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THE EFFECTS AND RELATIONSHIP OF MOTIVATION AND ACHIEVEMENT IN STEM LEARNING AMONG ORANG ASLI STUDENTS USING AUGMENTED REALITY APPLICATIONS

NURHANISAH BINTI SURDI

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DISSERTATION SUBMITTED TO FULFILL THE REQUIREMENTS TO OBTAIN THE DEGREE OF MASTER OF EDUCATION (MULTIMEDIA) (RESEARCH AND COURSEWORK MODE)

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ABSTRACT

Augmented reality (AR) applications are increasingly gaining attention in education due to its ability to create interactive and engaging learning. However, there are limited studies on their effect towards motivation and achievement in STEM learning among Orang Asli students. As such, this study aims to: i) identify the effects of using AR applications to assess the level of motivation among Orang Asli students in STEM learning; ii) establish the effects of using AR applications on the achievement level of Orang Asli students in STEM learning; and iii) measure the strength of the correlation between motivation and achievement in STEM learning among Orang Asli students when using AR applications. A total of thirty (30) Form 1 Orang Asli students from a school in Perak. This study employed a quasi-experimental design involving control and treatment groups, where the data were collected through pretest and posttest, as well as from questionnaires based on the Attention, Relevance, Confidence, and Satisfaction (ARCS) Model of Motivation and achievement scores. In this research, two (2) AR applications that were developed by previous researchers, which are ARSiGaSTEM and AR-Tradisi, were used for the integration of traditional game elements with STEM concepts to create a more engaging and contextual learning experience. Data analysis involved the use of descriptive statistics and Spearman's correlation tests, as the data were non-parametric and did not meet normality assumptions. Three results were obtained; the first and second objectives indicated increased level of motivation in terms of attention, relevance, confidence, and satisfaction, along with significant improvement in academic achievement with the adoption of AR applications. Meanwhile, the third result revealed a strong positive correlation between student motivation and achievement (Spearman's $r = 0.781$, $p < 0.01$). This study provides meaningful insights into the role of AR applications in enhancing STEM education among Orang Asli students, aligning with the aspirations of the Malaysia Education Blueprint 2013–2025 to provide inclusive and quality learning opportunities.

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KESAN DAN HUBUNGAN ANTARA MOTIVASI DAN PENCAPAIAN PEMBELAJARAN STEM DALAM KALANGAN PELAJAR ORANG ASLI MENGGUNAKAN APLIKASI REALITI TERIMBUH

ABSTRAK

Aplikasi Realiti Terimbuh (AR) semakin mendapat perhatian dalam bidang pendidikan kerana keupayaannya menyediakan persekitaran pembelajaran yang interaktif dan menarik. Namun begitu, kajian mengenai kesannya terhadap motivasi dan pencapaian dalam pembelajaran STEM, khususnya dalam kalangan pelajar Orang Asli, masih terhad. Kajian ini bertujuan untuk mengkaji penggunaan aplikasi AR dalam merapatkan jurang pencapaian akademik dan meningkatkan motivasi pelajar, seterusnya menyediakan akses pembelajaran moden yang lebih saksama kepada komuniti Orang Asli. Objektif kajian ini adalah i) untuk mengenal pasti kesan penggunaan aplikasi AR terhadap tahap motivasi dalam kalangan murid Orang Asli dalam pembelajaran STEM; ii) untuk mengenal pasti kesan penggunaan aplikasi AR terhadap tahap pencapaian murid Orang Asli dalam pembelajaran STEM; dan iii) untuk mengukur sifat dan kekuatan perkaitan antara motivasi dan pencapaian dalam pembelajaran STEM apabila menggunakan aplikasi AR dalam kalangan murid Orang Asli. Kajian ini menggunakan reka bentuk kuasi-eksperimen yang melibatkan ujian pra dan pasca serta kaedah tinjauan mrnggunakan soal selidik yang merangkumi tahap motivasi berdasarkan Model Motivasi ARCS dan skor pencapaian pelajar. Seramai 30 pelajar Orang Asli Tingkatan 1 dari sebuah sekolah di Perak telah dipilih melalui persampelan bertujuan. Aplikasi AR yang digunakan dalam kajian ini adalah AR-SiGaSTEM dan AR-Tradisi. Aplikasi ini menggabungkan elemen simulasi permainan tradisional dengan konsep STEM bagi mewujudkan pengalaman pembelajaran yang lebih menarik dan kontekstual. Data dianalisis menggunakan statistik deskriptif dan analisis korelasi Spearman. Dapatan menunjukkan wujudnya korelasi positif yang kuat antara motivasi dan pencapaian pelajar (Spearman's $r = 0.781$, $p < 0.01$), yang menunjukkan bahawa peningkatan motivasi berkait rapat dengan peningkatan pencapaian dalam pembelajaran STEM. Kajian ini memberi sumbangan bermakna terhadap pemahaman tentang peranan aplikasi AR dalam memperkasakan pendidikan STEM dalam kalangan pelajar Orang Asli, sejajar dengan aspirasi Pelan Pembangunan Pendidikan Malaysia 2013–2025 untuk menyediakan peluang pembelajaran yang inklusif dan berkualiti.

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LIST OF ABBREVIATIONS

3D	3 Dimension
AR	Augmented Reality
AUREL	Augmented Reality Learning
COVID-19	Coronavirus Disease 2019
CTML	Cognitive Theory of Multimedia Learning
GEN-Z	Generation Z
ICT	Information and Communication Technology
MCMC	Malaysian Communication and Multimedia Commission
PPPM	The Malaysia Education Blueprint
QR	Quick-Response
SDT	Self - Determination Theory
STEM	Science, Technology, Engineering and Mathematics

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CHAPTER 1

INTRODUCTION

1.1 Introduction

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The twenty-first century has seen a significant advancement in educational modernisation, which has improved the quality of Malaysia's educational system (Kamini Karthigesu, & Maslawati Mohamad, 2020). Technological innovations in education reflect Malaysia's commitment to global relevance. The Digital Education Policy is a fundamental aspect of Malaysia's educational strategies, demonstrating a proactive embrace of technology. This policy exemplifies the government's commitment to enhancing educational quality in Malaysia (Aminamul Saidah Mad Nordin et al, 2023).

Information and Communication Technology (ICT) is vital in the educational landscape, impacting teaching and learning (Koushik Das, 2019). ICT is essential in modern education as it facilitates the blending of various technologies and multimedia resources. A key aspect of ICT is its ability to merge different technological forms,

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enhancing communication effectiveness and information dissemination (Tariq Zafar, 2019), otherwise known as technology integration. In fact, ongoing technological advancements have been reported to significantly alter knowledge application and cognitive processes (Nurin Nuha Zakeri et al., 2023).

ICT enhances education by providing dynamic and interactive experiences to students. Multimedia content through ICT engages diverse learning styles and offers interactive opportunities absent in traditional methods (Chen, 2020). This combination creates a productive learning environment. In particular, integrating multimedia elements such as text, audio, video, and interactive elements through digital platforms can enhance learning experiences (Salma Almira Hamdani et al., 2022).

In education, multimedia and technology help create engaging learning materials like digital presentations, e-books, and online courses (Lai et al, 2019). Moreover, research shows that self-guided mobile learning tools help students explore nature, emphasising the role of textual prompts in enhancing observation (Chen, 2020). Supporting this perspective, positive findings indicate that multimedia blended learning approaches yield better outcomes than traditional teaching methods (Vagg et al., 2020).

Advancements in new media technology have enabled teachers to utilise multimedia learning environments effectively. Today, Augmented Reality (AR) has been identified as a significant learning facilitator that amplifies comprehension through the application of virtual enhancements of scientific realities (Chen, 2024). The growing interest in AR within academia is linked to its proficiency in merging diverse

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multimedia formats including audio tracks, pictures, written material, video content, animations, and three-dimensional (3D) objects (Yilmaz & Göktaş, 2018).

AR represents a significant leap in technology, greatly improving both teaching methods and the educational journey (Laurens-Arredondo, 2022). In line with this technological evolution, adolescents have demonstrated a high level of familiarity with AR due to their frequent engagement with AR-based applications and digital games (Chang et al., 2020). This makes AR a suitable educational learning tool for students. Furthermore, a multitude of AR platforms have been utilised in classrooms, encompassing smartphones, tablets, and personal computers. For instance, the essential functionality of AR can be discerned in secondary school textbooks that incorporate Quick Response (QR) codes, which have notably augmented students' motivation throughout the educational process (Tan & Chee, 2021).

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However, the fruitful implementation of AR within Science, Technology, Engineering, and Mathematics (STEM) education has encountered difficulties, particularly in countryside regions where the setup for ICT could be inadequate (Jin, 2021). The acceptance of such technologies by the Orang Asli community is characterised by persistent scepticism regarding their authenticity. This demographic also faces considerable obstacles attributable to the digital divide, which limits their access to advanced technologies such as AR (Mohamad Subaidi Abdul Samat & Azlina Abdul Aziz, 2020). This inequality in ICT access not only limits the application of AR in educational settings but also impairs the efficacy of STEM education in these regions, thereby exacerbating educational disparities (Bala & Chong, 2021).

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STEM is an educational approach based on the fields of science and mathematics, which utilises the advantages offered by technological and engineering methodologies (Asigigan & Samur, 2021). In Malaysia, STEM serves as a pivotal component of the national education system. The Malaysia Education Blueprint (Pelan Pembagunan Pendidikan Malaysia, PPPM) 2013-2025 emphasises the critical importance of STEM, highlighted by the execution of various initiatives designed to fortify STEM education within academic institutions by enhancing the curriculum to be more relevant and contemporary, as well as by providing superior educational resources (Rashidin Idris et al., 2023). For instance, the 2022 PPPM Annual Report highlights the establishment of the "STEMforALL" initiative that was designed to collaborate with the industry, with the aim to ensure that STEM education is accessible to all students across Malaysia (Kementerian Pendidikan Malaysia, 2022).

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STEM is important for Gen Z students' success in education and their future career paths (Nurin Nuha Zakeri et al., 2023). A key factor contributing to this is students' motivation and proactive engagement in STEM, which impacts it significantly (Luo et al., 2019). Innovative teaching methods that incorporate STEM have been reported to markedly increase students' enthusiasm (Nurin Nuha Zakeri et al., 2023), which include technologies like AR that is particularly effective in educational settings, enhancing the learning experience and improving academic performance (Parmaxi & Demetriou, 2020). Moreover, AR offers considerable educational benefits in STEM by improving spatial skills, practical abilities, conceptual comprehension, and inquiry-based learning (Ibáñez & Delgado-Kloos, 2018).

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AR is a technology that merges 3D virtual objects into the real-world environment, creating an artificial setting (Zsila et al., 2018). It enhances the physical environment by integrating virtual information in real-time (Pellas et al., 2019). This combination facilitates interaction with simulated objects and helps students comprehend complex phenomena. As a result, AR technology enhances the understanding of abstract concepts, thereby promoting cognitive development and learning efficacy (Pellas et al., 2019). Consequently, this study aims to explore the effect of AR applications on Orang Asli students' motivation and achievement in STEM learning.

1.2 Research Background

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Through the evolution of technology, the traditional approach to teaching has changed to digital approaches (Buabeng-Andoh, 2018). Nowadays, the effectiveness of the traditional approach to learning alone is no longer adequate in the classroom. Digital teaching not only facilitates the learning process but also plays a critical role in maintaining the attention of students who are no longer responsive to traditional methods of instruction (Moraes et al., 2022).

Moreover, traditional pedagogical practices such as drill-and-practice and textbook-centric activities have been associated with diminished interest in learning science (Chen, 2020). To overcome these challenges, the integration of practical, student-centred teaching strategies has been shown to significantly enhance student engagement, academic competence, and the development of essential soft skills,

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including critical thinking, creativity, and problem-solving (Noor Anita Rahman et al., 2021). Importantly, existing research underscores the critical importance of educational advancement, as the strength and progress of a nation are intrinsically linked to the quality of its education system and the intellectual capacity of its citizens (Pellas et. al, 2019).

The COVID-19 pandemic has led to the increased use of computers in Malaysia, especially in secondary schools (Rajantheran Muniandy et al., 2022). This trend is further evidenced by the normalised use of computers and other technologies in education through the efficient implementation of digital teaching. Statistics also show that the internet usage rate in Malaysia reached 88.7% in 2020, a 1.3% increase from 2018, according to the Malaysian Communication and Multimedia Commission (MCMC) (Siti Noor Ismail et al., 2022). This data reflects the reality that the computer has been used more broadly and has become a standard in conventional approaches. As a result, the expectation that computers and other technologies will increase innovations in digital education and the practical learning system continues to rise.

The advancement of the Malaysian education system is crucial to ensuring equitable access for all segments of society, including the Orang Asli communities (Muhammad Fuad Abdullah et al., 2023). One effective approach to achieving this goal is through the integration of technology in education. In line with this vision, Malaysia has incorporated technology-driven lessons into its national curriculum to enhance students' familiarity with current global educational trends (Kamini Karthigesu, & Maslawati Mohamad, 2020).

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However, as a minority group, the Orang Asli have historically lagged behind the mainstream population in terms of educational attainment, and the implementation of technology-based lessons within Orang Asli communities remains limited (Mohamad Subaidi Abdul Samat & Azlina Abdul Aziz, 2020). Despite continuous efforts by the Malaysian government to improve educational opportunities for the Orang Asli since independence, significant disparities still persist (Muhammad Fuad Abdullah et al., 2023).

STEM education is a specialised pedagogical approach that emphasises the integration of science and mathematics disciplines to prepare students for careers in science, technology, and engineering (Mohd Azry Abdul Malik et al., 2021). As a core element of education in developed nations, STEM plays a critical role in Malaysia's educational agenda. In alignment with this, the Malaysian Ministry of Education introduced the 60:40 Policy, which targets a student ratio of 60% in the science and technical stream and 40% in the arts and non-technical stream (Ahmad Ismail, 2023). Consequently, STEM education significantly influences the formulation of students' learning objectives (Nurin Nuha Zakeri et al., 2023).

However, STEM subjects, particularly mathematics, are often perceived as challenging. A study by Nurin Nuha Zakeri et al. (2023) revealed that mathematics involves various subtopics that require creative thinking, such as mathematical reasoning, probability, and geometry. For instance, many students face difficulties in visualising 3D objects, which is a crucial skill required mainly in geometry. A lack of understanding of mathematics can cause students to lose confidence and perform poorly. One study found that incorporating STEM into mathematics instruction

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promotes active learning, which requires a constructivist-based teaching method that encourages dynamic student participation over passive involvement (Ješková et al., 2022).

Orang Asli students still face numerous challenges in STEM subjects, especially in science, physics and mathematics. Studies indicate that many Orang Asli students in Malaysia encounter difficulties in solving mathematical word problems, which demand strong literacy skills encompassing contextual comprehension and accurate procedure-following (Zaleha Ismail et al., 2020). This challenge is compounded by the fact that mathematics requires visualisation abilities, especially in geometry (Nurin Nuha Zakeri et al., 2023). This contributes to challenges in learning mathematics, leading to unsatisfactory outcomes in students' learning and achievement (Ruzlan Md-Ali et al., 2021). Innovative approaches such as AR, therefore, can enhance students' motivation and engagement in learning (Ahsan et al., 2019).

AR combines the real and virtual world, producing the simultaneous interaction between the two (Bursali & Yilmaz, 2018). This makes AR a practical learning approach that is suitable for STEM education, as elements within STEM do not exist independently without interaction; instead, they cohesively coexist in a multidimensional, skilful approach (Pimthong & Williams, 2018). For example, the AUREL mobile application exemplifies how AR can project mathematical objects onto real-world images, enhancing comprehension and retention (Ang & Lim, 2019). This proves that AR facilitates hands-on learning experiences, allowing students to experiment and solve real-world problems, which is crucial for developing critical thinking skills in mathematics (Ahmad Syawaludin et al., 2019).

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AR is a 3D technology that helps increase users' sensory perception of the real world through a contextual layer of information (Pratama & Sukirman, 2023). AR can increase student enthusiasm and participation, as evidenced by positive feedback from both students and teachers (Ahmad Syawaludin et al., 2019). For example, AR applications enable students to interact with 3D models by making abstract mathematical concepts more tangible (Hasnain Ali Poonja et al., 2023). AR therefore improves the learning experience, enabling digital content to exist in the real world, enhance understanding, gain attention and improve the knowledge of reality (Pinto et al., 2017).

This study focuses on measuring both the effects of AR applications on motivation and achievement and the correlation between these two variables when AR is used as a teaching tool in STEM learning. Additionally, the study focuses on understanding how AR can serve as an effective educational tool to improve learning outcomes for Orang Asli students. The AR applications that are used in this study are ARSiGaSTEM and AR-Tradisi. The study employs a quantitative approach with a quasi-experimental design, involving pre- and post-tests to evaluate the effect of AR applications.

1.3 Problem Statement

The absence of a new and practical educational approach is a primary concern that holds significant importance in STEM education. This problem arises due to the limited

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availability of innovative teaching techniques related to STEM, particularly with regards to Orang Asli students (Habibah Norehan Haron et al., 2019). Mathematics a STEM subject that Orang Asli students around the world face learning difficulties with (Ruzlan Md-Ali et al., 2021).

Regarding learning achievements, particularly in mathematics, Orang Asli students have displayed a persistent pattern of underperformance within the educational environment, falling behind their peers from other student groups (Abdul Halim Abdullah, 2022). Studies have indicated that Orang Asli students in Malaysia face challenges when attempting to solve mathematical problems (Zaleha Ismail et al., 2020). This struggle is further compounded by a decline in the motivation of these students to engage in learning. In addition, STEM subjects, including mathematics, present considerable challenges, resulting in a consistent generation of unsatisfactory outcomes in mathematics (Jin, 2021). The reasons for this gap are complex and multifaceted, with factors such as inadequate resources, lack of access to quality education, and cultural barriers playing a role (Ruzlan Md-Ali et al., 2021). Without a doubt, creative approaches to teaching are important to implement in the classroom (Nurin Nuha Zakeri et al., 2023).

AR technologies can be effective creative approaches in the classroom, especially in mathematics, as it requires the visualisation of abstract concepts more than other subject areas. This helps increase students' motivation and understanding levels compared to traditional methods (Türkan & Çetin, 2022). On the other hand, the lack of practical teaching aids poses a significant concern, particularly for Orang Asli students who face limited access to innovative teaching tools in STEM education (Jin,

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2021). However, while AR technology has the potential to provide unique educational experiences to engage students, its effectiveness for Orang Asli students remains a topic of discussion (Nor Intan Adha Hafit et al., 2021).

The increasing use of technology in education, including AR applications, can be insufficient in meeting the needs of Orang Asli students due to factors such as limited access to reliable internet connections, inefficient technology devices, and a need for digital literacy skills (Nam et al., 2020). In this context, it is essential to consider factors such as students' interests, access to technology, cultural relevance, and the overall quality of AR experiences when introducing AR tools to Orang Asli learners (Martin et al., 2021). The limited awareness and understanding of AR's educational potential may contribute to a lack of interest among Orang Asli students in using such applications (Cherubini, 2020).

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The lack of knowledge about the effect of AR technology towards the motivation and achievements of Orang Asli students is a significant challenge that needs to be addressed (Habibah Norehan Haron et al., 2019). Therefore, this thesis focuses on exploring the multifaceted effect of AR interventions on the motivational aspects and achievements of Orang Asli students in the STEM field. By conducting quantitative analysis and the quasi-experimental research design, this study aims to contribute to the discourse on inclusive educational practices in Malaysia. It also seeks to provide valuable insights and recommendations for creating a more enriched learning environment that caters to the unique needs of the Orang Asli community.

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1.4 Research Objectives

The objective of this study is to investigate the effect and correlation of incorporating AR in STEM learning on the motivation and achievement levels of Orang Asli students:

1. To identify the effect of using AR applications for STEM learning towards the level of motivation of Orang Asli students.

2. To identify the effect of using AR applications for STEM learning towards the level of achievement of Orang Asli students.

3. To measure the strength of the correlation between motivation and achievement in STEM learning among Orang Asli students when using AR applications.

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1.5 Research Questions

1. What is the effect on Orang Asli students' motivation level when using AR applications in STEM learning?

2. What is the effect on Orang Asli students' achievement level when using AR applications in STEM learning?

3. What are the strength of the correlation between student motivation and achievement in STEM learning when using AR applications?

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1.6 Research Hypothesis

1. H_0: $\rho = 0$: There is no significant correlation between motivation level and achievement in using AR applications in STEM learning among Orang Asli students.

2. H_1: $\rho \neq 0$: There are significant correlations between motivation level and achievement using AR applications in STEM learning among Orang Asli students.

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1.7 Conceptual Framework

Figure 1.1 shows a conceptual framework that demonstrates how AR applications contribute to motivation and achievement in STEM learning. The figure shows the framework connecting AR applications with STEM learning, motivation, and achievement. It highlights how AR integrates multimedia elements, interactive features (such as exploration and game-based applications), and types like marker-based and marker-less AR to enhance STEM education. These applications are based on learning theories such as the Cognitive Theory of Multimedia Learning, designed using the 5E Instructional Model, which includes the stages of Engage, Explore, Explain, Elaborate, and Evaluate. In addition, AR-based learning experiences aim to boost student motivation through the Attention, Relevance, Confidence, Satisfaction (ARCS) model,

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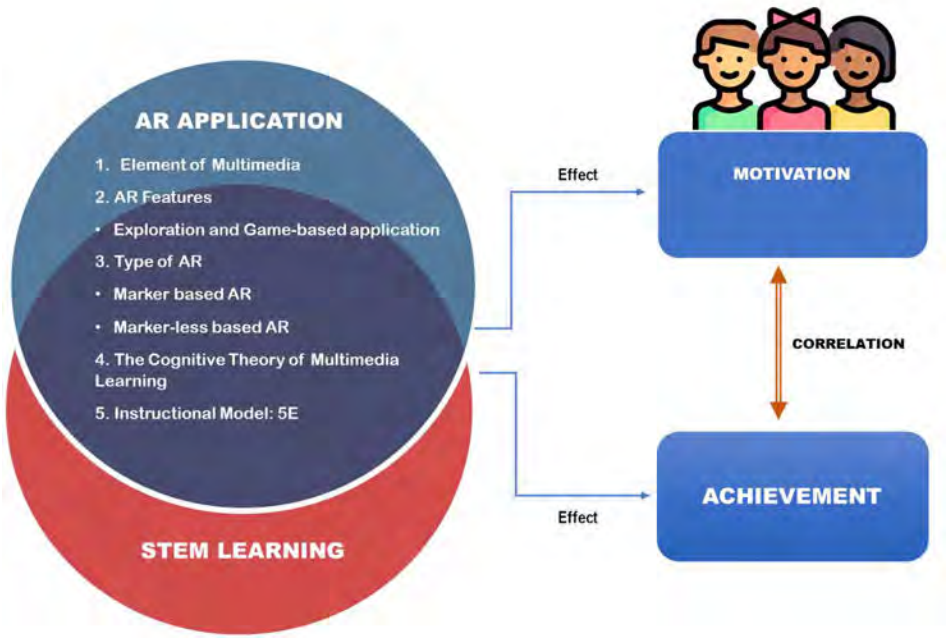
which directly influences achievement or academic performance. The diagram shows a positive correlation between motivation and achievement, where AR applications in STEM learning are designed to engage students and improve both their motivation and learning outcomes.

AR applications are central to this framework. It is described as a tool that enhances learning through various multimedia elements and specific AR features. Moreover, AR applications is a new media technology that consists of multimedia elements that can help enhance students' motivation in learning and contribute to improved achievement (Khan et al., 2019). Specifically, multimedia elements consist of text, audio, video, graphics and animation, which can provide a practical and multi-sensory learning experience (Valarmathie Gopalan et al., 2018).

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Figure 1.1

Conceptual framework of the effect and correlation of Orang Asli students' motivation and achievement in STEM learning using AR applications



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Figure 1.1 shows AR features including simulation and game-based applications. Simulation replicates real-world phenomena through AR. Students can interact with 3D models or animated content to understand scientific principles, visualise abstract concepts, or explore otherwise invisible elements (Ibáñez & Delgado-Kloos, 2018). In AR-Tradisi, students are introduced to traditional games such as *gasing*, where through these AR applications, they can view the 3D model of *gasing* clearly. Meanwhile, with game-based AR applications, students can play the *gasing* virtually using AR-SiGaSTEM.

Game-based AR applications utilise gamification elements, offering immediate feedback and rewarding correct actions (Ibáñez & Delgado-Kloos, 2018). The score after playing the virtual *gasing* appears as how many *gasing* units enter the *gasing* court. Through this game, students can understand the prediction and calculation of angle and distance which can be applied in their mathematical knowledge. This approach enhances STEM education by making it more interactive and engaging for students. At the same time, it encourages active participation and a deeper understanding of complex concepts.

The framework identifies two types of AR technologies: marker-based AR, which uses physical markers to trigger digital content, and marker-less AR, which operates without physical markers, offering greater flexibility and accessibility in various learning environments (Tan & Chee, 2021). For AR-SiGaSTEM, marker-based AR is essential, as it ensures precise interaction and enhanced experiences. In contrast,

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AR-Tradisi leverages the flexibility of marker-less AR to provide a more adaptable and engaging user experience.

The development of the AR application is grounded in the Cognitive Theory of Multimedia Learning (CTML), which posits that effective learning occurs when individuals are able to actively process and integrate information presented through both verbal and visual modalities (Keller et al., 2021). This theory emphasises the importance of designing instructional materials that support dual-channel information processing, promote cognitive engagement, and reduce extraneous cognitive load to enhance comprehension and retention (Mayer, 2024). Additionally, the instructional approach within AR applications follows the 5E Model (Engage, Explore, Explain, Elaborate, and Evaluate); a structured and iterative method widely recognised in STEM education for fostering deeper understanding (Pacala, 2024).

AR applications are perceived as an interactive and captivating approach to impart STEM disciplines, which are congruent with contemporary pedagogical strategies. The synthesis of AR and STEM education has been demonstrated to exert a direct influence on learners' motivation. Motivation is analysed using the ARCS model, which emphasises the design of educational experiences that sustain student engagement. It is anticipated that AR applications will cultivate enhanced motivation by rendering learning more pertinent, engaging, and fulfilling, particularly for marginalised populations such as the Orang Asli students (Pinto, et al., 2017).

Additionally, the framework underscores the importance of student achievement, which is evaluated through scores in achievement assessment. It proposes

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that the use of AR in the classroom will have a direct positive effect on students' achievement, suggesting that a more interactive and engaging learning environment will lead to better learning outcomes (Khan et al., 2019).

Figure 1.1 shows a correlation between motivation and achievement, implying that as students become more motivated through the use of AR, their achievement in STEM subjects is also likely to improve. The framework proposes that the use of AR in STEM learning affects Orang Asli students by enhancing their motivation, which in turn improves their achievement. The interactive and immersive nature of AR technology offers an innovative approach to education that could address motivational challenges and improve learning outcomes for underserved communities like Orang Asli students.

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1.8 Operational Definition

The operational definition is based on several key components, as elaborated below.

1.8.1 AR Applications

AR is a technology that combines real-world and virtual objects, allowing for simultaneous interaction with the physical environment and digital elements (Sirakaya & Cakmar, 2018). There are two types of popular AR: marker-based AR and marker-less-based AR. Both types are used in this study. Marker-based AR relies on specific

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triggers, such as QR codes or images, to activate the display of digital content (Tan & Chee, 2021).

Meanwhile, marker-less AR is known as location-based or location-aware AR, which does not require specific markers. Instead, it uses GPS, compass, accelerometer, and other sensors in devices to determine the user's location and orientation (Cheng et al., 2017). The digital content is overlaid onto the real world based on these parameters. The AR platforms used are AR-TRADISI and AR-SiGaSTEM. The AR application is an Android application, which can be used using mobile phones and tablets. AR-SiGaSTEM uses marker-based AR, while AR-Tradisi employs marker-less AR technology.

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1.8.2 Motivation

Motivation refers to the inner drive that stimulates individuals to pursue and achieve their goals. In the context of AR, research has indicated that AR-based learning can enhance learners' motivation and reflective thinking (Sabbah et al., 2023). The motivation theory applied in this study is based on the ARCS model. ARCS is the acronym for Attention, Relevance, Confidence, and Satisfaction. It is an instructional design framework developed by John Keller that focuses on strategies to enhance and sustain learner motivation in educational settings (Dinçer, 2020). These four key elements guide learning to enhance motivation and improve learning outcomes (Keller, 2010).

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1.8.3 Achievement

Achievement in education refers to students' learning outcomes, which is assessed through examinations and is crucial for evaluating education quality and guiding policy and interventions (Tian & Sun, 2018). Achievement is often quantified through academic outcomes, such as grades and test scores, which serve as indicators of a student's success in educational settings (Muhammad Saidi Rahman & Yusup Indra Wijaya, 2023). In this study, a quiz-based achievement indicator is used, known as a geometry assessment. The geometry assessment is used to indicate students' scores after answering a question given to them.

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1.8.4 STEM Learning

STEM learning refers to an interdisciplinary approach to education that integrates concepts and skills from four key disciplines: Science, Technology, Engineering, and Mathematics (Nurin Nuha Zakeri et al., 2023). STEM learning encourages students to explore real-world problems, conduct experiments, engage in design challenges, and use technology to find solutions (Siti Hamizah Aspin et al., 2022). This approach emphasises a hands-on, inquiry-based methodology to teach and apply knowledge in these areas, fostering critical thinking, problem-solving, creativity, and innovation among learners (Aida Suraya Md. Yunus, 2020). The approach used in this study is interdisciplinary, hands-on learning and inquiry-based learning.

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1.8.5 Orang Asli

The Orang Asli refers to the Orang Asli people in Malaysia. While direct studies on the effect of AR on the Orang Asli community may be scarce, research on the effects of AR on achievement and motivation among secondary school students in Malaysia provides valuable insights (Özeren & Top, 2023). For this study, the Orang Asli are Form 1 students, and most of them are from Suku Temiar in Perak.

1.8.6 Conventional Method

The conventional method is the traditional way of teaching, which primarily uses the lecture method (Dange, 2018). Conventional methods use traditional assessment and evaluation techniques focusing on summative assessments, academic knowledge, and memory skills, often lacking adaptability and inclusivity (Meylani, 2024). This method of teaching is textbook-centred, teacher dominant and exam-oriented (Dange, 2018). In this study, the conventional method uses the textbook and slide presentation.

1.9 Study Limitations

This study aims to determine the effect of AR applications towards motivation and achievement among Orang Asli students. Additionally, the study was conducted in Perak, Malaysia, focusing on Form 1 students, which may limit the generalisability of

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the findings to other populations. The students are from Suku Temiar. This study specifically emphasises on Orang Asli students, which is vital for addressing their educational needs; however, this may lead to potential limitations in generalising the findings to a broader context.

Moreover, this study focuses on quantitative data collection; incorporating qualitative data, however, could provide valuable insights into participants' experiences and perceptions of AR technology (Marrahi-Gomez & Belda-Medina, 2023). The study implements two AR applications: AR-SiGaSTEM and AR-Tradisi. The AR application used is an Android application, which can be accessed using mobile phones and tablets. The traditional game in this application is *gasing.* The syllabus in this study is in the Mathematics Form 1 textbook, Chapter 10, on Parameter and Area.

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However, it is important to acknowledge that this study has some limitations that could affect the AR applications and its compatibility with participants' devices, potentially influencing the study outcomes. The specific device chosen for generating the AR applications is crucial for ensuring the functionality and accessibility of the AR experience.

1.10 Importance of Research

Based on the study, the importance of this study varies across different groups, including Orang Asli students, teachers, the Orang Asli community, and the Ministry of Education. Each of these groups stands to benefit significantly from the findings.

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1.10.1 Orang Asli Students

The rise in the development of AR applications, along with growing research into their use in STEM education, has not yet extended significantly to the Orang Asli. The interactive features of AR applications hold great potential for enhancing students' engagement in STEM subjects that may be perceived as challenging. This is particularly relevant for Orang Asli students, as teaching and learning can often be difficult, ultimately hindering their motivation and involvement. Integrating AR applications in STEM learning can create a significant opportunity to improve engagement, motivation and achievement among these students in demanding fields. Therefore, this study aims to address educational gaps by equipping Orang Asli students with innovative learning tools that can cater to their needs and challenges.

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1.10.2 Teachers

This study offers valuable insights into innovative teaching methods, encouraging teachers to integrate AR applications into their lessons. These tools can help simplify and clarify challenging STEM concepts. The research also supports professional development by broadening teachers' instructional approaches, enabling them to better address the diverse needs of their students. Furthermore, by recognising the motivational and achievement-enhancing effects of AR, teachers can refine their teaching strategies to make learning more engaging and effective, ultimately improving their overall teaching efficacy.

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1.10.3 Ministry of Education Malaysia

This study offers crucial data that can aid in developing more inclusive and effective educational policies. By demonstrating the success of AR applications in engaging and improving learning outcomes for marginalised communities like the Orang Asli, the Ministry of Education can use these findings to shape policies that ensure equitable access to educational tools and resources. This study aligns with the Ministry of Education's broader goals of integrating technology into the national curriculum and supporting the modernisation of the education system in Malaysia. Additionally, the study provides a framework for monitoring and evaluating the success of digital tools in improving educational outcomes, particularly in rural and underserved regions, ensuring that the benefits of technological advancements are extended to all students.

1.10.4 Orang Asli Community

This study has broader implications beyond the classroom. It empowers the community through education by improving access to quality learning resources that can foster better opportunities in the future, especially in STEM fields. The use of culturally relevant AR applications can also help bridge the gap between traditional knowledge and modern education, allowing Orang Asli students to connect with their cultural heritage while embracing new technological tools. This not only promotes educational

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growth but also supports the preservation of their cultural identity within an evolving educational landscape.

1.11 Summary

Malaysia's education system has been modernised through the Digital Education Policy, integrating multimedia and AR technology. AR in STEM education has resulted in superior outcomes, especially for Orang Asli communities. The study aims to identify the effect of AR integration in STEM learning on Orang Asli students' motivation level and achievement in STEM learning. The study employs a correlation research design and quantitative data collection method with a sample of 30 Orang Asli Form 1 students at Sungai Siput, Perak. This study investigates the effect of AR applications on the motivation and achievements of Orang Asli students in STEM learning. The study addresses concerns related to student achievement, emphasising the importance of evaluating learning outcomes. It highlights the significance of AR applications as effective teaching tools to improve motivation and learning outcomes in STEM education for Orang Asli students.

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CHAPTER 2

LITERATURE REVIEW

2.1 AR in Multimedia and STEM Education

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The integration of AR into education has gained significant attention in recent years, particularly its potential to enhance learning experiences by combining real-world and virtual environments (Pinto, et al., 2017). AR is known for its ability to present digital content in real-time, offering immersive, interactive experiences that have proven to be beneficial in education, especially in STEM learning (Ibáñez & Delgado-Kloos, 2018). This literature review explores the effect of AR in educational contexts, focusing on its applications in multimedia and STEM education. It highlights how AR can increase student motivation, engagement, and achievement, particularly among Orang Asli students. The review also addresses the challenges and limitations of AR technology in educational settings, providing a comprehensive understanding of its potential and practical implications (Ahsan et al., 2019).

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This thorough review of the literature examines the emerging role of AR as a transformative tool in education. Focusing specifically on its application in STEM education, the study seeks to provide a foundational understanding that can guide future research into how AR can effectively support the learning experiences of Orang Asli students in Malaysia. By analysing various studies and educational models, the review emphasises the potential of AR to create interactive and immersive learning environments. These environments can enrich the educational journey for students, making complex STEM concepts more accessible and engaging. The goal is to identify best practices and innovative approaches that utilise AR to cater to the unique cultural and educational contexts of Orang Asli students, ultimately promoting enhanced understanding and achievement in STEM learning.

2.1.1 AR in Multimedia

Multimedia is defined as a multi-component and multi-sphere environment that allows for the use of text, graphics, video, and animation (Ganihanova, 2022). Multimedia is also defined as an interactive application that integrates text, colour, graphical images, animation, audio, sound, and full-motion video in a single application (Lanre et al., 2018). Integrating multiple components of multimedia learning can enhance the learning process and boost motivation (Mohamad Subaidi Abdul Samat & Azlina Abdul Aziz, 2020).

This integration not only improves the educational experience but also aligns with Mayer's instructional model, which highlights the importance of presenting information strategically. By utilising the principles of modality, contiguity, split

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attention, individual differences, and coherence, this model highlights the strategic combination and presentation of various information types while recognising individual learning. Differences in multimedia content are important when advocating for concise and essential information (Mayer, 2021). Additionally, AR technology allows users to interact with various multimedia elements, including images, text, and audiovisual materials (Lin et al., 2018). In AR learning environments, it is crucial to apply multimedia design principles, particularly the spatial contiguity principle and the coherence principle (Krüger & Bodemer, 2022). For example, video compression helps enhance the immersion and efficiency of experiences on the platform (Chen, 2020).

AR is a technology that integrates real-world and virtual visuals, which allows the simultaneous interaction between the two (Bursali & Yilmaz, 2018). By merging real-world imagery with computer graphics, AR uses computer-generated objects or elements that overlay one or more layers onto a real-world environment in real time (Pinto et al., 2017). This integration allows users to engage with both tangible and digital components seamlessly, enhancing their overall experience (Parmaxi & Demetriou, 2020). Furthermore, AR serves as a projection of virtual information, such as images, texts, video, and sounds through user devices (Lo et al., 2021). Mobile applications and AR technologies, in addition to electronic devices such as tablets and smartphones, can significantly enhance the learning experience. These tools not only make learning more engaging but also provide a variety of interaction methods that cater to different learning styles (Ahsan et al., 2019).

AR occupies a critical position within Milgram's Reality-Virtuality Continuum, functioning as an influential pedagogical tool that enhances the educational experience

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(Skarbez et al., 2021). By seamlessly integrating digital content with real-world environments, AR significantly enriches the process of learning and improves knowledge retention among students by allowing learners to engage with both physical and virtual elements simultaneously (Sirakaya & Sirakaya, 2020). Figure 2.1 presents a visual representation of the complex relationship between tangible reality and digital enhancements, illustrating how these components converge to foster a more immersive and interactive educational landscape.

Figure 2.1

Milgram's Reality-Virtuality Continuum from P. Milgram, 1995



The Milgram Reality-Virtuality Continuum describes the spectrum between fully real and fully virtual environments (Skarbez et al., 2021). On the far left of the continuum is the Real Environment (RE), characterised by the physical and tangible aspects of the world we experience through our senses (Lo et al., 2021). Conversely, on the far right is the Virtual Environment (VE); an entirely digital construct that immerses users in a simulated realm created by technological advancements (Sirakaya & Sirakaya, 2020). Situated between these two endpoints is Mixed Reality (MR), which serves as a sophisticated integration of real and virtual elements, facilitating an interactive experience that leverages both environments to enhance user engagement

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and perception (Dodevska & Mihić, 2018). In this context, AR is closer to the real environment, as it overlays digital content onto the real world that enhances the user's perception without completely replacing their real surroundings (Lo et al., 2021).

Conversely, Augmented Virtuality (AV) tends to lean more towards the virtual side, showcasing how these technologies differ in their interaction with the real world (Dodevska & Mihić, 2018). AR is considered complex in this continuum because it refers to a real world augmented by virtual items, and AV refers to an immersive virtual environment with elements from the real world (Lo et al., 2021). This distinction is further evidenced by the interactive nature of AR, which facilitates a synthesis of real-world elements and virtual content, enriching the user's experience and understanding of their environment (Parmaxi & Demetriou, 2020). Other than that, AR is defined as a technology that enables the superimposition of virtual information onto the real world, such as by superimposing text or an image on what the user sees (Parveau & Mehdi Adda, 2018). Overall, this continuum illustrates the concept of AR, which blends real-world elements with virtual components that are superimposed over the physical environment in real time.

One of the most known examples of AR is the Pokémon Go mobile AR game that can be downloaded on smartphones (Dodevska & Mihić, 2018). This game allows users to see the characters of the Pokémon through a smartphone in real-time. AR is also related to VR technologies and has been used almost in every industry. However, they are different from each other, and the meaning of AR is a direct or indirect view of the physical real-world environment in real-time (Dodevska & Mihić, 2018). By integrating virtual, computer-generated information with the real world, AR creates an

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interactive experience that can be classified as 3D (Skarbez et al., 2021). This enhancement of reality can be achieved through two primary types of AR: marker-based AR and marker-less AR (Cheng et al., 2017).

Marker-based AR is a type of AR that uses the recognition of images, eyes, or other real-world objects in real-time to provide the user with additional digital data (Rusnida Romli et al., 2020). Marker-based AR is a predefined two-dimensional (2D) image, QR code, or 3D object used as a marker to recognise the position of virtual objects (Abdinejad et al., 2021). Marker-based AR uses a marker as a trigger (Cheng et al., 2017), while marker-less AR allows virtual objects to be placed anywhere in the physical environment without relying on markers (Rusnida Romli et al., 2020). Marker-less AR is known for presenting many advantages over marker-based AR because the virtual object does not need to be anchored to any image or shape in the real world to be visualised (Abdinejad et al., 2021). The dependency on markers highlights the interactive potential of AR and distinguishes it from marker-less systems, making it an interesting area of study in the broader context of AR applications.

AR incorporates both virtual and physical elements, allowing users to experience actual objects alongside digital enhancements in a 3D environment (Zsila, et al., 2018). In contrast to VR, which is fully immersive, AR is described as non-immersive since users continue to engage in the actual world. AR became popular in education as it brings virtual objects into real life, which enhances the user experience (Dodevska & Mihić, 2018). AR is primarily made to give users the excitement of image scanning and identification, giving them a distinctive visual experience and access to in-depth multimedia information about the items on display (Skarbez et al., 2021). As

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a result, AR has found widespread application across various domains, such as museums, educational institutions, and tourism, enhancing how we interact with our surroundings and learn about the world.

2.1.2 Learning Theory in AR

The integration of learning theory in AR provides a comprehensive framework to understand how AR can enhance the teaching and learning process (Pellas et al., 2019). AR enhances learning experiences by merging real and virtual environments, thereby allowing learners to engage actively, visualise abstract concepts, and develop deeper cognitive understanding through interaction (Pinto et al., 2017; Ibáñez & Delgado-Kloos, 2018). The application of learning theories ensures that AR-based educational tools promote motivation, knowledge retention, and critical thinking skills (Khan et al., 2019).

AR applications are aligned with constructivist learning principles, which emphasise active participation and knowledge construction through meaningful experiences (Sirakaya & Sirakaya, 2020). Within STEM education, AR allows students to explore real-world applications of scientific and mathematical concepts in an interactive and inquiry-based manner (Pinto et al., 2017). This study applies two principal learning theories to guide the development of the AR applications used, such as CTML and the 5E Instructional Model. These theories provide the instructional foundation for the design of AR-SiGaSTEM and AR-Tradisi applications to enhance STEM learning among Orang Asli students.

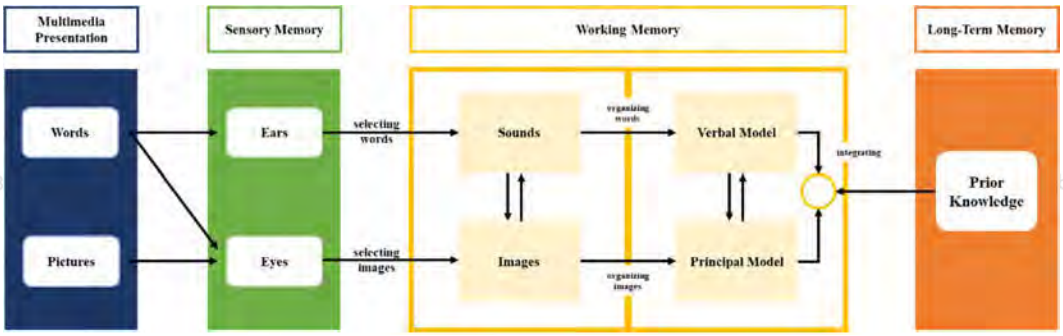
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Figure 2.2 shows CTML proposed by Mayer (2024), which posits that individuals learn more effectively when information is presented through both visual and verbal channels rather than a single channel. The theory is founded on three assumptions: (1) the existence of separate channels for verbal and visual information processing; (2) the limited capacity of each channel; and (3) the necessity for active cognitive processing, which includes selecting, organising, and integrating information.

Figure 2.2

Cognitive Theory of Multimedia by Mayer (2024)



In AR learning environments, CTML principles are crucial in minimising cognitive overload and fostering deeper information integration (Keller et al., 2021). By combining 3D models, animations, textual explanations, and interactive elements, AR applications support dual-channel processing, thus enhancing comprehension and learning outcomes (Pinto et al., 2017; Ibáñez & Delgado-Kloos, 2018). Accordingly, the AR-SiGaSTEM and AR-Tradisi applications utilised in this study were developed in alignment with CTML principles, presenting STEM content through multimedia elements that promote cognitive engagement and support efficient learning (Khan et al., 2019).

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The 5E Instructional Model structures the learning process into five sequential phases: Engage, Explore, Explain, Elaborate, and Evaluate (Suhaizal Hashim et al. 2022). This model is particularly effective in science and STEM education as it encourages inquiry-based and student-centred learning (Ibáñez & Delgado-Kloos, 2018; Pellas et al., 2019). This is evidenced through recent studies that have demonstrated the effectiveness of this model in enhancing students' conceptual understanding, scientific reasoning, and attitudes towards science (Bozkurt et al., 2023).

In the Engagement phase, students' curiosity is sparked by stimulating questions or phenomena that connect to their prior knowledge. During the Exploration phase, learners participate in hands-on activities, encouraging them to investigate and develop initial ideas independently (Bozkurt et al., 2023). In the Explanation phase, students articulate their understanding while instructors introduce formal concepts and terminologies. The Elaboration phase extends learning by applying knowledge to new contexts, promoting deeper understanding and skills transfer (Suhaizal Hashim et al. 2022). Finally, the Evaluation phase assesses students' conceptual growth and identifies remaining misconceptions through various assessment strategies (Bozkurt et al., 2023).

Figure 2.3 illustrates the dynamic nature of the 5E model, emphasising the continuous interaction among phases. Integrating the 5E Instructional Model into AR-based STEM learning, such as through the AR-SiGaSTEM and AR-Tradisi applications, helps foster inquiry-based, interactive, and student-centred experiences, effectively enhancing both motivation and achievement among marginalised groups

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like the Orang Asli students (Suhaizal Hashim et al. 2022). Other than that, the incorporation of the 5E model ensures that learning experiences are structured systematically, thereby facilitating deeper cognitive engagement and promoting higher-order thinking skills among Orang Asli students (Bozkurt et al., 2023).

Figure 2.3

The 5E Model of Instruction by Suhaizal Hashim et al. (2023)



In conclusion, the CTML and the 5E Instructional Model provide robust theoretical underpinnings for the development of AR-based learning interventions. By strategically integrating multimedia elements with inquiry-driven instructional phases, the AR-SiGaSTEM and AR-Tradisi applications are designed to enhance learner

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motivation, engagement, and achievement in STEM education, particularly among marginalised student populations.

2.1.3 AR in STEM Education

In recent years, AR has emerged as one of the promising methods for the teaching and learning process in the modern world (Laurens-Arredondo, 2022). AR technology has become essential for educational purposes since it allows for the seamless integration of real-world and virtual items into the actual world (Geng & Yamada, 2021). By connecting digital content with the real world, AR enhances learning experiences, improves environmental awareness, and boosts engagement and understanding of reality (Pinto et al., 2017).

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AR can create virtual environments that do not exist in reality, allowing for innovative ways to interact with the real world and craft experiences that would be impossible in purely real or virtual contexts (Khan et al., 2019). For instance, the main function of AR, which consists of utilising visual information such as images, text, video, audio, web links, and 3D models, is convenient to apply in education, especially in STEM (Salma Almira Hamdani et al., 2022). This is because STEM education is a fields that requires the use of imagination and visualisation to understand concepts and images. According to Petrov and Atanasova (2020), AR is a technology that enables users in a classroom to control 3D objects and receive information from a real environment, which gives tremendous value in the educational field. The potential of AR in education, in fact, has been recognised since the beginning of its invention. Studies have found numerous educational companies implementing VR and AR

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technologies to bring life experiences into the classroom, due to the technology's ability to inspire and grab the attention of the students. However, the use of AR in education should also concentrate on finding ways to promote and facilitate meaningful learning (Khan et al., 2019).

2.1.3.1 AR in STEM Learning

AR applications are technologies that connect the physical and virtual worlds, enabling users to engage in interactive and immersive experiences through digital devices equipped with cameras such as smartphones, tablets, laptops, or desktop computers (Sánchez-Juárez et al., 2023). In other words, AR applications are tools that overlay digital content onto the real-world environment using the camera of a mobile phone (Mohan et al., 2023). AR applications are a technology that can turn virtual objects into objects that look real and can be displayed in real time (Pratama & Sukirman, 2023).

There are many types of AR applications that have been developed in STEM learning as a teaching aid to help students' learning process. The ArloonGeometry application window (Rashevska et al., 2020), SMP IPA book (Fauzi Bakri et al., 2021), Battle against the Colossus & Save the Planet! (Rebollo, Remolar, Rossano & Lanzilotti, 2021), SCIENEX (Noor Hidayah Che Lah et al., 2024), cleARmaths (Schutera, Schnierle, Pertzel, Seybold, & Bauer, 2021), FootMath (Cerqueira et al., 2020) GeoGebra AR (Kramarenko et al., 2019), AR-Tradisi and AR-SiGaSTEM (Laili Farhana Md Ibharim, 2023) are examples of AR applications that are built based on their usability and functions. These applications have been used in STEM learning to cater to specific fields.

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Table 2.1 shows the comparison of ten different AR applications used in education based on their technology, features, and how users can engage with them in an educational context. It shows important details about each app, including the platform it works on (Android or iOS), the type of AR it uses (marker-based or marker-less), and whether it displays content in 2D or 3D. It also highlights the types of media used, like graphics, text, sound, video, and animation, which are key to how content is presented. Additionally, the table explains how users interact with the AR apps, such as through hand gestures, voice control, touch screens, head or device movements, and eye tracking.

In this study, the AR applications used are AR-Tradisi and AR-SiGaSTEM. While the usability of the applications have been studied, this study aims to determine the effect of these AR applications towards the motivation and achievement of Orang Asli students in STEM learning specifically.

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Table 2.1

Overview of AR applications in Education

NO.	AR APPLICATIONS	DEVELOPMENT		AR FEATURES				MULTIMEDIA ELEMENT					AR USER INTERACTION TYPE					
				Marker-based		Markless							EXPLICIT INTERACTION				IMPLICIT INTERACTION	
		Android	IOS	2D	3D	2D	3D	GRAPHIC	TEXT	SOUND	VIDEO	ANIMATION	HAND GESTURE	HAND CONTROLLER	VOICE	TOUCH SCREEN	Head / Device Movement	Eye Tracking
1.	The ArloonGeometry application window (Rashevska et al., 2020)	✓		✓				✓	✓	✓			✓			✓		
2.	SMP IPA book (Fauzi Bakri et al., 2021)	✓	✓	✓				✓	✓	✓	✓	✓				✓		
3.	Battle against the Colossus & Save the Planet! (Rebollo et al., 2021)	✓	✓	✓	✓			✓	✓	✓	✓	✓				✓		
4.	SCIENEX (Noor Hidayah Che Lah et al., 2024)	✓	✓		✓			✓	✓	✓		✓				✓		
5.	cleARmaths (Schutera et al., 2021)	✓	✓	✓				✓	✓							✓		
6.	FootMath (Cerqueira et al., 2020)	✓	✓	✓				✓	✓	✓		✓				✓		
7.	GeoGebra AR (Kramarenko et al., 2019)	✓	✓		✓			✓	✓	✓						✓	✓	
8.	AR-Tradisi (Laili Farhana Md Ibharim, 2023)	✓	✓		✓			✓	✓	✓		✓	✓			✓	✓	
9..	AR-SiGaSTEM (Laili Farhana Md Ibharim, 2023)	✓	✓				✓	✓	✓	✓	✓	✓				✓	✓	

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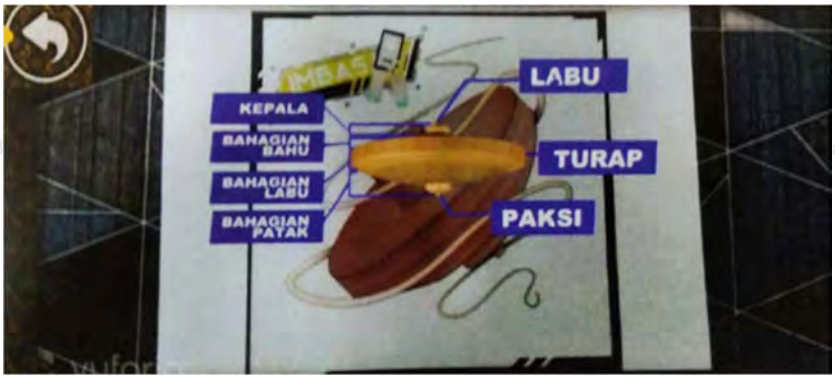
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i. AR-Tradisi

Based on Figure 2.4, the main function of AR-Tradisi is to enable teachers and students to look into the model as a traditional game in 3D, including *gasing* by using AR technology. The application must be downloaded and the image of the traditional game model needs to be scanned. Every model has a label on the tools of the game to help the teacher and students determine the look and shape of the model.

Figure 2.4

QR Marker-Based AR Visualisation of a Traditional Gasing Anatomy in AR-Tradisi Application



ii. AR-SiGaSTEM

AR-SiGaSTEM aims to help teachers strengthen STEM skills among students through folk games (Laili Farhana Md Ibharim, 2023). The application uses the theme of the *gasing* game. It consists of three main features: Info, Quiz and Play. Figure 2.5 illustrates one of the application's features, which provides detailed information about *gasing* including the weight of *gasing,* the circumference of *gasing,* and the height of

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gasing. Additionally, the AR-SiGaSTEM application includes a 2D model of *gasing* to offer users a visual representation of the *gasing* anatomy that is shown in Figure 2.5.

Figure 2.6 further presents the various models of *gasing* found in Malaysia, highlighting their cultural significance. This feature aims to educate the younger generation about this traditional game, which is increasingly at risk of becoming extinct. Other than that, the user can choose to learn about each type of *gasing*. The user can play the *gasing* in this feature, where the camera will present the real world and the *gasing* court. Users can throw the *gasing* into the court, and every entry of the *gasing* will be counted. This not only provides entertainment for the user, but it also helps in developing the user's ability to calculate the right angle to throw the *gasing* inside the court. Furthermore, the quiz section, also shown in Figure 2.7 tests users' knowledge of *gasing*. The quiz consists of 10 questions related to STEM through the *gasing* game. This interactive quiz is designed not only to test knowledge but also to enhance users' engagement with the application.

Figure 2.5

The content of AR-SiGaSTEM: Gasing anatomy



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Figure 2.6

The content of AR-SiGaSTEM: Different types of Gasing



Figure 2.7

The content of AR-SiGaSTEM: Quiz



2.1.3.2 Pros and Cons of AR Applications in Education

i. Advantages of AR in Education

AR technology is widely used in education and is one of the most promising tools in the teaching and learning process as it integrates the real world completely with the virtual environment (Pellas et. al, 2019). According to Pinto et al. (2017), AR has many educational benefits, including enhanced learning gains, motivated interaction, and

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cooperation, all of which are important features of lifelong learning. Studies have found that AR technologies help the understanding of learning and improve learning performance (Geng & Yamada, 2021).

The combination of various technological innovations and trends, such as AR applications, has garnered attention for their potential impact, utility, and efficacy in the educational field. In recent times, the use of AR has emerged as a promising tool in teaching and enhancing the learning experience (Chin & Wang, 2021). AR provides numerous advantages in assisting students in acquiring learning gains, motivation, interaction, and collaboration, which are all critical aspects of lifelong learning. With the advancement towards the Industry 4.0 era, digital technology integration into the education systems has become imperative to meet its demands (Moraes et al., 2022). It is therefore essential to prepare students with the critical skills and competencies to meet the dynamic and evolving needs of the contemporary industry (Subramaniam Kolandan, 2019).

Previous studies have shown that AR technology has the potential to increase students' achievement and eliminate misconceptions (Sirakaya & Cakmak, 2018). According to (Kazanidis, Pellas, & Christopoulos, 2021), the effect of AR technology on students' engagement remains unclear and studies suggest that prior familiarity or exposure to AR applications and related technologies may moderate its influence on students' motivation and achievement. This highlights the need to explore the conditions under which AR integration has the highest effect in enhancing students' motivation and achievement.

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AR is a real-time interactive tool that combines virtual digital information, text, images, and other data in the real world (Petrov & Atanasova, 2020). It can help supplement information that is absent in the actual environment and assist learners in acquiring abstract concepts and developing knowledge (Lo et al., 2021). Students can directly interact between actual environments and virtual objects, giving them the ability to manipulate virtual information naturally (Geng & Yamada, 2021). This helps them immerse themselves in the learning material and is also simple to use for those with little computer experience (Noor Hidayah Che Lah et al., 2024). These advantages ensure that AR places the learner in a specific learning environment that can provide learning opportunities not available in regular classrooms. As highlighted by recent studies, AR applications have the potential to enrich the learning experience by providing sensory information that extends beyond what the physical environment can offer.

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AR technology increases motivation in learning especially in STEM (Petrov & Atanasova, 2020). The activities of an AR learning environment are motivating and enjoyable for students (Irma Shayana Samaden et al., 2020). This is because AR can lead to excellent engagement and generate authentic learning activity, interactivity, and realism (Khan et al., 2019). The immersion and engagement elements provided by AR encourage students to engage in learning activities and boost their motivation to study (Geng & Yamada, 2021). Hence, studies have shown positive feedback towards the effectiveness of AR technology in the teaching and learning process, where AR potentially increases students' interest in learning (Laurens-Arredondo, 2022).

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According to surveys conducted, teachers are positive about AR since it improves teaching, fosters self-directed and teamwork learning, and boosts students' exploratory behaviour (Perifanou et al., 2023). Ultimately, utilising AR technologies not only boosts students' understanding and motivation in the learning process but also improves their performance (Geng & Yamada, 2021).

ii. Disadvantages of Augmented Reality in Education

Despite the numerous advantages of AR technologies used in education, there are multiple challenges in using AR technologies among students and educators themselves. For example, some students do not have basic skills in AR technology and are unfamiliar with its applications. This may cause them to become disinterested in participating in the learning session due to the complexity or error-prone AR applications (Mohd Hafizuddin Mohamed Jamrus & Abu Bakar Razali, 2019).

Some AR elements are not enough to design a meaningful learning environment (Buchner & Zumbach, 2020). One study found several barriers to the widespread adoption of AR applications, including a lack of quality AR resources, time, digital infrastructure, and the need for institutional support (Perifanou et al., 2023). Moreover, using AR applications in teaching and learning sessions might cause difficulties and problems in maintaining superimposed information (Ibáñez & Delgado-Kloos, 2018). Studies have highlighted that while AR can be convenient in the classroom, such technology could impose an additional cognitive load on students (Chin & Wang,

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2021). These challenges should be studied to increase the usability and optimal benefits of AR technologies in the future.

On top of that, some students may lack basic skills in AR technology and the complexity or error-prone nature of AR applications can lead to disinterest in learning (Ahsan et al., 2019). This can impose additional cognitive loads on the students through the use of AR applications (Chin & Wang, 2021). Other than that, Orang Asli students might not be familiar with AR applications because there are barriers to the widespread adoption of AR applications, such as a lack of quality resources and digital infrastructure (Habibah Norehan Haron et al., 2019). Therefore, these challenges should be studied to increase the usability and optimal benefits of AR technologies.

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2.2 STEM Education

STEM, an acronym for Science, Technology, Engineering, and Mathematics, is a term used to describe an interdisciplinary approach to education that emphasises the importance of these four subjects in preparing students for future careers and addressing global challenges (Mohd Azry Abdul Malik et al., 2021). STEM education has a long history, but it has gained renewed attention in recent years due to concerns about the shortage of skilled workers in STEM fields (Abdul Halim Abdullah, 2022).

One study identified a growing interest in STEM education globally, as revealed from 2000 to 2018 (Li, Wang, Xiao, & Froyd, 2020). There is also a strong misalignment between Malaysia's approach to STEM education and its

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implementation, due to several challenges including a lack of motivation, poor learning experiences, and ineffective teaching methods (Siti Hamizah Aspin et al., 2022).

Figure 2.8 represents a framework for STEM education, aimed at embedding STEM practices into various aspects of life (Kementerian Pendidikan Malaysia, 2016). The figure highlights the holistic approach to developing a STEM culture (*Budaya STEM*) through education. The triangle illustrates three core contexts in which STEM knowledge, skills, and values are applied: Daily Life (*Kehidupan Harian*), The Environment (*Alam Sekitar*), and Local and Global Communities (*Masyarakat Lokal dan Global*). These contexts emphasise that STEM is not limited to academics but is a critical part of solving everyday problems, promoting environmental sustainability, and addressing societal challenges at both local and global levels (Siti Hamizah Aspin et. al, 2022).

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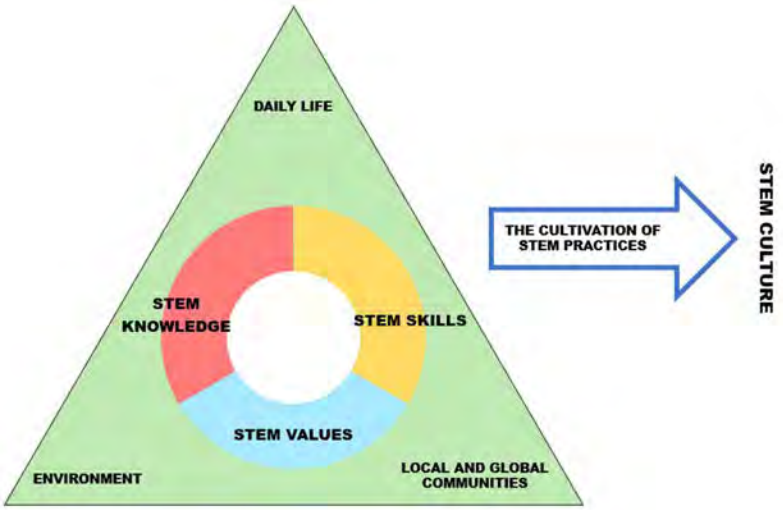
At the centre of the diagram, the three main components of STEM education are shown: STEM knowledge (*Pengetahuan STEM*), STEM skills (*Kemahiran STEM*), and STEM Values (*Nilai STEM*). Knowledge refers to the understanding of scientific and technological concepts. Skills focus on the practical abilities needed to solve real-world problems, and values emphasise ethical considerations and social responsibility in the application of STEM. The arrow labelled Cultivation of STEM Practices (*Pembudayaan Amalan STEM*) is depicted to foster a continuous and sustainable integration of STEM into all aspects of life. This approach aims to prepare individuals not only to excel in STEM-related fields but also to become proactive contributors to their communities and the environment, ensuring long-term societal benefits through a solid STEM foundation (Laili Farhana Md Ibharim, 2023).

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Figure 2.8

Teaching and Learning Approach in STEM by Kementerian Pendidikan Malaysia (2016)



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According to a study by Ješková et al. (2022), STEM skills are categorised into two types: process skills and technical skills. Each STEM field has specific goals aimed at enhancing the effectiveness of STEM learning and improving students' STEM skills. For example, in the technology field, the goal is to provide students with hands-on experience using digital tools and materials to access information and complete tasks. In contrast, the goal of mathematics education is to help students grasp and perform mathematical processes (Ibáñez & Delgado-Kloos, 2018). However, STEM education in Malaysia faces several challenges. A study highlighted issues such as a shortage of qualified teachers, inadequate infrastructure, and insufficient funding as key obstacles in the current implementation of STEM education (Rashidin Idris et al., 2023).

One promising approach to improving STEM learning among Orang Asli students is the use of AR applications as teaching tools (Habibah Norehan Haron et al.,

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2019). AR technology can enhance students' learning experiences by providing interactive and immersive learning environments (McMahon et al., 2019). The studies show that hands-on activities carried out with the students using AR applications increased their motivation to learn STEM subjects (Habibah Norehan Haron et al., 2019). The AR used for this study, AR-SiGaSTEM and AR-Tradisi, are AR applications that enhance STEM skills among the students. The module for these AR applications was designed as an additional teaching aid and guideline to help secondary teachers understand the concept and the good practice in STEM education while using these AR applications (Laili Farhana Md Ibharim, 2023).

According to Fazilah Razali (2020), STEM education is an interdisciplinary approach to education that emphasises the importance of its subjects in preparing students for future careers and addressing global challenges. This helps provide valuable insights into the current trends, challenges, and potential areas for further research in STEM education. In Malaysia, initiatives have been implemented to improve STEM learning in rural schools, particularly among Orang Asli students based on the study of Habibah Norehan Haron et al. (2019). Their findings suggest that integrated approaches to STEM education can produce students with high interest and motivation to learn science and enhance achievement. However, further research is needed to fully understand the effect of AR technology on STEM learning outcomes among Orang Asli students (Fazilah Razali, Umi Kalthom Abdul Manaf, & Ahmad Fauzi Mohd Ayub, 2020).

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2.3 Orang Asli Students In Malaysia

The Orang Asli are the indigenous people of Malaysia, who have lived in the country for thousands of years (Badli Esham Ahmad et al., 2022). They are divided into three main groups: the Negrito, Senoi, and Proto-Malay (Azizah Osman et al., 2023). The Orang Asli have their own unique culture, language, and way of life, which differ from those of the mainstream Malaysian population (Norshariani Abd Rahman et al., 2018). The Malaysian government has recognised the need to address the educational development of Orang Asli children to achieve the vision of "education for all" (Muhammad Fuad Abdullah et al., 2023).

However, the development of Orang Asli students in Malaysia poses significant challenges due to language barriers, cultural differences, and a lack of resources (Azizah Osman et al., 2023). Perak, a state in Malaysia, is home to a significant population of Orang Asli. Studies have highlighted the educational challenges faced by Orang Asli students in this state, including low achievement, limited access to quality education, and cultural barriers (Misnaton Rabahi et al., 2016). The mainstream syllabi and curriculum in Malaysia do not fully address the learning capabilities of Orang Asli students, leading to low performance and participation in STEM subjects due to their low level of mastery in STEM literacy (Azizah Osman et al., 2023).

The Malaysian Ministry of Education, expressing concern over the academic performance of Orang Asli students, has invested into teaching to tackle this issue, especially in mathematics, where studies have investigated various teaching and learning methods like the Think Pair Share (TPS) approach to enhance their

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achievement (Abdul Halim Abdullah, 2022). Despite efforts to engage Orang Asli students by employing simplified language and teaching methods, these approaches have unfortunately led to low achievement. A more promising strategy for advancing STEM education among Orang Asli students involves leveraging AR applications as effective teaching tools, offering interactive and immersive learning environments that enhance their educational experiences (Azizah Osman et al., 2023).

In Malaysia, there are differences in STEM achievement between students in urban and rural areas (Nor Intan Adha Hafit et al., 2021). One study showed that Orang Asli students have low performance and participation in STEM due to their low level of mastery in STEM literacy (Azizah Osman et al., 2023). Orang Asli students have been reported to face challenges such as low self-esteem, lack of interest in school, and difficulty in mixing with other races, which can impact their academic performance in STEM subjects, including mathematics (Habibah Norehan Haron et al., 2019).

Furthermore, studies have shown that Orang Asli students face challenges in understanding certain teaching methods, leading to a lack of enthusiasm for learning and low attendance rates (Ruzlan Md-Ali et al., 2021). Despite this, there is potential for technology, such as AR applications, to enhance their learning experiences and increase their motivation to teach STEM subjects to tackle this problem (Abdul Halim Abdullah, 2022). The promising use of AR applications as a teaching tool suggests its potential to stimulate the interest of Orang Asli students in STEM subjects and potentially narrow the gap in STEM learning outcomes among this demographic (Siti Hamizah Aspin et al., 2022).

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AR technology has the potential to offer unique educational experiences that can be engaging for students (Chang et al., 2020). However, the use of AR technology in education for Orang Asli students remains a topic of ongoing discussion. For example, the acceptance and enthusiasm for AR among Orang Asli students depend on various factors, including their interests, access to technology, cultural relevance, and the quality of the AR experiences provided (Martin et al., 2021). The limited access to reliable internet connections, inefficient technology devices, and need for digital literacy skills are among the challenges for Orang Asli communities (Nam et al., 2020). The other factor is that Orang Asli students may have unique cultural, linguistic, or socioeconomic backgrounds that require tailored approaches to effectively integrate technology into their learning experiences (Mohamad Subaidi Abdul Samat & Azlina Abdul Aziz, 2020). This situation could be the reason Orang Asli students are not aware of the uses of AR in education (Cherubini, 2020).

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2.4 Motivation of Students Using AR Applications

In educational psychology, motivation theories are spread throughout a broad spectrum of historical perspectives, overlapping ideas and differentially related components (Kovach, 2018). According to Bandhu (2024), motivation is the yearning to complete a task, paired with enthusiasm and determination to see it through. Motivation is key to understanding and fostering educational success (Duncan et al., 2021). Without motivation, learners may struggle to find the energy and determination to complete assignments, prepare for exams, and achieve their educational goal (Bandhu et al.,

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2024). Therefore, motivation is important for a student to achieve in education (Albrecht & Karabenick, 2018).

According to Duncan et al. (2021), self-efficacy, attribution, control, self-determination, expectancy value, intrinsic and extrinsic, flow, and mindset are the types of diffusion in the proliferation of terminology and constructs in educational physiology. Studies have shown that several motivation theories can influence learning (Bandhu et al., 2024). Even though there are multiple versions of motivation theories, the main theories that emerge most clearly from the literature on human motivation and learning are the Self-Determination Theory (SDT), Self-Efficacy Theory, and Expectancy-Value Theory (Duncan et al, 2021).

Table 2.2 shows a summary of key motivational theories by Bandhu (2024), highlighting their definitions, core concepts, and theoretical foundations. The Extrinsic Theory explains motivation as driven by external rewards or punishments, rooted in behaviourist principles (Hamdi Serin, 2018). In contrast, Intrinsic Theory focuses on internal drivers such as autonomy, mastery, and purpose, influenced by humanistic psychology (Ryan & Deci, 2020). The Attribution Theory, based on the work of Fritz Heider and Bernard Weiner, examines how individuals attribute successes or failures to internal or external causes (Bandhu et al., 2024). The Expectancy Theory, developed by Victor Vroom, describes motivation as a function of belief in effort-outcome relationships, while the Expectancy-Value Theory, expanded by Wigfield and Eccles, adds the importance of subjective task value (Albrecht & Karabenick, 2018). The Goal-Orientation Theory, based on the research of Carol Dweck and John Nicholls, differentiates between mastery-oriented goals, which focus on learning, and

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performance-oriented goals, which emphasise demonstrating ability (Bandhu et al., 2024).

Table 2.2 shows the ARCS Model, created by John Keller, which focuses on designing motivational learning environments by addressing attention, relevance, confidence, and satisfaction (Ma & Lee, 2020). The SDT, developed by Ryan and Deci (2020), emphasises the importance of autonomy, competence, and relatedness in sustaining motivation. The Social Cognitive Theory, proposed by Albert Bandura, highlights the role of self-efficacy, observation, and self-regulation in learning and behaviour (Bandhu et al., 2024). These theories provide valuable insights into the factors that drive human motivation in various settings.

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Table 2.2

Overview of the theories of motivation by Bandhu et al. (2024)

Term/Construct	Definition	Key Concept	Theoretical Background
Extrinsic Theory	Motivation is driven by external rewards like money, fame, or grades.	Focuses on tangible rewards and punishments as motivators.	Rooted in behaviourist principles emphasising external stimuli's influence on behaviour.
Attribution Theory	Explains how individuals interpret events and how this relates to thinking and behaviour.	Causality (internal vs external), stability, controllability.	Developed by Fritz Heider and expanded by Weiner, integrating cognitive processes in motivation.
Expectancy Theory	Describes motivation as a function of expectancy, instrumentality, and valence.	Belief in capability (expectancy), connection of actions to outcomes (instrumentality), and value of outcomes (valence).	Originated from Victor Vroom's work emphasising rational decision-making in motivation.
Intrinsic Theory	Motivation arises from internal desires, interests, and enjoyment.	Emphasises autonomy, mastery, and purpose as intrinsic motivators.	Rooted in humanistic psychology, particularly in Maslow's and Ryan and Deci's (2020) SDT frameworks.
Expectancy-Value	Motivation depends on expectancy for success and the value placed on that success.	Combines cognitive beliefs about outcomes (expectancy) with subjective task value (importance, interest).	Synthesised by Wigfield and Eccles, expanding on expectancy theory by integrating subjective values.
ARCS Model of Motivation	Focuses on instructional design to maintain learners' attention and motivation.	Attention, Relevance, Confidence, Satisfaction (ARCS).	Developed by John Keller, grounded in educational psychology to enhance learning environments.
SDT	Differentiates between intrinsic and extrinsic motivation in relation to autonomy.	Autonomy, competence, and relatedness as psychological needs.	Created by Ryan and Deci (2020), motivation to psychological growth and self-regulation.
Social Cognitive Theory	Explains learning and motivation through observation, self-efficacy, and reciprocal determinism.	Self-regulation, modelling, and self-efficacy are central components.	Albert Bandura's theory integrates behaviourism with cognitive processes in learning and motivation.
Goal-Orientation Theory	Explores how goal setting influences learning and motivation outcomes.	Mastery goals (focus on learning) and performance goals (focus on demonstrating ability).	Based on Dweck and Nicholls' research on achievement motivation and how goals shape behaviour and learning strategies.

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Motivation is most commonly defined as a condition that triggers and supports behaviour towards a goal (Albrecht & Karabenick, 2018). Motivation is essential for learners because it gives them the desire and motivation to put in an effort, stay involved, work hard, and feel connected to their learning (Bandhu et al., 2024). In the context of learning and education, motivation can be distinguished from general cognitive functions, which are critical to learning and achievement and helps explain gains in achievement, independent of test scores on intelligence tests (Duncan et al., 2021).

Intrinsic motivation is generally applied to an activity that is seen as its end, whereas extrinsic motivation applies to an activity that is distinct from its end (Kruglanski et al., 2018). Intrinsic motivation also refers to motivation that comes from within a person, such as personal interest, enjoyment, or a sense of purpose (Wee & Choong, 2019). Intrinsic motivation is identified by an advanced value for personal investment and participation (Fischer et al., 2019). Thus, intrinsic motivation is considered the main source of help in triggering and maintaining the process of learning (Fırat et al., 2018) using AR applications in STEM.

Intrinsically motivated individuals complete tasks for the sake of satisfaction, with no extra reward or consequence (Kotera et al., 2023). This form of motivation plays a crucial role in fostering sustained motivation and deeper learning. Emerging pedagogical approaches, such as the utilisation of AR applications, potentially increase students' engagement, increase their understanding, and help them achieve in their studies, especially in STEM (Hsu et al., 2017). This is because external factors are

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important in fostering students' intrinsic motivation such as the learning environment or the role of teachers (Hamdi Serin, 2018).

SDT is a theory that explains the various internal and external motivation types and their dependencies in more detail (Fischer et al., 2019). SDT is also the theoretical framework that has provided the most significant insight into cognitive, emotional, and behavioural aspects associated with successful learning (Claver et al., 2020). The SDT theory is one potential guideline in comprehending students' experiences in physical education and developing strategies that could improve their learning and motivation.

SDT is commonly utilised to enhance students' learning (Shweta Singh et al., 2020). The theory proposes many methods of understanding and evaluating motivation. According to Minitheory, three key needs must be met for outstanding motivation to develop and for individuals to achieve optimal functioning: the need for autonomy, the need for competence, and the need for relatedness (Vasconcellos et al., 2020). These ideas are founded on a self-determination continuum shown in Figure 2.7, in which intrinsic motivation corresponds to increasingly autonomous, volitional motivation (Kotera et al., 2023). The study by Vasconcellos et al. (2019) shows that SDT defines four distinct forms of motivation within extrinsic motivation, which differ in their features and level of autonomy.

Figure 2.9 shows six types of regulation along a self-determination continuum. Motivation ranges from the least autonomous forms, such as external and introjected regulation, to more autonomous forms like identified and integrated regulation, which

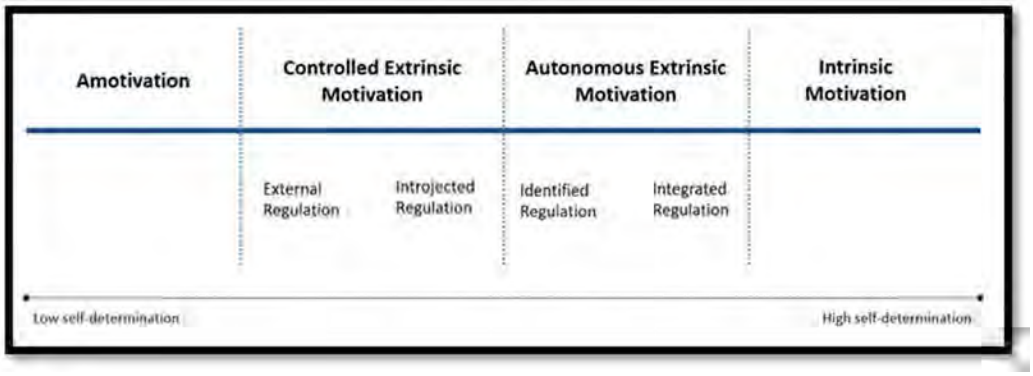
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are often categorised as autonomous and controlled motivations in various studies (Ryan & Deci, 2020).

Figure 2.9

The self-determination continuum by Ryan and Deci (2020)



Motivation provides the energy and drive for students to make an effort, stay engaged, work hard, and feel connected to their learning. A student desires to engage in the learning environment, which is necessary for academic performance. The intrinsic motivation theory explains motivation in learning. Factors like challenge, curiosity, control, and fantasy influence intrinsic motivation. Sustaining motivation requires willpower and a positive attitude. Intrinsic motivation can lead students to engage in academic activities without external pressure or rewards. Effective learning strategies play a role in boosting motivation, and AR has been found to consistently improve student motivation, particularly in science learning. AR's elements of curiosity, fantasy, and control contribute to increased motivation. The use of attractive and stimulating learning materials, such as AR technology, can also directly impact student motivation (Khan et al., 2019).

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This study attempts to determine the effect of AR applications towards Orang Asli students' learning motivation and achievement in STEM learning. The motivational design is important to identify Orang Asli students' motivational level in learning when using AR applications. Moreover, it is essential to improve and enhance Orang Asli students' achievement in their learning. In this study, the ARCS model is implemented to identify the motivational level of Orang Asli students based on its key elements.

The ARCS model is defined as a framework that is designed to enhance motivation in instructional design and teaching (Keller, 2012). This model can help identify the motivation level of students in the learning process (Ma & Lee, 2020). The ARCS model was created by an urge to discover more effective methods of learning as the primary factors of motivation in the learning process, which was founded by Keller (Laurens-Arredondo, 2022).

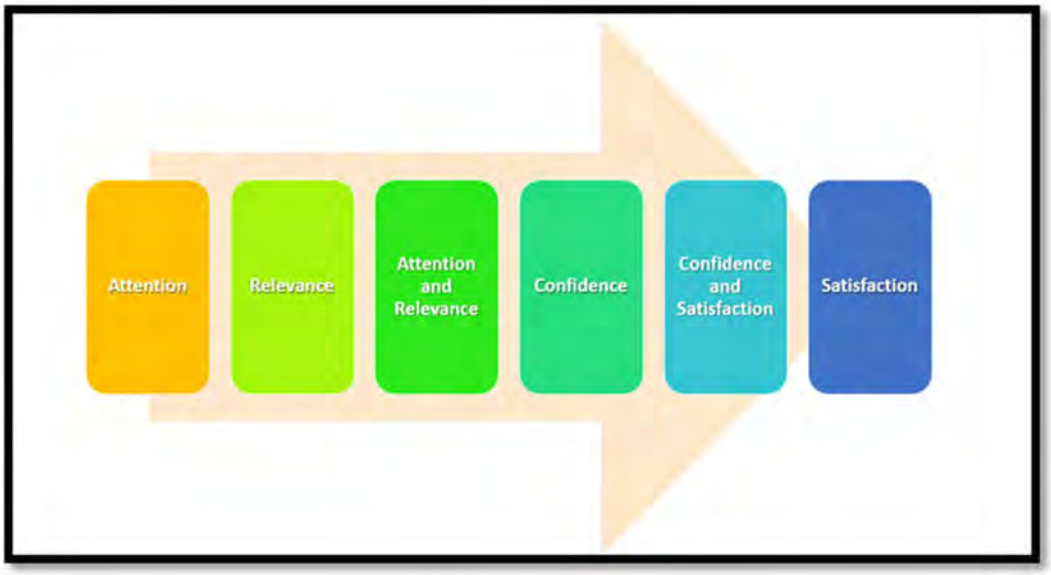
Figure 2.10 shows the key elements of ARCS. First, Attention is captured through engaging content (Bandhu et al., 2024). Then, Relevance ensures the material connects to the learner's goals or interests. Once attention and relevance are established, Confidence is built by providing achievable challenges and positive feedback, helping learners feel capable (Ryan & Deci, 2020). Finally, Satisfaction is achieved when learners feel fulfilled and rewarded, reinforcing their motivation to continue learning. This cycle sustains engagement throughout the learning process (Ma & Lee, 2020).

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Figure 2.10

ARCS Model Continuum



The study of Suherman et al. (2021) suggests that when learning new material, students should first review the information and connect it to the lesson. In the relevance step, they should clearly understand the objectives and outcomes. To improve understanding, attention, and relevance, real-life examples are recommended for explanations, making the content more meaningful. Finally, presenting sample questions helps students better understand and remember the information by practising what they have learned. This method helps improve learning and retention.

Additionally, during the Confidence phase, students should be guided to boost their confidence in working on practice questions. Students following the confidence and satisfaction track should be encouraged to ask questions, address challenges, and engage with the material. Finally, at the Satisfaction step, feedback should be given to stimulate students' thinking patterns. The ARCS model provides a useful method for

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diagnosing students' motivational issues and educational results (Sdravopoulou, González, & Hidalgo-Ariza, 2021). It proves that the combination of AR applications and innovative digital technology in teaching practice is effective (Chang et al., 2020).

Motivation is a crucial factor in learning and academic performance. It is defined as a condition that triggers and supports behaviour towards a goal. The Intrinsic Motivation Theory explains motivation in learning, which comes from within a person, such as personal interest, enjoyment, or a sense of purpose. Effective learning strategies play a role in boosting motivation, and AR has been found to consistently improve student motivation, particularly in science learning. The ARCS model of motivational design provides a useful method for diagnosing students' motivational issues and educational results (Dinçer, 2020). The ARCS model can be used to identify deficiencies in specific areas of learner motivation so that remedial strategies can be developed (Bandhu et al., 2024).

Motivation may increase, and thus learning can be easier, on the condition that these factors are structured according to the students and teachers (Kovach, 2018). Motivation can be increased by the effective strategies and tactics applied. These include interaction, feedback, diversity (innovation and attractive course tools), and technologies (Fırat et al., 2018). The theoretical framework of this research is also referred to as the ARCS Model of Motivational Theory. The ARCS model was used in the development of a questionnaire as a measurement tool for students' motivation level for this study.

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The introduction and use of AR applications in STEM learning can significantly impact students' learning theories (Mystakidis et al., 2022), which consist of Constructivism, Behaviourism and Cognitivism. Constructivism is defined as an educational theory that emphasises the active role of learners in constructing their understanding and knowledge (Maj, 2022). AR applications in STEM provide interactive, hands-on experiences that allow students to explore concepts more tangibly and engagingly (Ibáñez & Delgado-Kloos, 2018). By manipulating digital elements overlaid in the real world, students actively construct their understanding of STEM concepts through experimentation and exploration (Chen & Liu, 2020). This aligns with constructivist learning theories, emphasising the importance of active engagement and hands-on experiences in knowledge construction.

Behaviourism in STEM learning is an approach that focuses on observable behaviours and external stimuli to understand and shape learning outcomes (Maj, 2022). The integration of AR applications in STEM learning can influence and align with aspects of behaviourism in learning theories, although behaviourism primarily focuses on observable behaviours rather than internal mental processes (Efgivia et al., 2021). Meanwhile, Cognitivism is defined as an educational approach that focuses on understanding the mental processes involved in learning, including memory, problem-solving, critical thinking, and comprehension of complex concepts (Maj, 2022). Unlike behaviourism, which emphasises observable behaviours, cognitivism explores the internal mental structures and processes that drive learning. For example, AR applications provide interactive and immersive experiences that engage students' cognitive processes (Chen & Liu, 2020). By allowing students to visualise abstract concepts, manipulate 3D models, and interact with virtual environments, AR enhances

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cognitive processes like mental imagery, comprehension, and problem-solving, thereby supporting cognitivist learning theories (Khan et al., 2019).

2.5 Achievement of Students Using Augmented Reality Applications

Achievement in education includes various aspects, such as academic performance, active participation in meaningful activities, satisfaction, development of knowledge and skills, persistence, and fulfilment of educational goals (Alyahyan & Düştegör, 2020). Academic success is a key component of achievement in education, often measured by grade (Ryan & Deci, 2020). Achievement in education can be defined as academic success, engagement in educationally purposeful activities, satisfaction, acquisition of desired knowledge, skills and competencies, persistence, attainment of educational outcomes, and performance (Alyahyan & Düştegör, 2020). Ryan and Deci (2020) proved that there are two types of achievement goals: mastery goals and performance goals. Mastery goals enhance individual competence and knowledge, while performance goals focus on outperforming others. This distinction is crucial as it influences students' motivation and outcomes in learning environments (Ryan & Deci, 2020). This multifaceted definition emphasises the importance of holistic educational experiences in determining achievement.

The Achievement Theory suggests that there is a reciprocal relationship between motivation and achievement and that perceived achievement is not only determined by true achievement but also by elements of educational design (Vu et al., 2022). Research has shown that students tend to perform better academically when they

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are intrinsically motivated, as this motivation fosters a deeper engagement with the material (Ryan & Deci, 2020). The theory posits a reciprocal relationship between motivation and achievement, suggesting that perceived achievement is influenced not only by actual performance but also by elements of educational design and that motivation and achievement are intertwined, with motivation influencing academic success and vice versa (Vu et al., 2022).

Motivation, particularly intrinsic motivation and well-internalised forms of extrinsic motivation, plays a critical role in enhancing achievement by promoting deeper engagement and learning, particularly within educational environments that fulfil students' psychological needs for autonomy, competence, and relatedness (Ryan & Deci, 2020). This is proven in Figure 2.11, which conceptualises the dynamic interplay between motivation and achievement and demonstrates how these constructs influence each other through behavioural intermediaries, external factors, and feedback mechanisms, whereby motivation drives effort and learning strategies, while achievement reinforces perceptions of competence and value (Vu et al., 2022).

Evidence have suggested the positive effect of AR towards achievement in STEM learning. A study by Brew et al. (2021) found that AR can improve students' understanding of complex scientific concepts and increase their motivation to learn. However, more research is needed to fully understand the effect of AR on achievement in STEM learning. Overall, factors that influence academic performance include prior achievement, motivation, effort, parental levels of education and income, textbook availability and accessibility, libraries, practical laboratories, meal provision, and teachers (Brew et al., 2021).

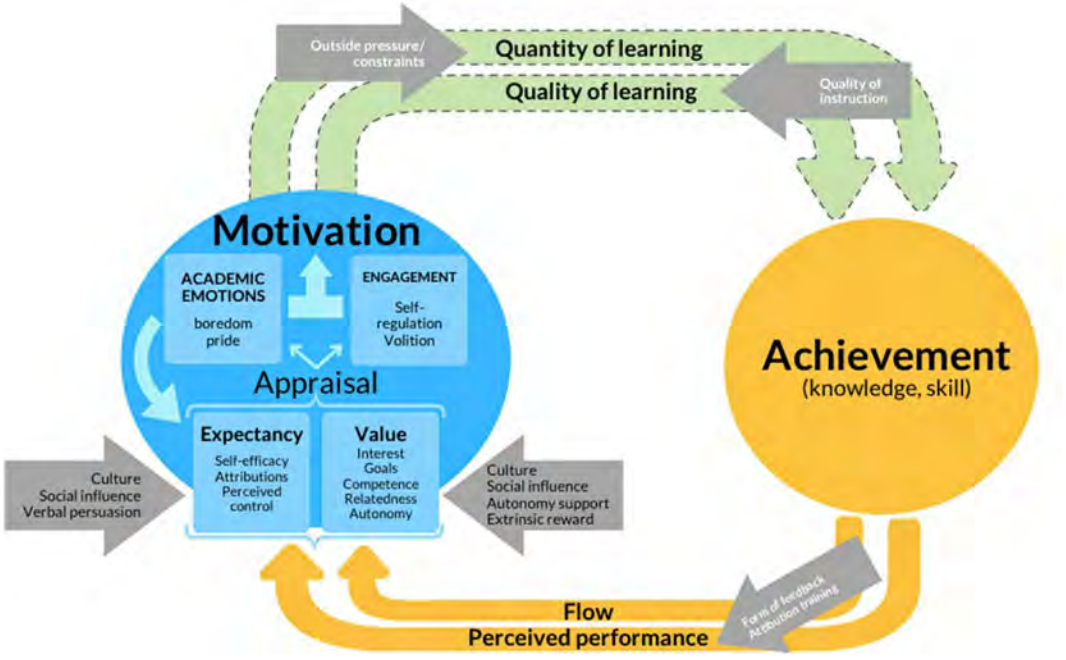
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The Achievement Theory highlights the reciprocal relationship between motivation and achievement, while research suggests that AR can positively impact achievement in STEM learning (Petrov & Atanasova, 2020). Understanding the multifaceted nature of achievement and the factors influencing academic performance is crucial for designing effective educational interventions and promoting inclusive learning environments (Albrecht & Karabenick, 2018). This literature review provides insights into the complex interplay of factors that contribute to achievement in education, however, further research is needed for the development of evidence-based strategies to support student success.

Figure 2.11

The motivation-achievement cycle by Vu T. V. (2022)



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2.6 Summary

This chapter provided a comprehensive review of literature related to the integration of AR in multimedia and STEM education, emphasising its role in enhancing learning experiences through interactive and immersive environments. The discussion began with an overview of AR in multimedia applications, followed by an exploration of its application within STEM education contexts. The incorporation of learning theories, particularly the CTML and the 5E Instructional Model, was examined to highlight their relevance in structuring effective AR-based learning environments. The chapter further analysed the advantages and limitations of AR applications in education, underscoring their potential to support conceptual understanding, motivation, and student engagement. In addition, specific attention was given to the educational challenges faced by Orang Asli students, positioning AR as a promising tool to bridge existing educational gaps. The motivational effects by AR applications were also explored, demonstrating their effectiveness in fostering higher engagement and improved academic achievement. Overall, this chapter established a strong theoretical foundation for the study by linking AR applications, instructional models, and STEM learning, providing a basis for investigating their effects on Orang Asli students' motivation and achievement in subsequent chapters. Building upon the theoretical framework established in this chapter, the next chapter outlines the research methodology that was employed to investigate the effects of AR applications on the motivation and achievement of Orang Asli students in STEM learning.

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CHAPTER 3

METHODOLOGY

3.1 Introduction

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Methodology in research refers to the systematic and structured plan of procedures and techniques used by researchers to gather, analyse, and interpret data in a study (Kapur, 2018). It outlines the framework for conducting research and achieving the study's objectives.

This study aimed to determine the effect and correlation of motivation and achievement of Orang Asli students in STEM learning using AR applications, which is a promising educational tool that has emerged as an effective approach to STEM learning. AR applications enable interactive and immersive experiences for students, which can enhance their motivation and achievement. The research methodology employed quantitative approaches, focusing on the correlation between AR application utilisation and student motivation and achievement levels.

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This study consisted of three main objectives studies. The first was to determine the effect of AR applications towards the motivation level of Orang Asli students in STEM learning. Data regarding their motivational level towards AR applications after the use of this technology was collected through the questionnaires to determine the effect of AR applications. Secondly, this study also identified Orang Asli students' achievement in STEM learning through a geometry assessment that needed to be answered to test their knowledge towards the STEM syllabus. This was done before and after applying the AR applications to the learning. This indicator determined and analysed their level of achievement regarding the instant knowledge obtained through using the AR applications. The AR applications used for this study were AR-Tradisi and AR-SiGaSTEM.

The third objective was to study the correlation between motivation and achievement of Orang Asli students using AR applications in STEM learning. This study measured the strength of the correlation between student motivation and achievement in STEM learning when AR applications were utilised as a learning tool among Orang Asli students. This study aimed to evaluate the effect of AR applications on the motivation and achievement of Orang Asli students in STEM education. By utilising a well-structured survey instrument, a targeted sample population, and a research methodology aligned with the objectives, the study aimed to provide valuable insights into the potential of AR applications as an educational tool for this specific demographic. The findings of this research contributed to enhancing STEM learning experiences for Orang Asli students.

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3.2 Research Approach

The research approach concerns the methods to be implemented for collecting pertinent data and the techniques to be used in their analysis, keeping in view the objective of the research and the availability of human resources, time and financial resources (Kapur, 2018). A research approach is essential in data collection and analysis.

3.2.1 Quantitative Research Design

This study aimed to identify the effect of AR on motivation and achievement among Orang Asli students in STEM learning. The research approach adopted for this study was quantitative. Quantitative research is a systematic investigation method that relies on collecting and analysing numerical data to understand phenomena, establish patterns, relationships, or correlations, and draw statistical inferences (Abuhamda et al., 2021).

The goal of this quantitative research was to analyse the correlation relationships between motivation and achievement and to make generalisations about a population based on the sample data collected. Quantitative data refers to numerical values or counts, which are typically gathered through the use of surveys or questionnaires (Phoong & Phoong, 2021).

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3.2.2 Data Collection Methods

The research methodology employed in this study integrated multiple data collection methods, specifically a survey and an experiment. Specifically, the data were collected through a survey questionnaire administered to Orang Asli students engaged in STEM learning. The questionnaire was designed to assess the students' motivation levels in STEM education following the implementation of AR applications. Subsequently, the collected data were analysed using statistical software to determine the effect of AR applications on the motivation and achievement levels of Orang Asli students.

The experimental component was implemented in this study to identify Orang Asli students' achievement levels in STEM learning with and without using AR applications. The experiment was conducted to expand the understanding and application of diverse control mechanisms, enabling more effective regulation or management of variables (Bacon-Shone, 2013).

3.2.3 Experimental Design

The quasi-experimental research design was adopted in this study as it does not require participants to be randomly assigned to different groups, unlike true experiments (Kapur, 2018). A quasi-experiment is a research design that involves designs and analyses that resemble experiments (Reichardt et al., 2023). The pre- and post-test structure was implemented in this study. The non-equivalent control group design was conducted in this study in which 30 Orang Asli students were divided into two groups:

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the Treatment Group and Control Group. In the Treatment Group, the students implemented AR applications in their learning session, while the Control Group used textbooks and slide presentations for their learning session.

Table 3.1 illustrates the quasi-experimental design used to compare the effects of different teaching interventions on student achievement. The study involved two groups: a Treatment Group and a Control Group. Each group underwent the same testing process to measure the effect of their respective interventions on their learning outcomes. The design was structured to assess whether the introduction of AR applications in the teaching process had a significant effect on student performance compared to conventional teaching methods.

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Table 3.1

Quasi-experiment Design

Group	Pre-Test	Intervention	Post-Test
Treatment Group	T1	X	T2
Control Group	T1	Y	T2

Notes:

T1: Pre-Test of student achievement

T2: Post-Test of student achievement

X : AR applications

Y : Conventional approach (Textbook and presentation slide)

Both groups participated in a pre-test, labelled as T1, which measured their baseline achievement levels. This initial assessment provided a benchmark against which future changes in student performance could be measured. Following this, each

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group was subjected to different interventions. The Treatment Group was exposed to AR applications (intervention labelled as X), while the Control Group continued with conventional teaching methods (intervention labelled as Y). These interventions represent the independent variable of the study, intending to identify the approach that yielded better outcomes in student achievement.

After the interventions, both groups completed a post-test, labelled T2, to evaluate any changes in their achievement levels. By comparing the results of the pre-test (T1) and post-test (T2) within each group, and between the groups, the study aimed to identify the effect of AR applications towards achievement level. If the Treatment Group, which used the AR applications, showed greater improvement from T1 to T2 compared to the Control Group, it would suggest that AR can be a more effective teaching tool than conventional methods. This experimental design allowed for the conclusion on the relative effect of AR technology in enhancing student learning. By using a Control Group, the study could better attribute any differences in outcomes to the specific intervention being tested rather than other external factors. The design was structured to provide clear, comparative data on how innovative teaching tools like AR applications could affect achievement, offering valuable insights for educators considering the integration of new technologies into their teaching strategies.

3.3 Samples and Location

Sampling is defined as a process of selecting a subset of individuals or elements from a larger population to represent and draw conclusions about that population (Kapur,

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2018). For this study, samples were chosen through non-probability sampling, and participants were chosen through the purposive sampling technique.

Non-probability sampling is a method of selecting respondents for research where not every member of the population has an equal chance of being included (Kapur, 2018). This study focused on Form 1 Orang Asli students in one of the schools located in Perak. The non-probability sample was considered as the most suitable sampling technique for this research due to the quasi-experimental research design of this study that involved comparing groups that were not randomly assigned (Kapur, 2018). This aligned with the purposive sampling selected for this study.

Purposive sampling is a sampling technique where the characteristics of the sample are defined for a specific purpose relevant to the study (Chittaranjan Andrade, 2021). Purposeful sampling is defined as a method to select a sample to collect a wide range of responses by sampling across all factors to influence the outcomes (Bacon-Shone, 2013). Even though this sampling technique is often used in qualitative research, purposive sampling can enhance the quality of quantitative data as long as it is aligned with the objectives of the study (Chittaranjan Andrade, 2021). This can be particularly useful when the researcher has a clear understanding of the population and wants to study specific subgroups that are most informative for the study (Kapur, 2018).

A total of 30 Form 1 Orang Asli students were selected through purposive sampling for this study. Although the sample size appeared relatively small, it was considered appropriate and sufficient for several reasons. Recent research has emphasised that purposive sampling is suitable when the study involves a specific,

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hard-to-reach population, allowing researchers to gather rich, focused data even with a smaller sample size (Etikan et al., 2020). To further ensure that the sample accurately represents the target population, the students were enrolled in a school situated close to their community. This approach helped fulfil the study's required characteristics, such as maintaining the cultural and community background of the participants.

In the context of quasi-experimental educational research, small samples ranging from 20 to 30 participants are widely accepted, especially when pre- and post-test designs are used to measure intervention effects (Creswell & Creswell, 2023). Moreover, according to Rahi (2018), when studying specialised groups with limited accessibility, a smaller but carefully selected sample can still yield valid, meaningful results. Given that this study employed structured quantitative methods, including pre-tests, post-tests, and correlation analysis, the sample size of 30 participants was methodologically appropriate and consistent with contemporary educational research practices. Furthermore, due to logistical constraints and the relatively small size of the Orang Asli student population in the selected school, expanding the sample size beyond 30 participants was not feasible without compromising the focus and manageability of the study. To maintain consistency and ensure the data collected remained relevant to the participants' contextual environment, all testing and data collection were conducted within the same school.

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3.4 Instruments

An instrument in research is defined as a tool used to collect data or measure objects of a research variable (Febrinawati Yusup, 2018). The research was conducted using the quasi-experimental research design via pre- and post-tests and a survey as the research instruments. A survey is usually in the form of a questionnaire that a person fills out or answers by interview (Balnaves & Caputi, 2001). The questionnaire is the management of indirect data collection (Qurotul Aini et al., 2018). This study used a questionnaire to determine the level of motivation and achievement in Orang Asli before and after the use of AR applications in STEM learning. The instrument was developed into three sections and is provided in Appendices A, B and C.

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Table 3.2 shows the overview of the questionnaire for this study, as outlined below:

1. Section A: Demographic of the Students-Respondents

This section collects the demography data of students. This constructive section comprised six questions including, gender, owned device, Wi-Fi access, AR knowledge, AR experience and used applications.

2. Section B: Evaluation of Motivational Level

This questionnaire was distributed after the use of AR applications into the teaching and learning for the Treatment Group. This construct analysed Orang Asli students' motivational levels. This section was developed based on the ARCS model by (Keller, 1987). The construct consisted of Attention, Relevance, Confidence and Satisfaction aligned with the model, consisting of five items that needed to be answered by the Orang Asli students using a five-point Likert scale where 1 = Strongly Disagree, 2 =

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Disagree, 3 = Uncertain, 4 = Agree, and 5 = Strongly Agree. The Likert scale used ordered response levels that were labelled to ensure clear ordering (Bacon-Shone, 2013).

3. Section C: Evaluation for Achievement Level

This instrument used a geometry assessment for the pre- and post-test. The geometry assessment is a mathematical quiz from the Mathematics Form 1 textbook, Chapter 10 "Parameter and Area" that needed to be answered by the respondents from the Treatment Group and Control Group before and after the learning session. The evaluation of this section consisted of the process of mathematics skills. The evaluation of this section was based on respondents' scores after answering the questions given.

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Table 3.2

Table of Instruments in Research

Section	Objectives	Construct	Item	Number of Item
Section A	To identify the background of participants	Demography	Gender Owned Device Wi-Fi Access AR Knowledge AR Experience Used Application	1 1 1 1 1 1
Section B	To identify Orang Asli students' motivational levels.	Motivational level	Attention Relevance Confidence Satisfaction	5 5 5 5
Section C	To identify the Orang Asli students' achievement in their understanding and skills	Achievement Level	STEM Learning	4

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Moreover, the research approach was quantitative, employing a correlation research design. The choice of this multivariate and correlation analysis aligned with the research objectives to determine the effect of AR on motivation and achievement in STEM learning among Orang Asli students. Section A utilised the nominal scale, Section B utilised the ordinal scale, and Section C utilised the rational scale.

3.5 Validity and Reliability

The instruments utilised in this research study encompassed a precise method to determine validity and reliability. To gather pertinent data, the survey or questionnaire was employed as the primary data collection method. A validity test was conducted to ensure the instrument accurately measured the intended constructs of motivation and achievement in STEM learning among Orang Asli students. This was validated through expert assessment and referencing previous studies that examined similar constructs within different cultural contexts, such as the research by Asigigan and Samur (2021) on the effect of technology on student motivation in STEM education, offering foundational support for instrument development.

The instrument developed was reviewed and validated by three experts and improvements were made based on their feedback. The involved experts consisted of lecturers from the Faculty of Computing and Meta-Technology who possessed skills and knowledge in the field of multimedia. Based on expert evaluation, all three evaluators agreed that the instrument was suitable for use, as indicated by a Cronbach's alpha value of 0.951. However, some improvements were made based on the experts'

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assessments of the appropriateness of each construct and item in the questionnaire and their recommendations for several areas for improvement. The instrument was revised based on the evaluators' suggestions for use in the actual study.

The reliability of AR applications in STEM learning among secondary school Orang Asli students is supported by various studies highlighting the effect of AR in enhancing educational experiences. Research employing quasi-experimental designs utilise questionnaires and performance tests to assess motivation levels and learning outcomes, revealing that the ARCS model positively influenced students' mathematical skills (Suherman et al., 2021). This was proven through a study involving 150 secondary school students, which showed that using AR-based activities achieved significantly higher learning outcomes compared to traditional methods (Nurshamshida Md Shamsudin & Corrienna Abdul Talib, 2023).

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The reliability test for this study was conducted involving five Orang Asli Form 1 respondents selected from the same school who did not join the group of students who took part in the study. The results of the pilot study recorded a Cronbach's alpha value of 0.891. This value indicated that the questionnaire instrument was reliable and suitable for use. The validation form is provided in Appendix D.

The validity and reliability for the geometry assessment questions were established based on calculation found in the book *Peraturan Permainan Gasing Banyak Uri* (1999), which were used as questions for respondents to measure their level of achievement. The reliability of the achievement level for AR applications in STEM learning among secondary school Orang Asli students is supported by various studies

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that have indicated that AR applications significantly improve geometry topic achievement. One study reported that their Treatment Group's post-test mean score was 78.23, compared to the Control Group's score of 57.42, demonstrating the effectiveness of AR in enhancing students' learning outcomes (Mohd Fadzil Abdul Hanid et al., 2022).

3.6 Data Collections Procedures

The data collection procedures are presented in Figure 3.1, depicting the steps to investigate the effect of AR on motivation and achievement among Orang Asli students in STEM learning. The procedures adhered to rigorous methods to ensure the accuracy and reliability of the findings.

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Figure 3.1 shows the research process adopted to study the effects of using AR applications in STEM learning among Orang Asli students. The research began with the determination of research objectives, which aimed to identify the effects of AR on student motivation and achievement, as well as the correlation between these two factors. The next step was the research design, identified as quantitative research, which suggested a structured, numerical approach to data collection and analysis.

The research population consisted of 30 Orang Asli students from Form 1, specifically located in Sungai Siput, Perak. To ensure the reliability and accuracy of the research instruments, validity and reliability were determined through professional validation and a pilot study. The data collection phase involved the distribution of the

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questionnaire to gather necessary information. The study was conducted by dividing the students into two groups: the Treatment Group and the Control Group. Section C of the questionnaire was distributed to both groups before and after the learning session. Meanwhile, Section B was distributed to the Treatment Group after the learning session using AR applications. Prior to data collection, approvals from the Ministry of Education and the State Department of Education were acquired through Eras 2.0. The school administration was informed about the purpose of the study and permission to conduct the data collection process was obtained. The participants' identities were protected by ensuring that all collected data was anonymous.

Finally, in the data analysis stage, the collected data was analysed using SPSS software, with a focus on measuring the strength of the correlation between motivation and achievement among these students when using the AR applications in their STEM learning.

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Figure 3.1

Research Flow Chart of Data Collection Procedures



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3.7 Methods of Analysing Data

Through the data collection process, the data was analysed to determine the motivation level of the Treatment Group. The questionnaire was used to identify and determine any significant effect on Orang Asli students' motivation by using statistical tools. Meanwhile, the achievement level was indicated by distributing the quizzes to the Treatment Group and Control Group based on the pre- and post-tests. The pre- and post-tests were conducted to identify the achievement level of students and the splitting of the group was to identify the differences in achievement level of students when using different approaches and teaching tools.

Next, to determine the correlation of AR on motivation and achievement among Orang Asli students in STEM education, spearman correlation analysis was employed. This helped establish the strength of the relationship between motivation and achievement based on the pre- and post-tests implementation in AR applications in STEM learning. Through this analysis, the study was able to conclude the effect of AR as an educational tool for this specific demographic. By using scientific methods to analyse the data, the study aimed to provide valuable insights into the potential of AR to enhance STEM learning experiences for Orang Asli students. The data interpretation for motivation and achievement levels was based on the average (mean) as shown in Tables 3.3 and 3.4

Table 3.3 shows the interpretation of motivation levels based on mean values. A mean of 4.21 to 5.00 reflected very high motivation, where individuals were highly driven and committed. Scores between 4.20 and 3.41 indicated high motivation,

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showing strong enthusiasm and engagement. A moderate level of motivation, ranging from 3.40 to 2.61, suggested that individuals had an average drive but may need encouragement. Low motivation, between 1.81 and 2.60, pointed to struggles with staying focused or committed, while very low motivation, from 1.00 to 1.80, highlighted a lack of drive, requiring significant intervention to improve.

Table 3.3

Motivation level data interpretation

Mean Values	Interpretations
4.21-5.00	Very High
4.20-3.41	High
3.40-2.61	Moderate
1.81-2.60	Low
1.00-1.80	Very Low

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Based on Table 3.4, the scoring range based on score improvement provided a clear interpretation of performance levels using specific score categories. The highest range, 4.00 – 10.00, indicated strong or excellent performance. Scores in this range reflected a high mastery, achievement, or understanding level in the measured area, often signalling exceptional capability or effort. The 2.00 – 3.99 range represented moderate performance. This suggested an average or satisfactory level of achievement, where basic competency was evident. While sufficient, this category often has room for further development and improvement. Lastly, the 0 – 1.99 range signified low performance. Scores in this category highlighted significant challenges or gaps in understanding or achievement. These results often indicated the need for additional support, attention, or targeted interventions to address underlying difficulties.

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Table 3.4

Achievement level data interpretation

Score range	Interpretations
4.00 – 10.00	High
2.00 – 3.99	Moderate
0 – 1.99	Low

Since this study used a quantitative research approach, correlation analysis was used as it is a type of multivariate analysis that was considered suitable in analysing the data for this research. The SPSS statistical software was utilised for data analysis. These tools facilitate various statistical tests and Spearman correlation to test the hypotheses and answer the research questions related to the effect of AR applications on motivation and achievement in STEM learning. Following these outlined steps, subsequent analysis ensured a methodical approach towards understanding the effects of AR on motivation and achievement among Orang Asli students in STEM education. The questionnaire and quizzes are attached in the appendix. Procedures were in place to uphold participant confidentiality and anonymity. Data entry and management protocols were implemented to organise and securely store information.

Spearman correlation was used in this study to identify the strength of the correlation between motivation and achievement of Orang Asli students in STEM learning when using AR applications. It is an appropriate statistical method for this analysis as it measures the strength and direction of a monotonic relationship between two variables, without requiring them to be normally distributed or on an interval or ratio scale. In this study, motivational levels were assessed using a Likert scale, which produces ordinal data, while achievement was measured through test scores, which

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were on a ratio scale. Spearman correlation can handle these different types of data by ranking the values and analysing their relationship in terms of their ranks.

Applying the Spearman correlation helped determine whether there was a meaningful association between the student's motivation and their achievement, such as whether higher motivation corresponded to better achievement scores. This non-parametric approach was considered suitable as it does not rely on assumptions of normality or linearity, making it ideal for the study's mixed data types. Ultimately, the test provided valuable insights into how motivational factors influenced by AR application use relate to the academic outcomes of the students, guiding further educational strategies and interventions.

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3.8 Summary

The research methodology was employed to identify the effect of AR applications on the motivation and achievement of Orang Asli students in STEM learning. The study adopted a quantitative research approach, focusing on the correlation between AR applications usage and student outcomes. The AR applications used in this study were AR-Tradisi and AR-SiGaSTEM. The methodology was designed to systematically examine how these applications affected the motivation and learning achievements of students using a structured framework for data collection and analysis.

A quasi-experimental design was selected to evaluate student achievement through both pre- and post-tests. The study involved two groups of students: a treatment

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group, which used AR applications in their learning, and a control group, which followed conventional learning methods. The aim was to identify the effect of AR on the learning process, using Spearman correlation analysis to identify the strength of the relationship between student motivation and achievement when AR was incorporated into the learning environment.

The sample for this study consisted of 30 Form 1 Orang Asli students from a school in Perak. Participants were selected using non-probability purposive sampling; a method that allowed for the deliberate selection of participants with specific characteristics that aligned with the research objectives. This approach ensured that the study focused on a specific demographic, enhancing the relevance and applicability of the findings. To gather data, a questionnaire was used to assess students' motivational levels and learning outcomes. The questionnaire was divided into three sections: Section A, which collected demographic information; Section B, which evaluated motivation using Keller's ARCS model (Attention, Relevance, Confidence, and Satisfaction); and Section C, which assessed student achievement in geometry. The use of this structured instrument allowed for a detailed analysis of both motivation and learning achievement.

The data collection process involved the administration of pre-tests to both groups, followed by an intervention where the Treatment Group used AR applications and the Control Group used traditional methods. After the learning sessions, post-tests were conducted to evaluate changes in student achievement. Additionally, the Treatment Group completed questionnaires to assess changes in their motivation levels. The study received approval from educational authorities, and all data were collected

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anonymously to ensure participant confidentiality. Data analysis was conducted using the SPSS software, with a focus on determining the relationship between AR use, student motivation, and achievement. Spearman correlation was employed to assess the strength of the relationships between these variables. This analysis provides insights into the effect of AR as an educational tool, particularly for improving STEM learning outcomes among Orang Asli students.

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CHAPTER 4

RESULT AND FINDINGS

4.1 Introduction

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This chapter presents the data collected from the questionnaires obtained from respondents through the survey study and the results of the pre- and post-tests. The findings of this study were analysed using the procedures and methods discussed in Chapter 3. The purpose of this study was to examine the effect and correlation between Orang Asli students' motivation and achievement using AR applications. This study employed a quantitative approach through a quasi-experimental research design by employing pre- and post-tests and survey methods.

4.2 Demography Information

The demographic information is important to understand the background of the respondents who provided the feedback (Durog, 2024). Data related to gender were

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collected as part of the respondents' backgrounds. In addition, there were items related to their accessibility of certain technology such as mobile phones, tablets, laptops, computers and Wi-Fi in their community. General knowledge about AR was also questioned in the demography to determine whether the students had experience with AR applications. In addition, some items identified the students' motivation level and achievement using AR applications in STEM learning. The results are presented in the following subsections.

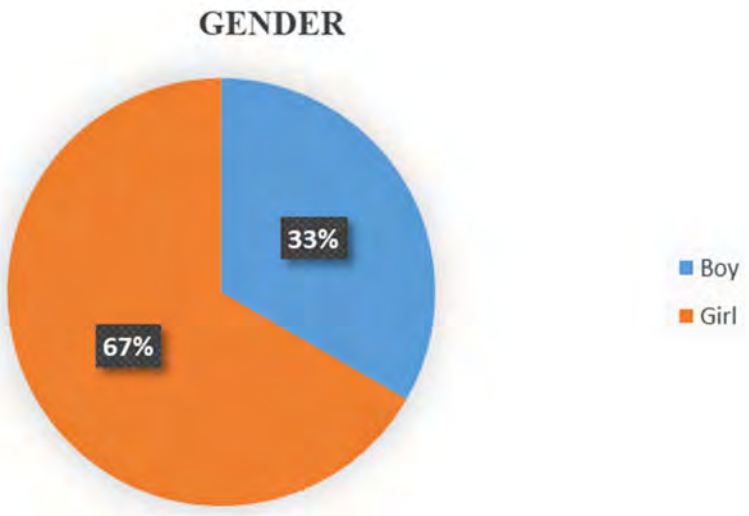
4.2.1 Respondents' Gender

As shown in Figure 4.1, that the majority of the respondents for this research were female at 66.7% (n = 20). Meanwhile, there were only 33.3% (n = 10) of respondents who were male.

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Figure 4.1

Distribution of respondents' gender



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4.2.2 Possession of Devices Among Respondents

The next item related to the mobile devices possessed by the respondents, referring to smartphones, tablets, laptops and computers. Figure 4.2 shows that the majority of respondents (86.7%, n = 26) possessed devices. Meanwhile, 13.3% (n = 4) of respondents did not have devices.

Figure 4.2

Possession of Devices

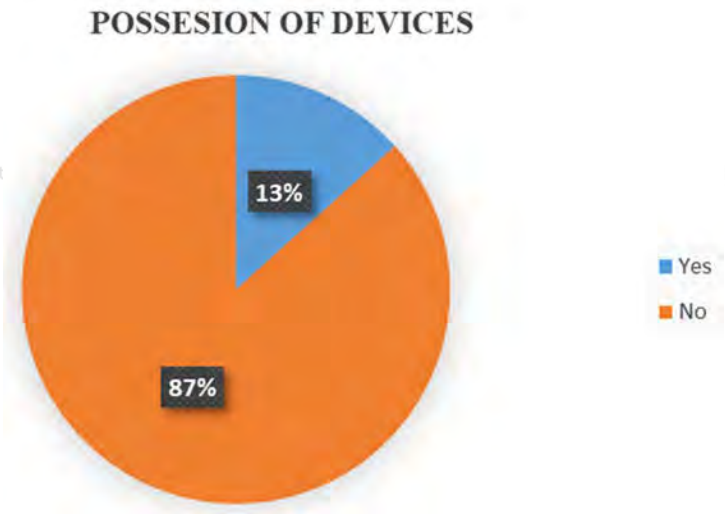


Figure 4.3 shows that the majority of respondents (80%, n = 24) had smartphones. Meanwhile, the frequency of students who did not have smartphones was 20% (n = 6).

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Figure 4.3

Owned a Smartphone

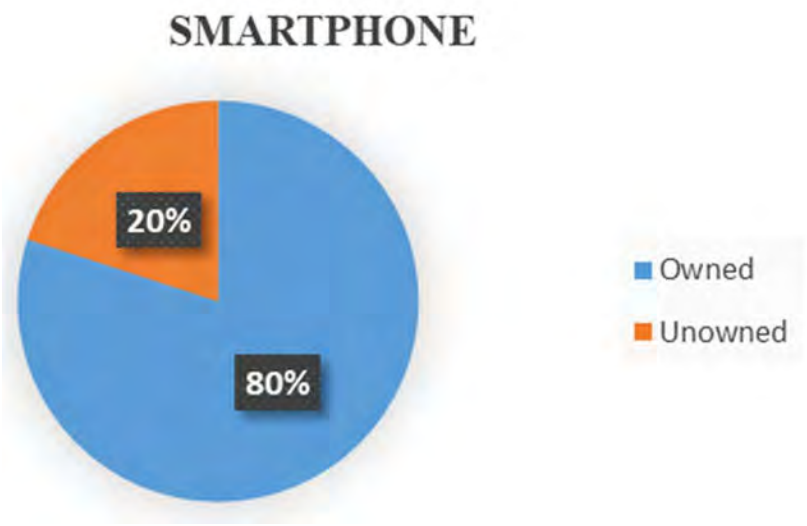
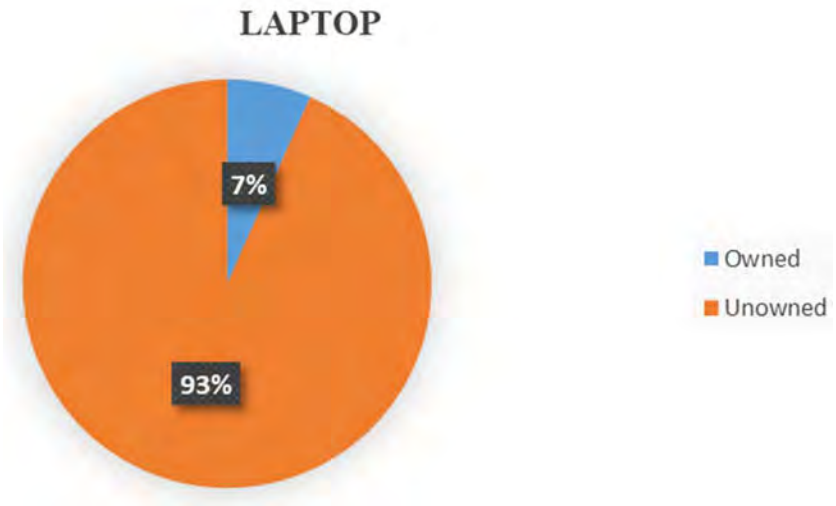


Figure 4.4 shows that the majority of respondents (93.3%, n = 28) did not have laptops. Meanwhile, 6.7% (n = 2) of respondents owned laptops. All respondents did not own a tablet or computer.

Figure 4.4

Owned a Laptop



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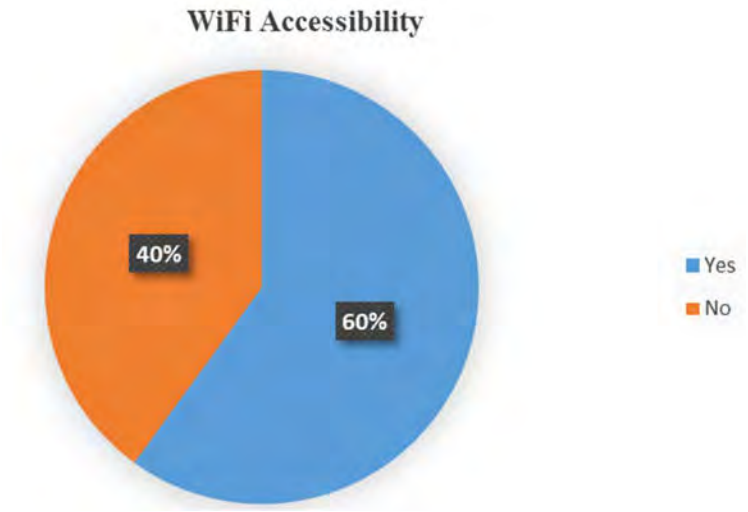
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4.2.3 Wi-Fi Accessibility

The next questions related to the Wi-Fi accessibility possessed by the respondents. Based on Figure 4.5, 60% (n = 18) of respondents said they possessed Wi-Fi connectivity at home while 40% (n = 12) of respondents did not. This data indicates that the accessibility of the internet is still lacking in rural areas, suggesting the potential of other factors in some households in this community that do not have Wi-Fi at home.

Figure 4.5

Wi-Fi Accessibility



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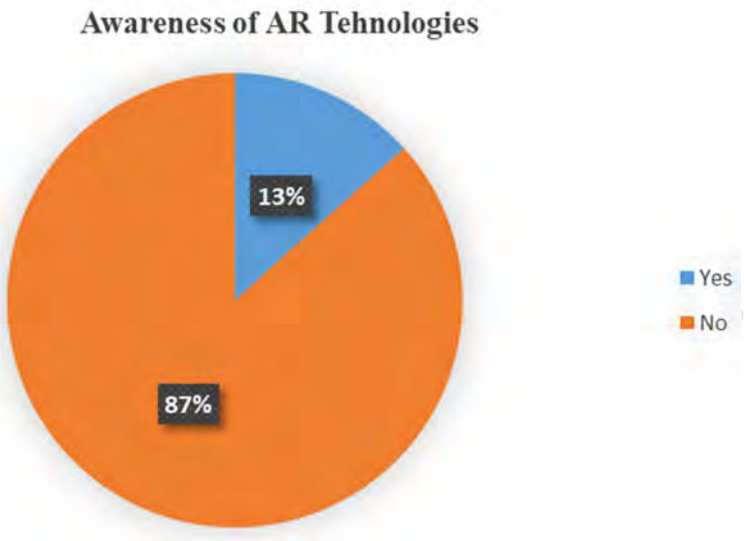
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4.2.4 Knowledge of AR Technologies

The next question related to the knowledge of AR technologies among the respondents. Based on Figure 4.6, only 13.3% (n = 4) of respondents knew about AR technologies. Meanwhile, 86.7% (n = 26) of respondents did not know about AR.

Figure 4.6

Knowledge of AR Technologies



4.2.5 Experience in AR Technologies

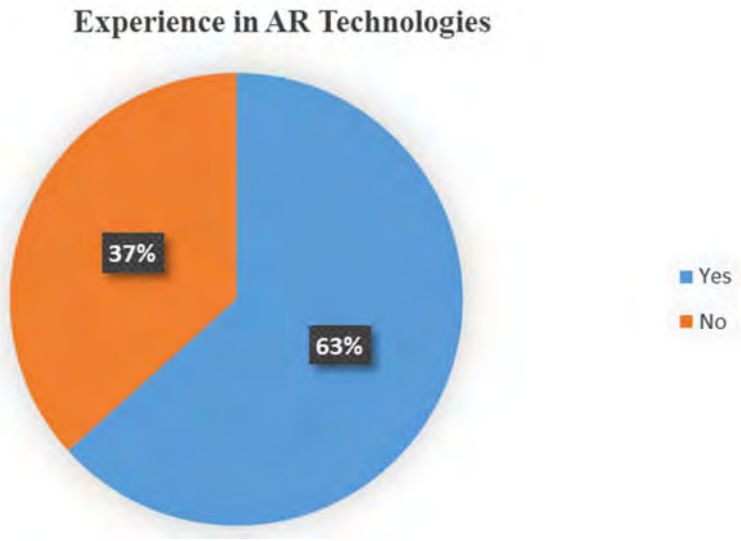
The next question related to their experience in using AR technologies. Figure 4.7 shows that among 30 respondents, 63.3% (n = 19) have experience in using AR applications. Meanwhile, 36.7% (n = 11) of respondents did not have any experience with AR technologies.

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Figure 4.7

Experience with AR Technologies



4.2.6 AR Applications and Technologies

This instrument included questions based on the respondents' experience in AR technologies to determine the AR applications and technologies they had used before. This question was only answered by respondents who had answered "Yes" to the previous question. This question was an open-ended question based on the respondents' opinions.

Table 4.1 shows that 36.7% (n = 11) of respondents had no experience and therefore did not answer this question. The majority of respondents 40% (n = 12) had experience using AR applications through the TikTok filter and a minority of respondents 10% (n = 3) had experience with AR applications through the Instagram

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filter. Meanwhile, 13.3% of respondents (n = 4) had experience with AR applications through their phone devices with smartphone camera features.

Table 4.1

AR Applications and Technology

AR APPLICATIONS AND TECHNOLOGIES		
	Frequency	Percentage
No experience	11	36.7
Instagram Filter	3	10.0
TikTok Filter	12	40.0
Phone device	4	13.3
Total	30	100.0

4.3 The Motivation Level of Orang Asli Students in STEM Learning Using AR Applications

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Items in Section B related to motivational elements among the Orang Asli respondents. The four motivational elements studied were Attention, Relevance, Confidence and Satisfaction. Each section contained five questions that assessed each element. This mean score was calculated based on the results of a 5-point Likert scale. This questions were developed to identify the respondents' level of motivation in using AR applications in STEM learning. This data was collected only for the Treatment Group who used AR applications in their learning.

The subsections below provide the descriptive statistics results for 20 statements related to the motivation of respondents in STEM learning when using AR applications, as evaluated by 15 respondents from the Treatment Group. The responses were rated

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on a scale that was averaged to generate mean scores for each statement. The standard deviation indicates the variability in the responses, and an interpretation column provides a quantitative assessment of the mean scores, such as "High" or "Very High".

4.3.1 Motivation Level Based on Attention

Table 4.2 shows the responses towards five statements based on respondents' motivation in STEM learning when using AR applications. These statements related to Attention elements based on the ARCS model. For the first item, the mean score was 3.80, with a standard deviation of 1.21. This score was interpreted as high, suggesting that students generally felt that AR applications helped them become immersed in STEM learning. However, the relatively high standard deviation indicated some variability in how strongly students agreed with this statement.

For the second item, the mean score was 3.93 with a standard deviation of 0.80, also interpreted as high. This suggested that students largely agreed that AR helped them maintain attention in STEM learning, with responses being fairly consistent. The third item received a mean score of 4.13 and a standard deviation of 0.74, which was interpreted as high. The fourth item had the highest mean score of 4.33 and a standard deviation of 0.72, leading to an interpretation of "Very High". This result suggests that AR applications significantly enhanced students' focus on classroom learning, with little variation in responses. For the fifth item, the mean score was 4.07, with a standard deviation of 1.03, which was interpreted as high. This suggests that students generally felt more interested in STEM learning when using AR applications, although the responses showed some variability.

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The overall mean score across all items was 4.05, interpreted as high, indicating that the use of AR applications in STEM education was perceived positively overall, enhancing various aspects of student engagement and focus. The data suggests that AR applications had a positive effect on students' motivation in STEM learning in the Attention element, with particularly strong effects on their focus in class.

Table 4.2

Table of Descriptive Statistics: Attention

Item No.	Item	Mean	Std. Deviation	Interpretation
1	I am immersed in STEM learning when using AR applications (AR-SiGaSTEM and AR-Tradisi).	3.80	1.21	High
2	I can give full attention in STEM learning when using AR applications (AR-SiGaSTEM and AR-Tradisi).	3.93	0.80	High
3	I am more diligent in STEM learning when using AR applications (AR-SiGaSTEM and ARTradisi).	4.13	0.74	High
4	I am more focused with what I learn in class when using AR applications (AR-SiGaSTEM and AR-Tradisi).	4.33	0.72	Very High
5	I am more interested in learning STEM when using AR applications (AR-SiGaSTEM and ARTradisi).	4.07	1.03	High
	Overall Mean	4.05		High

4.3.2 Motivation Level Based on Relevance

Table 4.3 presents the analysis of respondents' motivation in STEM learning when using AR applications, specifically AR-SiGaSTEM and AR-Tradisi. The data was interpreted through the lens of the ARCS model, focusing on relevance. The first item showed that respondents had a very high level of interest in STEM subjects when these AR applications were integrated, with a mean score of 4.27.

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The second item also showed that the AR applications were highly suitable for STEM learning, as reflected by a mean score of 4.07. Moreover, the features within these AR tools were considered very important for STEM education, as indicated by the highest mean score of 4.80 represented in the third item. In the fourth item, respondents believed that using AR applications enhanced the effect of STEM learning, with a score of 4.07.

Table 4.3

Table of Descriptive Statistics: Relevance

Item No.	Item	Mean	Std. Deviation	Interpretation
1	I find STEM interesting to study when using AR applications (AR-SiGaSTEM and AR-Tradisi).	4.27	0.59	Very High
2	I find AR applications (AR-SiGaSTEM and AR-Tradisi) suitable for use in STEM learning.	4.07	1.03	High
3	I find the features in AR applications (AR-SiGaSTEM and ARTradisi) important in STEM learning.	4.80	0.56	Very High
4	I feel that STEM learning is more effective when using AR applications (AR-SiGaSTEM and AR-Tradisi).	4.07	0.88	High
5	I feel that the topics studied are related to activities in the AR applications (AR-SiGaSTEM and ARTradisi).	4.27	0.70	Very High
	Overall Mean	4.30		Very High

Lastly, the respondents felt that the topics studied were closely related to activities in the AR applications, earning a mean score of 4.27 for the fifth item. The overall mean score of 4.30 suggested that respondents were highly motivated and found significant relevance in using AR applications for STEM education. This pointed to a strong positive perception of the role of AR in making STEM learning more engaging and effective.

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4.3.3 Motivation Level Based on Confidence

Table 4.4 presents data on respondents' confidence in using AR applications, specifically AR-SiGaSTEM and AR-Tradisi, to enhance their STEM learning. Overall, the responses reflected a positive attitude towards the use of AR in education. The highest mean score of 4.40 in the first item showed that learners felt very confident when using AR to learn STEM. The respondents believed that AR enhanced their understanding, with a mean score of 4.00 for the second item, and felt comfortable exploring the features freely, also reflected in a mean of 4.00 for the third item.

Table 4.4

Table of Descriptive Statistics: Confidence

Item No.	Item	Mean	Std. Deviation	Interpretation
1	I feel more confident learning STEM when using AR applications (AR-SiGaSTEM and AR-Tradisi).	4.40	.74	Very High
2	I believe that AR applications (AR-SiGaSTEM and AR-Tradisi) enhance my understanding in STEM learning.	4.00	1.07	High
3	I can explore the features in AR applications (AR-SiGaSTEM and ARTradisi) freely.	4.00	.76	High
4	I am optimistic that I can learn STEM by using AR applications (AR-SiGaSTEM and AR-Tradisi).	4.20	.78	High
5	I am brave to try out the functions and features available in AR applications (AR-SiGaSTEM and ARTradisi).	4.13	.64	High
	Overall Mean	4.15		High

Additionally, in the fourth item, respondents expressed optimism about learning STEM through AR, with a mean score of 4.20, and showed bravery in trying out different AR functions as shown in the fifth item, indicated by a mean of 4.13. The

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overall mean of 4.15 suggested that the use of AR applications significantly boosted learners' confidence in STEM education, fostering a more engaging and effective learning environment.

4.3.4 Motivation Level Based on Satisfaction

Table 4.5 illustrates respondents' satisfaction with using AR applications, specifically AR-SiGaSTEM and AR-Tradisi, in STEM learning. This data was based on five statements reflecting the satisfaction element of the ARCS model. The overall satisfaction was high, with an average mean score of 4.25.

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The highest mean value was 4.47 as shown in Item 2, which reflected respondents' strong satisfaction with their overall learning experience using AR applications in STEM, categorised as very high. In the third item, satisfaction with AR features was also notably high, with a mean of 4.40. Other areas, such as increased knowledge and implementation of AR in lessons, received positive feedback, with mean scores of 4.13 in the fourth item and 4.20 in the fifth item.

The lowest value shown in the first item with a mean value was 4.07 which still indicated a high level of satisfaction with the use of AR in general STEM learning. The data suggested that AR applications were highly effective in satisfying students' learning needs in STEM education, enhancing both their experience and knowledge acquisition.

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Table 4.5

Table of Descriptive Statistics: Satisfaction

Item No.	Item	Mean	Std. Deviation	Interpretation
1	I am satisfied with the use of AR applications (AR-SiGaSTEM and AR-Tradisi) in STEM learning.	4.07	0.59	High
2	I am satisfied with my learning experience using AR applications (AR-SiGaSTEM and AR-Tradisi) in STEM.	4.47	1.03	Very High
3	I am satisfied with the features in this AR applications (AR-SiGaSTEM and ARTrdaisi).	4.40	0.56	Very High
4	I am satisfied with the AR applications (AR-SiGaSTEM and ARTradisi) because it increased my knowledge in STEM learning.	4.13	0.88	High
5	I am satisfied with my knowledge in STEM learning by implementing AR applications (AR-SiGaSTEM and AR-Tradisi) in my lesson.	4.20	0.70	High
	Overall Mean	4.25		High

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4.3.5 Motivation Level

Table 4.6 presents data on students' motivation in STEM learning when using AR applications, evaluated through the ARCS model. Each of these elements served as a key indicator of student engagement and motivation, reflecting how well the AR applications fostered an interactive learning environment.

In the Attention element, the value of the mean was 4.05, which was interpreted as high. The values showed that the tool was successful in capturing and maintaining students' focus during the learning process. The use of AR technology often introduces novel and immersive experiences, which likely contributes to ensuring students are attentive to the educational content.

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Next, the Relevance component had the highest mean score of 4.29, interpreted as very high, implying that students perceived the material provided by the AR applications as closely aligned with their academic goals in STEM learning. When learners find content applicable to their needs and real-world contexts, their intrinsic motivation to engage increases. This suggests that the AR applications successfully connected the learning material to the students' interests and objectives, which is critical for sustaining motivation.

Meanwhile, the Confidence mean score was 4.15, which was also rated high, showing that students felt capable of mastering the content presented through the AR tool. A high level of confidence is essential in motivating learners, as it reinforces their belief in their ability to succeed. The interactive nature of AR applications, which often allows for self-paced and personalised learning experiences, likely contributed to this positive perception, helping students feel in control of their learning process.

Lastly, Satisfaction had a mean of 4.25, which was interpreted as "Very High", indicating that students felt highly satisfied with their overall experience using the AR applications. Satisfaction in the ARCS model is crucial because it reflects whether learners find the experience rewarding and enjoyable. A high satisfaction score suggests that the application not only helped students achieve their learning goals but also made the process enjoyable, which can lead to higher long-term motivation and continued use of the tool.

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In summary, the overall mean score of 4.19 suggested that the AR applications had a significant positive effect on student motivation in STEM learning. With relevance and satisfaction rated as "Very High" and attention and confidence rated as "High", the ARCS model data demonstrated that the application was an effective tool in promoting a motivational learning environment.

Table 4.6

Overall Values based on ARCS Elements

Item No.	ARCS Elements	Mean	Std. Deviation	Interpretation
1	Attention	4.05	0.49	High
2	Relevance	4.29	0.49	Very High
3	Confidence	4.15	0.47	High
4	Satisfaction	4.25	0.62	Very High
	Overall Mean	4.19	0.47	High

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4.4 The Achievement Level of Orang Asli Students in STEM Learning When Using Ar Applications

Items in Section C were related to the achievement of the respondents. This section consisted of a geometry assessment test that needed to be answered by every respondent. The respondents were split into two groups: those who learned STEM using AR applications, and those without.

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4.4.1 Pre-Test and Post-Test Achievement Scores for Treatment Group and Control Group

Tables 4.7 and 4.8 present the comparison between the Treatment Group and Control Group, with each group assessed through pre- and post-tests scores, followed by an analysis of their score improvement. The focus of the analysis was to evaluate the effect of the intervention applied to the Treatment Group compared to the Control Group, which did not receive the intervention.

Table 4.7 shows the results of the Treatment Group, which consisted of 15 respondents who underwent the intervention. The table shows their pre- and post-tests scores, as well as the calculated score improvement for each individual. A noticeable pattern was that the majority of respondents experienced a significant improvement in their scores after the treatment. Respondent 15 exhibited the highest increase, with a score improvement of 5.5 points, moving from a pre-test score of 2 to a post-test score of 7.5.

Another notable case was Respondent 11, who had an improvement of 4 points, from 4 to 8. Overall, most participants demonstrated marked progress, with only two respondents (4 and 5) showing no improvement at all. This suggests that the treatment had a substantial effect on the group, as most individuals saw notable positive changes in their performance.

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Table 4.7

Pre- and Post-Tests Scores for Treatment Group

TREATMENT GROUP			
No.	**Pre-Test Score**	**Post-Test Score**	**Score Improvement**
1	2	8	6
2	2	5	3
3	2	6.5	4.5
4	0	2	2
5	0	2	2
6	2	5	3
7	1.5	5	3.5
8	2	3.5	1.5
9	2	4	2
10	3	6.5	3.5
11	4	8	4
12	1	4	3
13	1	4.5	3.5
14	1	4.5	3.5
15	2	7.5	5.5

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Table 4.8 shows the pre- and post-tests results for the Control Group who did not receive the intervention. The scores in this group were generally smaller compared to those in the Treatment Group. While every respondent in the Control Group showed some level of improvement, the magnitude of change was considerably less. The largest score in this group was Respondent 3, who improved by 5 points, followed by Respondent 12, who improved by 4 points. However, many respondents in the Control Group saw only minimal gains, such as Respondent 2, who improved by only 0.5 points. These results indicate that without the treatment, the Control Group still showed some natural progression, but was much less significant than the score seen in the Treatment Group.

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Table 4.8

Pre- and Post-Tests Scores for Control Group

CONTROL GROUP			
No.	**Pre-Test Score**	**Post-Test Score**	**Score Improvement**
1	1	3.5	2.5
2	4.5	5	0.5
3	1.5	6.5	5
4	2	2.5	0.5
5	3.5	5	1.5
6	3.5	4.5	1
7	1	5.5	4.5
8	0	1.5	1.5
9	3.5	5	1.5
10	1.5	1.5	0
11	1	2	1
12	1	2	1
13	1.5	4.5	3
14	1	4.5	3.5
15	2	4.5	2.5

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Figure 4.8, presented in a bar graph, compares the achievement levels of students in both the Treatment Group and the Control Group, categorised into three levels: Low (1), Moderate (2), and High (3). In the Control Group, a majority of the students (nine respondents) were placed in the Low achievement category, while four students were in the Moderate category. Importantly, none of the students from the Control Group reached the High achievement level.

In contrast, the Treatment Group showed a more favourable distribution. One student from the Treatment Group was placed in the Low achievement category, indicating a significant reduction in the number of low achievers compared to the Control Group. The majority of the Treatment Group (10 respondents) were classified under Moderate achievement, which was a slight increase compared to the Control

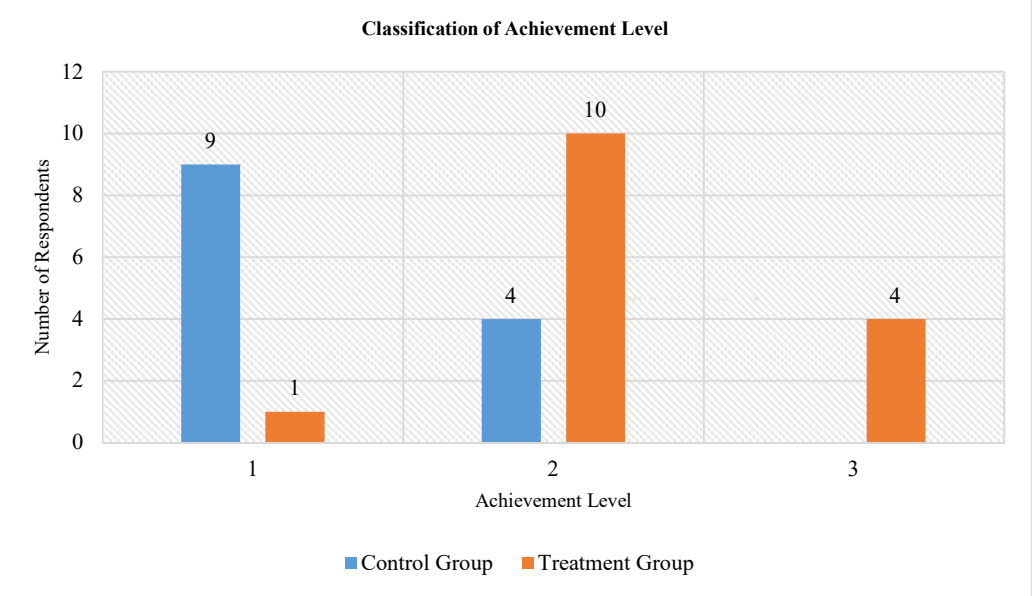
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Group. Additionally, four students from the Treatment Group reached the High achievement level, a category where the Control Group had no representation.

Figure 4.8

Classification of Achievement Level



This distribution suggests that the intervention applied to the Treatment Group was effective in improving overall achievement levels. It not only reduced the number of low achievers but also increased the number of students who achieved higher performance levels, with some even reaching the High category. In contrast, the Control Group did not exhibit the same level of progress, particularly in terms of producing high achievers, reinforcing the positive effect of the intervention on the Treatment Group.

Table 4.9 shows the pre- and post-tests results of two groups: the Treatment Group and the Control Group. Both groups started with an identical pre-test score of

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1.900. After applying the respective interventions X (AR applications) for the Treatment Group and Y (Conventional) for the Control Group, the post-test scores showed a notable difference. The Treatment Group, which received intervention X, improved significantly, achieving a post-test score of 5.067, resulting in an improvement of 3.167 points.

In contrast, the Control Group, which received intervention Y, achieved a post-test score of 3.867, with an improvement of 1.967 points. These results indicate that intervention X had a stronger positive effect on the performance of the Treatment Group compared to intervention Y, which was applied to the Control Group.

Table 4.9

Pre- and Post-Tests Overall Results

Group	Pre-Test	Intervention	Post-Test	Score Improvement	Overall Score
Treatment Group	1.900	X	5.067	3.167	3.483
Control Group	1.900	Y	3.867	1.967	2.883

4.5 The Correlation of Motivation and Achievement of Orang Asli Students in STEM Learning Using AR Applications

This section presents an analysis of the relationship between motivation and academic achievement among Orang Asli students in the context of STEM learning utilising AR

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applications. Investigating this correlation is essential to understand whether enhancements in student motivation, facilitated by AR-based learning environments, are associated with improvements in academic performance.

The analysis was conducted through the application of normality tests to ensure the appropriateness of the data for further statistical procedures, followed by correlation coefficient tests to determine the strength of the relationship between the two variables. The findings of this section are expected to provide empirical evidence on the effect of AR technology as a teaching aid in promoting both motivation and achievement among Orang Asli students, thereby contributing to the broader discourse on inclusive and technology-enhanced education.

4.5.1 Normality Test for Motivation and Achievement Level

Table 4.10 shows the normality tests for the motivation level and conflicting outcomes. The Kolmogorov-Smirnov test (Sig. = 0.200) suggested that the data did not significantly deviate from normality, while the Shapiro-Wilk test (Sig. = 0.048) indicated a significant deviation, suggesting non-normality. Since the sample size was small (n = 15), the Shapiro-Wilk test, which was more sensitive for small samples, was more reliable, indicating that the data likely deviated from normality. Further inspection using visual methods (e.g., Q-Q plots) or transformations may help confirm this conclusion in Figure 4.9.

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Table 4.10

Normality Test for Motivation Level

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Motivation Level	.160	15	.200*	.880	15	0.48

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Figure 4.9 shows the Q-Q plot for the motivation level and visually assesses the normality of the data by comparing observed values to a theoretical normal distribution. In this plot, most points aligned closely with the diagonal line, which suggested the data approximately followed a normal distribution. However, deviations at both the lower and upper ends (tails) indicated potential minor departures from normality. These deviations aligned with the Shapiro-Wilk test result, which suggested slight non-normality; however, overall, the data appeared reasonably close to normal for many practical purposes.

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Figure 4.9

The Q-Q Plot for Motivation Level

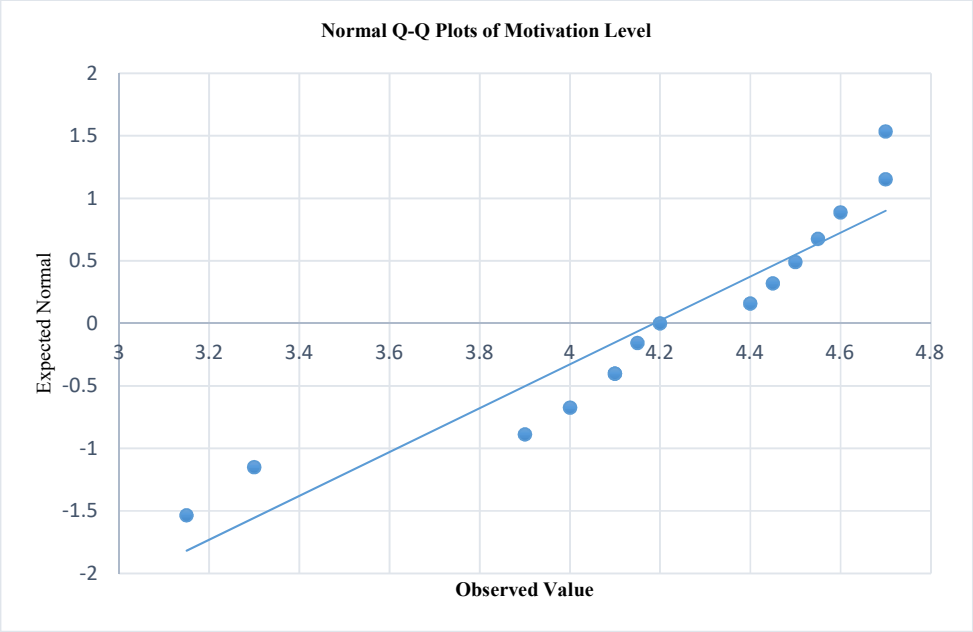


Table 4.11 shows the Kolmogorov-Smirnov (K-S) test results and the Shapiro-Wilk (S-W) test, indicating that the achievement level followed a normal distribution. In the K-S test, the statistic was 0.127, with a significance value (p-value) of 0.200, which was above the commonly used threshold of 0.05.

Similarly, the Shapiro-Wilk test produced a statistic of 0.961 and a p-value of 0.712, also well above 0.05. These high p-values implied that there was no significant evidence to reject the null hypothesis of normality for the data. Therefore, both tests confirmed that the data for achievement level were consistent with a normal distribution.

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Table 4.11

Normality Test for Achievement Level

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Achievement Level	.127	15	.200*	.961	15	.712

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Figure 4.10 shows the normal Q-Q plot for achievement level. It evaluates whether the achievement level data followed a normal distribution. The observed values (on the x-axis) were plotted against the expected normal quantiles (on the y-axis), with the diagonal line representing a perfectly normal distribution. In this plot, most data points closely aligned with the line, indicating that the achievement level was approximately normally distributed.

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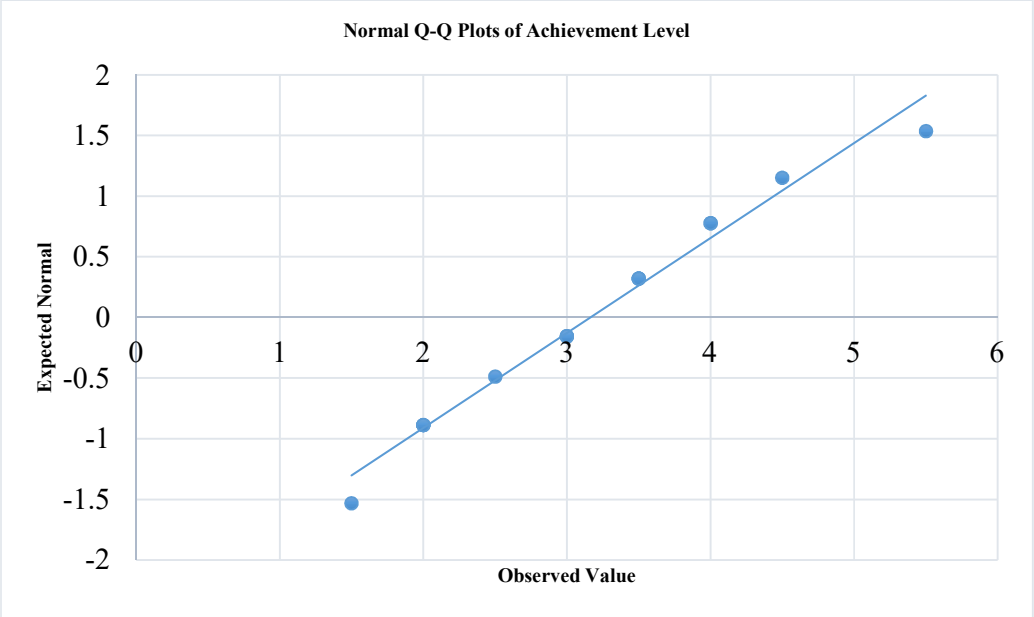
However, there were slight deviations at the extremes (the tails). Specifically, the highest observed value was slightly above the line, suggesting it was larger than expected under normality, and the smallest observed value was slightly below the line, indicating it was smaller than expected. These deviations suggested mild skewness or the presence of outliers, but they were not substantial enough to suggest significant departures from normality. Overall, the data appeared to be reasonably normal, with only minor irregularities that may or may not impact analyses depending on the context.

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Figure 4.10

The Q-Q Plot for Achievement Level



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4.5.2 Correlation Coefficient Test for Motivation Level and Achievement Level

Table 4.12 shows the results of the Spearman correlation analysis aimed at examining the relationship between motivation levels and achievement levels of Orang Asli students who used AR applications in their STEM learning (Treatment Group). This analysis is crucial for understanding the effect of motivation towards achievement of students when innovative educational tools like AR applications are employed.

The hypothesis test was conducted to examine whether there was a significant correlation between motivation level and achievement level in using AR applications for STEM learning among Orang Asli students. The null hypothesis (H_0) posited that there was no significant relationship between motivation and achievement (i.e., $\rho = 0$),

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while the alternative hypothesis (H_1) suggested that a significant correlation existed (i.e., $\rho \neq 0$). In other words, the study aimed to determine whether higher motivation levels were associated with better achievement outcomes in this educational context.

Table 4.12 presents the results of Spearman's rank-order correlation analysis between the motivation level and the overall achievement score among 15 participants from the Treatment Group. The result showed a Spearman's rho (ρ) value of 0.781 with a significance level of $p < 0.001$. This indicated a positive and statistically significant relationship between motivation and achievement levels. In other words, students who demonstrated higher motivation levels after using AR applications tended to also achieve higher in STEM learning. These findings suggest that motivation is a contributing factor to students' learning outcomes, particularly when engaging with AR technologies in an educational setting.

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Based on the correlation coefficient obtained, further interpretation regarding the strength of the relationship was necessary. The strength of the correlation between motivation and achievement was found to be strong based on the Spearman's rank-order correlation coefficient ($\rho = 0.781$, $p < 0.001$).

According to general interpretation guidelines, a coefficient value between 0.70 and 0.89 indicated a strong positive relationship (Cohen, 1988). This suggested that increases in students' motivation levels were closely associated with corresponding increases in their academic achievement. In practical terms, this strong positive correlation reflected that the more motivated the Orang Asli students were after experiencing the AR applications, the more likely they were to achieve higher scores

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in STEM learning. The statistical significance ($p < 0.001$) further reinforced that this relationship was unlikely to have occurred by chance. The sample size for this analysis was 15 students, indicating a small but sufficiently representative group for this correlation.

Thus, it can be concluded that fostering student motivation through innovative educational tools like AR applications plays a crucial role in enhancing academic achievement, particularly for students in underserved communities such as the Orang Asli. Given this evidence, the null hypothesis (H_0) can be rejected while the alternative hypothesis (H_1) can be accepted.

Table 4.12

Correlation between Motivation and Achievement of Orang Asli Students in STEM Learning Using AR applications

Correlations				
			Motivation level	Achievement Level
Spearman's rho	Motivation level	Correlation Coefficient	1.000	.781**
		Sig. (2-tailed)		<.001
		N	15	15
	Achievement Level	Correlation Coefficient	.781**	1.000
		Sig. (2-tailed)	<.001	
		N	15	15
**. Correlation is significant at the 0.01 level (2-tailed).				

The findings demonstrate that there was a statistically significant correlation between motivation and achievement when using AR applications in STEM learning among Orang Asli students. This implies that more motivated students tend to achieve higher scores, highlighting the potential importance of fostering motivation in

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educational interventions that use AR technology for STEM subjects in this specific population.

4.6 Summary

This chapter had comprehensively presented the results and findings related to the effect and correlation of Orang Asli students' motivation and achievement in STEM learning through the use of AR applications. The chapter began by outlining the demographic profiles of the respondents, which included their ownership of digital devices, access to Wi-Fi, and familiarity with AR technologies. These demographic insights were essential in establishing a contextual foundation for understanding the students' technological readiness and the subsequent impact of AR integration.

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The analysis then focused on the motivation levels of students, assessed through the four components of the ARCS model: Attention, Relevance, Confidence, and Satisfaction. The findings revealed that the use of AR applications significantly enhanced motivation across all dimensions. Students demonstrated heightened attention, found the learning content more relevant to their interests, exhibited increased confidence in engaging with STEM materials, and expressed greater satisfaction with the learning experience. These results suggest that AR technology is capable of fostering intrinsic motivation, which is crucial for sustained engagement in STEM education.

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Subsequently, the achievement levels of students were evaluated by comparing the pre- and post-tests scores between the Treatment Group and the Control Group. The Treatment Group, which engaged with AR-based learning, exhibited a notable improvement in post-test scores, whereas the Control Group, which followed conventional learning methods, showed relatively minimal progress. This comparison provided empirical evidence supporting the effectiveness of AR applications in enhancing academic performance.

Furthermore, the correlation between motivation and achievement was examined through the application of normality tests and correlation coefficient analyses. A significant positive correlation was identified, indicating that higher motivation levels were associated with higher achievement scores. This finding reinforces the assertion that motivation serves as a key determinant of academic success, particularly in technology-enhanced learning environments.

In conclusion, the results of this chapter provide strong empirical support for the integration of AR applications in STEM education as a strategy to enhance both motivation and achievement among Orang Asli students. The findings serve as a foundation for the discussion, implications, and recommendations that are elaborated upon in Chapter 5.

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CHAPTER 5

DISCUSSION AND CONCLUSION

5.1 Introduction

This section discusses the findings of the study based on the analysis from Chapter 4, which presented the collected data along with a comprehensive and detailed analysis. In this chapter, the research data is discussed to obtain the study's findings based on the objectives and research questions as stated in Chapter 1. Several suggestions for improvements in the studied field are also provided so that this research can serve as a reference for future researchers. The chapter also includes the discussion, recommendation, and the study's conclusion.

5.2 Summary of Study

This study examined the effect of AR applications on the motivation and achievement of Orang Asli students in STEM learning. Conducted at a school in Sungai Siput, Perak

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involving 30 participants, this study employed the quasi-experimental design with pre-tests and post-tests to measure AR's effects. The study focused on how two AR applications, AR-SiGaSTEM and AR-Tradisi, enhanced learning experiences by integrating multimedia elements like 3D models to make STEM more engaging. Data analysis through SPSS evaluated the correlation between motivation and achievement. The research aimed to provide insights into how AR can improve educational outcomes for marginalised communities, bridging the gap in STEM education for Orang Asli students.

5.3 Discussion of Research Findings

This section provides insights into how AR applications influenced both the motivation and achievement of Orang Asli students in STEM education. It highlights key patterns observed in the pre- and post-tests results, offering a comparison between the Control and Treatment Groups. Additionally, the discussion explores the correlation between motivation levels and academic performance when AR is integrated into learning. By examining these findings, the study aims to shed light on the effect of AR technology in enhancing educational outcomes, particularly for underserved communities like the Orang Asli. Through these insights, the research contributes to understanding the role of AR in fostering motivation and improving achievement in STEM subjects, providing a basis for future educational innovations and policy developments.

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5.3.1 RO1: To Identify The Effect of Using AR Applications for STEM Learning Towards The Level of Motivation Among Orang Asli Students.

The findings revealed a significant positive effect resulting from the use of the ARCS model. The analysis showed consistently high mean scores across all elements, indicating enhanced student motivation. These results demonstrate the overall effectiveness of the AR-based STEM intervention, with all ARCS components achieving interpretations ranging from High to Very High. This underscores the potential of AR technology to significantly enhance learning motivation and achievement, particularly among Orang Asli students who face unique educational challenges.

The Attention element, with a mean score of 4.05, indicated that AR applications had successfully captured students' interest and maintained their engagement throughout the STEM learning process. This finding is consistent with research by Khan et al. (2019), who found that the interactive features of AR significantly enhanced student engagement and attentiveness in educational environments. Moreover, AR technology offers interactive and visually stimulating experiences that can overcome the limitations of traditional learning methods (Ibáñez & Delgado-Kloos, 2018), a particularly important advantage for Orang Asli students who may find conventional instruction less engaging. These results align with Keller's ARCS model, which highlights the importance of stimulating curiosity to sustain students' focus. Observational data from learning sessions further confirm that students in the Treatment Group, particularly Orang Asli students, exhibited greater enthusiasm and sustained attention during class activities compared to those in the Control Group.

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The Relevance element recorded the highest mean score of 4.29, suggesting that students found the AR content highly applicable to their learning objectives, thereby increasing their intrinsic motivation. This finding is supported by Geng and Yamada (2021), who emphasised the importance of AR in providing contextually relevant and immersive learning experiences that foster deeper interest in STEM subjects. Furthermore, these outcomes align with the principles of SDT, which asserts that relatedness is a fundamental psychological need critical for enhancing intrinsic motivation (Pinto et al., 2017).

The culturally sensitive integration of STEM concepts within AR scenarios likely enabled Orang Asli students to perceive meaningful connections between academic learning and their cultural and environmental contexts (Jin, 2021). By situating STEM concepts within frameworks that resonate with students' lived experiences, AR applications significantly enhanced engagement and increased the perceived value of the content delivered (Laurens-Arredondo, 2022). Observations from learning sessions showed that students in the Treatment Group demonstrated higher levels of participation and interaction than those in the Control Group. This can be attributed, in part, to the familiarity of traditional activities such as the *gasing* game, which made the content more relatable and accessible. During class, Orang Asli students did not hesitate to raise their hands to ask and answer questions, illustrating the effectiveness of AR technology in creating an engaging and contextually relevant learning environment that supports both academic achievement and cultural identity (Pinto et al., 2017).

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The Confidence element achieved a mean score of 4.15, indicating that AR tools significantly enhanced students' self-efficacy in STEM education. This finding is supported by Ibáñez and Delgado-Kloos (2018), who demonstrated that AR applications assist students in visualising abstract STEM concepts, thus boosting their confidence in mastering complex material. Classroom observations revealed that students in the Treatment Group displayed considerable confidence when responding to questions and interacted with the AR applications independently, without requiring teacher assistance. This behaviour is closely linked to self-efficacy, highlighting the crucial role of belief in one's abilities as a driver of motivation (Nor Intan Adha Hafit et al., 2021). The interactive and self-paced features of AR likely provided students with opportunities to practice STEM tasks and receive immediate feedback, gradually strengthening their confidence over time (Ibáñez & Delgado-Kloos, 2018).

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The Satisfaction element, with a mean score of 4.25, indicated that students felt highly rewarded and fulfilled during the learning process, particularly in enjoying their interactions with AR applications. Satisfaction is an important component of motivation, as outlined in SDT, which identifies autonomy, competence, and relatedness as key drivers of intrinsic motivation (Ryan & Deci, 2020). The autonomy afforded by AR applications allowed students to control their learning pace and make independent decisions within the learning environment, likely contributing to their overall satisfaction (Lo et al., 2021). After the learning sessions, students in the Treatment Group expressed positive reactions, often articulating their enjoyment of the class activities. In contrast, the Control Group demonstrated significantly lower levels of engagement. These findings align with research by Chen (2024), who reported that AR-based learning environments enhance not only motivation but also satisfaction and

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enjoyment in educational settings. Overall, the integration of AR into STEM education significantly boosts the motivation of Orang Asli students, as evidenced by both quantitative data and qualitative observations.

The findings of this study are further supported by key learning theories, including cognitivism, constructivism, and behaviourism, each explaining the effectiveness of AR applications in enhancing motivation and achievement in STEM learning. From a cognitivist perspective, AR reduces cognitive load and enhances information processing by presenting complex STEM concepts through engaging and interactive visuals (Pinto et al., 2017). AR's visual and interactive content improves students' attention and memory by reducing cognitive demands (Chen & Liu, 2020).

Classroom observations revealed that Orang Asli students in the Treatment Group memorised and understood the anatomy of the *gasing* model better than those in the Control Group. This suggests that applying 3D models and AR applications attracted the students and enhanced their comprehension more effectively than conventional methods (Salma Almira Hamdani et al., 2022). These results align with constructivist principles, which emphasise that experiential learning within AR applications fosters deeper understanding (Maj, 2022). This is further supported by the study of Habibah Norehan Haron et al. (2019), who highlighted that AR fosters hands-on exploration, allowing students to manipulate virtual objects and conduct experiments, thereby making STEM concepts meaningful and relevant. This approach directly supports the "Attention" and "Relevance" dimensions of the ARCS model, as it enhances students' ability to process and retain information.

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Behaviourism emphasises the critical role of reinforcement in the learning process (Ryan & Deci, 2020). In the context of AR applications, reinforcement was implemented by offering both intrinsic and extrinsic rewards. These rewards included badges, digital certificates, congratulatory messages, and celebratory animations, all of which helped to strengthen positive learning behaviours and outcomes (Yilmaz & Göktaş, 2018). The use of these interactive rewards supported the "Relevance" and "Confidence" components of the ARCS model, enabling students to see clear connections between their learning activities and real-world applications while fostering a stronger sense of competence. In this study, observations revealed that Orang Asli students using the AR-SiGaSTEM application actively participated in quizzes and immediately received feedback on their performance through displayed scores. To further encourage motivation, teachers provided additional rewards to students who achieved high marks, promoting a healthy sense of competition and a greater drive to succeed. This strategy aligns with goal orientation theory and attribution theory, both of which emphasise encouraging students' exploration, perseverance, and skill development through positive reinforcement (Bandhu et al., 2024).

Observational data also indicated that students who were already familiar with tablets and smartphones demonstrated higher confidence when using AR applications compared to students with less digital experience. Students who initially lacked experience with digital devices showed significant interest and actively explored AR application features to enhance their learning. This observation supports the social cognitive theory, which highlights the ability of AR environments to strengthen students’ belief in their capabilities through active participation and self-directed exploration.

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The analysis of data and integration of motivational theories with the ARCS model highlights how AR applications effectively support both intrinsic and extrinsic motivation, build self-efficacy, and foster a strong sense of relevance and competence. By aligning with the Attribution Theory, the Expectancy-Value Theory, Self-Determination Theory, Social Cognitive Theory, and Goal Orientation Theory, AR technology emerged as a powerful tool for enhancing motivation and achievement in STEM education, particularly among Orang Asli students.

The significant positive effects observed in motivation levels after the introduction of AR applications can also be explained by the CTML proposed by Mayer (2024). According to CTML, learning improves when instructional materials incorporate both visual and verbal information across dual channels, thereby promoting active cognitive processing. The AR applications utilised in this study integrated 3D models, animated simulations, textual descriptions, and auditory feedback, thus supporting dual-channel learning and minimising cognitive overload (Mayer, 2024). Research by Keller et al. (2023) supports this framework, emphasising that multimedia-rich environments designed according to CTML principles significantly increase learner motivation and engagement. Similarly, Sirakaya and Sirakaya (2020) found that AR applications structured based on CTML fostered deeper engagement and intrinsic motivation, particularly in STEM disciplines. The interactive nature of AR, combined with immediate feedback mechanisms, created an engaging learning environment that met both the cognitive and emotional needs of students, thereby enhancing motivation.

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Although this study specifically focused on Orang Asli students in Malaysia, the positive impact of AR on motivation was consistent with findings from other global contexts. For example, studies have indicated the significant differences in motivation and engagement levels when technology is integrated into learning environment by involving indigenous high school students (Martin et al., 2021). Research by Kumar et al. (2024) further demonstrated that AR and digital technologies enhanced STEM education by fostering inclusive learning environments, which can significantly improve engagement and academic success among diverse student populations, including indigenous students in Australia and rural students in the United States. The capacity of AR to provide interactive and multisensory experiences appears to transcend cultural differences, although careful adaptation of content to local cultures remains critical for maximising its effectiveness. Ultimately, the ARCS elements embedded within AR environments have a direct and positive influence on motivational aspects across diverse educational systems (Keller, 2010).

5.3.2 RO2: To Identify The Effect of Using AR Applications for STEM Learning Towards The Level of Achievement Among Orang Asli Students

Tables 4.7, 4.8, and 4.9 as well as Figure 4.8 provide compelling evidence of the significant impact of AR applications on the achievement levels of Orang Asli students in STEM learning. Tables 4.7 and 4.8 compared the pre- and post-tests scores of the Treatment and Control Groups, highlighting substantial differences in their learning outcomes. In the Treatment Group, the majority of students exhibited significant score improvements, with some achieving increases of 5 to 6 points. For example,

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Respondent 1 in the Treatment Group improved from a pre-test score of 2 to a post-test score of 8, resulting in an improvement of 6 points. In contrast, the Control Group showed more modest score improvements, with many students improving by only 0.5 to 2.5 points. This demonstrates that the AR intervention was more effective in fostering meaningful learning gains compared to conventional teaching methods. This aligns with the study by Yilmaz and Göktaş (2018), where AR can simulate real-world scenarios, providing students with practical experiences that traditional methods may not offer.

Figure 4.8 visually illustrates the distribution of achievement levels between the two groups. The Control Group remained largely at Achievement Level 1, with nine out of 15 students failing to progress beyond this level. Only a small number of Control Group students advanced to Achievement Level 2, and none reached Achievement Level 3. On the other hand, the Treatment Group displayed a more favourable distribution, with the majority of students (10 out of 15) achieving Achievement Level 2 and four students reaching the highest level, Achievement Level 3. This sharp contrast highlights the transformative impact the AR applications in elevating students' performance and pushing them towards higher achievement levels. The research conducted by Lo et al. (2021) indicates that applying AR applications in the classroom significantly enhances student motivation and engagement, thereby facilitating improved academic achievement.

Table 4.9 further summarises the overall results of the intervention. Both groups began with the same average pre-test score of 1.900. After the intervention, the Treatment Group achieved a significantly higher average post-test score (5.067)

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compared to the Control Group (3.867). Moreover, the Treatment Group exhibited a larger average score improvement (3.167) compared to the Control Group (1.967), indicating the greater efficacy of AR in helping students acquire and retain STEM knowledge. The overall score, which reflects cumulative performance, was also higher for the Treatment Group (3.483) than the Control Group (2.883). These findings provide clear evidence of the superiority of AR applications in enhancing both engagement and learning outcomes. This was proven by Dodevska and Mihić's (2018) study which showed that AR applications play a crucial role in enhancing engagement and learning outcomes by providing interactive, real-time, and immersive experiences.

In conclusion, the data demonstrate that AR applications significantly improve achievement levels in STEM education among Orang Asli students. By making learning more interactive and engaging, AR also helps students understand and apply complex STEM concepts, resulting in higher test scores and greater overall progress. The study highlights AR as a transformative tool that has the potential to address educational challenges faced by marginalised communities. These findings strongly advocate for integrating AR applications into STEM curricula to foster equity and better learning outcomes.

This finding echoes broader educational research, which has shown that AR enhances learning outcomes by making abstract STEM concepts more accessible (Ibáñez & Delgado-Kloos, 2018). Studies across various cultural contexts suggest that AR-supported learning activities can effectively bridge achievement gaps, particularly among marginalised or rural students. This underscores the global applicability of AR technology in enhancing STEM education outcomes regardless of geographical or

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socioeconomic background. Similarly, the significant improvement in achievement observed in this study resonates with global trends where AR interventions have positively impacted academic performance among marginalised and indigenous students (Tamur et al., 2024).

5.3.3 RO3: To Measure The Strength of The Correlation Between Motivation and Achievement in STEM Learning of Orang Asli Students When Using AR Applications.

This study aimed to determine the correlation between the motivation and achievement levels among Orang Asli students in STEM learning using AR applications. The results presented in Table 4.10 indicate that the motivation level data followed a normal distribution. The Kolmogorov-Smirnov test yielded a statistic of .160 with a significance level (P) of .200, and the Shapiro-Wilk test showed a statistic of .880 with a P-value of .48. Both p-values exceeded the threshold of .05, suggesting that there was no significant deviation from normality. These findings were further supported by the Q-Q plot in Figure 4.9, which provided a visual assessment of normality. The data points aligned closely with the diagonal reference line, indicating that the observed values corresponded well to the expected normal distribution. Although minor deviations were observed at the tails, they were not substantial enough to challenge the assumption of normality.

However, Table 4.11 shows the normality tests for achievement level, including the Kolmogorov-Smirnov and Shapiro-Wilk tests, which demonstrated p-values of

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0.200 and 0.712, respectively, both exceeding the 0.05 threshold. This indicates that the achievement level data did not deviate significantly from normality. This finding was further supported by the Q-Q plot shown in Figure 4.10, where the observed values aligned closely with the expected normal distribution line.

In analysing the correlation between motivation and achievement levels in Table 4.12, Spearman's rank correlation coefficient revealed a strong positive correlation (rho = 0.781, $p < 0.001$). This result shows that as the motivation levels among Orang Asli increased, their achievements in STEM subjects also improved. The significance of this correlation underscores the critical role of motivation in determining achievement. Supporting this, Brew et al. (2021) showed that students' motivation, when bolstered by interactive tools such as AR, directly contributes to better academic outcomes. Similarly, Ibáñez and Delgado-Kloos (2018) found that AR applications help students build confidence and engage more deeply with educational content, leading to improved achievement.

The findings of this study can be effectively justified using the Motivation-Achievement Cycle framework by Vu et al. (2022) in Figure 2.9, which highlights motivation as a foundational driver for achieving knowledge and skills. The framework emphasises the role of academic emotions, appraisal, expectancy, and value in fostering motivation, which subsequently influences achievement. AR applications, known for their interactive and immersive qualities, can greatly enhance motivation by making STEM concepts more engaging and accessible (Petrov & Atanasova, 2020). These factors boosted motivation, leading to higher achievement, as shown by the strong positive correlation (Spearman's rho = 0.781, $p < 0.001$).

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A positive and significant correlation between motivation and achievement was observed, aligning with motivational theories posited by Ryan and Deci (2020), who emphasised that intrinsic motivation substantially contributes to improved academic performance. This correlation appears consistent across diverse educational settings, suggesting that motivated students, irrespective of cultural origin, are more likely to excel academically when provided with engaging and supportive learning tools such as AR. The positive correlation between motivation and achievement mirrors findings from international contexts where culturally responsive AR applications enhanced learning engagement and academic (Tiede et al., n.d.).

The framework also emphasises the importance of instructional quality and cultural support, both addressed through the immersive features in AR to simplify STEM concepts and provide a culturally responsive learning environment for Orang Asli students. For instance, throughout the class, students in the Treatment Group responded positively and were more eager to share knowledge compared to those in the Control Group. For Orang Asli students, who may encounter educational and cultural challenges, AR technology provided a learning environment that simplified abstract concepts through visual simulations and interactive features (Aditama & Setiawan, 2020). This not only increased interest but also improved understanding, focus, and effort, which in turn positively affected the achievement levels.

The findings of this study also aligned with the teaching and learning approach in the STEM framework (Kementerian Pendidikan Malaysia, 2016) shown in Figure 2.6, which emphasised the integration of STEM Knowledge, STEM Skills, and STEM

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Values to cultivate STEM practices and culture. AR applications support this by simplifying abstract concepts (knowledge), fostering hands-on engagement (skills), and building curiosity and confidence (values) (Ješková et al., 2022). AR also connects STEM learning to daily life, the environment, and global communities, helping students relate concepts to real-world applications (Habibah Norehan Haron et al., 2019). This approach enhances achievement and encourages the cultivation of a strong STEM culture among Orang Asli students, making learning more engaging and impactful (Lo et al., 2021).

The results of this study strongly support the integration of AR applications into STEM education for Orang Asli students. The data's normal distribution ensured the reliability of the findings, while the strong positive correlation indicated that motivation was a key driver of achievement. By fostering focus and engagement, AR technology improved perceived performance and created a positive feedback loop, where achievement further reinforced motivation (Vu et al., 2022). Moreover, AR effectively connected engagement and achievement by making learning interactive, culturally relevant, and easier to understand (Sirakaya & Sirakaya, 2020). These findings highlight the significance of technology-driven interventions in enhancing both motivation and achievement, demonstrating that AR has the potential to transform STEM learning experiences for Orang Asli students.

This finding aligned with the 5E model on the effect of AR applications on Orang Asli students in STEM learning. In the Engage phase, AR captured students' interest by linking STEM concepts to real-world scenarios, motivating active participation. Through observation, the Orang Asli students in the Treatment Group

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became attracted to the application when the teacher asked them to use it through the tablets provided. During the Explain phase, AR helped students articulate their learning, connecting experiences to real-world applications.

During the class, students in the Treatment Group did not hesitate to express their curiosity by asking about the mathematical method when using the AR application. Next, the Elaborate phase allowed students to apply knowledge to new challenges, reflected in higher achievement levels. This became evident when the teachers gave a new question to students in the Treatment Group, who were able to answer the question, while for the Control Group, the students appeared to struggle and the teachers needed to inquire their understanding.

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Last but not least, the Evaluation phase used AR for assessments, showing reliable data on learning progress. This was evident through the data on achievement level, which compared the pre- and post-tests results, showing that the Treatment Group demonstrated greater improvement than the Control Group. This suggests that AR enhances engagement, motivation, and achievement, making it a powerful tool for fostering deeper learning and addressing educational challenges for Orang Asli students, particularly in STEM learning.

5.3.4 Cultural Relevance and Unexpected Observations

The findings of this study affirm the critical role of cultural relevance in the implementation of AR-based learning tool. Integrating culturally meaningful content,

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such as traditional games and local knowledge, significantly enhanced engagement and motivation among Orang Asli students. This observation aligns with Medina-Carrión et al. (2018), who found that culturally contextualised mobile AR learning environments foster a sense of belongings and increase learning engagement among indigenous learners. Similarly, Vargas et al. (2023) emphasised that AR applications that incorporate learners' cultural background not only stimulate cognitive engagement but also emotional connection, leading to improved learning outcomes.

Unexpectedly, this study observed that students with limited prior digital exposure adapted rapidly to AR technologies. This outcome contrasts with the conventional assumption that digital literacy is prerequisite for effective AR integration (Soutthaboualy et al., 2021). Sirakaya and Sirakaya (2020) further support these findings, stating that user-centred design in AR applications can minimise the dependency on prior technological experience and facilitate smoother adoption even among novice users.

Moreover, rural students demonstrated higher-than-expected enthusiasm towards AR usage, suggesting that novelty and immediate feedback provided by AR systems may have compensated for any initial apprehension or technological unfamiliarity. Overall, these findings emphasise that AR applications, when tailored to cultural contexts, can act as powerful catalysts for engagement, even among traditionally underserved populations.

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5.3.5 Interpretation of Motivation and Achievement Findings

The interpretation of the study's findings is grounded in the Cognitive Theory of Multimedia Learning (Mayer, 2024) and the ARCS Model of Motivation (Keller, 2010). The AR applications utilised in this study engaged learners by combining text, images, animations, and interactive 3D models, facilitating dual-channel processing and enhancing retention (Ibáñez & Delgado-Kloos, 2020). The interactive design captured students' attention, while culturally resonant content ensured relevance; successful task completion fostered confidence, and positive feedback systems promoted satisfaction. These elements collectively operationalised the ARCS model, providing a robust explanation for the observed improvements in motivation.

Moreover, the significant correlation between increased motivation and higher achievement supports Ryan and Deci's (2020) SDT, which highlights the intrinsic connection between motivation and performance. Recent research by Pinto et al. (2017) also found that AR-based interventions significantly enhance not only engagement but also academic success across diverse student groups. Therefore, the findings suggest that AR technology can fulfil both cognitive and emotional needs in learning, leading to superior educational outcomes.

5.3.6 Strengths and Limitations of the Study

This study offers a unique contribution by exploring the implementation of AR applications within marginalised indigenous contexts, focusing specifically on Orang

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Asli students. The quasi-experimental design enhances the rigour of the research, enabling more reliable interpretation of outcomes, while the findings help to expand the currently limited discourse on the role of technology in indigenous education.

However, there are limitations that must be acknowledged. The sample size was relatively small (n=30) and geographically confined, limiting external validity. The exclusive use of quantitative methods, without accompanying qualitative data, constrained deeper exploration into students' subjective experiences. Furthermore, infrastructural limitations, such as inconsistent device performance and internet access disparities, may have influenced the overall effectiveness of AR integration but were not systematically controlled for (Nam et al., 2020). Future research should incorporate mixed methods designs and larger, more diverse samples, possibly across multiple Orang Asli communities, to enhance generalisability and capture richer insights.

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5.4 Research Implication

The findings of this study hold significant implications for various parties, including students, teachers, the KPM, and the Orang Asli community. By incorporating AR technology into STEM education, this research provides insights into how digital tools can enhance motivation and achievement, particularly among Orang Asli students.

These implications will guide future educational strategies, policy developments, and community empowerment efforts, ensuring more inclusive and effective learning environments.

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5.4.1 Orang Asli Students

The research shows that AR significantly enhances Orang Asli student motivation and achievement, especially in subjects like STEM, where concepts can be abstract and difficult to grasp. This is particularly relevant for Orang Asli students, who often struggle with subjects like mathematics and science. The interactive nature of AR fosters greater student motivation by making learning more engaging and less intimidating. A study by Ibáñez and Delgado-Kloos (2018) shows that AR has interactive elements which can improve students' spatial reasoning and understanding of complex concepts. By offering more immersive and hands-on learning experiences, AR also increases students' curiosity and interest, which are critical to boosting long-term educational outcomes for the Orang Asli students.

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5.4.2 Teachers

The integration of AR into their teaching methods offers new tools to explain difficult STEM concepts more effectively. Teachers can use AR applications to demonstrate abstract or complex ideas, making lessons more interactive and student-centred. The study by Laurens-Arredondo (2022) emphasises the importance of technological tools like AR in creating more dynamic and engaging classrooms, which helps teachers address diverse learning needs. Moreover, AR allows teachers to implement more creative teaching strategies, enhancing their instructional delivery and improving student outcomes, particularly for marginalised groups like the Orang Asli.

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5.4.3 Ministry of Education (KPM)

For the Ministry of Education, the study provides crucial insights into how AR can be used to improve learning outcomes and close educational gaps, particularly for underserved populations. The research demonstrates that AR can be a powerful tool in supporting KPM's broader objectives of integrating technology into the national curriculum, in line with the Digital Education Policy. Mohamad Subaidi Abdul Samat and Azlina Abdul Aziz (2020) highlight that the implementation of AR in rural and underserved areas is essential for reducing the digital divide and promoting equitable access to quality education. Therefore, KPM can use the study's findings to shape policies that ensure the benefits of educational technology reach all students, especially those from marginalised communities like the Orang Asli.

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5.4.4 Orang Asli Community

For the Orang Asli community, the implementation of AR in education not only improves academic performance but also supports the preservation of cultural identity. By incorporating AR tools that include culturally relevant content, students can connect their traditional knowledge with modern education, thus fostering a stronger sense of belonging and engagement in learning. Pellas et al. (2019) support this by showing that culturally tailored educational technologies improve learning outcomes in Orang Asli communities. This approach can also help Orang Asli students feel more included in

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the educational system, enhancing both their academic success and their sense of cultural pride.

5.4.5 Broader Educational Implications

The study's findings have significant broader implications for global educational practices. AR technologies, when thoughtfully designed, offer powerful tools to address educational inequities among marginalised groups. The evidence that culturally sensitive AR applications can boost motivation and achievement among students supports on of aspiration of UNESCO for inclusive and equitable education through technology (Velázquez & Méndez, 2018).

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Policymakers and curriculum developers must recognise the importance of integrating AR technologies that are culturally relevant and accessible. Efforts must also be directed towards bridging infrastructural gaps, such as providing affordable devices and ensuring reliable internet access in rural areas (Mohamad Subaidi Abdul Samat & Azlina Abdul Aziz, 2020).

Professional development programs should prepare educators to effectively incorporate AR into pedagogical practices, fostering inclusive learning environments. In sum, this study confirms that AR can be a transformative educational tool across diverse settings, empowering marginalised learners, preserving cultural identity, and advancing global educational equity in the digital era.

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5.5 Recommendation And Future Research

Several recommendations for future research and implementation need to be made. First, expanding the application of AR beyond STEM subjects into areas such as languages, history, and social sciences is crucial. AR has been shown to enhance learning across disciplines by making abstract concepts more tangible, as highlighted by Ibáñez and Delgado-Kloos (2018), who found that AR improves spatial skills and conceptual understanding. Current research, including this study, primarily focuses on the short-term effects of AR on motivation and achievement. Future research should explore the long-term effects by conducting longitudinal studies to evaluate whether improvements in motivation and academic performance are sustained over time. Pinto et al. (2017) supports this recommendation, highlighting the importance of extended time frames to assess the ongoing impact of AR on student outcome

The implications of this study extend beyond the immediate results, highlighting the transformative potential of AR as an educational tool. The findings suggest that AR applications not only enhance students' motivation but also significantly contribute to better achievement by making learning more interactive and engaging. These outcomes are particularly relevant for Orang Asli students, who often face barriers to educational access and success due to socio-economic and systemic challenges (Zaleha Ismail et al., 2020). By leveraging AR technology, educators can bridge these gaps, providing an inclusive and supportive learning environment that fosters both academic and personal growth (Dodevska & Mihić, 2018). This aligns with the objectives outlined in the Malaysia Education Blueprint 2013–2025, which emphasises the integration of digital technologies to enhance the quality and equity of

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education across diverse student populations (Kementerian Pendidikan Malaysia, 2016).

This study is particularly unique in its focus on the application of multimedia technologies to Orang Asli communities in educational research. By integrating AR into the STEM curriculum for Orang Asli students, the study demonstrates the capacity of immersive and interactive technologies to address disparities in educational outcomes. AR facilitates the simplification of complex STEM concepts, making them accessible and comprehensible while simultaneously cultivating interest and enthusiasm for learning. Moreover, this research highlights the importance of culturally relevant content, digital infrastructure, and teacher training in maximising the potential of AR in education. These findings contribute to the broader field of multimedia in education by showcasing how innovative technological interventions can improve both motivation and comprehension in marginalised communities.

Moreover, the results align with Malaysia's Fourth Industrial Revolution (4IR) Policy, which underscores the importance of equipping students with skills in STEM and digital technologies to prepare them for the demands of a rapidly evolving global landscape (Moraes, et al., 2022). The use of AR in education aligns with these national aspirations by providing a means to enhance learning experiences and outcomes in ways that are engaging, inclusive, and future-focused. While the study's context is specific to Malaysia, its implications are globally relevant, offering insights into how AR technologies can be leveraged to address similar challenges faced by other underrepresented communities worldwide. In conclusion, this study demonstrates the potential of AR applications to enhance motivation and achievement in STEM learning,

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offering a pathway towards more inclusive, equitable, and technology-driven education. The findings support the broader goal of achieving inclusive, equitable, and high-quality education, as emphasised in Malaysia's national policies, and provide a foundation for further research and implementation of AR technologies in diverse educational contexts.

It is recommended that AR content be tailored to reflect the cultural heritage of specific groups, such as the Orang Asli community. This approach can bridge the gap between traditional knowledge and modern education, fostering both cultural pride and educational engagement. This aligns with findings from Pellas et al. (2019), who argue that culturally relevant AR tools significantly enhance learning experiences for Orang Asli and marginalised groups. To fully harness the benefits of AR, issues of digital access must be addressed, particularly in rural or underserved areas.

The digital divide remains a significant barrier for marginalised communities. Mohamad Subaidi Abdul Samat and Azlina Abdul Aziz (2020) emphasise the need for infrastructural improvements in rural areas to provide equal access to technological resources, which is essential for the widespread adoption of AR in education. Teachers play a critical role in successfully integrating AR into classrooms. Therefore, targeted professional development programs should be introduced to equip educators with the necessary skills to use AR effectively. Laurens-Arredondo (2022) supports this recommendation, highlighting the importance of teacher preparedness in maximising the educational potential of AR technologies. However, future research should continue to refine these approaches to ensure sustained engagement and inclusivity in diverse educational contexts.

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5.6 Summary

The research findings indicate that the integration of AR applications in STEM education had a significant positive effect on the motivation and achievement of Orang Asli students. The study explored these effects through the lens of the ARCS motivational model, CTML, and the 5E Instructional Model, providing a multi-theoretical understanding of how AR influences learning outcomes among underserved students.

For Research Objective 1 (RO1), the findings showed that AR applications, guided by the ARCS model, enhanced all four motivational components such as Attention, Relevance, Confidence, and Satisfaction. AR's interactive and immersive features captured students' interest (Attention), made content more relatable through cultural integration (Relevance), improved self-efficacy by supporting independent exploration (Confidence), and increased learner enjoyment (Satisfaction). These outcomes were further supported by SDT and Social Cognitive Theory, emphasising autonomy, competence, and relatedness as critical to motivation. The findings also align with constructivist and cognitivist perspectives, showing how AR facilitates experiential learning and reduces cognitive load.

The CTML was crucial in explaining how AR enhances learning by engaging both visual and auditory channels, thereby optimising cognitive processing. AR tools in the study provided 3D visuals, animations, narration, and text, promoting dual-

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channel learning and minimising cognitive overload. This multimedia integration not only boosted motivation but also supported deep learning and concept retention.

In parallel, the 5E Instructional Model served as a pedagogical foundation in designing the AR learning experience. AR applications aligned with this model by engaging learners through culturally familiar stimuli, encouraging exploration of STEM concepts via interactive simulations, facilitating explanations through immediate feedback, allowing elaboration through hands-on manipulation of 3D models, and supporting evaluation via quizzes and assessments. This structured approach enhanced student-centred learning and reinforced motivation and achievement.

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For Research Objective 2 (RO2), quantitative data from pre- and post-tests clearly demonstrated that the Treatment Group (who used AR applications) showed significantly greater gains in STEM achievement compared to the Control Group. Students in the AR group not only scored higher but also reached more advanced achievement levels. These results affirm AR's effectiveness in facilitating deeper understanding and application of STEM concepts, aligning with prior studies that highlight the role of AR in improving educational outcomes through immersive and experiential learning environments.

Research Objective 3 (RO3) examined the correlation between motivation and achievement, revealing a strong positive relationship. As motivation levels increased especially among those exposed to AR, achievement levels also increased. This supports the notion that enhancing motivation through interactive and culturally

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relevant technologies leads to improved academic outcomes. The statistical normality of the data further validated the strength of this correlation.

In summary, the integration of AR in STEM learning, underpinned by the ARCS model, CTML, and the 5E instructional framework, significantly enhanced both motivation and academic achievement among Orang Asli students. The study not only confirms AR's educational potential but also advocates for its inclusion in STEM curricula, especially for marginalised communities. These findings contribute valuable insights to future innovations in educational technology and inclusive pedagogy.

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APPENDIX A

SECTION A: DEMOGRAPHIC QUESTIONNAIRE OF THE STUDENTS-RESPONDENTS
BAHAGIAN A: SOAL SELIDIK DEMOGRAFIK KEPADA PELAJAR-RESPONDEN

The researcher is currently conducting a research entitled, "The Effect And Correlation Of Using Augmented Reality Application In Stem Learning Among Orang Asli Students". Please answer the questionnaire by ticking (√) the appropriate boxes or by filling in the blanks.

Pengkaji sedang menjalankan penyelidikan bertajuk, "Kesan dan Korelasi Penggunaan Aplikasi Realiti Terumbuh dalam Pembelajaran STEM dalam kalangan Pelajar Orang Asli". Sila jawab soal selidik dengan menanda **(√)** *pada petak yang berkenaan atau dengan mengisi tempat kosong.*

Gender/Jantina: □ Male/Lelaki □ Female/Perempuan

Owned Mobile Device/Peranti Mudah Alih dimiliki:

□ Smartphone/Telefon Pintar □ Tablet Device/Peranti Tablet
□ Laptop/Komputer Riba □ Computer/Komputer

Do you use WiFi for internet access at home?/
Adakah anda menggunakan WiFi untuk akses internet di rumah?

□ Yes/Ya □ No/Tidak

Do you know about AR application?/
Adakah anda mengetahui tentang aplikasi AR?

□ Ya □ Tidak

Do you have experience using AR applications?/
Adakah anda mempunyai pengalaman menggunakan aplikasi AR?

□ Ya □ Tidak

If yes, justify/ Jika Ya, nyatakan.

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APPENDIX B

SECTION B: THE MOTIVATIONAL LEVEL OF THE STUDENTS-RESPONDENTS QUESTIONNAIRE

BAHAGIAN B: SOAL SELIDIK TAHAP MOTIVASI PELAJAR-RESPONDEN

The researcher is currently conducting a research entitled, "The Effect And Correlation Of Using Augmented Reality Application In Stem Learning Among Orang Asli Students". The purpose of this questionnaire is to understand students' motivation level when using AR application in STEM learning. Please answer the questionnaire by ticking (√) the appropriate boxes or by filling in the blanks.

Pengkaji sedang menjalankan penyelidikan bertajuk, "Kesan dan Korelasi Penggunaan Aplikasi Realiti Terumbuh dalam Pembelajaran STEM dalam kalangan Pelajar Orang Asli". Tujuan soal selidik ini dijalankan andalah untuk memahami tahap motivasi pelajar apabila menggunakan applikasi AR dalam pembelajaran STEM. Sila jawab soal selidik dengan menanda (√) pada petak yang berkenaan atau dengan mengisi tempat kosong.

Direction: Please check (√) and rate your agreement honestly based on the statements given using the following scales:

Arahan: *Sila tandakan betul* (√) *dan nilaikan tahap setuju anda secara jujur berpandukan pada pernyataan yang diberikan dibawah mengikut skala:*

5 – Very Agree/*Sangat Setuju* **4 –** Agree/*Setuju* **3 –** Uncertain/*Tidak pasti*
2 – Disagree/*Tidak setuju* **1 –** Strongly Disagree/*Sangat Tidak setuju*

		5	4	3	2	1
1.	I become too engrossed in learning about STEM when using AR applications (ARSiGaSTEM and AR-Tradisi)./ *Saya menjadi terlalu asyik belajar tentang STEM apabila menggunakan aplikasi AR (ARSiGaSTEM dan AR-Tradisi).*	☐	☐	☐	☐	☐
2.	I can give a fully attention in STEM learning when using AR application (AR-SiGaSTEM and AR-Tradisi)./ *Saya dapat memberi tumpuan yang penuh dalam pembelajaran STEM apabila menggunakan aplikasi AR (AR-SiGaSTEM dan AR-Tradisi)*	☐	☐	☐	☐	☐
3.	I can be more diligent in STEM learning when using AR application (AR-SiGaSTEM and ARTradisi)./ *Saya menjadi lebih tekun terhadap pembelajaran STEM apabila menggunakan aplikasi AR (ARSiGaSTEM dan AR-Tradisi*	☐	☐	☐	☐	☐

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4.	I can focus with what I learn in class when using AR application (AR-SiGaSTEM and AR-Tradisi)./ *Saya boleh fokus dengan apa yang saya belajar dalam bilik darjah apabila menggunakan aplikasi AR (AR-SiGaSTEM dan AR-Tradisi)*	☐	☐	☐	☐	☐
5.	I can be more interest in learning STEM when using AR application (AR-SiGaSTEM and ARTradisi)./ *Saya menjadi lebih berminat untuk belajar tentang STEM apabila menggunakan aplikasi AR (AR-SiGaSTEM dan AR-Tradisi)*	☐	☐	☐	☐	☐
		5	**4**	**3**	**2**	**1**
1.	I think that learning STEM by using AR is interesting./*Saya rasa mempelajari STEM dengan menggunakan AR menarik.*	☐	☐	☐	☐	☐
2.	AR -based STEM is interesting to be use in lesson./*STEM berasaskan-AR menarik untuk digunakan dalam pembelajaran.*	☐	☐	☐	☐	☐
3.	Features in AR applications look interesting and to be use./*Ciri-ciri dalam AR application menarik dilihat dan digunakan.*	☐	☐	☐	☐	☐
4.	The STEM learning more interesting when using AR application./*Pembelajaran STEM lebih menyeronokkan apabila menggunakan aplikasi AR.*	☐	☐	☐	☐	☐
5.	STEM subjects is more fun to learn when using AR application./*Matapelajaran STEM lebih menyeronakkan di perlajari apabila menggunakan aplikasi AR.*	☐	☐	☐	☐	☐
		5	**4**	**3**	**2**	**1**
1.	I am more confidence learning STEM when using AR application./*Saya lebih yakin mempelajari STEM apabila menggunakan aplikasi AR.*	☐	☐	☐	☐	☐
2.	I have confidence that AR applications increase my understanding in STEM learning./*Saya yakin bahawa aplikasi AR meningkatkan kefahaman saya dalam pembelajaran STEM.*	☐	☐	☐	☐	☐
3.	The features in AR applications makes me confidence to explore STEM learning./*Ciri-ciri*					

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	dalam aplikasi AR membuat saya yakin untuk meneroka pembelajaran STEM.	☐	☐	☐	☐	☐
4.	I am confidence I can learn STEM by using AR applications./*Saya yakin saya boleh mempelajari STEM dengan menggunakan AR applikasi.*	☐	☐	☐	☐	☐
5.	I have confidence with STEM subjects when using AR application./*Saya yakin dengan matapelajaran STEM apabila menggunakan aplikasi AR.*	☐	☐	☐	☐	☐
		5	**4**	**3**	**2**	**1**
1.	I am satisfy the use of AR application in STEM learning./*Saya berpuas hati dengan penggunaan aplikasi AR dalam pembelajaran STEM.*	☐	☐	☐	☐	☐
2.	I am satisfy with my learning experience using AR application in STEM./*Saya berpuas hati dengan pengalaman pembelajaran saya dengan menggunakan aplikasi AR dalam STEM.*	☐	☐	☐	☐	☐
3.	I am satisfy with the features in this AR application./*Saya berpuas hati dengan ciri-ciri terdapat dalam aplikasi AR ini.*	☐	☐	☐	☐	☐
4.	I am satisfy with the AR application because its increase my knowledge in STEM learning./*Saya berpuas hati dengan aplikasi AR kerana ia meningkatkan pengetahuan saya dalam pembelajaran STEM.*	☐	☐	☐	☐	☐
5.	I am satisfy with my knowledge in STEM learning by implementing AR applications in my lesson./*Saya berpuas hati dengan pengetahuan dalam pembelajaran STEM dengan menggunapakai aplikasi AR dalam pembelajaran saya.*	☐	☐	☐	☐	☐

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APPENDIX C

SECTION C: ACHIEVEMENT
BAHAGIAN C: PENCAPAIAN

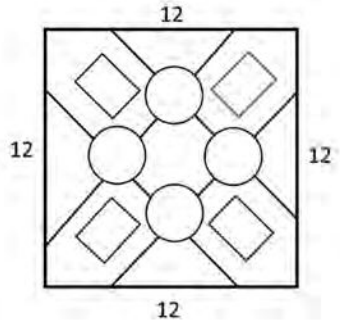
The researcher is currently conducting a research entitled, "The Effect And Correlation Of Using Augmented Reality Application In Stem Learning Among Orang Asli Students". The purpose of this exercise question is to identify students' achievement effect when using AR application in STEM learning. Please answer all question.
Pengkaji sedang menjalankan penyelidikan bertajuk, "Kesan dan Korelasi Penggunaan Aplikasi Realiti Terumbuh dalam Pembelajaran STEM dalam kalangan Pelajar Orang Asli". Tujuan latih tubi ini dijalankan adalah untuk mengenal pasti pencapaian pelajar apabila menggunakan applikasi AR dalam pembelajaran STEM. Sila jawab semua soalan.

Direction: Please answer all the question below. You will be given 20 minutes to answer all the question.

Arahan: *Sila jawap semua soalan dibawah. Anda diberikan masa selama 20 minit untuk menjawab soalan.*

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1. Rajah menunjukkan kawasan gelanggang gasing. Sila hitung perimeter bagi keliling kawasan gelanggang gasing. (2 markah)

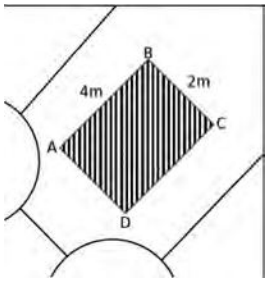


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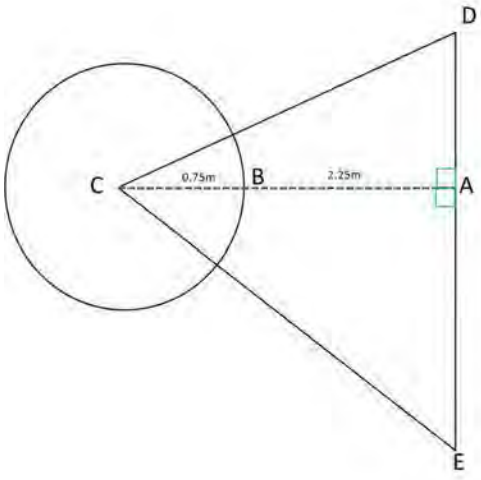
2. Rajah menunjukkan sebuah segi empat tepat ABCD yang merupakan gelanggang uri. Diberi panjang AB = CD = 4m dan BC = DA = 2m.

   Hitung perimeter, dalam m, kawasan berlorek dibawah. (3 markah)



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3. Rajah menunjukkan sebuah bulatan dan segi tiga tidak sama kaki iaiti CDE. Jumlah nilai keliling CDE adalah 15m, panjang CB = 0.75m dan panjang BA=2.25m.



   a) Hitung perimeter CDA, sekiranya nilai CD = 4m dan DA = 2m (2 markah).

   b) Cari panjang AE, sekiranya CE = 6m (3 markah).

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D1

APPENDIX D

SULTAN IDRIS EDUCATION UNIVERSITY

CONTENT VALIDITY ASSESSMENT FORM / QUESTIONNAIRE CHECKLIST CONSTRUCT

This validity assessment form is intended to obtain content / construct validity from experts on the instrument study titled:

THE EFFECT AND CORRELATION OF AUGMENTED REALITY APPLICATION IN STEM LEARNING AMONG ORANG ASLI STUDENTS

This evaluation form contains:

i) B1: Content Validity Assessment Form

Instructions:

Expert evaluators are asked to mark (/) on the content / construct validity option section and note comments or suggestions on the provided evaluator note section. Expert evaluators should also provide an overall review of the instrument and suggestions for instrument improvement. Next confirm the content / construct of this instrument whether it can be used or not in this study. All cooperation is greatly appreciated. Thank you.

[The use of this Instrument is adapted from Yuh-Shihng Chang (2021). and ARCS model by John Kellers (1987)]

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D2

THE CONTENT VALIDITY ASSESSMENT FORM/QUESTIONNAIRE CHECKLIST CONSTRUCT:
THE MOTIVATIONAL LEVEL OF THE STUDENTS-RESPONDENTS QUESTIONNAIRE
BORANG PENILAIAN KESAHAN KANDUNGAN / KONSTRUK SENARAI SEMAK SOAL SELIDIK: SOAL SELIDIK TAHAP MOTIVASI PELAJAR-RESPONDEN

The researcher is currently conducting a research entitled, "The Effect And Correlation Of Using Augmented Reality Application In Stem Learning Among Orang Asli Students". The purpose of this questionnaire is to identify students' motivation effect when using AR application in STEM learning. Please answer the questionnaire by ticking (√) the appropriate boxes. Please provide suggestions for improvement on the reviewer's post./*Pengkaji sedang menjalankan penyelidikan bertajuk, "Kesan dan Korelasi Penggunaan Aplikazi Realiti Terumbuh dalam Pembelajaran STEM dalam kalangan Pelajar Orang Asli". Tujuan soal selidik ini dijalankan andalah untuk mengenalpazti kesan motivazi pelajar apabila menggunakan applikazi AR dalam pembelajaran STEM. Sila jawab soal selidik dengan menanda (√) pada petak yang berkenaan atau dengan mengisi tempat kosong. Sila nyatakan cadangan untuk penambahbaikkan pada catatan penilai.*

Direction: Please check (√) if the questions based on the statements is correspond by using the following scales:

***Arahan**: Sila tandakan betul (√) sekiranya soalan pada pernyataan dibawah adalah sesuai dengan menggunakan skala dibawah:*

5 – Exactly Correspond/*Sangat Sesuai* **4 – Correspond**/*Sesuai* **3 – Moderately Correspond**/*Sederhana Sesuai*
2 – Less Correspond/*Kurang Sesuai* **1 – Does not Correspond**/*Sangat Tidak Sesuai*

	ATTENTION/*PERHATIAN*	ITEM INDICATOR	5	4	3	2	1	REVIEWER'S POST
1.	I can immerse in STEM learning when using AR application (AR-SiGaSTEM and AR-Tradisi)./ *Saya menjadi terlalu asyik belajar tentang STEM apabila menggunakan aplikasi AR (AR-SiGaSTEM dan AR-Tradisi).*	**IMMERSE/ *KEASYIKAN***	☐	☑	☐	☐	☐	Item sesuai untuk digunakan, cuma berhati-hati bila melakukan terjemahan. Item dalam Bahasa Inggeris dan Bahasa Melayu seperti membawa maksud yang sedikit berbeza.

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2.	I can give a fully attention in STEM learning when using AR application (AR-SiGaSTEM and AR-Tradisi)./ *Saya dapat memberi tumpuan yang penuh dalam pembelajaran STEM apabila menggunakan aplikasi AR (AR-SiGaSTEM dan AR-Tradisi)*	**SERIOUS/ *TUMPUAN***	/☐	☐	☐	☐	☐	Item sangat sesuai.
3.	I can be more diligent in STEM learning when using AR application (AR-SiGaSTEM and AR-Tradisi)./ *Saya menjadi lebih tekun terhadap pembelajaran STEM apabila menggunakan aplikasi AR (AR-SiGaSTEM dan AR-Tradisi)*	**DILIGENT/ *TEKUN***	/☐	☐	☐	☐	☐	Item sangat sesuai.
4.	I can be more focus with what I learn in class when using AR application (AR-SiGaSTEM and AR-Tradisi)./ *Saya boleh fokus dengan apa yang saya belajar dalam bilik darjah apabila menggunakan aplikasi AR (AR-SiGaSTEM dan AR-Tradisi)*	**FOCUS/ *FOKUS***	☐	/☐	☐	☐	☐	Semak semula item dan terjemahan supaya membawa maksud yang sama.
5.	I can be more interest in learning STEM when using AR application (AR-SiGaSTEM and AR-Tradisi)./ *Saya menjadi lebih berminat untuk belajar tentang STEM apabila menggunakan aplikasi AR (AR-SiGaSTEM dan AR-Tradisi)*	**INTEREST/ *MINAT***	/☐	☐	☐	☐	☐	Item sangat sesuai.

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CONTENT VALIDITY ASSESSMENT FORM / QUESTIONNAIRE CHECKLIST CONSTRUCT

	RELEVANCE/*RELEVAN*		5	4	3	2	1	
1.	I find STEM interesting to study when using AR applications (AR-SiGaSTEM and AR-Tradisi) / *Saya mendapati STEM menarik untuk dipelajari apabila menggunakan aplikasi AR (AR-SiGaSTEM dan AR-Tradisi).*	**INTERESTING TO LEARN/ *MENARIK UNTUK DIPELAJARI***	/	☐	☐	☐	☐	Item sangat sesuai.
2.	I find AR applications (AR-SiGaSTEM and AR-Tradisi) suitable for use in STEM learning / *Saya mendapati aplikasi AR (AR-SiGaSTEM dan AR-Tradisi) sesuai digunakan dalam pembelajaran STEM.*	**SUITABLE/ *SESUAI***	/	☐	☐	☐	☐	Item sangat sesuai
3.	I find the features in AR applications (AR-SiGaSTEM and AR-Tradisi) important in STEM learning / *Saya mendapati ciri-ciri dalam aplikasi AR (AR-SiGaSTEM dan AR-Tradisi) penting dalam pembelajaran STEM*	**IMPORTANT/ *PENTING***	/	☐	☐	☐	☐	Item sangat sesuai.
4.	I feel that STEM learning is more effective when using AR applications (AR-SiGaSTEM and AR-Tradisi) / *Saya merasakan pembelajaran STEM lebih berkesan apabila menggunakan aplikasi AR (AR-SiGaSTEM dan AR-Tradisi)*	**EFFECTIVE/ *BERKESAN***	/	☐	☐	☐	☐	Item sangat sesuai.
5.	I feel that the topics studied are related to activities in the AR applications (AR-SiGaSTEM and AR-Tradisi) /	**CONNECTION/ *KAITAN***	/	☐	☐	☐	☐	Item sangat sesuai.

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CONTENT VALIDITY ASSESSMENT FORM / QUESTIONNAIRE CHECKLIST CONSTRUCT

	Saya merasakan topik yang dipelajari mempunyai kaitan dengan aktiviti dalam aplikasi AR (AR-SiGaSTEM dan AR-Tradisi)			
	CONFIDENCE/*KEYAKINAN DIRI*		**5 4 3 2 1**	
1.	I am more confidence learning STEM when using AR application (AR-SiGaSTEM and AR-Tradisi)./ *Saya lebih yakin mempelajari STEM apabila menggunakan aplikasi AR (AR-SiGaSTEM dan AR-Tradisi).*	**CONFIDENCE/ *YAKIN***	☑ ☐ ☐ ☐ ☐	Item sangat sesuai.
2.	I believe that AR applications (AR-SiGaSTEM and AR-Tradisi) enhance my understanding in STEM learning./ *Saya percaya bahawa aplikasi AR (AR-SiGaSTEM dan AR-Tradisi) meningkatkan kefahaman saya dalam pembelajaran STEM*	**SELF-BELIEF/ *PERCAYA***	☑ ☐ ☐ ☐ ☐	Item sangat sesuai.
3.	I can explore the features in AR applications (AR-SiGaSTEM and AR-Tradisi) freely./ *Saya dapat meneroka ciri-ciri dalam aplikasi AR AR (AR-SiGaSTEM dan AR-Tradisi) dengan bebas.*	**FREEDOM/ *BEBAS***	☑ ☐ ☐ ☐ ☐	Item sangat sesuai.
4.	I am optimist I can learn STEM by using AR applications /*Saya optimis saya boleh mempelajari STEM dengan menggunakan AR applikasi (AR-SiGaSTEM dan AR-Tradisi).*	**OPTIMIST/ *OPTIMIS***	☑ ☐ ☐ ☐ ☐	Item sangat sesuai.

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5.	I am brave to try out the functions and features available in AR applications (AR-SiGaSTEM and AR-Tradisi) while studying STEM./ *Saya berani mencuba fungsi dan ciri-ciri yang terdapat dalam aplikasi AR (AR-SiGaSTEM dan AR-Tradisi) semasa belajar STEM.*	**BRAVE/ *BERANI***	☑	☐	☐	☐	☐	Item sangat sesuai.
	SATISFACTION/KEPUASAN		**5**	**4**	**3**	**2**	**1**	
1.	I am satisfy the use of AR application (AR-SiGaSTEM and AR-Tradisi) in STEM learning./ *Saya berpuas hati dengan penggunaan aplikasi AR (AR-SiGaSTEM dan AR-Tradisi) dalam pembelajaran STEM.*	**TECHNOLOGY USE/ *PENGGUNAAN TEKNOLOGI***	☑	☐	☐	☐	☐	Item sangat sesuai.
2.	I am satisfy with my learning experience using AR application (AR-SiGaSTEM and AR-Tradisi) in STEM./ *Saya berpuas hati dengan pengalaman pembelajaran saya dengan menggunakan aplikasi AR (AR-SiGaSTEM dan AR-Tradisi) dalam STEM.*	**LEARNING EXPERIENCE/ *PENGALAMAN PEMBELAJARAN***	☑	☐	☐	☐	☐	Item sangat sesuai.
3.	I am satisfy with the features in this AR application (AR-SiGaSTEM and AR-Tradisi)./ *Saya berpuas hati dengan ciri-ciri terdapat dalam aplikasi AR (AR-SiGaSTEM dan AR-Tradisi) ini.*	**FEATURES AND FUNCTIONALITY/ *CIRI DAN FUNGSI***	☑	☐	☐	☐	☐	Item sangat sesuai.

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4.	I am satisfy with the AR application (AR-SiGaSTEM and AR-Tradisi) because its increase my knowledge in STEM learning./ *Saya berpuas hati dengan aplikasi AR (AR-SiGaSTEM dan AR-Tradisi) kerana ia meningkatkan pengetahuan saya dalam pembelajaran STEM.*	**KNOWLEDGE/ *PENGETAHUAN***	☑ ☐ ☐ ☐ ☐	Item sangat sesuai.
5.	I am satisfy with my knowledge in STEM learning by implementing AR applications (AR-SiGaSTEM and AR-Tradisi) in my lesson./ *Saya berpuas hati dengan pengetahuan dalam pembelajaran STEM dengan menggunapakai aplikasi AR (AR-SiGaSTEM dan AR-Tradisi) dalam pembelajaran saya.*	**LEARNING INTEREST/ *KETETARIKAN BELAJAR***	☑ ☐ ☐ ☐ ☐	Item sangat sesuai

EXPERT VALIDATION/*KESAHAN PAKAR*

I have reviewed and evaluated this questionnaire. I hereby confirm whether this questionnaire is SUITABLE/~~NOT SUITABLE~~ for use in this study based on the suggested improvements given. Thank you,
Saya telah menyemak dan menilai soal selidik ini. Dengan ini saya mengesahkan soal selidik ini sesuai/tidak sesuai untuk digunakan dalam kajian ini berdasarkan cadangan penambahbaikkan yang diberi. Terima Kasih,

Dr. Nor Farhah Binti Saidin
Pensyarah
Fakulti Komputeran dan Meta-Teknologi
Universiti Pendidikan Sultan Idris
35900 Tanjong Malim, Perak

Name/*Name*: DR. NOR FARHAH SAIDIN
Field of Expertise/*Bidang Kepakaran*: Teknologi Pendidikan, Pembelajaran Multimedia, Augmented Reality
Official Stamp/*Cop Rasmi*:

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E1

APPENDIX E

THE CONTENT VALIDITY ASSESSMENT FORM: **THE ACHIEVEMENT LEVEL OF THE STUDENTS-RESPONDENTS** *BORANG PENILAIAN KESAHAN KANDUNGAN: TAHAP PENCAPAIAN PELAJAR-RESPONDEN*
The researcher is currently conducting a research entitled, "The Effect And Correlation Of Using Augmented Reality Application In Stem Learning Among Orang Asli Students". The purpose of this exercise question is to identify students' achievement effect when using AR application in STEM learning. Please answer all question. *Pengkaji sedang menjalankan penyelidikan bertajuk, "Kesan dan Korelasi Penggunaan Aplikasi Realiti Terumbuh dalam Pembelajaran STEM dalam kalangan Pelajar Orang Asli". Tujuan latih tubi ini dijalankan adalah untuk mengenal pasti pencapaian pelajar apabila menggunakan applikasi AR dalam pembelajaran STEM. Sila jawab semua soalan.*

Direction: Please check (√) if the questions based on the statements is correspond by using the following scales:

Arahan: *Sila tandakan betul* (√) *sekiranya soalan pada pernyataan dibawah adalah sesuai dengan menggunakan skala dibawah:*

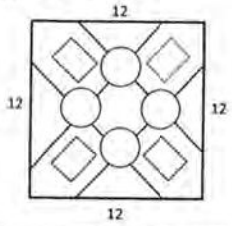
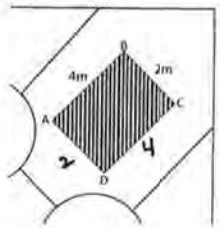
5 – Exactly Correspond/*Sangat Sesuai* **4 – Correspond**/*Sesuai* **3 – Moderately Correspond**/*Sederhana Sesuai*
2 – Less Correspond/*Kurang Sesuai* **1 – Does not Correspond**/*Sangat Tidak Sesuai*

	5 4 3 2 1	**REVIEWER'S POST**
Direction: Please answer all the question below. You will be given 20 minutes to answer all the question. *Arahan: Sila jawap semua soalan dibawah. Anda diberikan masa selama 20 minit untuk menjawab soalan.*		

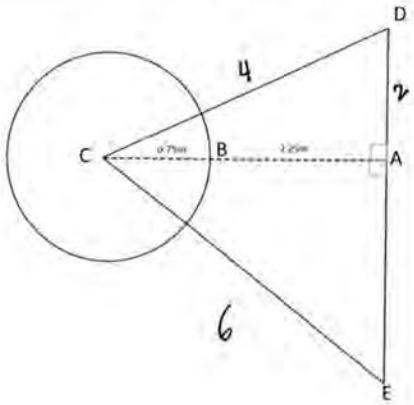
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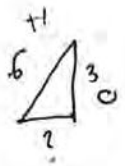
CONTENT VALIDITY ASSESSMENT FORM/GEOMETRY ASSESSMENT TEST

1. The diagram shows the area of the gelanggang gasing. Please calculate the perimeter of the gelanggang gasing area. *Rajah menunjukkan kawasan gelanggang gasing. Sila hitung perimeter bagi keliling kawasan gelanggang gasing. (2 markah)*  	☑ ☐ ☐ ☐ ☐	48
2. The diagram shows a rectangle ABCD, which is a playground. Given that the length AB=CD=4 meters and BC=DA=2 meters. **Calculate the perimeter, in meters, of the shaded area below. (3 marks)** *Rajah menunjukkan sebuah segi empat tepat ABCD yang merupakan gelanggang uri. Diberi panjang AB = CD = 4m dan BC = DA = 2m. Hitung perimeter, dalam m, kawasan berlorek dibawah. (3 markah)*  	☑ ☐ ☐ ☐ ☐	12

3. **The diagram shows a circle and triangle, CDE. The total of CDE perimeter is 15m, the length of CB = 0.75m and length of BA=2.25M.**
Rajah menunjukkan sebuah bulatan dan segi tiga, CDE. Jumlah perimeter CDE adalah 15m, panjang CB = 0.75m dan panjang BA=2.25m.



$\frac{1}{2} \times P \times L = 15$



a) Calculate the perimeter of CDA, if the length of CD=4m and DA=2m. (2marks)
Hitung perimeter CDA, sekiranya panjang CD = 4m dan DA = 2m (2 markah).

b) Find the length of AE, if CE=6m (3marks).
Cari panjang AE, sekiranya CE = 6m (3 markah).

a) 9

b) 5.196

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E4

CONTENT VALIDITY ASSESSMENT FORM/GEOMETRY ASSESSMENT TEST

EXPERT VALIDATION/*KESAHAN PAKAR*

I have reviewed and evaluated this geometry assessment test. I hereby confirm whether this questionnaire is SUITABLE/NOT SUITABLE for use in this study based on the suggested improvements given. Thank you,
Saya telah menyemak dan menilai soal selidik ini. Dengan ini saya mengesahkan soal selidik ini sesuai/~~tidak sesuai~~ untuk digunakan dalam kajian ini berdasarkan cadangan penambahbaikkan yang diberi. Terima Kasih,



Name/*Name*:
Field of Expertise/*Bidang Kepakaran*: MATEMATIK
Official Stamp/*Cop Rasmi*:

NORSAFIDA BINTI MOHAMAD ASSARI
PENSYARAH MATEMATIK
KOLEJ VOKASIONAL SLIM RIVER

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APPENDIX F

KEMENTERIAN PENDIDIKAN MALAYSIA
BAHAGIAN PERANCANGAN DAN PENYELIDIKAN DASAR PENDIDIKAN
ARAS 1-4, BLOK E8
KOMPLEKS KERAJAAN PARCEL E
PUSAT PENTADBIRAN KERAJAAN PERSEKUTUAN
62604 PUTRAJAYA

TEL : 0388846591
FAKS : 0388846579

Ruj. Kami : KPM.600-3/2/3-eras(21055)
Tarikh : 5 Ogos 2024

NURHANISAH BINTI SURDI
NO. KP : 961212016702

NO. 6, LOT 6796, LORONG HJ KUSAIRI, KG BARU 1, BATU 7, JALAN KEBUN, 42450, KLANG, SELANGOR
42450 KLANG
SELANGOR

Tuan,

KELULUSAN BERSYARAT UNTUK MENJALANKAN KAJIAN :
THE EFFECT AND CORRELATION OF MOTIVATION AND ACHIEVEMENT USING AR APPLICATION IN STEM LEARNING AMONG ORANG ASLI STUDENTS

Perkara di atas adalah dirujuk.

2. Sukacita dimaklumkan bahawa permohonan tuan untuk menjalankan kajian seperti di bawah telah diluluskan dengan syarat :

" KELULUSAN INI BERGANTUNG KEPADA KEBENARAN PENGARAH JPN DAN PERTIMBANGAN PENTADBIR SEKOLAH. PENGUTIPAN DATA TIDAK BOLEH MENGGANGGU AKTIVITI PENGAJARAN DAN PEMBELAJARAN MURID. PENYELIDIK MESTI MENDAPATKAN KEBENARAN BERTULIS DARIPADA IBU BAPA MURID YANG DILIBATKAN DALAM KAJIAN INI. PIHAK PENTADBIR SEKOLAH PERLU MENELITI KESESUAIAN MODUL YANG DIBANGUNKAN SEBELUM DIGUNAKAN OLEH MURID. "

3. Kelulusan adalah berdasarkan kepada kertas cadangan penyelidikan dan instrumen kajian yang dikemukakan oleh tuan kepada bahagian ini. Walau bagaimanapun kelulusan ini bergantung kepada kebenaran Jabatan Pendidikan Negeri dan Pengetua / Guru Besar yang berkenaan.

4. Surat kelulusan ini sah digunakan bermula dari **26 Ogos 2024** hingga **20 Februari 2025**

5. Tuan dikehendaki menyerahkan senaskhah laporan akhir kajian dalam bentuk *hardcopy* bersama salinan *softcopy* berformat pdf dalam CD kepada Bahagian ini.Tuan juga diingatkan supaya mendapat kebenaran terlebih dahulu daripada Bahagian ini sekiranya sebahagian atau sepenuhnya dapatan kajian tersebut hendak diterbitkan di mana-mana forum, seminar atau diumumkan kepada media massa.

Sekian untuk makluman dan tindakan tuan selanjutnya. Terima kasih.

"BERKHIDMAT UNTUK NEGARA"

Saya yang menjalankan amanah,

Ketua Penolong Pengarah Kanan
Sektor Penyelidikan dan Penilaian Dasar
b.p. Pengarah
Bahagian Perancangan dan Penyelidikan Dasar Pendidikan
Kementerian Pendidikan Malaysia

salinan kepada:-

JABATAN PENDIDIKAN PERAK

* SURAT INI DIJANA OLEH KOMPUTER DAN TIADA TANDATANGAN DIPERLUKAN *

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APPENDIX G

KEMENTERIAN PENDIDIKAN
Jabatan Pendidikan Negeri Perak
Jalan Tun Abdul Razak
30640 Ipoh, Perak Darul Ridzuan

Tel : 605 501 5000
Faks : 605 527 7273
Laman Web : http://jpnperak.moe.gov.my

"PENDIDIKAN BERKUALITI, SEKOLAH UNGGUL, MURID HOLISTIK"

Ruj. Kami : JPNPk.SPS.USJK.600-1Jld.13(20)
Tarikh : 23 Ogos 2024

Nurhanisah binti Surdi
No.6, Lot 6796 Lorong Haji Kusairi
Kg Baru 1, Batu 7, Jalan Kebun
42450 Klang, Selangor

Tuan,

KELULUSAN UNTUK MENJALANKAN KAJIAN DI SEKOLAH-SEKOLAH NEGERI PERAK DI BAWAH JABATAN PENDIDIKAN NEGERI PERAK

Dengan segala hormatnya, perkara di atas adalah dirujuk dan surat tuan yang diterima pada 20 Ogos 2024 adalah berkaitan.

2. Sehubungan dengan itu, dimaklumkan bahawa Jabatan Pendidikan Negeri Perak tiada halangan untuk membenarkan pihak tuan menjalankan kajian yang bertajuk ***"THE EFFECT AND CORRELATION OF MOTIVATION AND ACHIEVEMENT USING AR APPLICATION IN STEM LEARNING AMONG ORANG ASLI STUDENTS"*** seperti dinyatakan dalam surat tuan dengan syarat-syarat berikut:

2.1 pihak tuan perlu mendapatkan kebenaran terlebih dahulu daripada Pegawai Pendidikan Daerah dan Pengetua / Guru Besar sekolah sebelum melaksanakan kajian;

2.2 tidak digalakkan untuk melibatkan guru dan murid di kelas peperiksaan sebagai responden;

2.3 tidak mengganggu proses pengajaran dan pembelajaran murid kelas Peperiksaan semasa menjalankan pengutipan data;

2.4 objektif atau bidang kajian tidak bercanggah dengan dasar pendidikan;

2.5 kaedah penyelidikan mengikut peraturan dan pekeliling yang sedang berkuatkuasa; dan

2.6 penyelidikan mempunyai kepentingan kepada KPM.

.../2-

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KELULUSAN UNTUK MENJALANKAN KAJIAN DI SEKOLAH-SEKOLAH NEGERI PERAK DI BAWAH JABATAN PENDIDIKAN NEGERI PERAK

Ruj. Kami : JPNPk.SPS.USJK.600-1 Jld.13(20) Tarikh: 29 Ogos 2024

3. Sukacita juga diingatkan, sekiranya sebahagian atau sepenuhnya dapatan kajian tersebut hendak dibentangkan di mana-mana forum atau seminar atau diumumkan kepada media massa, pihak tuan perlu mendapatkan kebenaran terlebih dahulu daripada Bahagian Perancangan dan Penyelidikan Dasar Pendidikan, Kementerian Pendidikan Malaysia dan satu (1) salinan kepada Jabatan Pendidikan Negeri Perak.

4. Kebenaran ini adalah untuk tujuan yang dipohon dan melibatkan sekolah dalam daerah yang dinyatakan sahaja dan luput **selepas tarikh 20 FEBRUARI 2025.**

Sekian, terima kasih.

"MALAYSIA MADANI"

"BERKHIDMAT UNTUK NEGARA"

Saya yang menjalankan amanah,

(SABARINA BINTI JAMALUDDIN)
Timbalan Pengarah
Sektor Pengurusan Sekolah
b.p Pengarah Pendidikan Negeri Perak

s.k : 1. Pengarah Pendidikan Negeri Perak
2. Pegawai Pendidikan Daerah Kuala Kangsar

PERAK SEJAHTERA 2030"

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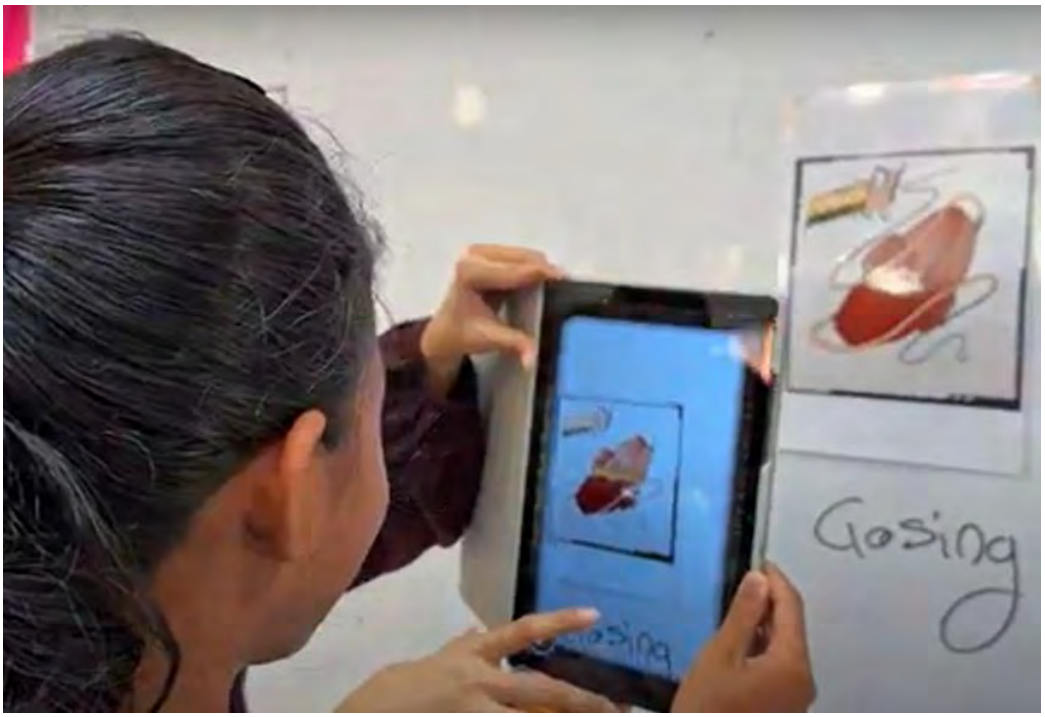
APPENDIX H





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APPENDIX I

life linguist

Certificate of Proofreading

This is to certify that the document(s)

THE EFFECTS AND RELATIONSHIP OF MOTIVATION AND ACHIEVEMENT IN STEM LEARNING AMONG ORANG ASLI STUDENTS USING AN AUGMENTED REALITY APPLICATION

Which has 202 pages

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Has been edited for English language accuracy by Life Linguist Enterprise. The document has been edited for proper English language usage including grammar, spelling, punctuation, and style by one of our editors.

Date Issued:

11 May 2025

Kind regards,

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Our reference: **CERT-050625U-01Hanisah**

Proofreaders United

Certificate of Acknowledgement

(Editing)

We certify that the following Abstract (Thesis/Dissertation)

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by

Nurhanisah Binti Surdi

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Full details of the Editing service can be found at ProofreadersUnited.com.

06 June 2025

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DR. MUHAMMAD ZAKI RAMLI
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