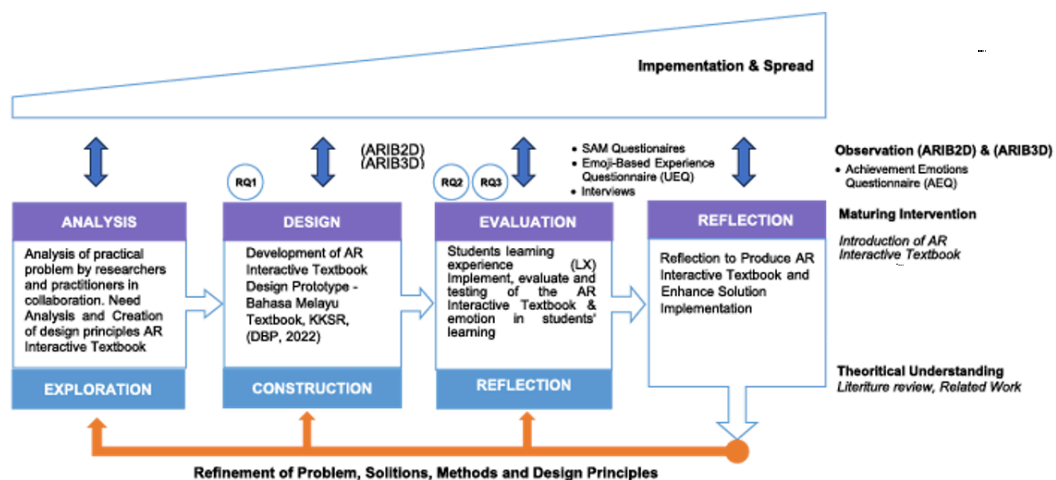

Fig. 7. Relationship between the animation production process and Design-Based Research (DBR)

a. Phase I (analysis): Analysis of the requirements for an Interactive AR Textbook

The researcher assessed the application's suitability to assist Orang Asli students in recognising the vowels a, e, è, i, o, and u as presented in the KSSR Bahasa Melayu textbook Grade 1. Various procedures were employed during this stage to ascertain and label issues. Following problem identification, an analysis is conducted to ascertain the underlying cause or factors associated with the issue. The analysis procedure comprises multiple components:

i. User evaluation of the KSSR Malay Textbook for Grade 1.

ii.   Analysis of 3M learning and achievement

iii. Determine whether a mobile application necessary for acquiring the vowels a, e, è, i, o, and u is required.

During the analysis phase, in light of Figure 8, the researcher thoroughly investigates all facets that must be incorporated during the creation of the Interactive AR Textbook application. Developing software for educational objectives typically entails ongoing collaboration among multiple stakeholders, research, and evaluation of diverse facets. Further consideration should be given to the validity of the content in order to generate an instructional analysis that determines whether the software fulfils the anticipated objectives and competencies. Additionally, interview sessions were conducted to determine whether a mobile application for learning the vowels a, e, è, i, o, and u was necessary.

(a)   (b)

Fig. 8. *Bahasa Melayu* textbook KSSR, (a) textbook cover (b) page 6 topic *Mendengar dan Bertutur*

b.   *Phase II (*development): Design and development of an Interactive AR Textbook
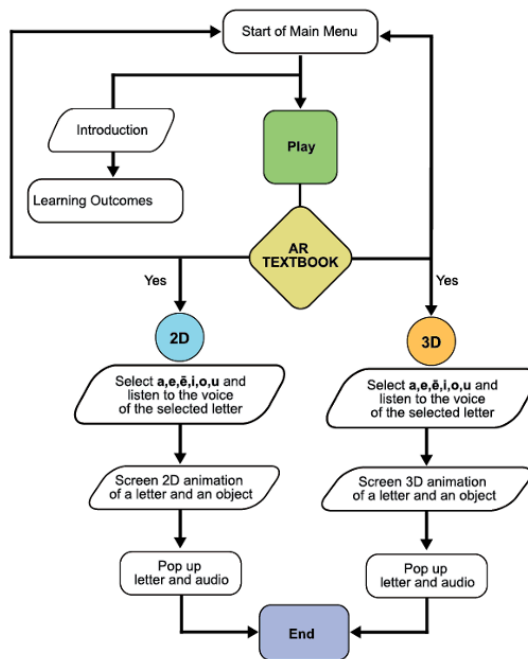
c.

Fig. 9. Flowchart of Interactive AR Textbook

Phase II involved the development of an Interactive AR Textbook. Based on Figure 9, the interactive augmented reality textbook flow of this application was meticulously designed in advance using storyboards. During this stage, the interface design for the Interactive AR Textbook was developed. The development of this application required the use of multiple applications, including Unity, Adobe Illustrator CS6, and Photoshop CS6. This research develops applications utilising the ADDIE Model as an instructional design. Additional research has also implemented the ADDIE model in the development of their educational materials [79]. The Interactive AR Textbook was validated by a panel of ten specialists.

d. Phase III (evaluation): Interactive AR Textbook evaluation

The evaluation of the Interactive AR Textbook constitutes the final phase. The researcher assesses student motivation and efficacy in relation to the application.

3.2 Population and Sample

The experiment involved 62 Orang Asli students, all of whom were seven years old, who were enrolled in a primary school. The study sample comprises respondents who have been specifically chosen to serve as representatives of the population. The researchers investigated the degree to which mobile application-based learning and instruction can benefit both instructors and learners. In conducting this investigation, 62 Orang Asli students were guided by research ethics. Parents were provided with consent forms and subsequently granted permission and agreement for their offspring to partake in the aforementioned study.

3.3 Instrument

Three instruments were utilised in this research: performance evaluations, observation checklists, and interview inquiries. The interview comprised seven inquiries pertaining to the necessity of Interactive AR Textbook applications for vowels a, e, è, i, o, and u learning among primary school Orang Asli students. Then, an observation checklist pertaining to the Interactive AR Textbook's usability was formulated. Student performance in vowels a, e, è, i, o, and u learning is subsequently assessed through performance assessments. The pre-test and post-test consist of 22 questions each, both pertaining to the vowels a, e, i, o, u, and are administered to primary school Orang Asli students. Six experts independently validated each instrument, ensuring that it remained valid and reliable for the purposes of this study.

3.4 Data Analysis

The researcher conducted a number of data analyses, including descriptive and thematic analyses, percentages, agreement percentages, pre-test and post-test scores, a normality test, and a paired sample t-test, in order to address the research questions.

e. Phase IV (documentation): Evaluate the solution and refine it based on feedback

The phases of design are delineated in the Phase documentation by DBR researchers in order to facilitate logical decision-making regarding the selection and application of methods. In addition, they assess the efficacy of the artefacts via summative and formative assessments employing a

combination of qualitative and quantitative methodologies. They refine the artefacts in response to the evaluation results in order to resolve any identified issues and increase their efficacy. In addition to the research questions, design decisions, evaluation methods, and refinement strategies, they conclude by documenting the DBR process. For subsequent research and development endeavours, the documentation is an invaluable resource. Phase documentation of the Interactive AR Textbook Application for 3M Orang Asli Students in primary school may utilise DBR to ensure that the students' learning experiences and emotions are effectively captured.

4. Results

    a.   The needs of Interactive AR Textbook for learning vowels a, e, è, i, o, and u from the Bahasa Melayu textbook (KSSR) Grade 1
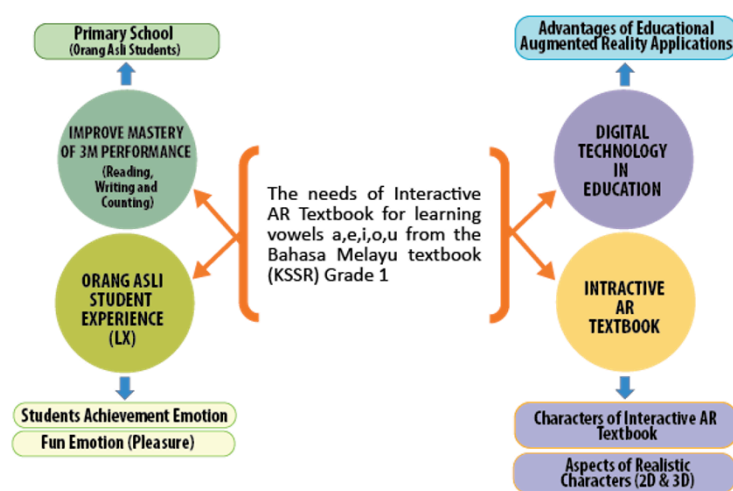

Fig. 10. The need for Orang Asli in Perak primary schools' Interactive AR Textbook prototype

The study's findings indicate that Orang Asli students at Perak State Primary School need to improve their 3M performance (reading, writing, and counting); they also need to use interactive digital technology in the classroom to benefit from educational augmented reality applications; various activities in interactive AR textbooks; and mobile applications that are compatible with learning for Orang Asli students to achieve pleasurable emotions in learning, with a focus on interactive materials derived from augmented reality. A thematic examination of the necessity of Interactive AR textbooks for learning the vowels a, e, i, o, and u involved sixty-two Orang Asli students from Perak State Primary School. Figure 10 presents the analysis's conclusions. The study's conclusions indicate that Orang Asli students enrolled in Perak State Primary Schools require and need digital technology in the classroom, in accordance with the illustration presented in Figure 11, specifically Interactive AR Textbooks to enhance 3M skill mastery and improve learning experiences that are engaging and appropriate for the current curriculum.

Fig. 11. Perak State Primary School Orang Asli students implement an Interactive AR Textbook

b. Development of Interactive AR Textbook prototype

In order to develop an interactive augmented reality textbook prototype, one must initially select various forms of content, including text, video, animation, and 3D models, that are in accordance with the prescribed KSSR Grade 1 Bahasa Malay syllabus, which can be found in Table 1. Determine whether the presentation format is interactive, inert, narrated, linear, or non-linear. Keeping the syllabus unchanged, the content was scaled and quality-controlled to permit AR integration and student accessibility. Interactive games and cards boost student engagement and learning. According to the Interactive AR Textbook design strategy, building AR experiences involves planning, prototyping, coding, revising, and testing AR material on certain platforms and tools.

Table 1
The screenshot of Interactive AR Textbook application

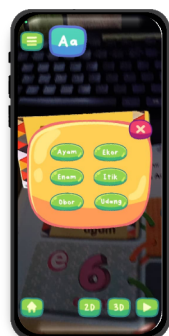| Interactive AR Textbook App screenshot	Justification
Fig. 12. Main page Interactive AR Textbook application	Figure 12 displays the main screen of the Interactive AR Textbook app. There will be another screen after clicking the "Mula" button.
Fig. 13. Menu Vowel option	Figure 13 shows the vowel selection 'menu' *a, e, è, i, o,* and u. This interface is located in the second scene. Each text and graphic in this interface have its own layer. The user needs to select and click on the word *ayam, ekor, enam, itik, obor* or *udang* to change it. As a result, the user has to press the continue button to go to the next section.

Fig. 14. Vowel A section

Figure 14 presents the 'A' vowel selection interface and the chicken display which symbolises the spelling of A to *ayam*. This interface has two-dimension options, which are 2D and 3 dimensions. Each text and graphic in this interface have its own layer in addition to producing the vocal and spelling sounds of *ayam* and crowing chickens. The user has to press on the desired character to change it. The user has to press the continue button to go to the next section.

Fig. 15. Vowel E section

Figure 15 shows the topic's subtopic interface or options. This interface is in the 'E' vowel scene. All text and graphics in this interface have layers. This page offers 2D and 3D possibilities. This interface has layers for each text and visual and produces vocal sounds, spelling sounds of '*enam*', and whistling. Each subtopic has buttons. Clicking takes you to the topic scene.

Fig. 16. Vowel `E section

Figure 16 shows the topic's subtopic interface or options. This interface is in the 'E' vowel scene. All text and graphics in this interface have layers. This page offers 2D and 3D possibilities. This interface's texts and graphics have layers and produce vocal and spelling sounds of '*ekor*' of cat and meowing cat. Each subtopic has buttons. Clicking takes you to the topic scene.

Fig. 17. Vowel I section

The subtopic interface or topic options are shown in Figure 17. This interface is in the 'I' vowel scene. All text and graphics in this interface have layers. This page offers 2D and 3D possibilities. This interface produces vocal noises, spelling sounds of '*itik*' and quacking duck, and layers for each text and picture. Each subtopic has buttons. Clicking takes you to the topic scene.

Fig. 18. Vowel O section

Figure 18 depicts the topic's subtopic interface or options. This interface is in the 'O' vowel scene. All text and graphics in this interface have layers. This page offers 2D and 3D possibilities. This interface features layers for each text and picture and produces vocal and spelling sounds of '*obor*' and torch burn. Each subtopic has buttons. Clicking takes you to the topic scene.

Figure 19 shows the topic settings, or subtopic interface. 'U' vowel scene interface. This interface offers layers for text and graphics. There are 2D and 3D options on this page. Besides the vocal sounds and writing sounds of '*udang*' and water splash, each text and visual in this interface has its own layer. Subtopics have buttons. Clicking navigates to the topic scene.

Fig. 19. Vowel U section

Figure 20 The last section gives appreciation and words of encouragement to users who finish mentioning and complaining about vocal discomfort. Then, the user must press the home button to repeat the activities.

Fig. 20. Aappreciation and encouragement section

c. Usability of the Interactive AR Textbook prototype application

Using the observations of 62 Orang Asli primary school students, the efficacy of the Interactive AR Textbook was assessed. Six teachers observed how the students at Orang Asli Primary School used their applications. Students in the first grade of Bahasa Melayu (KSSR) are allotted a specific time frame to utilise the mobile application. Based on the findings presented in Table 2, it is evident that the Interactive AR Textbook satisfies all the necessary criteria for teaching the vowels a, e, è, i, o, and u, usability (99%), learning simplicity (96%), and motivation (100%). The application's usability yielded favourable results, as evidenced by the data in Table 2. It has been demonstrated that Orang Asli Primary school students in Grade 1 can utilise the application to study the vowel letters a, e, `e, i, o, u for the Malay language subject (KSSR).

Table 2
Results of the observation on the usability of Interactive AR Textbook

	Teacher 1	Teacher 2	Teacher 3	Teacher 4	Teacher 5	Teacher 6	Total level of agreement	Percent of teachers' agreements (%)
Level of agreements								
USEFULNESS								**99**
1. Primary School students like the interface of The Interactive AR Textbook.	3	3	2	3	3	3	9/9	100
2. Primary School students like the colors in The Interactive AR Textbook.	3	3	3	3	3	3	9/9	100
3. The Interactive AR Textbook display is appropriate for Primary School students in learning the vowels *a, e, è, i, o,* and u.	3	3	3	3	3	3	9/9	100
4. Primary School students can read the text in The Interactive AR Textbook easily	3	3	3	3	3	3	9/9	100

5.	Primary School students like the graphic visuals displayed in The Interactive AR Textbook	3	3	3	3	2	3	8/9	88.88
6.	Overall, Primary School students are satisfied with Interactive AR Textbook	3	3	3	3	3	3	9/9	100
	EASE OF USE								**98**
7.	Primary School students can use The Interactive AR Textbook easily.	3	3	3	3	3	3	9/9	100
8.	The link in The Interactive AR Textbook menu works properly for Primary School students.	3	3	3	3	3	3	9/9	100
9.	The organization of learning materials in The Interactive AR Textbook is well-structured for Primary School students.	3	3	3	3	3	3	8/9	100
10.	Primary School students can easily access all the content in The Interactive AR Textbook	3	3	3	3	3	3	9/9	100
11.	The Interactive AR Textbook application has prominent and interactive features with excellent multimedia elements for Primary School	3	3	3	3	2	3	8/9	88.88
	EASE OF LEARNING								**96**
12.	Primary School Orang Asli students can easily understand the learning content in The Interactive AR Textbook.	3	3	3	3	3	3	9/9	100
13.	The topic of each lesson in The Interactive AR Textbook is relevant to the instructional materials.	3	3	3	3	2	3	8/9	88.88
14.	The content in The Interactive AR Textbook is flexible for Primary School Orang Asli students.	3	3	3	3	2	3	8/9	88.88
15.	Primary School Orang Asli students can easily find the source of learning materials provided by teachers.	3	3	3	3	3	3	9/9	100
	MOTIVATION								**100**
16.	Students enjoy the challenge of learning this learning material.	3	3	3	3	3	3	9/9	100
17.	Students enjoy gaining new knowledge.	3	3	3	3	3	3	9/9	100
18.	Students learn more than necessary because I like to learn.	3	3	3	3	3	3	9/9	100
19.	Students are very happy with my progress which makes me enthusiastic to continue learning.	3	3	3	3	3	3	9/9	100
20.	Students look forward to reading more deeply about some subjects because I love them.	3	3	3	3	3	3	9/9	100
21.	When a student's lesson goes well, the student looks very happy.	3	3	3	3	3	3	9/9	100
22.	Students become physically excited when my learning goes well.	3	3	3	3	3	3	9/9	100

Note: Level of agreement (3: Strongly agree, 2: Agree, 1: Disagree)

Interactive AR Textbook is a learning application for mobile devices that functions as a textbook. The use of mobile applications in the classroom has benefits for Orang Asli primary school students. The Interactive AR Textbook promotes the acquisition of the vowel a, e, è, i, o, and u among primary

school students through its interactive design. A robust interface design significantly affects the way in which children interact with touch-screen applications, according to the findings of a number of independently conducted studies. This opinion is supported by this study [80-82]. Additionally, the mobile application's usability is critical in order to assist students in its operation. The multimedia components and prominent, interactive features of the Interactive AR Textbook make it an ideal resource for primary school Aboriginal students. The study argues by Wang *et al.*, and Lee *et al.*, [83,84]. Furthermore, the Interactive AR Textbook exhibits a commendable level of organisation in its compilation of educational resources tailored specifically for Grade 1 Malay Language students in primary school.

Usability of mobile applications also considers ease of learning to be an essential component. An inverse relationship exists between ease of learning and both user satisfaction and adoption rates. Furthermore, user satisfaction with the interactive augmented reality textbook is critical. Al-Basumatary et al. corroborated this notion, asserting that user satisfaction serves as the primary factor influencing both loyalty and the propensity to recommend this particular application to others absorb by Basumatary *et al.*, [5].

Consistent with the findings of Jdaitawi *et al.*, [85] the outcomes of this research demonstrate that learning and hand-eye coordination are enhanced when fine psychomotor skills are integrated with conceptual understanding [85]. Moreover, the results of this research align with those of AlNajdi *et al.*, [60] and Chang *et al.*, [87] which indicate that the adoption of technological tools in education has increased due to the gradual transition from traditional textbooks and instructional videos to digital-based media, including educational games, electronic textbooks, and instructional videos. This study provides support for this view [86,87]. As a result, it can be deduced that the Interactive AR Textbook application is beneficial in all respects and has the potential to assist Orang Asli in primary schools in enhancing their 3M mastery of vocal learning.

2.1 Student Performance

In 62 Orang Asli primary school grade 1 Malay-learning pupils, the pre- and post-tests were given. An examination of 62 Orang Asli kids at a school in the State of Perak, both before and after the test, is shown in Figure 21. Positive progress is shown in the pre- and post-test findings. In the post-test, every one of the 62 pupils demonstrated improvement over the pre-test response. Conducting a normality test to confirm that the data is normally distributed is necessary before moving forward with the paired sample t-test analysis of the study hypothesis. For the normalcy test in this investigation, the Shapiro-Wilk test was utilised. For both pre- and post-test data, Table 3 displays the results of the Shapiro-Wilk test. The pre-test has a significance of 0.595 and the post-test has a significance of 0.948 according to the Shapiro-Wilk results. An analysis of the data's overall distribution to determine whether it deviates from a similar normal distribution is done using the Shapiro-Wilk test. If there is no significant difference between the sample distribution and the normal distribution ($p > 0.005$), the test is considered non-significant. Indicating that the data are normal, the Shapiro-Wilk test value is higher than 0.05. Consequently, it is decided to reject the null hypothesis. This leads to a normally distribution of the pre-test and post-test data in this investigation. The study hypothesis was examined using a paired sample t-test after the data's normal distribution was confirmed. To investigate H0 and H1, two hypotheses, the paired sample t-test method was employed. As stated at the outset of the investigation, the null hypothesis (H0) states that there is no significant change in student performance between before and after utilising the Interactive AR Textbook. The research hypothesis is to determine whether or not this study will accept or reject H0.

In this investigation, 0.05 is the confidence threshold. The hypothesis H0 is rejected if the obtained confidence level is greater than 0.05.

Table 3
Shapiro-Wilk Test

Shapiro-Wilk	Statistic	df	Sig.
Pre-Test Score	0.975	62	0.595
Post-Test Score	0.986	62	0.948

Table 4
Mean and standard deviation

	N	Min	Standard Deviation
Pre-Test	62	57.94	14.721
Post-Test	62	78.13	12.447

The pre-test mean is 57.94, and the post-test mean is 78.13, according to paired sample statistics, as indicated in Table 4. Table 5 displays the significant value less than 0.05 for the paired sample t-test result, which is t = 14.721, p = 0.000. Consequently, it is decided to reject the null hypothesis. Results demonstrate how using The Interactive AR Textbook greatly raised student performance. Student proficiency with the alphabet is enhanced via interactive AR textbooks. As stated by Düzyol *et al.,* mobile applications can support Orang Asli students' elementary school 3M learning. This study supports their findings [7]. Furthermore, mobile applications can aid in raising student performance [88]. Bonilla *et al.,* [89] have highlighted several benefits of utilising mobile applications for education, including cost and time savings, increased accessibility, and increased interest, consistent with the findings of the study [89].

Table 5
Paired Sample Test

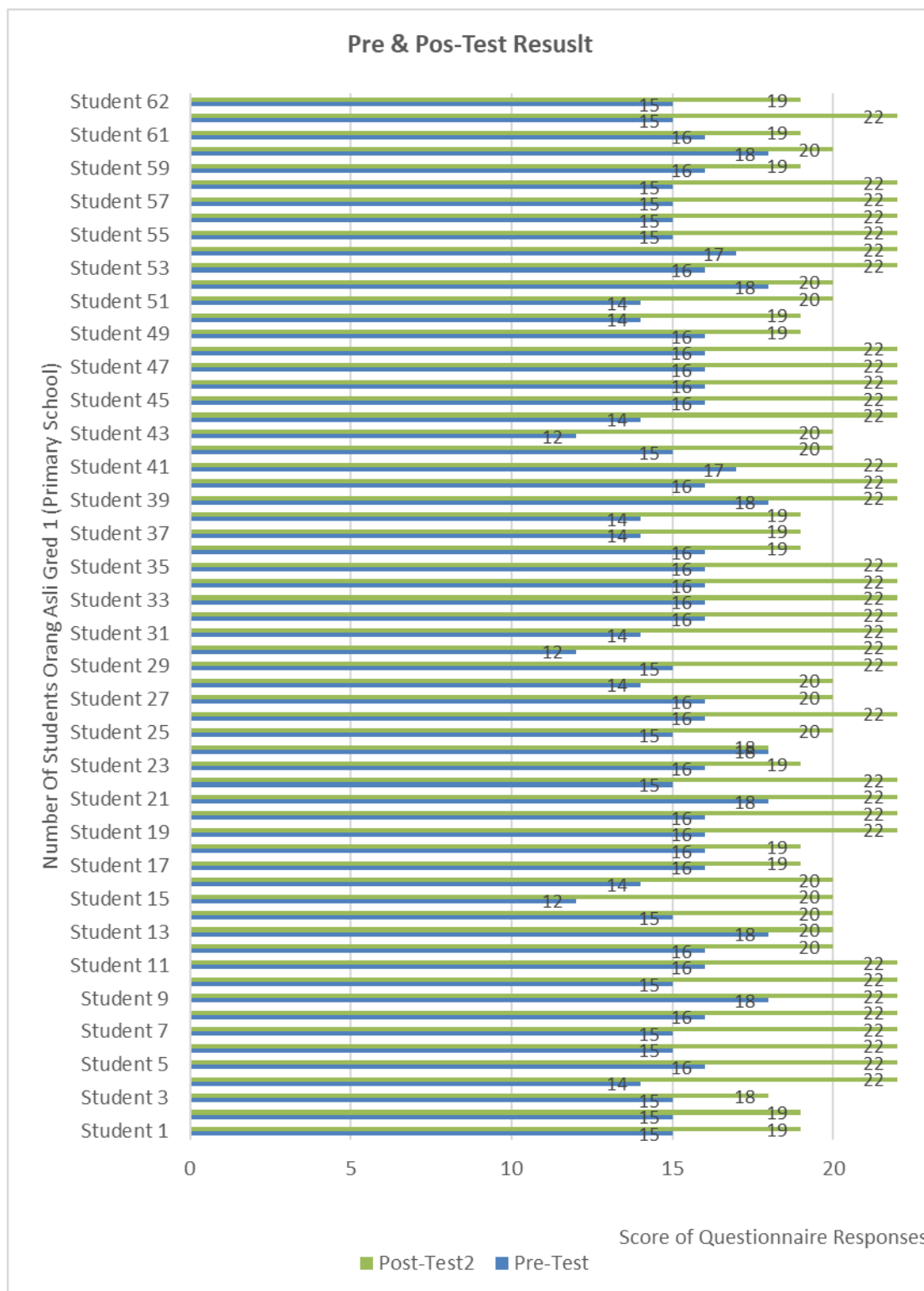|	Paired Differences					t	df	Sig. 2-tail
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the				
				Lower	Upper			
Pre-Test Score Post-Test Score	12.771	5.694	0.962	10.816	14.727	13.271	60	0.000

Fig. 21. Results of the pre-test and post-test of the Interactive AR Textbook for each student

2.1 Motivation of Orang Asli Student

A total of seven questionnaire items were examined by knowledgeable teachers on student motivation while using the programme, and practically all of them received excellent comments. There is a clear indication that students take pleasure in the difficulty of studying this content.

Because they have a passion for learning, they are always acquiring new information and learning more than what is needed of them. Additionally, it appears that the students are quite pleased with the progress they have made in recognising and pronouncing the vowel a, e, i, o, and u, which motivates them to continue their education as illustrated in Figure 22. Students are also noticed to be interested in reading more extensively about certain pages from the Malay language textbook that serves as the application. This is something that can be observed. As the learning process progresses, they experience a surge of bodily excitement.

The Interactive AR Textbook has a substantial impact on student performance, as indicated by the findings. Consistent with the results of prior, this discovery demonstrates that technology possesses the capacity to enhance academic performance and inspire students to acquire new knowledge, consistent with the findings of the study [85,90,91]. Further, students demonstrated considerable enthusiasm for mobile application-based ABC alphabet learning sessions. Learning activities are designed to encourage independent exploration and discovery, which is a preference of preschoolers. The disparity in scores between the pre-test and the post-test indicates that the use of the mobile application resulted in a higher score discrepancy than the initial score. This study provides support for this view, concerning the use of technology in the classroom, the study's findings are also consistent with those of Kwok *et al.,* [92], Özeren *et al.,* [88] a widely acknowledged viewpoint that technology enhances students' motivation and engagement with Malay textbooks (KSSR) and facilitates their learning [88,92].

Fig. 22. Orang Asli Primary School students in Perak are overjoyed with the Interactive AR Textbook

5. Limitations and Future Enhancements

Several limitations apply to this investigation. Initially, the content is limited to the subtopic of vowel comprehension, specifically a, e, i, o, and u. Further research could be conducted to explore the evolution of mobile applications designed for children, with the inclusion of supplementary subjects like the reading of longer essays, which would serve to enhance the practical skills of young children. A second limitation of this investigation is the small sample size. Respondents for future studies may be selected from a variety of groups. Primary school students from levels 1 and 2 may participate in the survey. By expanding the study's scope or incorporating additional groups, the conclusions will have a more comprehensive and high-quality nature. Functionally, the mobile application utilised in this research has its own set of limitations. Due to this circumstance, mobile applications are incomplete and have restricted functionality. Consequently, further functionalities may be integrated into this mobile application in subsequent iterations.

6. Conclusions

Orang Asli children who are enrolled in primary schools benefit from The Interactive AR Textbook in terms of both their comprehension and their motivation to acquire vowel a, e, i, o, and u. Additionally, the findings of this study demonstrate that a mobile application that is based on augmented reality has the potential to be utilised as one of the most effective learning aids in order to enhance the comprehension of Orang Asli students about two-dimensional or three-dimensional design and animation. When it comes to teaching vowels a, e, i, o, and u, this study came to the conclusion that the combination of teaching delivery and facilitation methods with the utilisation of mobile applications is more effective than the traditional teaching methods. Through the implementation of the Interactive AR Textbook approach, a total of 62 Orang Asli children attending a primary school in the state of Perak shown significant improvement in their academic performance. Despite the fact that they are updated with the most recent technology, Bahasa Melayu textbooks continue to serve as the primary reference for learning. Because of this, other researchers in the future can use this study as a guide and reference to help them with their own research.

References

[1] Polyzou, Stamoulia, Kafenia Botsoglou, Nikolaos, C. Zygouris, and George Stamoulis. "Interactive books for preschool children: from traditional interactive paper books to augmented reality books: listening to children's voices through mosaic approach." *Education 3-13* 51, no. 6 (2023): 881-892. https://doi.org/10.1080/03004279.2021.2025131

[2] Malik, Mohd Azry Abdul, Nur Izzatulsyimah Madzuki, Nur Syahidah Shahnirul Hizam, Nuramanina Husna Shamsul Kamal, Nur Syaliza Hanim Che Yusof, Mohd Faiez Suhaimin, and Siti Nurani Zulkifli. "Teachers' Readiness and Practices in School-Based Assessment Implementation: Primary Education in Malaysia." *International Journal of Advanced Research in Future Ready Learning and Education* 23, no. 1 (2021): 1-9.

[3] Sharma, Priya. "Digital revolution of education 4.0." *International Journal of Engineering and Advanced Technology* 9, no. 2 (2019): 3558-3564.https://doi.org/10.35940/ijeat.A1293.129219

[4] Kurniasih, Eem, Barokah Widuroyekti, and Lusi Rachmiazasi Masduki. "Implementation of Augmented Reality-based thematic elementary school textbooks to improve students' literacy skills." *Pegem Journal of Education and Instruction* 13, no. 4 (2023): 379-387. https://doi.org/10.18502/kss.v7i14.12057

[5] Basumatary, Dipali, and Ranjan Maity. "Effects of Augmented Reality in Primary Education: A Literature Review." *Human Behavior and Emerging Technologies* 2023 (2023). doi: 10.1155/2023/4695759. https://doi.org/10.1155/2023/4695759

[6] Wen, Yun, Longkai Wu, Sujin He, Nathanael Hsien-Ern Ng, Beng Chong Teo, Chee Kit Looi, and Yiyu Cai. "Integrating augmented reality into inquiry-based learning approach in primary science classrooms." *Educational technology research and development* 71, no. 4 (2023): 1631-1651.https://doi.org/10.1007/s11423-023-10235-y

[7] Düzyol, Endam, Günseli Yildirim, and Güzin Özyilmaz. "Investigation of the effect of augmented reality application on preschool children's knowledge of space." *Journal of Educational Technology and Online Learning* 5, no. 1 (2022): 190-203. https://doi.org/10.31681/jetol.976885

[8] Casteleiro-Pitrez, Joana. "Augmented reality textbook: A classroom quasi-experimental study." *IEEE Revista Iberoamericana de Tecnologias del Aprendizaje* 16, no. 3 (2021): 258-266.https://doi.org/10.1109/RITA.2021.3122887

[9] S. Naw and A. Hkyeng, "AUGMENTED REALITY TEXTBOOKS Thet Thet Aung , H Seng Naw Aung," no. December, 2021, https://doi.org/10.18502/kss.v7i14.12057

[10] Balanadam, Jayaganes, and Khairul Azhar Jamaluddin. "Isu dan Cabaran dalam Kemahiran Membaca Dikalangan Murid Sekolah Rendah di Malaysia." *Jurnal Dunia Pendidikan* 3, no. 4 (2021): 127- 135. https://doi.org/10.18502/kss.v7i14.12057

[11] K. Jamaludin, "Isu dan Cabaran Dalam Kemahiran Membaca Dikalangan Murid Sekolah Rendah di Malaysia," Jurnal Dunia Pendidikan, no. December 2021, 2021, doi: 10.55057/jdpd.2021.3.4.11. https://doi.org/10.55057/jdpd.2021.3.4.11

[12] Abdul Rashid Jamian, "Permasalahan Kemahiran Membaca Dan Menulis Bahasa," Jurnal Pendidikan Bahasa Melayu, vol. 1, no. 1, pp. 1-11, 2011.

[13] Masnan, Abdul Halim, Siok Peh Seah, and Azila Alias. "Aplikasi Digital Didik Hibur 3M murid Orang Asli Sekolah Rendah." (2021): 27-32., https://www.researchgate.net/publication/356439339

[14] A. Haimi *et al.,*"The formal education of Malaysian 'Orang Asli' and views of Orang Asli teachers," 2020. [Online]. Available: https://www.researchgate.net/publication/354705066

[15] Adnan, Airil Haimi Mohd, Mohamad Safwat Ashahri Mohd Salim, Mohd Haniff, Mohd Tahir, Dianna Suzieanna Mohamad Shah, and Ahmad Muhyiddin Yusof. "Educating the 'Orang Asli'(native people) of Malaysia in the eyes of Orang Asli teachers." *Journal of Academic Research in Business and Social Sciences* 11, no. 9 (2021): 717-731. https://doi.org/10.6007/IJARBSS/v11-i9/11061

[16] Jumaat, Nurul Farhana, and Dayang Tiawa Awang Hamid. "ICT dalam pendidikan anak-anak Orang Asli di Sekolah-Sekolah Rendah." PhD diss., Universiti Teknologi Malaysia, 2010.

[17] Indiran, Dinesiriy, Hanita Hanim Ismail, and Radzuwan Ab Rashid. "Exploring opportunities and challenges of using WhatsApp in teaching reading: A Malaysian rural primary school context." *Creative Education* 13, no. 5 (2022): 1689-1709. https://doi.org/10.4236/ce.2022.135107

[18] Mahyuddin, Rahil, and Habibah Elias. "Reading and Literacy Skills among Children in the Early School Years." *The International Journal Of Interdisciplinary Social Sciences.* 3 (2008). https://doi.org/10.18848/1833-1882/CGP/v03i03/52554

[19] Zakaria, Marmi Mariana, and Dahlia Janan. "Penggunaan buku teks dan penerimaan ilustrasi dalam kalangan guru dan murid: pendekatan kualitatif dan kuantitatif." *Journal Of Research, Policy & Practice Of Teachers And Teacher Education* 12, no. 1 (2022): 80-98. https://doi.org/10.37134/jrpptte.vol12.1.6.2022

[20] Mayrendra, Ronan Rizky, and Bhanu Sri Nugraha. "Perancangan Buku Mewarnai Interaktif Berbasis Teknologi Augmented Reality Dengan Unity Region Capture." *Jikom: Jurnal Informatika dan Komputer* 13, no. 1 (2023): 10-17.https://doi.org/10.55794/jikom.v13i1.94

[21] N. Haida, S. N. Sha, and I. Y. Azian Nor, "Keberkesanan Penggunaan Buku Teks Bahasa Malaysia (KSSR) Sekolah Rendah," pp. 49-56, 2016.

[22] Kravtsov, Hennadiy, and Anastasiia Pulinets. "Interactive Augmented Reality Technologies for Model Visualization in the School Textbook." In *ICTERI Workshops*, pp. 918-933. 2020.

[23] Eleftheriadi, A., K. Lavidas, and V. Komis. "Teaching mathematics in early childhood education with ICT: The views of two contrasting teachers' groups."*Journal of Digital Educational Technology* 1, no. 1 (2021): 1-10. https://doi.org/10.21601/jdet/11117

[24] Saforrudin, Norabeerah, Halimah Badioze Zaman, and Azlina Ahmad. "Pengajaran masa depan menggunakan teknologi Augmented Reality dalam pendidikan Bahasa Melayu: Tahap kesedaran guru." *Jurnal Pendidikan Bahasa Melayu* 2, no. 2 (2016): 1-10.

[25] Ivanova, Galina, Yuksel Aliev, and Aleksandar Ivanov. "Augmented reality textbook for future blended education." In *International Conference on e-Learning*, vol. 14, pp. 130-136. 2014.

[26] Saxena, Anika, and K. F. T. Hew. "Using ict in early childhood: what teachers, principals, and parents say." In *International Conference on Computers in Education. Asia-Pacific Society for Computers in Education*. 2016.

[27] Kinasevych, Orest. "The Effect of Culture on Online Learning." *Online Submission* (2010)., doi: 10.34293/education.v11iS1-July.6203. https://doi.org/10.34293/education.v11iS1-July.6203

[28] J. Casteleiro-pitrez, "Buku Teks Realiti Diperkukuh : Bilik Darjah Kajian Kuasi Eksperimen," vol. 16, no. 3, pp. 258-266, 2022.

[29] So'ad, Siti Nur Amierah Mohd, and Mohd Norasri Ismail. "Development of Augmented Reality-based Color Learning Application for Pre-school." *Applied Information Technology And Computer Science* 3, no. 1 (2022): 94-112. doi: 10.30880/aitcs.2022.03.01.007

[30] Wang, Xiangyu. "Augmented reality in architecture and design: potentials and challenges for application." *International journal of architectural computing* 7, no. 2 (2009): 309-326. doi: 10.1260/147807709788921985. https://doi.org/10.1260/147807709788921985

[31] Sulaiman, Adel, Hameedur Rahman, Numan Ali, Asadullah Shaikh, Muhammad Akram, and Wei Hong Lim. "An augmented reality PQRST based method to improve self-learning skills for preschool autistic children." *Evolving Systems* 14, no. 5 (2023): 859-872. https://doi.org/10.1007/s12530-022-09472-y

[32] G. Kipper, "What Is Augmented Reality?," Augmented Reality, pp. 1-27, 2013, https://doi.org/10.1016/B978-1-59-749733-6.00001-2

[33] J. Kartawidjaja, "sejarah augmented reality," Orphanet J Rare Dis, vol. 21, no. 1, 2020.

[34] Azuma, Ronald T. "Making augmented reality a reality." In *Propagation Through and Characterization of Atmospheric and Oceanic Phenomena*, pp. JTu1F-1. Optica Publishing Group, 2017. https://doi.org/10.1364/3D.2017.JTu1F.1

[35] Bolter, Jay David, Maria Engberg, and Blair MacIntyre. *Reality media: Augmented and virtual reality*. MIT Press, 2021. https://doi.org/10.7551/mitpress/11708.001.0001

[36] S. Rukmani and M. Vasimalairaja, "Augmented Reality in Classroom," no. April, 2021, [Online]. Available: https://www.researchgate.net/publication/351096007_AUGMENTED_REALITY_IN_CLASSROOM

[37] S. Faramarzi and J. D. Dayag, "Augmented Reality and Virtual Reality," no. May, pp. 166-189, 2023, https://doi.org/10.4018/978-1-6684-8282-7.ch007

[38] Furht, Borko, ed. *Handbook of augmented reality*. Springer Science & Business Media, 2011. https://doi.org/10.1007/978-1-4614-0064-6

[39] A. B. Craig, Mobile Augmented Reality. Elsevier Inc., 2013. https://doi.org/10.1016/B978-0-240-82408-6.00007-2

[40] Kholiq, Abd. "Development of BD F-AR 2 (physics digital book based augmented reality) to train students' scientific literacy on global warming material." *Berkala Ilmiah Pendidikan Fisika* 8, no. 1 (2020): 50-58. https://doi.org/10.20527/bipf.v8i1.7881

[41] Lampropoulos, Georgios, Euclid Keramopoulos, Konstantinos Diamantaras, and Georgios Evangelidis. "Integrating augmented reality, gamification, and serious games in computer science education." *Education Sciences* 13, no. 6 (2023): 618. https://doi.org/10.3390/educsci13060618

[42] Maulana, Iwan, Nunuk Suryani, and Asrowi Asrowi. "Augmented reality: solusi pembelajaran ipa di era revolusi industri 4.0." *Proceedings of the ICECRS* 2, no. 1 (2019): 19-26. https://doi.org/10.21070/picecrs.v2i1.2399

[43] Daniel, A. "Enhancing pupil engagement and learning through augmented reality-based interactive phonetics education." *World Journal of Advanced Engineering Technology and Sciences* 9, no. 1 (2023): 260-271. https://doi.org/10.30574/wjaets.2023.9.1.0131

[44] Kaliraj, P., and Devi Thirupathi, eds. *Innovating with augmented reality: applications in education and industry*. CRC Press, 2021. https://doi.org/10.1201/9781003175896

[45] Hossain, Mohammad Jaber, and Towfik Ahmed. "Augmented reality-based elementary level education for bengali character familiarization." *SN Computer Science* 2, no. 1 (2021): 31. https://doi.org/10.1007/s42979-020-00402-w

[46] Bimber, Oliver, and Ramesh Raskar. *Spatial augmented reality: merging real and virtual worlds*. CRC press, 2005. https://doi.org/10.1201/b10624

[47] Nincarean, Danakorn, Mohamad Bilal Alia, Noor Dayana Abdul Halim, and Mohd Hishamuddin Abdul Rahman. "Mobile augmented reality: The potential for education." *Procedia-social and behavioral sciences* 103 (2013): 657-664. https://doi.org/10.1016/j.sbspro.2013.10.385

[48] Kiryakova, Gabriela, Nadezhda Angelova, and Lina Yordanova. "The potential of augmented reality to transform education into smart education." *TEM Journal* 7, no. 3 (2018): 556. doi: 10.18421/TEM73-11.

[49] Adil, Ahmat, Samsul Hadi, and Bambang Krismono Triwijoyo. "An Interactive Mobile Augmented Reality System For Learning Human Vision Structure." *ICIC Express Letters* 15, no. 12 (2021). doi: 10.24507/icicel.15.12.1337.

[50] Sapri, N., and Fariza Khalid. "Keberkesanan Teknik Augmented Reality(AR) Dalam MeningkatkanKefahaman Konsep Asas Matematik." *Persidangan Kebangsaan Amalan Terbaik Pembelajaran & Pemudahcara (PdC) Dan Inovasi* (2019).

[51] Iqbal, Muhammad Zahid, Eleni Mangina, and Abraham G. Campbell. "Current challenges and future research directions in augmented reality for education." *Multimodal Technologies and Interaction* 6, no. 9 (2022): 75. https://doi.org/10.3390/mti6090075

[52] Mahendra, Made Kevin Ihza, I. Gede Partha Sindu, and Dewa Gede Hendra Divayana. "Pengembangan Media Pembelajaran Augmented Reality Book 2 Dimensi Sub Tema Lingkungan Alam di PAUD Telkom Singaraja." *KARMAPATI (Kumpulan Artikel Mahasiswa Pendidikan Teknik Informatika)* 10, no. 1 (2021): 1-12. 2021. https://doi.org/10.23887/karmapati.v10i1.30217

[53] Blattgerste, Jonas, Jan Behrends, and Thies Pfeiffer. "TrainAR: An Open-Source Visual Scripting-Based Authoring Tool for Procedural Mobile Augmented Reality Trainings." *Information* 14, no. 4 (2023): 219. https://doi.org/10.3390/info14040219

[54] Hashim, Mohd Ekram AlHafis Bin, Muhammad Zaffwan Bin Idris, and Che Soh Bin Said. "The Potential of Integrating User Experience (UX) and Aesthetic Experience (AX) in Augmented Reality Comic (AR Comic)." doi: 10.17706/ijeeee.2021.11.2.34-41.

[55] Miningrum, Tika, Herman Tolle, and Fitra A. Bachtiar. "Augmented reality adapted book (AREmotion) design as emotional expression recognition media for children with autistic spectrum disorders (ASD)." *International Journal of Advanced Computer Science and Applications* 12, no. 6 (2021). https://doi.org/10.14569/IJACSA.2021.0120674

[56] Antoniadi, Georgia. "Using an augmented reality application for teaching plant parts: A case study in 1st-grade primary school students." *Advances in Mobile Learning Educational Research* 3, no. 1 (2023): 630-637. https://doi.org/10.25082/AMLER.2023.01.012

[57]   Ntagiantas, Antonis, Markos Konstantakis, John Aliprantis, Dimitris Manousos, Lefteris Koumakis, and George Caridakis. "An augmented reality children's book edutainment through participatory content creation and promotion based on the pastoral life of psiloritis." *Applied Sciences* 12, no. 3 (2022): 1339. https://doi.org/10.3390/app12031339

[58]   Alarcón-Yaquetto, Dulce E., Jean P. Tincopa, Daniel Guillén-Pinto, Nataly Bailon, and César P. Cárcamo. "Effect of augmented reality books in salivary cortisol levels in hospitalized pediatric patients: A randomized cross-over trial." *International Journal of Medical Informatics* 148 (2021): 104404. doi: 10.1016/j.ijmedinf.2021.104404. https://doi.org/10.1016/j.ijmedinf.2021.104404

[59]   Rojas-Contreras, M., C. A. Peña-Cortés, and S. M. Cañas-Rodríguez. "Measurement of emotional variables through a brain-computer interface in the interaction with books with augmented reality in higher education." In *Journal of Physics: Conference Series*, vol. 1674, no. 1, p. 012016. IOP Publishing, 2020. https://doi.org/10.1088/1742-6596/1674/1/012016

[60]   AlNajdi, Sameer Mosa. "The effectiveness of using augmented reality (AR) to enhance student performance: using quick response (QR) codes in student textbooks in the Saudi education system." *Educational technology research and development* 70, no. 3 (2022): 1105-1124. https://doi.org/10.1007/s11423-022-10100-4

[61]   G. Kaur, Supplementing the markerless AR with machine learning: Methods and approaches. 2023. https://doi.org/10.1515/9783110785234-001

[62]   B. Cubukcu and B. Üniversitesi, "An Augmented Reality Based Mobile Education Application for Preschool Children Design and Implementation of Hybrid Energy Storage System Integrated Fast Charge Station Providing Reactive Power Support to Network for Electric Vehicles View project Buse Ase," no. July, 2021, [Online]. Available: https://www.researchgate.net/publication/352877315

[63]   Ramli, Noraini, Mohd Ekram Al Hafis Hashim, and Ahmad Nizam Othman. "Augmented Reality Technology in Early Schools: A Literature Review." *Journal of Advanced Research in Applied Sciences and Engineering Technology* 33, no. 1 (2023): 141-151. https://doi.org/10.37934/araset.33.1.141151

[64]   M. Billinghurst, "Augmented Reality in Education," 2002. https://doi.org/10.1145/514236.514265

[65]   Kiryakova, Gabriela. "The immersive power of augmented reality." In *Human 4.0-from biology to cybernetic*. IntechOpen, 2020. https://doi.org/10.5772/intechopen.92361

[66]   Piatykop, Olena, Olha Pronina, Iryna Tymofieieva, and Ihor Palii. "Using augmented reality for early literacy." (2021).

[67]   Hlod, Serhii, and Anastasiya Doroshenko. "Application of augmented reality technologies for education." In *2021 IEEE 16th International Conference on Computer Sciences and Information Technologies (CSIT)*, vol. 2, pp. 159-162. IEEE, 2021. https://doi.org/10.1109/CSIT52700.2021.9648783

[68]   R. Daud, N. Azah Abd Raman, and Z. Ab Jalil, "PENGGUNAAN AUGMENTED REALITY VIDEO DI DALAM PENDIDIKAN TVET," 2020. [Online]. Available: http://myjms.moe.gov.my/index.php/ijeap

[69]   J. J. Chen, Y. Hsu, W. Wei, and C. Yang, "Continuance intention of augmented reality textbooks in basic design course," Educ Sci (Basel), vol. 11, no. 5, May 2021. https://doi.org/10.3390/educsci11050208

[70]   Kravtsov, Hennadiy, and Anastasiia Pulinets. "Interactive Augmented Reality Technologies for Model Visualization in the School Textbook." In *ICTERI Workshops*, pp. 918-933. 2020.

[71]   Damopolii, Insar, Fridolin Febrianto Paiki, and Jan Hendriek Nunaki. "The development of comic book as marker of augmented reality to raise students' critical thinking." *TEM Journal* 11, no. 1 (2022): 348. https://doi.org/10.18421/TEM111-44

[72]   Kravtsov, Hennadiy, and Anastasiia Pulinets. "Interactive Augmented Reality Technologies for Model Visualization in the School Textbook." In *ICTERI Workshops*, pp. 918-933. 2020.

[73]   Mahamod, Zamri, and Mohamed Amin Embi. "Penggunaan strategi pembelajaran bahasa untuk menguasai kemahiran membaca." *Sains Humanika* 42, no. 1 (2005).

[74]   Andrea, Reza, Siti Lailiyah, Fahrul Agus, and Ramadiani Ramadiani. ""Magic Boosed" an elementary school geometry textbook with marker-based augmented reality." *TELKOMNIKA (Telecommunication Computing Electronics and Control)* 17, no. 3 (2019): 1242-1249. https://doi.org/10.12928/telkomnika.v17i3.11559

[75]   Nordin, Nurhazlina, and Md Yusoff Daud. "Level of Readiness of Daily Secondary School Students for the Use of Augmented Reality in Form 2 Science Textbooks." *Universal Journal of Educational Research* 8, no. 11A (2020): 17-24. https://doi.org/10.13189/ujer.2020.082103

[76]   Abdusselam, Mustafa Serkan, and Selcan Kilis. "Development and Evaluation of an Augmented Reality Microscope for Science Learning: A Design-Based Research." *International Journal of Technology in Education* 4, no. 4 (2021): 708-728. https://doi.org/10.46328/ijte.88

[77] Scott, Emily E., Mary Pat Wenderoth, and Jennifer H. Doherty. "Design-based research: A methodology to extend and enrich biology education research." *CBE—Life Sciences Education* 19, no. 2 (2020): es11. https://doi.org/10.1187/cbe.19-11-0245

[78] Frågåt, Thomas, Maria Vetleseter Bøe, and Carl Angell. "Providing Professional Development for Physics Teachers through Participation in a Design-Based Research Project." *Nordic Studies in Science Education* 18, no. 1 (2022): 112-127. https://doi.org/10.5617/nordina.8712

[79] Nadzeri, Mohamad Basri, Muzirah Musa, Chew Cheng Meng, Irwan Mahazir Ismail, Mohd Erfy Ismail, and Mohd Shahril Izwan Mustafa. "Development And Evaluation Of Augmented Reality Learning Application (LearnGeoAR) On Geometry Topic Primary School Pupils." *International Journal of Education, Islamic Studies and Social Sciences Research* 7, no. 2 (2022): 1-9.. https://doi.org/10.6007/IJARPED/v11-i1/12279

[80] X. Wang, " Wang, Xiaoyi. "Optimization of child literature curriculum settings for preschool education based on numerical analysis." *Mathematical Problems in Engineering* 2022 (2022). https://doi.org/10.1155/2022/8452166

[81] Wang, Rui. "Application of augmented reality technology in children's picture books based on educational psychology." *Frontiers in Psychology* 13 (2022): 782958. https://doi.org/10.3389/fpsyg.2022.782958

[82] Zhao, Jun, and Na Wang. "Innovating Pedagogical Practices for Handmade Courses in Preschool Education Using Artificial Intelligence." *Computational and Mathematical Methods in Medicine* 2022 (2022). https://doi.org/10.1155/2022/3585958

[83] Wang, Guangjun, Bangguo Zhu, Yi Fan, Ming Wu, Xueshu Wang, Hanyuan Zhang, Liangliang Yao, Yining Sun, Benyue Su, and Zuchang Ma. "Design and evaluation of an exergame system to assist knee disorders patients' rehabilitation based on gesture interaction." *Health Information Science and Systems* 10, no. 1 (2022): 20. https://doi.org/10.1007/s13755-022-00189-5

[84] Lee, I-Jui, Chien-Hsu Chen, Chuan-Po Wang, and Chi-Hsuan Chung. "Augmented reality plus concept map technique to teach children with ASD to use social cues when meeting and greeting." *The Asia-Pacific Education Researcher* 27 (2018): 227-243. https://doi.org/10.1007/s40299-018-0382-5

[85] Jdaitawi, Malek, Fatima Muhaidat, Ayat Alsharoa, Abeer Alshlowi, Marwa Torki, and Mona Abdelmoneim. "The Effectiveness of Augmented Reality in Improving Students Motivation: An Experimental Study." *Athens Journal of Education* 10, no. 2 (2023): 365-379. https://doi.org/10.30958/aje.10-2-10

[86] AlNajdi, Sameer Mosa. "The effectiveness of using augmented reality (AR) to enhance student performance: using quick response (QR) codes in student textbooks in the Saudi education system." *Educational technology research and development* 70, no. 3 (2022): 1105-1124. https://doi.org/10.1007/s11423-022-10100-4

[87] Chang, Yuh-Shihng, Kuo-Jui Hu, Cheng-Wei Chiang, and Artur Lugmayr. "Applying mobile augmented reality (AR) to teach interior design students in layout plans: Evaluation of learning effectiveness based on the ARCS model of learning motivation theory." *Sensors* 20, no. 1 (2019): 105. https://doi.org/10.3390/s20010105

[88] Özeren, Seçil, and Ercan Top. "The effects of Augmented Reality applications on the academic achievement and motivation of secondary school students." *Malaysian Online Journal of Educational Technology* 11, no. 1 (2023): 25-40. https://doi.org/10.52380/mojet.2023.11.1.425

[89] Bonilla-Sánchez, María del Rosario, Marco Antonio García-Flores, Ignacio Méndez-Balbuena, Jocelyn Guadalupe Silva-González, and Ernesto Vladimir Ramírez-Arroyo. "The benefits of role play in the development of drawing in preschool children." *Frontiers in psychology* 13 (2022): 1010512. https://doi.org/10.3389/fpsyg.2022.1010512

[90] Yusof, Hamidah. "The Motivation Stimulating Factors And The Orang Asli Students' Motivation: Is There A Relationship?." *Turkish Journal of Computer and Mathematics Education (TURCOMAT)* 12, no. 8 (2021): 205-210.

[91] Fiusa, Mariana, Cátia Peres, and Ana Luísa Marques. "Reading motivation factors through interactive narratives and augmented reality." In *International Conference on Design and Digital Communication*, pp. 805-822. Cham: Springer Nature Switzerland, 2022. https://doi.org/10.1007/978-3-031-20364-0_67

[92] Kwok, Man Lung Jonathan, Raymond Kwong, and Macy Wong. "How to facilitate motivational regulation strategies: Perspectives on teacher humility and teacher-student relationship." *Computers & Education* 191 (2022): 104645.https://doi.org/10.1016/j.compedu.2022.104645