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EFFECTIVENESS OF INTERACTIVE AUGMENTED REALITY TEXTBOOKS ON PRIMARY SCHOOL STUDENTS' LEARNING EXPERIENCES AND EMOTIONS



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UNIVERSITI PENDIDIKAN SULTAN IDRIS

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DOCTOR OF PHILOSOPHY

FACULTY OF ART, SUSTAINABILITY AND CREATIVE INDUSTRY
UNIVERSITI PENDIDIKAN SULTAN IDRIS

2025



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ABSTRACT

Technology has transformed the education system, influenced economic growth, and emphasised the need for creative teaching and learning methods. This study uses the Design-Based Research (DBR) circle to look into how interactive augmented reality (AR) textbooks affect the learning and feelings of primary school students. It focuses on 2D (ARIB2D) and 3D (ARIB3D) designs by looking at the Uncanny Valley phenomenon. This research uses linear regression and ANOVA to examine both the direct effects and the mediating effects of ARIB design on student outcomes. Using linear regression and the Mann-Whitney U test, this study examines the direct effects and the mediating effects of this design on student enjoyment and learning outcomes. The Mann-Whitney U test results indicate a significant difference in favour of ARIB3D in terms of enjoyment ($U = 2341.500$, $p = 0.027$). Linear regression analysis confirms that the ARIB3D design has a positive effect on student enjoyment, which in turn contributes to the relationship between realism and emotional engagement in learning ($\text{Beta} = 0.164$, $p = 0.027$). Descriptive statistics indicate a high level of agreement among students regarding the measure of enjoyment, with an average score close to 5.00 and a low standard deviation, highlighting the enhanced engagement provided by the 3D features. This discovery shows that 3D interactive elements in AR textbooks significantly enhance the learning experience and emotional engagement of primary school students, providing important insights for educators and content developers looking to optimise educational tools.





KEBERKESANAN BUKU TEKS INTERAKTIF *AUGMENTED REALITY* TERHADAP PENGALAMAN DAN EMOSI PEMBELAJARAN MURID SEKOLAH RENDAH

ABSTRAK

Teknologi telah mengubah sistem pendidikan, mempengaruhi pertumbuhan ekonomi, dan menekankan keperluan untuk kaedah pengajaran dan pembelajaran yang kreatif. Menggunakan lingkaran Penyelidikan Berasaskan Reka Bentuk (DBR), kajian ini menyelidik keberkesanan buku teks AR interaktif terhadap pengalaman pembelajaran dan Emosi pelajar sekolah rendah, dengan memberi tumpuan kepada reka bentuk 2D (ARIB2D) dan 3D (ARIB3D) melalui fenomena *Uncanny Valley*. Penyelidikan ini menggunakan regresi linear dan ANOVA untuk mengkaji kedua-dua kesan langsung dan kesan perantaraan reka bentuk ARIB terhadap hasil pelajar. Menggunakan regresi linear dan ujian Mann-Whitney U, kajian ini mengkaji kesan langsung dan kesan perantaraan reka bentuk ini terhadap keseronokan dan hasil pembelajaran pelajar. Keputusan ujian Mann-Whitney U menunjukkan perbezaan yang signifikan memihak kepada ARIB3D dari segi keseronokan ($U = 2341.500$, $p = 0.027$). Analisis regresi linear mengesahkan bahawa reka bentuk ARIB3D mempunyai kesan positif terhadap keseronokan pelajar, yang seterusnya menyumbang kepada hubungan antara realisme dan penglibatan Emosi dalam pembelajaran ($Beta = 0.164$, $p = 0.027$). Statistik deskriptif menunjukkan tahap persetujuan yang tinggi di kalangan pelajar mengenai ukuran keseronokan, dengan skor purata hampir 5.00 dan sisihan piawai yang rendah, menekankan penglibatan yang lebih baik yang diberikan oleh ciri 3D. Penemuan ini menunjukkan bahawa elemen interaktif 3D dalam buku teks AR secara signifikan meningkatkan pengalaman pembelajaran dan penglibatan Emosi pelajar sekolah rendah, memberikan pandangan penting bagi pendidik dan pembangun kandungan yang ingin mengoptimumkan alat pendidikan.





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LIST OF ABBREVIATIONS

2D	2 Dimensions
3D	3 Dimensions
AEQ	Achievement Emotions Questionnaire
ARIB2D	Augmented Reality Interactive Textbook 2 Dimension
ARIB3D	Augmented Reality Interactive Textbook 3 Dimension
DSKP	Dokumen Standard Kurikulum Dan Pentaksiran
DBR	Design Based Research
GPMP	Gred Purata Mata Pelajaran
JPN	Jabatan Pendidikan Negeri
JSI	Jadual Spesifikasi Item
KBAT	Kemahiran Berfikir Aras Tinggi
KBSM	Kurikulum Bersepadu Sekolah Menengah
KPM	Kementerian Pendidikan Malaysia
MOE	Malaysian Ministry of Education
KSSR	Kurikulum Standard Sekolah Rendah
LX	Learning Experience
MKLFN	Model Konstruktivisme Lima Fasa Needham
MPEI	Mata Pelajaran Elektif Ikhtisas
PAK21	Pembelajaran Abad ke-21
PdPc	Pembelajaran dan Pemudahcaraan
PPD	Pejabat Pendidikan Daerah



PPPM	Pelan Pembangunan Pendidikan Malaysia
SAM	Self-Assessment Manikin
SAPS	Sistem Analisis Peperiksaan Sekolah
SK	Sekolah Rendah
SMK	Sekolah Menengah Kebangsaan
SPM	Sijil Pelajaran Malaysia
SPSS	Statistical Package For The Social Sciences
STAD	Students Teams-Achievement Division
UPE	Ujian Pencapaian Ekonomi
UEQ	User Experience Questionnaire



LIST OF APPENDICES

- A Approval of the Human Research Ethics Committee of Sultan Idris University of Education
- B Approval to Conduct Research of the Ministry of Higher Education
- C Approval to Conduct Research at the Perak State Department of Education
- D Approval to Conduct Research at the Pendidikan Daerah Hilir Perak
- E Approval to Conduct Research at the Pendidikan Daerah Kuala Kangsar
- F Approval to Conduct Research at the Pendidikan Batang Padang
- G Application to Conduct Research at School
- H Appointment as Assessor for Instrument Validation
- I Self-Assessment Manikin Questionnaire (SAM) and Achievement Emotion Questionnaire (AEQ)
- J Sampel of User Experience Questionnaire (UEQ)
- K Prototype Interactive AR Textbook Learning Content Expert Validation Questionnaire
- L Prototype Interactive AR Textbook Learning Content Expert Endorsement
- M Copyright of Prototype Interactive AR Textbook
- N List of Presentations in Conferences
- O Recognition from Innovation Awards Participation
- P Publication List
- Q List of Presentations in Conferences and Innovations Awards



CHAPTER 1

INTRODUCTION

1.1 Introduction

The transformation of the education system, driven by rapid technological advancement, has exerted a profound influence on the nation's economic growth. More importantly, it has intensified the demand for innovation in Teaching and Learning (TnL) practices to ensure that instructional methods remain relevant and impactful in the 21st-century educational landscape (Bielienska et al., 2021; Md Jaafar & Harun, 2022; Zazali & Nasir, 2022). In line with these developments, innovation in education is no longer perceived as an optional enhancement; rather, it is viewed as a critical driver for creating learning environments that are not only realistic and authentic but also engaging and enjoyable for learners (Malaysian Ministry of Education, 2013; MOE, 2022).

Recognising this paradigm shift, educators and academicians have increasingly emphasised the incorporation of emerging technologies into Learning and Facilitating





(PdPc) activities. Within this spectrum of innovations, Augmented Reality (AR) has emerged as a transformative tool capable of delivering interactive and multimodal learning experiences. By bridging physical and digital content, AR offers the potential to enhance learners' cognitive engagement, motivation, and emotional connection to the subject matter. Against this backdrop, the present study is positioned to evaluate the efficacy of implementing AR Interactive Textbooks, with a particular focus on design attributes and their influence on user experience and cognitive style in educational contexts.

To establish a coherent foundation for this investigation, this chapter is organised systematically to guide the reader through its logical progression. It commences with a background discussion, underpinned by a comprehensive literature review that informs the formulation of research questions and objectives. This is followed by the problem statement, which synthesises the contextual issues, identifies research gaps, and proposes potential strategies for addressing them. Subsequently, the rationale for the study is presented, emphasising its significance and potential contributions to enhancing the Malaysian education system. The chapter then moves to a detailed exposition of the theoretical framework, outlining the relevant theories and models that underpin the research. Based on these foundations, the research objectives, questions, and hypotheses are explicitly formulated to provide a clear direction for the study. Finally, the chapter concludes with an outline of the study's limitations, definitions of key operational terms, and a concise summary, thereby ensuring a seamless transition to the subsequent chapter.





1.2 Research Background

The Malaysian education system is currently implementing strategies that are better aligned with regional needs, ensuring that the delivery of education addresses both national aspirations and local contexts (Zakari et al., 2022; Zakaria & Janan, 2022a). Within this agenda, preparing primary school students with strong reading skills is of paramount importance, as reading proficiency serves as a foundation for enhancing vocabulary, writing skills, and overall literacy development (Jamaludin, 2021). Despite these efforts, literacy challenges persist in the country. For example, the 2019 Primary School Assessment Report revealed that 10.31% of students in National Primary Schools (SK) and 3.40% in National-Type Primary Schools (SJK) had not achieved the minimum proficiency level in Malay penmanship (MOE, 2022).



Further evidence of this issue was highlighted in a 2019 report by the Malaysian Examinations Board (LLM), which linked students' poor performance in Bahasa Melayu during the UPSR examination to their inability to select vocabulary that is both appropriate and engaging within the context of examination questions. This low language proficiency is characterised by limited vocabulary and insufficient delivery (MOE, 2019). In response to such challenges, the Ministry of Education introduced KIA2M, *Kelas Intervensi Asas Membaca dan Menulis*—a remedial programme aimed at helping Year 1 students master fundamental reading and writing skills (Jamian, 2011; Nordin & Abdul Wahab, 2021). The programme targets students who are either slow in acquiring literacy or have yet to develop basic skills, and it accommodates both special remedial students and those requiring classroom-based intervention. The urgency of this initiative was underscored by the KIA2M Screening Test conducted in January 2008, which revealed that 65.5% of Year 1 students in national schools in





Sabah—equivalent to 28,700 pupils—had yet to acquire reading, writing, and numeracy skills at the expected level (Che Hassan & Abd Rahman, 2011a). Consequently, Teaching and Learning (TnL) strategies must be carefully designed to ensure that such students acquire these fundamental competencies rapidly.

As the educational landscape evolves, the integration of technology into teaching practices has gained momentum. Increasingly, educators and scholars advocate for the incorporation of emerging technologies into *Pengajaran dan Pembelajaran* (PdPc) activities. Over recent years, the education sector has embraced a range of technologies, ranging from the Internet, computers, social media, and e-learning platforms to simulations, mobile devices, virtual worlds, and more recently, Augmented Reality (AR) (Zakari et al., 2022). This growing interest has prompted calls for further research into the persistent literacy challenges faced by primary school students, examining not only the core issues but also the content, instructional strategies, and modes of presentation employed in learning materials. In this regard, the *Kurikulum Standard Sekolah Menengah* (KSSM) textbook, which has been widely adopted, warrants analysis from multiple perspectives (Zakaria & Janan, 2022a).

Building on this context, recent initiatives have explored AR as a TnL technique, leveraging its capacity to merge the real and virtual worlds through 3D animations displayed in real time (Azuma, 2017). This capability enables technology-based learning to occur anytime and anywhere, enhancing traditional, lecture-centred approaches by making them more creative, engaging, and motivating for students (Chiew et al., 2019). In the 21st century, educators are urged to maximise the use of Information and Communication Technology (ICT) to facilitate meaningful learning





experiences (Usop et al., 2022). However, the reading habits of young learners are shifting; many no longer find physical books appealing, given their early and frequent exposure to computers and other digital devices (Nur Amierah Mohd So et al., 2022). These changes are particularly concerning for primary school students in marginalised communities, such as the Orang Asli, who often face a shortage of appropriate teaching aids, leading to lower motivation and heightened anxiety toward learning (Adnan et al., 2020; Md Jaafar & Harun, 2022). The negative effects of stress can significantly hinder children's psychological and physiological development (Semchuk, 2022; Yunusovich et al., 2022), with the National Strategic Plan for Mental Health 2020–2025 estimating that approximately 29.5% of Malaysian children and adolescents experience stress-related mental health disorders (MeSVIPP, 2020).



In addition to addressing emotional well-being, educators recognise the

interdependence between writing and reading skills. When students engage in writing or copying words, they not only see the words but also process and reinforce them cognitively. Frequent writing practice, therefore, indirectly strengthens reading proficiency and memory retention (Che Hassan & Abd Rahman, 2011b; Nahar, 2020).

Despite the promising potential of AR, its application in primary and higher education remains relatively nascent (Takkaç Tulgar et al., 2022). The blended use of manual and digital learning approaches has shown potential in enabling educators and parents to guide students more effectively, allowing them to navigate learning modules with greater ease and enjoyment (Usop, Mohd Noor, et al., 2022). Yet, the integration of AR into early childhood education remains underexplored (Aydoğdu & Kelpšiene, 2021; Zazali & Nasir, 2022). This gap underscores the need for research to develop





design principles that can enhance AR's effectiveness in supporting the TnL process. At the same time, it is critical to consider the differential impact of AR on students from urban and rural primary schools, as well as those of varying ages, given that demographic factors can influence technology adoption (Cascales et al., 2013; Mora-Alvarado & Llerena-Izquierdo, 2022; Roslan et al., 2022).

In light of these considerations, the present study seeks to evaluate the efficacy of Interactive AR Textbooks, with an emphasis on their design features and their relationship to user experience and cognitive style in the context of primary school education. Specifically, this research examines the learning experience (LX) of students as ICT users, focusing on AR as both a material and a teaching aid in literacy instruction. Furthermore, it investigates how cognitive styles interact with AR textbook design, as well as how varying levels of visual realism influence student learning motivation. Ultimately, the study aims to contribute to the identification of a conceptual framework and design principles for Interactive AR Textbooks that can effectively enhance student motivation and improve literacy learning outcomes.

1.3 Problem Statement

Innovative, competitive, and creative teaching materials must be created in order to execute Revolution 4.0 in education (Polyzou et al., 2022a). Mastering reading and reading skills for primary school students is vital in early education since it can enhance their vocabulary, language, and writing abilities (Jamaludin, 2021). However, only 10.31% of Primary School (SJK) students met the required level of Malay writing proficiency, according to the Primary School Assessment Report.





Based on reports, up to 20% of the 131,281 Year 1 students in Johor are believed to be lacking in the two fundamental skills of reading, writing, and counting (3M) (MOE, 2022):Johor state MOE, 2022). Note that 4.4% of primary school students (2013–2025) did not master the 3M competencies, per the Education Development Plan (Zakaria & Janan, 2022a). If this situation is not resolved, students will experience a decline in academic performance and a lack of interest in studying.

The effectiveness of students' reading habits in Malaysia is not as significant as the reading habits themselves, according to the Malaysian Education Development Plan's (PPPM) Annual Statistical Report for 2017. The results from the studies of (Jensen et al., 2024), (Kutay, 2014), and (Ulvinen et al., 2024) suggest that reading can lead to an increase in levels. The data in the report, which is based on how Malaysian students performed on all Program for International Student Assessment (PISA) exams prior to participation, shows that the nation is still significantly behind the Organization for Economic Co-operation and Development (OECD) average. The level of reading proficiency among students entering primary school is also amply demonstrated by these numbers. This circumstance allowed researchers to investigate the viability of utilizing current Malay textbooks and AR technology to promote reading among students.

On the other hand, Rashid (2011) observed that 161 rural primary school students in Pahang, Negeri Sembilan, as well as Sarawak in Year 1 s 4 and 5 have reading comprehension issues. These students did not comprehend the text's informational content (average = 3.40; sp =.71). Correspondingly, they also did not





comprehend the verse's meaning (minimum = 3.24; $sp = .60$). Children in Year 1 s 4 and 5 of primary school would undoubtedly perform worse in Year 1 provided that they could not understand the text's content, the meaning of the sentence being read, read fast, and tyre easily. Indiran et al. (2022) discovered students had challenges in the technical and pedagogical aspects of using WhatsApp to teach primary school students to read in rural Malaysia. WhatsApp can be used anytime and anywhere and comprises cell phone services. Therefore, apart from educators at school, family members can also use WhatsApp to learn and teach reading. Therefore, the space for Interactive AR Textbooks should be considered.

In order to avoid illiteracy, it is vital to identify readers at risk early on. In order to prevent illiteracy, it is essential to early identify at-risk readers. It is recommended that intensive activities be implemented in order to enhance motivation and psychomotor skills. Literacy fundamentally relates to the use of reading and writing skills. Therefore, identification and prevention are most effective in the early Year 1 s of education, according to Torgesen (1998). The findings of a previous study showed that a total of 168 students in Year 1 of primary school experienced deficiencies in specific aspects of other learning subjects (mathematics and language) that were associated with their reading and literacy abilities (Mahyuddin & Elias, 2008). It might be challenging for students to identify and assess less academically inclined students (Novaliendry et al., 2022). Although reading is essential for school, 33.8% of first-Year 1 rs are illiterate. If it is not controlled, perhaps the hardship of this situation will grow much greater. However, issues in math and language are linked to reading and literacy skills (Karuppannan et al., 2023; Mahyuddin & Elias, 2008; Net et al., 2023; Rudnik, 2022).





In light of this, primary school students rely on Malay textbooks as their primary source of knowledge and as a guide for reading. Malay textbooks serve as the primary source of knowledge and reading guides for primary school students. Nevertheless, the impact of textbooks on students' ability to make references and use them to develop their literacy skills can be challenging. This is due to the fact that students often prefer to consult other teaching aids, such as letter cards, rather than utilising the textbook to its maximum potential. Given this, previous research suggests examining this textbook from various angles (Zakaria & Janan, 2022a).

AR technology is used in classroom instruction to make learning about the PdPc process easier for students to understand (Eleftheriadi et al., 2021; Kravtsov, 2020). One of the attempts to increase Year 1 students' reading comprehension is the use of AR Interactive Textbooks, which does not preclude the usage of current textbooks (Haida et al., 2016a). Alpha-generation students can be drawn to interactive materials by including characters, audio, and movement (Kelpsiene, 2021; Polyzou et al., 2022a).

At the primary school level, there has not been much progress in the creation of formal reading, writing, and counting activities using interactive textbooks based on AR (Ivanova et al., 2021; Kiryakova, 2021; Saforrudin, Zaman, et al., 2012). Upon working with young children, it is important to always keep in mind the intimate relationship between the digital as well as physical realms of books and how they contribute to students' intellectual growth (Öngören, 2022a). YouTube views (Hatta et al., 2022), e-books (Sun et al., 2019), interactive whiteboards, iPads, digital cameras, desktop computers, laptops, digital audio recorders, as well as digital touch screens (Saxena & Hew, 2016) have all been the subject of prior studies. A study of Year 1





primary school students is required to determine the advantages of Interactive AR Textbook in reading, writing, and counting.

Year 1 students will be more appealing if they use AR Interactive Textbooks, which will grow more valuable and significant with time. Identification should be conducted to ascertain the appropriate character design and should be implement in Intetactive AR Textbook materials to enhance the learning experience and encourage students to persist in their studying. This is due to the fact that viewing 2D image on a video disply system can lead to varius effects (Casteleiro-Pitrez, 2022)

The Interactive AR Textbook presents pictures of cats as written symbols, as well as the alphabet and linguistic sounds that go with those words. Young learners will benefit from Interactive AR Textbooks for Malay subjects as they develop their reading, writing, and math skills. In addition, young individuals strengthen their memory and creativity, sharpen their cognitive abilities, ask questions, and undertake research (Polyzou et al., 2022a). In accordance with multiple research that have been conducted, the PdPc strategy may be implemented with the utilization of AR Interactive Textbooks. This promotes attractiveness and interest in creative thinking as well as suits the learning needs of the 21st century in preparation for the education era 4.0 (Lee & Mydin Kutty, 2022).

Findings from (Mohamad et al., 2022) indicate that the majority of instructors have a positive attitude toward the technology integration in PdPc and support it because they perceive positive effects on themselves, students, and the school. This circumstance will accelerate the deployment of the IR4.0, including Interactive AR





Textbooks. The Alpha generation, which is in sync with the diversity of virtual technology, requires this openness. The field of education should take advantage of this technological development to close the gap in teaching aids to equalize the space kids receive in the sphere of enjoyment (Kelpšienė, 2020).

Aware of the opportunities and significance of modern technology adoption in education, many teaching aid innovations are presented at all levels of education, from pre-kindergarten to higher education (Adili et al., 2022a). This includes technology based on AR that is utilized as a catalyst for learning English, understanding Mathematical formulas, studying Al-Quran, and art activities (Nur Amierah Mohd So et al., 2022; Sulaiman et al., 2022a; X. Wang, 2022). Meanwhile, emphasis should be placed on Year 1 children's reading proficiency. Reading instruction involves teachers asking questions that stimulate more complex reading transactions and constructing and facilitating activities in an atmosphere that encourages readers to construct their own meanings (Jamaludin, 2021).

Consequently, the primary contribution of this study is the development of a conceptual framework and character design rules for AR interactive novels. It is expected that the findings of this study will act as a guide, especially for understanding how character design influences students' positive emotions during learning. Consequentially, congruent character design is one of the essential aspects in determining the retention of favourable feelings of students toward an AR Interactive Textbook-based learning session.





1.4 Conceptual Framework

Within the first section of the investigation, design-based research, also known as DBR, is utilized to investigate and generate concepts. Design-Based Research (DBR) is a research approach aimed at solving real-world problems by designing, implementing, and refining interventions in practical settings, particularly in education. It emphasises iterative cycles of design, testing, and analysis, where researchers work closely with practitioners to improve both the interventions and the understanding of underlying theories. By blending theory with practice, DBR not only seeks to develop effective solutions but also to generate generalisable knowledge that can be applied in broader contexts. The process is flexible, evolving through continuous feedback from real-world applications.



Using Design-Based Research (DBR) for developing an interactive AR textbook involves iterative cycles of designing, testing, and refining the AR features in real classroom settings. Researchers and educators collaborate to create AR content that enhances student engagement and understanding. Teachers and students continuously provide feedback, allowing us to adjust the design to address practical challenges and enhance its effectiveness. DBR helps bridge the gap between theory and practice, ensuring that the AR textbook is not only innovative but also grounded in educational needs and learning outcomes. This approach leads to both improved interventions and broader insights for future use.

This study was developed using information from both phases, drawing on Figure 1.3 from the joint work network AR Interactive Textbook. This figure demonstrates the relationship between the two stages of maintenance. In addition,





researchers have the opportunity to investigate the LX about the utilization of AR in conjunction with live textbooks for Phase 1. One of the schools will be situated in a rural area, and the other six will be located in an urban area. The researcher will explore how different types of content, such as images, text, audio, videos, as well as interactive elements, from a multimedia system with an AR Interactive textbook app can help students enhance their reading skills in the classroom. Both positive and negative outcomes will be evaluated based on the instruments that were utilized for the research project. Using User Experience Questions (UEQ), the Uncanny Valley concept will be dissected into ARIB2D and ARIB3D, both of which will be utilized for analysis.

The real impact of the removed emotional traits develops in two phases, starting with Phase 2, which takes place between the textbooks. This involves the function of intermediate stimuli that can arise from the established framework of perception. Emotions are the result of this operation. Scientists employ a technique known as BDR, which is an acronym that stands for "researcher by design." Utilizing the textbook as a teaching tool to indirectly enhance skills via the emotions that have been formed during the learning process is something that the researcher can figure out how to do in the most effective method. For the purpose of analysing the evaluation process, we will be using emoji-based UEQ and Self-Assessment Manikin (SAM). The enhancement and further development of the series of design principles is the last phase in the BDR documentation process. This is accomplished by making use of the analysed stage evaluation data.

Control-Value theory, as well as the Uncanny Valley phenomenon were used to construct the conceptual framework for this study. These two theories are believed to





be more suitable for the study's objective, which is related to the emotions that students experience while they are learning as a result of the design of characters with various degrees of realism (Gu et al., 2022; R. Wang, 2022a). Several theoretical frameworks, concepts, models, and phenomena that are closely analogous to one another have been investigated in order to serve as a theoretical backup. There are two models that appear to have a strong connection to the study (Mori et al., 2012a).

To concentrate on the feelings associated with accomplishment, the Control-Value theory of success emotions (Pekrun, 2005; Pekrun et al., 2005) was chosen as the relevant framework. The research purpose is to study the aspects that cause changes in emotional states as well as the factors that have an effect on the emotions that are experienced during instruction. The emotive experiences that students undergo during and after they have completed learning activities are referred to as "achievement emotions" by Pekrun and Linnenbrink-Garcia (2012) and Pekrun, Frenzel, Goetz, and Perry (2007). Interactive texts and emotions are significant components of student learning.

The Control-Value theory concludes that the sensation of accomplishment can be broken down into two distinct values or dimensions. This encompasses the emotional response, which can be either positive or negative, the level of emotional activation (whether it is activating or deactivating), and the focal object, which can be either a learning outcome or an activity (Shao et al., 2023). The data in Table 1.1, as per (Pekrun, 2005; Shao et al., 2023), demonstrates a 2D taxonomy of achievement emotions that is structured around the two values.



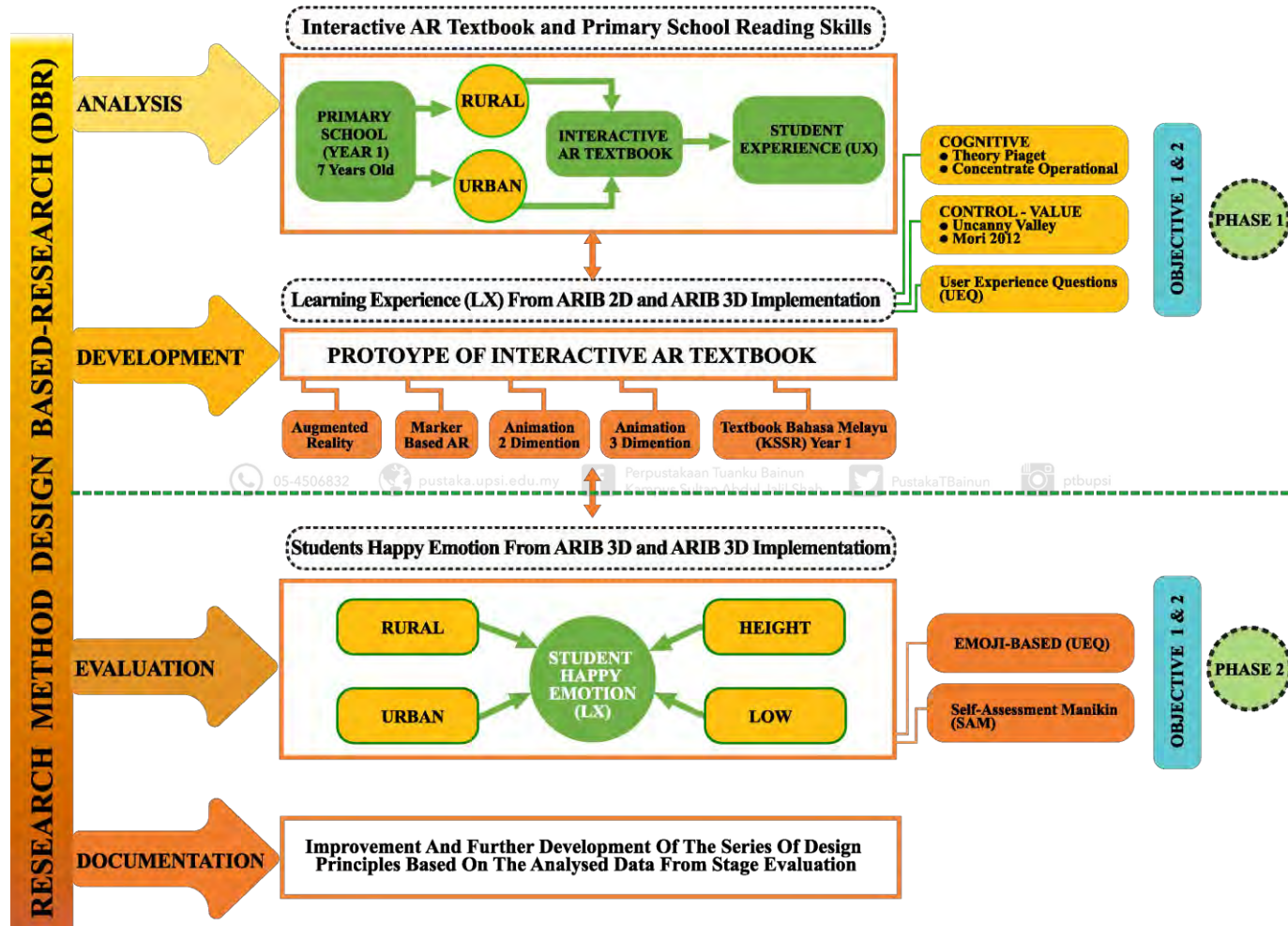


Figure 1.1. Conceptual Framework of Interactive AR Textbook



Table 1.1

2D Taxonomy of Achievement Emotions Based on Control-Value Theory (Pekrun, 2005)

	Positive		Negative	
Object focus	Activating	Deactivating	Activating	Deactivating
Outcome/Prospective	Hope Joy	Relief	Anxiety	Hopelessness
Outcome/Retrospective	Joy Pride Gratitude	Contentment Relief	Shame Anger	Sadness Disappointment

Table 1.1, derived from Pekrun's 2005 publication, presents a two-dimensional taxonomy of achievement emotions relying on the Control-Value Theory. This taxonomy organizes emotions into positive and negative categories, distinguishing them by their activation level (activating or deactivating) and temporal focus (prospective or retrospective outcomes). Positive activating emotions include hope and joy, which are associated with anticipating a successful outcome, while deactivating positive emotions like relief and contentment emerge from the alleviation of stress or satisfaction with an accomplished goal. These emotions highlight the spectrum of positive feelings that students experience in relation to their academic achievements, ranging from eager anticipation to calm satisfaction.

Conversely, the taxonomy also categorizes negative emotions into activating and deactivating types. Driving negative emotions, for example, anger and anxiety, are linked to fear of potential failure or frustration from unmet expectations. On the other hand, deactivating negative emotions like sadness and disappointment arise from perceived failures or unfulfilled goals, leading to sorrow and regret. This classification provides a nuanced understanding of the negative emotional responses students may





experience in academic settings, which can significantly impact their motivation and engagement.

By understanding this taxonomy, educators can better address the emotional aspects of learning. Recognizing the different emotions students experience in response to their achievements or failures allows educators to develop strategies that foster positive emotions and mitigate negative ones. For example, designing a supportive learning environment that motivates hope and pride can enhance motivation. Consequently, strategies aimed at reducing anxiety and managing disappointment can help sustain student engagement. Ultimately, this comprehensive approach to understanding achievement emotions enables educators to more effectively support students' emotional well-being and academic success.



As demonstrated by the two-dimensional taxonomy of accomplishment emotions that is described in this article, the positive emotions that students experience as a result of their participation in educational activities may be classified into two emotional activation levels: activating (fun) as well as deactivating (boring) (relaxing).

Chia and Lin's 2017 study, which investigated the effect of AR Interactive Textbook characters, found that these characters can boost the positive emotions of the students during classroom learning. Here, the study also explored the concept of a positive emotional response, encompassing enjoyment. Research has shown that positive emotions like enjoyment and excitement can enhance student motivation, while negative emotions like boredom during learning activities may have the opposite effect as well as decrease student motivation (Shao et al., 2023). Research has





established the usefulness of AR Interactive Textbook characters, offered in various designs, which can effectively impact students' emotional reactions. This is considered in light of the fact that this has been demonstrated.

Based on Control-Value theory, AR Interactive Textbook characters have been recognized as the most effective at eliciting positive emotions in students. More precisely, these characters are able to activate (fun) and deactivate (anger) the students' emotions. This inquiry bases its second hypothesis on the phenomenon known as the Uncanny Valley. Mori et al. (2012a) suggest that the Uncanny Valley phenomenon explains the relationship between the emotive and accurate depiction of a character from the perspective of human comfort.



During the process of character development, it is of the utmost importance to choose animated characters that have the appropriate level of realism. The reason for this is that animated characters that are exceedingly lifelike might have a negative influence on the emotional aspect as well as the comfort of the user who looks at the character (Ahmid et al., 2023). This is because of the fact that the user is viewing the character. According to the findings (Bouwer & Human, 2017), users will experience the phenomenon known as the Uncanny Valley if mistakes occur when choosing realistic levels and animated characters that are identical to one another

The Uncanny Valley effect could lead to negative emotional responses in students. Hence, it is important to select suitable characters for the AR Interactive Textbook. The performances of characters can be split into two categories: the performance of static characters as well as the performance of dynamic characters. In



both of these categories, the phenomenon known as the Uncanny Valley can be examined.

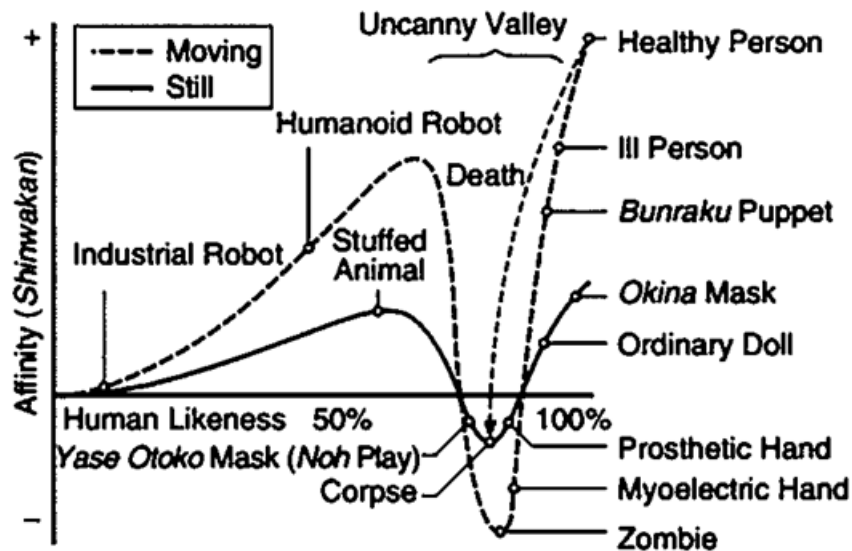


Figure 1.2. Original Graph of the Uncanny Valley (Reproduced from Mori et al.2012)

The Uncanny Valley Mori graph from 2012 provides a good illustration of the increase of positive human emotions and characters that are increasingly human. On the other hand, the graphs for both static as well as dynamic characters make it very evident that when the characters are terrible, there is a decrease to a negative level. The phenomenon depicted in this graph is referred to as the Uncanny Valley, and it features a declining level of comfort. This phenomenon occurs as the character's design becomes more and more similar to the design of real-life humans, causing the user to experience feelings of terror and horror (Bouwer & Human, 2017; Cantrell & Hawkes, 2021).

Consequently, the graph reveals that the inclusion of genuine human characters results in an increment to a positive level for the human emotional aspect (Mori et al., 2012b). The graph shows that the Uncanny Valley effect has a greater impact on dynamic characters compared to static ones. This Uncanny Valley phenomenon was



originally designed to find the effects of a realistic level for robotics research. Consequently, the utilisation of AR Interactive Textbook characters has the potential to have a similar effect, even though this phenomenon was originally created.

A 3D design was chosen as the principal component of the AR Interactive Textbook that will be used for this project. This choice was made because it is an ideal way for Interactive AR Textbooks. As a consequence of analyzing the Uncanny Valley phenomenon graph, it was discovered that dynamic characters that resembled humans had the most significant positive emotional influence on consumers. As a result, real people were chosen to serve as characters in the AR Interactive Textbook for the first treatment group. A high level of comfort is produced by 3D cartoon characters that resemble genuine humans, such as bunraku statues when the graph has fallen to its lowest point and entered the Uncanny Valley (Kudo et al., 2022).

As a result, the AR Interactive Textbook for the second treatment group contains 3D characters. It is possible that users of Interactive AR Textbook would experience a favourable emotional response when they encounter a mechanical character that is remarkably similar to a real person. The reason for this is that the utilization of the mechanical personality of the human-robot came before the dynamic graph, indicating an initial increase in the user's positive emotions (Strathearn & Ma, 2021).

Following that, a comparison was made between the selection of characters based on the graph of the Uncanny Valley phenomenon and the effects of the student's emotional aspects for the display mode of the AR Interactive Textbook. Because of this, this study is differentiated from previous studies on the realistic aspect of emotions.



In Chapter 4, which is about the development as well as the design of an AR Interactive Textbook, character design considerations are discussed in further detail.

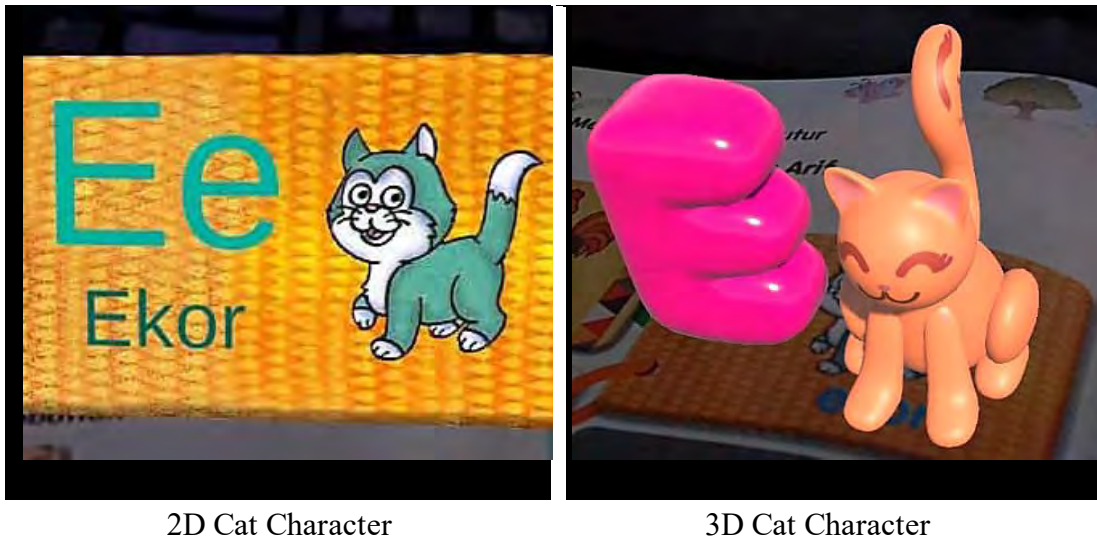


Figure 1.3. Two Realistic Levels have been Chosen for Cat Character Creation

1.5 Research Objective

This research intends to evaluate the LX in Year 1 from four primary schools concerning the utilization of Interactive AR Textbook as a teaching aid for reading, writing, and arithmetic in the Bahasa Melayu curriculum. This evaluation will rely on the literature review as well as relevant discussions that have occurred. Moreover, the research purpose is to assess the emotional effects of two Interactive AR Textbook character designs on the learning of primary school students, particularly those in Year 1.

Note that 2D & 3D character Interactive AR Textbook characters were tested on students in Year 1 from four different national schools in order to examine the user experience of Interactive AR Textbook among these students. At the same time, two



treatment groups were utilized to analyze emotions in the learning of higher education students. The treatment consisted of a lecture including two Interactive AR Textbook characters with varying degrees of realism. The animals (cats) are utilized in all two types of Interactive AR Textbook characters. The character is a two-dimensional cat in an artificial context. The second character is a three-dimensional cat.

Consequently, all of these Interactive AR textbooks were evaluated by a group of Year 1 students from five primary schools in order to determine the emotional impact of using two realistic levels of AR Interactive Textbooks.

Six primary schools with students in Year 1 participated in an analysis test of LX as an aid to reading, writing, and counting in class. The first category includes two groups: primary and secondary school students. The first group consisted of Year 1 primary school kids from metropolitan areas, whereas the second group consisted of Year 1 primary school students from rural areas in Perak.

For the goal of assessing the feelings of enjoyment and emotions in student learning, both urban and rural students employed two treatment groups: a normal animal AR Interactive Textbook, a 3D character AR Interactive Textbook, and an 2D characters AR Interactive Textbook. According to the discussion in the theoretical framework, only the enjoyment factor is assessed from an emotional assessment standpoint. The explanation for this selection is detailed in chapter 3, the methodology chapter of the research. The particular aims of this investigation are given below:





1. Develop two Interactive AR Textbook prototypes at two realistic levels. Two Interactive AR Textbook with various degrees of realism were developed, namely the Interactive AR 2D Character Textbook (ARIB2D) and the Interactive AR 3D Character Textbook (ARIB3D).
2. Analyzing the effect of text, graphics, video, audio and interactives using Interactive AR Textbook with 2D and 3D characters on the learning experience (LX) of Year 1 students from urban and rural primary schools.
3. Examining the effects of Interactive AR Textbook designs from ARIB2D and ARIB3D on the affective components of students' enjoyment.



4. Analyze whether students' enjoyment of Interactive AR Textbook design mediates the relationship between realism and emotion in student learning.

1.6 Research Questions

1. Is there a significant difference in the effect of text, graphics, video, audio and interactives using Interactive AR Textbook with 2D (ARIB2D) and 3D (ARIB3D) characters on the learning experience (LX) first?



2. What are the components in order to develop the idea that there is an effect of Interactive AR Textbook design (ARIB2D) and (ARIB3D) on the students' enjoyment component?
3. Is there a relationship between students' enjoyment of Interactive AR Textbook design and the relationship between realism and emotion in students' learning?

1.7 Hypothesis

H^{a1}: The type of media content (text, graphic, video, audio, and interactives) used in Interactive AR Textbook with 2D (ARIB2D) and 3D (ARIB3D) characters has a significant impact on the learning experience (LX) of Year 1 students from urban and rural primary schools.

H^{a2}: Interactive AR Textbook design from (ARIB2D) and (ARIB3D) has an effect on the emotive component of student enjoyment.

H^{a3}: Students' enjoyment of Interactive AR Textbook design contributes to the relationship between realism and emotion in student learning.

1.8 Limitations of the Research

This study focuses on the character design of the Interactive AR Textbook two levels of realism to identify the influence of the emotional aspect on students' spelling,



reading, and counting learning sessions. Only the Control-Value theory, presented in the theoretical framework, is employed to evaluate the emotional elements of enjoyment in this study. Note that this research does not involve subject-specific investigations and does not assess student performance.

This study was limited to only six primary school locations in order to examine characteristics of the LX. The first category consists of two groups of school students, namely 7-Year 1 -old Year 1 in urban areas, while the second category is comprised of 7-Year 1 -old first-Year 1 rs in rural areas. This quasi-experimental approach involved only four primary schools and no randomly selected participants. Consequently, classes are set by the administration of the primary school.

The research purpose is to evaluate the emotional states of students during learning sessions using Interactive AR Textbook characters, 2D and 3D as classroom teaching aids. Therefore, the character Interactive AR Textbook will serve as a platform for 45 minutes of spelling, reading, and counting activities in accordance with a school schedule. However, the duration of display by Interactive AR Textbook characters is not the primary issue in this study. The effect of employing Interactive AR Textbook characters for a particular period of time from the emotional perspective of students may be the subject of a future study.

The characters in this study's Interactive AR Textbook do not utilize any educational aids such as blackboards, supplementary screen displays, textbooks, etc. The character Interactive AR Textbook merely displays scanned characters, and





students engage with the vocabulary supplied by characters within a predetermined time frame. Moreover, the Interactive AR Textbook has only two directions.

This study focuses solely on the experience of 7-Year 1 -old children (LX) from four primary schools using an AR Interactive Textbook with actual characters (paint), as well as their emotional response to two Interactive AR Textbook character designs with varying levels of realism. Consequently, this study does not include pre-and post-testing.

1.9 Operational Definition

1.9.1 Interactive AR Textbook

The "Interactive AR Textbook" is an educational tool that merges AR with physical textbooks. This application enhances TnL sessions by creating an interactive experience between Year 1 students and their Bahasa Melayu textbook Kurikulum Standard Sekolah Rendah (KSSR). During lessons, the Interactive AR Textbook serves as a teaching aid, supporting listening and speaking activities for Year 1 students in learning the Malay language. The content of the Interactive AR Textbook is related to listening and speaking skills, emphasizing phrases, words, as well as sentences that include vowel letters. It provides audio, visual, as well as animated content for the vowels a, e, è, i, o, u, in line with the KSSR syllabus. Students are encouraged to practice using the Interactive AR Textbook application.





The Interactive AR Textbook app involves creating images, text paths, and the vowels a, e, è, i, o, and u across six pages, along with integrating video files, animations, as well as virtual page links. The app has a scanner and trigger that shows additional 2D or 3D layers when scanned with a smartphone or tablet. The Interactive AR Textbook enhances and emphasizes the transformation of traditional textbooks into an engaging and interactive learning experience. This application has helped overcome the problem of students who have weak mastery of 3M (Reading, Writing, and Counting).

1.9.2 Primary School Area

The primary school area includes the selected school's Year 1 students. There are six primary schools in Perak, three in urban regions and three in rural areas.



1.9.3 Primary Textbook

A textbook is a volume regarded as the primary source of information on a certain subject or area. Additionally, textbooks are a vital educational tool and are frequently employed by educators (Haida et al., 2016b). It does not just provide advice or measurements for each subject. Moreover, there is no doubt that textbooks are important for a developing nation like Malaysia in interpreting the philosophy, objectives, and guiding principles of the educational system. The creation of textbooks also complies with the standards set forth by the Philosophy of Education in a country that emphasizes the need for education to enable the full, balanced, and integrated progress of students' potential, including the formation of their intellectual and spiritual selves (KPM 2005).





Studies have demonstrated that when students use textbooks, their test scores are higher than those of the control group by employing experience, as demonstrated here. A textbook should form a part that can be highlighted as a teaching tool rather than just being opened and read in order to be used as a learning module. The assistance items that students can understand the quickest and easiest are those related to information technology. Direct student learning methods and systems can be improved using textbooks and information technology materials as learning resources. Focused learning materials are what kids need to develop their comprehension. Hence, they should be employed (Haida et al., 2016b).

While respondents to the survey from (Zakaria & Janan, 2022b) acknowledged that the graphical component encouraged people to use textbooks, the findings of the research simply demonstrate that the frequency of usage of Malay textbooks is at a satisfactory level. The inference is that there is still an opportunity for improvement in textbook development in order to raise their degree of usage. Other than that, the right kind of motivation should be offered to teachers and students to encourage them to use textbooks more actively during the Malay language TnL.

This research will employ AR technology and will build upon findings from previous studies regarding the advantages and disadvantages of using Malay textbooks and other subjects in schools. Future research on this textbook should consider several different angles. To learn more about using it and its advantages in engaging in-class activities, teachers must diligently investigate AR technology (Nair Vargavan & Yunus, 2021).





1.9.4 Primary Education Assessment

Table 1.2

KPM, Primary School Marking System

Score	Year 1 value	Year 1 status	Academic competence	Status
90 – 100	A	4.00	Excellent	Competent
85 – 89	A-	3.67	Honour	
80 – 84	B+	3.33		
75 – 79	B	3.00		Good
70 – 74	B-	2.67		
65 – 69	C+	2.33		
60 – 64	C	2.00		Fail
45 – 59	C-	1.67		
40 – 44	D	1.33		
0 – 39	F	0.00		Incompetent



1.9.5 Interactive AR Interactive Textbook – 2 Dimensional (ARIB2D)

Interactive AR Textbook characters are designed to resemble toys and do not possess real cat features. In 2D animation, characters and vowels primarily consist of length, height, and width, specifically the X (horizontal dimension) and Y (vertical dimension) coordinates. This study models the Interactive AR Textbook's characters for stuffed based on the original appearances found in the Malay language textbook's *Mendengar dan bertutur* subtopic on page 6.



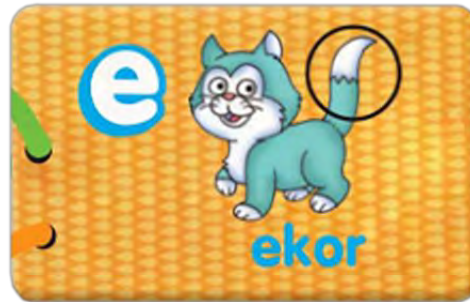


Figure 1.4. The interactive AR textbook uses an original 2D cat character from the syllabus to represent ARIB2D.

1.9.6 Interactive AR Textbook – 3 Dimensional (ARIB3D)

3D Cat Character for Interactive AR Textbook representing ARIB3D. 3D Character

The Interactive AR Textbook features an animal character, specifically a cat, which is designed to resemble a real animal character. Animated objects in 3D space are known as 3D character animations. These animations not only have height and width but also volume or depth (height, width, depth). Animated objects can rotate and move like real objects. The appearance looks real and alive. This study designed a 3D interactive AR textbook character, a cat, based on a real animal's figure, but highlighted it with cheerful colours.



Figure 1.5. 3D Cat Character and E vowel for Interactive AR Textbook representing ARIB3D.



1.9.7 Fun Emotion (Pleasure)

The student's pleasant emotion is the student's sensation that is analyzed when gazing at the two-level realistic Interactive AR Textbook character design that was created. In the framework of this study, students' fun emotions were rated as soon as they viewed the design of Interactive AR Textbook characters with varying levels of realism. The emotional impact on students was evaluated utilising the Self-Assessment Manikin (SAM) questionnaire and two visual dimensions of PAD, namely Pleasure, Arousal (stimulation), and Dominance (submission). The factor of pleasure was emphasized in this study to gauge students' joyful sentiments.

1.9.8 Learning's Uncanny Valley of Emotions Realistic Standards



The concept of the Uncanny Valley in interactive AR textbooks refers to the emotional dissonance that can arise when digital content, such as avatars or environments, approaches realistic quality but fails to achieve full realism. When this occurs, students may feel uncomfortable or anxious about participating, which can impede the learning process (Mori et al., 2012b). Representations that closely resemble humans may disturb students, disrupting the intended appreciation for a deeper understanding (Hepperle et al., 2022). The focus of educational content may shift from learning to processing the unpleasant nature of AR elements, which could lead to confusion and a reduction in effectiveness due to this emotional dissonance.

To prevent the occurrence of this "uncanny valley," interactive AR textbooks development must strike a balance between abstraction and realism. The objective is to





create an immersive experience that engages students' emotions, but not to the extent that it alienates them or causes feelings of stress (Cantrell & Hawkes, 2021). Development can set realistic standards to enhance understanding without overwhelming students, by ensuring emotional alignment of AR elements with educational materials and assessing students' emotional responses (Ratajczyk, 2022).

1.9.9 Learning Experience (LX)

The realistic level is used to evaluate a character's design in minute detail (Mori et al., 2012). Character designs that resemble real animals have a high level of realism, whereas characters that do not resemble real animals and appear like cartoons have a low level of realism (Mori et al., 2012). Toy characters (ARIB2D), and mechanical characters (cat) are the two levels of realism utilized in the context of this investigation (ARIB3D).

1.10 Summary

Implementing an Interactive AR Textbook as a teaching tool in the classroom is an approach that can pique students' attention and motivate them during the learning session. In fact, students undergoing learning sessions with the Interactive AR Interactive Textbook are observed to be more enthusiastic than students during standard learning sessions. However, the influence of LX on Interactive AR Interactive Textbook tutors may vary between urban and rural locations, where students' adoption of cutting-edge technology is reportedly low. Consequently, it will be necessary to identify the influence of these geographical disparities after implementing the





Interactive AR Textbook in educational institutions. In addition, the choice of Interactive AR Textbook character design is the most influential component in determining its usefulness. Effective implementation of Interactive AR Interactive Textbook necessitates correct character design to accomplish the goal of engaging students. Accurate character design also provides students with a sense of comfort and positive emotions, especially when it comes to encouraging them to continue learning. Consequently, the research focus is the impact of Interactive AR Textbook character design based on the emotional aspects of enjoyment and emotions on student learning. It is essential that this study be conducted so that a roadmap for the development of an Interactive AR Textbook for educational purposes may be compiled.

