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The Effects and relationship of motivation and achievement in STEM learning among Orang Asli students using Augmented Reality Applications

Kesan dan hubungan motivasi dan pencapaian dalam pembelajaran STEM dalam kalangan pelajar Orang Asli menggunakan Aplikasi Realiti Terimbuh

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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.

Keywords: Orang Asli, STEM learning, augmented reality, motivation, achievement, correlation, SPSS

ABSTRAK

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.

***Keywords**: Orang Asli, pembelajaran STEM, realiti terimbuh, motivasi, pencapaian, korelasi, SPSS*

INTRODUCTION

The rapid advancement of educational technology in the 21st century has significantly transformed teaching and learning approaches, enabling more interactive, engaging, and student-centred environments. In Malaysia, this transformation is supported by strategic initiatives such as the Digital Education Policy, which promotes the integration of digital tools in the classroom to modernize teaching practices and increase learning effectiveness (Nordin, Alias, & Mahamod, 2023). Among the many emerging technologies, Augmented Reality (AR) has emerged as a powerful tool in education. AR enhances real-world environments by overlaying virtual objects such as images, sounds, and 3D models, thereby enabling immersive and interactive learning experiences (Chen, 2024).

In the context of STEM (Science, Technology, Engineering, and Mathematics) education, AR applications offer substantial pedagogical benefits. They allow learners to visualise abstract scientific and mathematical concepts, encourage exploration through simulations, and foster problem-solving in a hands-on manner (Arshad, Ishak & Zaharudin, 2024). These features make STEM learning more engaging and accessible, ultimately contributing to better academic performance and increased student motivation. AR's ability to merge real and virtual environments aligns with Mayer's Cognitive Theory of Multimedia Learning, which emphasizes the importance of dual-channel processing and active cognitive engagement in improving learning outcomes (Mayer, 2024; Keller, Rumann & Habig, 2021). In addition, frameworks such as the 5E Instructional Model—comprising Engage, Explore, Explain, Elaborate, and Evaluate—have been found to complement AR's interactive features by promoting inquiry-based and student-centered STEM learning (Bozkurt et al., 2023; Hashim et al., 2022).

However, despite the increasing adoption of AR in mainstream educational settings, its implementation remains limited and underexplored among marginalized communities, particularly the Orang Asli students in Malaysia. These students often face persistent challenges such as inadequate access to ICT infrastructure, poor internet connectivity, low exposure to digital pedagogies, and a lack of culturally responsive learning materials (Samat & Aziz, 2020). These factors negatively affect their learning motivation and achievement, especially in STEM subjects that require strong cognitive and

visual-spatial skills (Md-Ali et al., 2021; Abdullah, 2022). While previous studies have demonstrated a strong correlation between student motivation and academic achievement in STEM, especially mathematics (Sabri et al., 2025), there is limited empirical research focusing specifically on the impact of AR applications on Orang Asli learners in rural and underprivileged settings (Hafit et al., 2021).

To address this gap, the current study investigates the effects and relationship of AR-based STEM learning applications—AR-SiGaSTEM and AR-Tradisi—on the motivation and academic achievement of Orang Asli students. These applications integrate STEM content with traditional cultural elements such as *Gasing* games, providing a contextualized and meaningful learning experience. The specific objectives of the study are:

1. To identify the effect of using AR applications for STEM learning on the level of motivation of Orang Asli students;
2. To identify the effect of AR applications on their level of achievement in STEM subjects; and
3. To measure the correlation between motivation and achievement in STEM learning using AR interventions.

The significance of this research lies in its dual contribution to educational practice and theory. Pedagogically, it offers insights into how AR can serve as an inclusive, culturally relevant teaching aid that enhances engagement and comprehension for marginalized learners (Kamaruddin et al., 2019). Technologically, it provides a framework for designing AR content based on validated theories such as The Cognitive Theory of Multimedia Learning (CTML) and ARCS Attention, Relevance, Confidence, and Satisfaction (ARCS) Motivation Model (Ryan & Deci, 2020; Ma & Lee, 2020), ensuring both usability and motivational impact. Furthermore, the use of culturally embedded AR applications aligns with national aspirations for equitable access to quality STEM education and supports the preservation of indigenous heritage (Marrahi-Gomez & Belda-Medina, 2023).

Ultimately, the findings of this study are expected to inform future curriculum design, teacher training, and policy formulation by highlighting how AR can bridge educational gaps through immersive, interactive, and context-sensitive learning experiences. This contributes to the broader goal of nurturing STEM literacy and lifelong learning among all student populations in Malaysia, including the traditionally underserved Orang Asli communities.

AR APPLICATION IN STEM EDUCATION FOR ORANG ASLI STUDENTS

STEM education emphasizes an interdisciplinary approach to learning to equip students for future careers and address global issues (Malik et al., 2021). STEM framework stated in Figure 1 by Kementerian Pendidikan Malaysia (2016) promotes the integration of STEM knowledge, skills and values into daily life, the environment, and local and global communities. It aims to cultivate a STEM culture that supports lifelong learning and problem-solving. STEM skills are categorised into process and technical skills, with each discipline targeting different educational goals. For example, the use of digital tools in technology or the mastery of mathematical processes in mathematics (Ješková et al., 2022).

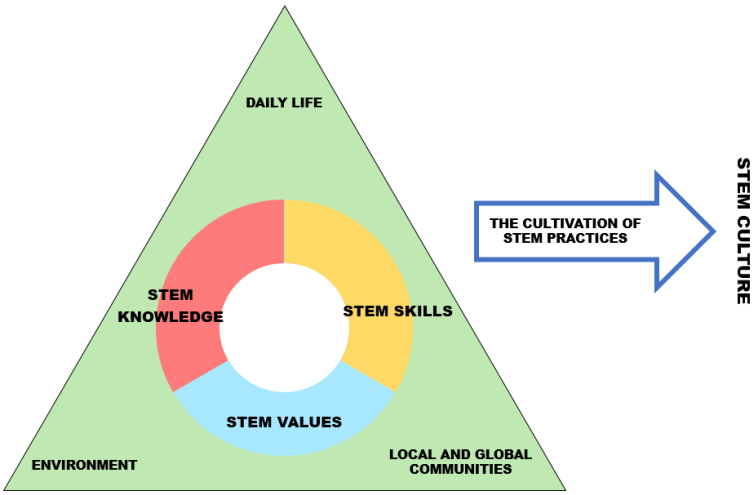

Figure 1 Teaching and learning approach in STEM by Kementerian Pendidikan Malaysia (2016)

The Orang Asli, which include the Negrito, Senoi and Proto-Malay groups, are the indigenous peoples of Malaysia and have distinct cultural, linguistic and social characteristics (Ahmad et al., 2022). Despite government initiatives aimed at inclusive education, Orang Asli students continue to face significant barriers to academic achievement, particularly in STEM subjects. These challenges are exacerbated by language differences, cultural discrepancies and limited access to quality educational resources (Abd Rahman et al., 2018). In states such as Perak, low achievement, low participation and minimal engagement in the regular curriculum have been consistently reported (Rabahi et al., 2016). Emerging educational technologies, particularly AR, have shown the potential to improve the learning outcomes of Orang Asli students by creating immersive and interactive STEM learning environments. AR-enhanced instruction can promote motivation, understanding, and participation in the classroom, addressing key issues related to STEM literacy (Aspin et al., 2022). However, the implementation of AR in Orang Asli education is not without its challenges. These include limited internet connectivity, inadequate access to technological devices and a lack of digital literacy in these communities (Samat & Aziz, 2020). Furthermore, the effectiveness of AR depends on its cultural relevance and its adaptability to the unique socio-economic and linguistic context of the Orang Asli population (Cherubini, 2020). Consequently, a culturally appropriate and technologically inclusive approach is essential to close the education gap of the Orang Asli students in Malaysia.

To address the specific needs of Orang Asli learners, two AR-based learning applications have been developed: AR-Tradisi and AR-SiGaSTEM as shown in Figure 2 and Figure 3. These applications embed STEM content within culturally familiar contexts, specifically the traditional G*asing* spinning top, which is well known among indigenous communities in Malaysia. The use of culturally relevant materials not only supports academic engagement but also affirms cultural identity, which is often overlooked in mainstream curricula.

AR-Tradisi enables students to scan printed markers to access interactive 3D models of the gasing. These models include labelled components and textual explanations that support dual-channel processing in line with CTML principles. On the other hand, AR-SiGaSTEM presents STEM content such as physics concepts related to rotation, balance, and geometry through different types of gasing from various Malaysian states. This application includes a quiz module with ten culturally contextualized STEM questions that provide instant feedback, encouraging active learning in a gamified environment.

The applications differ in their technological configurations—e.g., marker-based versus markerless AR—and support multiple modes of interaction such as touch, voice, and gesture. These multimodal features enable personalization of the learning experience and promote motivation and participation among diverse learners (Bozkurt et al., 2023). The gamified assessment components in

particular help maintain student attention and engagement while reinforcing learning outcomes. While these applications show promise in increasing motivation and achievement in STEM, especially among marginalized learners, successful implementation requires additional support such as teacher training, reliable infrastructure, and pedagogical alignment with national curriculum goals (Razali et al., 2020; Cherubini, 2020). Nevertheless, the culturally responsive design of AR-Tradisi and AR-SiGaSTEM demonstrates how immersive technology can serve as a bridge between modern scientific knowledge and traditional community values.

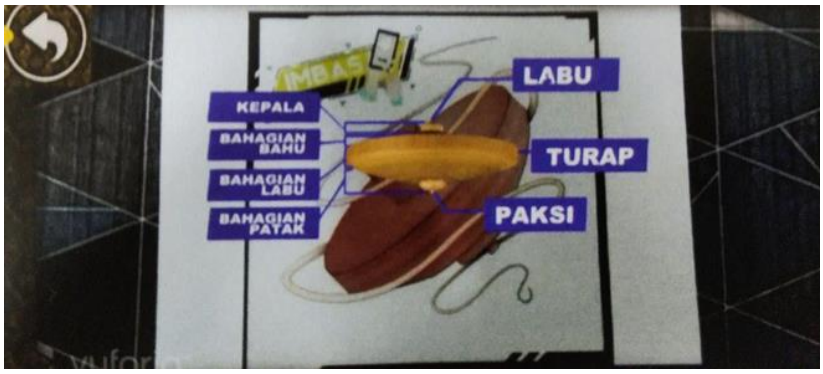

Figure 2 Marker-Based AR visualisation of a traditional gasing part in AR-Tradisi application

Figure 3 AR markless embedded in the Gasing game using AR technology in the AR-SiGaSTEM application

RESEARCH METHODOLOGY

This study employed a quantitative research approach using a quasi-experimental design to examine the effects of AR applications on Orang Asli students' motivation and achievement in STEM learning. A total of 30 Form One students from a secondary school in Perak participated in the study. The participants were selected through purposive sampling based on their willingness and availability. Although the sample size is relatively small, it is considered acceptable for quasi-experimental research involving specific, hard-to-reach populations. Previous research has shown that sample sizes between 20 and 30 are appropriate in such contexts, particularly when using pre- and post-test designs to measure the effects of educational interventions (Creswell & Creswell, 2023; Etikan et al., 2016).

Participants were divided into two groups: a treatment group that received instruction using AR applications (AR-SiGaSTEM and AR-Tradisi) and a control group that received instruction through conventional teaching methods. Both groups completed a pre-test, which assessed their understanding of geometry based on Chapter 10: Perimeter and Area from the Form 1 Mathematics syllabus. Following

the intervention, a post-test was administered to measure improvement in achievement. Additionally, the treatment group completed a motivation questionnaire based on the ARCS model, which measures Attention, Relevance, Confidence, and Satisfaction (Keller, 1987).

All instruments used in this study underwent validation by experts in the fields of measurement and evaluation. Reliability was assessed using Cronbach's Alpha, with the motivation questionnaire scoring 0.891 and the geometry achievement test scoring 0.912. These values indicate high internal consistency, meaning the instruments reliably measured the intended constructs. According to Asigigan (2021) and Suherman et al. (2021), Cronbach's Alpha values above 0.80 are considered strong and acceptable for use in educational research.

Data were analysed using SPSS software. Descriptive statistics were used to summarise student responses and test scores. Spearman's rank correlation was employed to examine the relationship between students' motivation and academic achievement, as it is suitable for non-parametric data that do not meet the assumption of normality.

FINDINGS

This chapter presents the findings of the study based on the data collected from Orang Asli students involved in STEM learning using AR applications. The results are organised into three main sections: students' motivation levels, achievement, and the relationship between motivation and achievement.

A. Motivation in STEM Learning Using AR Applications

Students' motivation levels were assessed using a questionnaire based on the ARCS model, which includes four dimensions: Attention, Relevance, Confidence, and Satisfaction. This analysis was conducted on students from the treatment group only, who experienced AR-based STEM learning.

The findings revealed high to very high levels of motivation across all components. Relevance (M = 4.29, SD = 0.49) and Satisfaction (M = 4.25, SD = 0.62) were rated as very high, indicating that students found the content meaningful and satisfying. Attention and Confidence also received high ratings (M = 4.05 and 4.15 respectively). The overall mean score was 4.19 (SD = 0.47), demonstrating that the AR applications positively influenced the students' motivation.

Table 1 Students' Motivation Levels Based on ARCS Model (n=15)

ARCS Elements	Mean (M)	Std. Deviation (SD)	Interpretation
Attention	4.05	.49	High
Relevance	4.29	.49	Very High
Confidence	4.15	.47	High
Satisfaction	4.25	.62	Very High
Overall	**4.19**	**.47**	**High**

C. Achievement in STEM Learning Using AR Applications

The achievement level was measured using pre- and post-tests administered to students in the treatment group, who engaged in STEM learning through AR applications. The analysis focused on the changes in students' performance before and after the AR-based intervention.

The treatment group demonstrated a clear improvement, with a mean pre-test score of 1.90, which increased to a mean post-test score of 5.07 following the use of AR in instruction. This represents a mean score gain of 3.17 points, indicating a positive impact of AR integration on students' learning outcomes in the geometry topic.

For reference, the control group, which received conventional instruction without AR, also began with a mean pre-test score of 1.90 and improved slightly to 3.87 in the post-test, representing a smaller gain of 1.97 points. These results are summarised in Table 2. However, since the focus of this study is not comparative, the control group data are included only to provide general context.

Table 2 Respondents' Pre-Test and Post-Test of Treatment Group (with Control Group for Reference)

Group	Pre-Test Score	Post-Test Score	Score Improvement
Treatment group	1.900	5.067	3.167
Control group	1.900	3.867	1.967

In terms of achievement classification within the treatment group, 10 students advanced to the medium level and 4 reached the high level after the intervention, while only 1 student remained at the low level. This shift in performance highlights the positive influence of AR applications on conceptual understanding and problem-solving. In contrast, the majority of students in the control group remained in the low category, with no students achieving high-level performance. The distribution of achievement levels by group is illustrated in Figure 1, with the focus primarily on the gains observed in the treatment group.

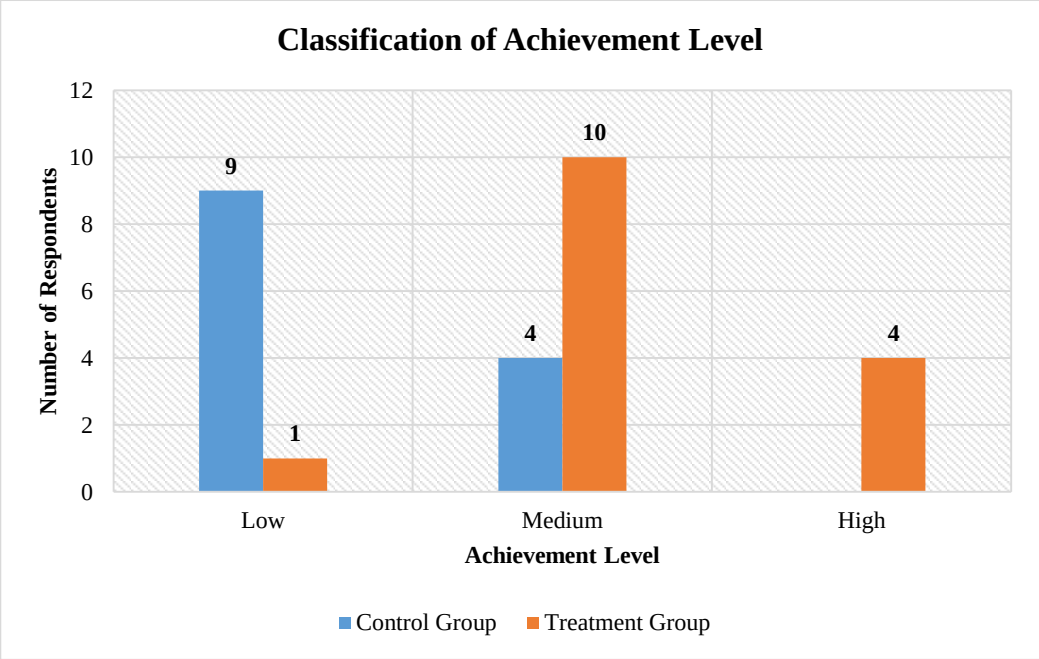

Figure 4 Distribution of Achievement Levels by Group

C. Correlation between Motivation and Achievement

A Spearman's rho correlation analysis was conducted to examine the relationship between students' motivation and achievement in STEM learning, using data from the treatment group. The analysis revealed a strong and statistically significant positive correlation ($\rho = .781$, $p < .001$), as shown in Table 3. This suggests that students who were more motivated by the AR-based learning environment tended to achieve higher scores in the post-test. This result reinforces the role of motivation as a key factor in learning outcomes and supports the use of AR to enhance both motivation and achievement.

Table 3 Spearman's Correlation between Motivation and Achievement

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).				

DISCUSSION

This study examined the impact of AR applications on the motivation and academic performance of Orang Asli students in STEM education. Conducted with 30 students from a rural school in Sungai Siput, Perak, the study employed a quasi-experimental design, using pre-test and post-test comparisons to evaluate differences between the treatment and control groups. The AR applications developed (AR-SiGaSTEM and AR-Tradisi) were specifically designed with interactive and culturally contextual multimedia features to foster learner engagement and relevance.

Findings revealed that students exposed to the AR-based learning environment exhibited significantly greater motivation across all four components of Keller's ARCS model: attention, relevance, confidence, and satisfaction. Notably, the relevance subscale achieved a high mean score of 4.29, indicating a strong cultural and contextual resonance with the learners. These motivational gains were paralleled by substantial improvements in academic performance; the treatment group recorded a mean post-test score of 5.067, compared to 3.867 in the control group. This statistically significant difference highlights the efficacy of AR in enhancing conceptual understanding and knowledge retention in STEM subjects.

The results are well supported by established theoretical models. The convergence of Keller's ARCS model with Mayer (2024) Cognitive Theory of Multimedia Learning (CTML) offers a robust explanation of the observed learning gains. The dual-channel processing and active cognitive engagement promoted by CTML are evident in the AR design, which utilized synchronized animations, visuals, and narrations to reduce cognitive overload and reinforce learning (Keller et al., 2021). These features enabled learners to interact with abstract STEM content in a meaningful way, resulting in both cognitive and motivational benefits.

Furthermore, the applications were grounded in constructivist learning theory, allowing students to actively construct knowledge through experiential and hands-on learning. Observational data collected during implementation showed that students in the AR group demonstrated higher levels of classroom engagement, including greater participation, more frequent questioning, and sustained focus. These behavioral indicators suggest that the immersive and interactive nature of AR fostered deeper learning involvement.

Importantly, the incorporation of culturally meaningful elements, such as the traditional *Gasing* game, emerged as a critical factor in enhancing the emotional and contextual relevance of the content. This finding is consistent with the work of Pellas et al. (2018), who argue that culturally embedded

educational technologies not only strengthen learning outcomes but also support cultural identity development, especially in Orang Asli contexts.

A strong, positive correlation was also observed between motivation and achievement (Spearman's rho = 0.781, $p < 0.001$), underscoring the interdependence of affective and cognitive domains in learning. This aligns with Self-Determination Theory (Ryan & Deci, 2020), which emphasizes the importance of fulfilling learners' psychological needs for autonomy, competence, and relatedness to foster intrinsic motivation. The present findings also corroborate those of Brew et al. (2021), who demonstrated that environments enriched with motivational support significantly enhance student performance. Notably, even students with limited prior exposure to digital technologies were able to navigate the AR tools effectively, supporting earlier claims by Sirakaya & Alsancak Sırakaya (2022) regarding the accessibility of well-designed, user-centred AR technology.

Despite the encouraging outcomes, the study is not without limitations. The relatively small sample size and single-site context limit the generalizability of the findings. Additionally, the exclusive reliance on quantitative methods constrained the depth of analysis regarding students' lived experiences with AR. Qualitative methods such as interviews or focus groups could have yielded richer insights into student perceptions and emotional engagement. Moreover, practical challenges such as inconsistent device functionality and limited internet connectivity, though not systematically analysed, may have influenced the learning environment. These infrastructural constraints mirror broader issues of digital inequity in rural schools (Samat & Aziz, 2020).

To advance this area of research, several directions are recommended. First, future studies should adopt a mixed-methods approach, combining quantitative metrics with qualitative data to capture the nuanced experiences of students and teachers. Expanding the sample size and including Orang Asli communities from different geographical areas would enhance the external validity of the findings. In addition, longitudinal studies are needed to evaluate the sustainability of motivation and achievement over time, as immediate gains do not necessarily translate into long-term success (Pinto, 2017).

From an implementation perspective, the development of AR content should continue to emphasize cultural relevance and learner identity, ensuring students perceive the curriculum as meaningful and inclusive. Beyond STEM, the integration of AR into other subjects—such as languages, history, and social studies—could foster cross-curricular competencies and deeper cultural awareness. Additionally, capacity-building initiatives for educators are essential; professional development programs that equip teachers with the skills to integrate AR effectively into their practice are key to successful adoption (Laurens-Arredondo, 2022). Finally, policymakers must prioritize investments in digital infrastructure, especially in underserved areas, to ensure equitable access to AR technologies. This recommendation aligns with the Malaysia Education Blueprint 2013–2025 and the Fourth Industrial Revolution (4IR) agenda, both of which underscore the importance of digital readiness in future-proofing education

CONCLUSION

This study provides empirical evidence on the effectiveness of AR applications in enhancing the motivation and academic achievement of Orang Asli students within the context of STEM education. Using a quasi-experimental design involving 30 Form 1 students in a rural Malaysian school, the findings reveal that AR-SiGaSTEM and AR-Tradisi significantly improved learning outcomes through the integration of interactive, immersive, and culturally contextualized content. Students exposed to AR interventions demonstrated marked improvements across all four dimensions of motivation—attention, relevance, confidence, and satisfaction—as outlined in Keller's ARCS model. These motivational gains translated into statistically significant improvements in academic achievement, as evidenced by post-test results, and a strong positive correlation was found between motivation and performance (Spearman's $r = 0.781$, $p < 0.01$).

The implications of this study extend beyond its immediate educational context. For educators, AR emerges as a pedagogically powerful and flexible tool that supports differentiated and student-centred instruction, particularly in delivering complex STEM content in more accessible and engaging ways. For the Ministry of Education, the findings offer actionable insights into how digital innovations like AR can support strategic goals under Malaysia's Digital Education Policy and the Malaysia Education Blueprint 2013–2025 by addressing disparities in digital access and learning outcomes, especially in rural and underserved communities.

Crucially, this study underscores the role of culturally responsive AR in bridging indigenous knowledge systems with modern curricula. When designed with cultural sensitivity, AR fosters not only academic engagement but also strengthens learners' sense of identity and belonging, key to educational inclusion. For the Orang Asli community, this represents a meaningful pathway towards reclaiming educational relevance while embracing future-ready competencies. In alignment with global education goals, including UNESCO's vision for inclusive and equitable quality education, this research contributes to the international discourse on how emerging technologies can be leveraged to address long-standing educational inequalities. To sustain and scale the transformative potential of AR, coordinated efforts are needed: investment in digital infrastructure, provision of affordable devices, and targeted professional development for teachers.

In conclusion, this study highlights the transformative potential of AR as a medium that not only improves learning outcomes but also promotes cultural relevance, digital equity, and educational inclusion. As Malaysia moves towards a more inclusive and innovation-driven education system, AR technologies when aligned with local context and learner diversity which can play a pivotal role in reshaping the future of education for marginalized communities.

REFERENCE

Abd Rahman, N., Halim, L., Ahmad, A. R., & Soh, T. M. T. (2018). Challenges of Environmental Education: Inculcating behavioural changes among indigenous students. *Creative Education*, *9*(1), 43-55. https://doi.org/10.4236/ce.2018.91004

Abdullah, A.H. (2022). A systematic review of what Malaysia can learn to improve orang asli students' mathematics learning from other countries. *Sustainability*, *14*(20),13201. https://doi.org/10.3390/su142013201

Ahmad, B. E., Abdullah, M. A., Sharif, T. I. S. T., Noor, M. Y. M., Ismail, M. R., & Akhir, N. F. L. M. (2022). Being successful in school: A case study of the Orang Asli (Aboriginal People) of Malaysia. *International Journal of Evaluation and Research in Education*, *11*(4), 1787-1797. https://doi.org/10.11591/ijere.v11i4.23051

Arshad, B., Ishak, N., & Zaharudin, R. (2024). New norms: Enhancing biology achievement, creativity, and student innovation post-covid-19 through virtual science inquiry-based learning and augmented reality applications. *Jurnal Pendidikan Sains dan Matematik Malaysia*, *14*(2), 49-63. https://doi.org/10.37134/jpsmm.vol14.2.5.2024

Asigigan, S. İ., & Samur, Y. (2021). The effect of gamified STEM practices on students' intrinsic motivation, critical thinking disposition levels, and perception of Problem-Solving skills. *International Journal of Education in Mathematics Science and Technology*, 9(2), 332-352. https://doi.org/10.46328/ijemst.1157

Aspin, S. H., Ali, M., & Bunyamin, M. A. H. (2021). *STEM education in Malaysia: A review. Learning Science and Mathematics*, *15*, 125-139.

Bozkurt, M., Altinözi, N., & Açikyildiz, M. (2023). Effects of 5E integrated STEM based activities on middle school students' attitudes towards science, science anxiety and perceptions of STEM fields. *International Journal of Progressive Education*, *19*(6), 50-65. https://doi.org/10.29329/ijpe.2023.615.4

Brew, E. A., Nketiah, B., & Koranteng, R. (2021). A Literature Review of Academic Performance, an Insight into Factors and their Influences on Academic Outcomes of Students at Senior High Schools. *Open Access Library Journal*, *08(06)*, 1-14. https://doi.org/10.4236/oalib.1107423

Chen, A. (2024). Leveraging virtual and augmented reality to boost student engagement in STEM disciplines. *Region-Educational Research and Reviews*, 6(12), 60-65. https://doi.org/10.12238/rerr.v6i12.2999

Cherubini, L. (2020). Education in the post-pandemic era: Indigenous children and youth. *The International Indigenous Policy Journal*, *11*(3), 1-11. https://doi.org/10.18584/iipj.2020.11.3.10679

Creswell, J., & Creswell, D. (2023). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. London: Sage.

Etikan, I., Musa, S. A., & Alkassim R. S. (2016). Comparison of convenience sampling and purposive sampling. *American Journal of Theoretical and Applied Statistics*, *5(1)*, 1-4. https://doi.org/10.11648/j.ajtas.20160501.11

Hafit, N. I. A., Anis, A., Shuhaime, N. L. S., & Miah, M. M. (2021). The relationship between internet self-efficacy, self-directed learning, and motivation for learning towards technology acceptance in digital learning among indigenous society in Malaysia. *International Journal of Advanced Research in Education and Society*, *3*(1), 142-150.

Hashim, S., Masek, A., Muda, W. H. N. W., Khamis, N., Zahir, N. Z. M., & Zulkifli, N. N. (2022, December). The development of a hypothesis testing learning module through 5E's model for technical and vocational education students. In *International Conference on Mathematical Sciences and Statistics 2022 (ICMSS 2022)* (pp. 466-483). Atlantis Press. https://doi.org/:10.2991/978-94-6463-014-5_40

Ibáñez, M. B., & Delgado-Kloos, C. (2018). Augmented reality for STEM learning: A systematic review. Computers & Education, 123, 109-123. https://doi.org/10.1016/j.compedu.2018.05.002

Ješková, Z., Lukáˇc, S., Šnajder, L., Guniš, J., Klein, D., & Kireš, M. (2022). Active learning in STEM education with regard to the development of inquiry skills. Education Science, 12(10), 686. https://doi.org/10.3390/educsci12100686.

Kamaruddin, S. A., Harun, H., Abas, H., & Salim, K. R. (2019). Science, technology, engineering and mathematics initiatives at rural schools and its impact on learning motivation. In *Journal of Physics: Conference Series*, *1174*(1), 012002.

Keller, J. (1987). Development and use of the ARCS model of instructional design. *Journal of Instructional Development*, *10(3)*, 2-10. https://doi.org/10.1007/bf02905780

Keller, S., Rumann, S., & Habig, S. (2021). Cognitive load implications for augmented reality supported chemistry learning. *Information*, *12*(3), 96. https://doi.org/10.3390/info12030096

Kementerian Pendidikan Malaysia. (2016). Panduan Pelaksanaan Sains, Teknologi, Kejuruteraan dan Matematik (STEM) dalam Pengajaran dan Pembelajaran. Putrajaya: Bahagian Pembangunan Kurikulum, Kementerian Pendidikan Malaysia.

Laurens-Arredondo, L. (2022). Mobile augmented reality adapted to the ARCS model of motivation: A case study during the COVID-19 pandemic. *Education and Information Technologies*, *27*(6), 7927-7946. https://doi.org/10.1007/s10639-022-10933-9

Ma, L., & Lee, C. S. (2021). Evaluating the effectiveness of blended learning using the ARCS model. *Journal of Computer Assisted Learning*, *37*(5), 1397-1408. https://doi.org/10.1111/jcal.12579

Malik, M. A. A., Nazri, A., Ridzwan, D., Azamin, A., Mustapha, M. F., & Noor, M. R. M. (2021). Factors influenced the students' intention to study STEM stream in upper secondary school. *Journal of Advanced Research in Social and Behavioural Sciences*, *22*(1), 21-29. https://doi.org/10.37934/arsbs.22.1.2129

Marrahi-Gomez, V., & Belda-Medina, J. (2023). The effect of using AR technology on language learning. *International Journal of English Language Studies*, *5*(1), 53-58. https://doi.org/10.32996/ijels.2023.5.1.5

Mayer, R. E. (2024). The past, present, and future of the cognitive theory of multimedia learning. *Educational Psychology Review*, *36(1)*. https://doi.org/10.1007/s10648-023-09842-1

Md-Ali, R., Veloo, A., Shanmugam, S., Yusoff, Y. A. J., & Awang Hashim, R. (2021). the issues and challenges of mathematics teaching and learning in Malaysia" Orang Asli" primary schools from teachers' perspectives. *Malaysian Journal of Learning and Instruction*, *18*(2), 129-160. https://doi.org/10.32890/mjli2021.18.2.5

Nordin, A. S. M., Alias, B. S., & Mahamod, Z. (2023). Pendigitalan pendidikan. *Jurnal Penyelidikan Pendidikan dan Teknologi Malaysia (JPPTM)*, *1*(1), 66.

Pellas, N., Fotaris, P., Kazanidis, I., & Wells, D. (2018). Augmenting the learning experience in primary and secondary school education: a systematic review of recent trends in augmented reality game-based learning. Virtual Reality, 23(4), 329-346. https://doi.org/10.1007/s10055-018-0347-2

Pinto, D., Mosquera, J., Gonzalez, C., Tobar-Muñoz, H., Fabregat, R., & Baldiris, S. (2017). Augmented Reality Board Game for supporting learning and motivation in an indigenous community. In Actas del V Congreso Internacional de Videojuegos y Educación (CIVE'17)

Rabahi, M., Yusof, H., & Awang, M. (2016). Leading learning among the indigenous Orang Asli students: Setting the scene. Malaysia Journal of Society and Space, 13(13), 120-134. http://dx.doi.org/10.6007/IJARBSS/v6-i12/2480

Razali, F., Manaf, U. K. A., & Ayub, A. F. M. (2020). STEM education in Malaysia towards developing a human capital through motivating science subject. International Journal of Learning, Teaching and Educational Research, 19(5), 411-422. https://doi.org/10.26803/ijlter.19.5.25

Ryan, R. M., & Deci, E. L. (2020). Intrinsic and extrinsic motivation from a self-determination theory perspective: Definitions, theory, practices, and future directions. Contemporary Educational Psychology, 61, 101860. https://doi.org/10.1016/j.cedpsych.2020.101860

Sabri, M. A., Mohamed, N. A., Mohamed, N. H., & Mohamed, N. F. Relationship between motivation level and mathematics achievement level for form four students. Jurnal Pendidikan Sains dan Matematik Malaysia, 15(1), 83-95. https://doi.org/10.37134/jpsmm.vol15.1.7.2025

Samat, M.S.A. & Aziz, A. A. (2020). The effectiveness of multimedia learning in enhancing reading comprehension among indigenous pupils. *Arab World English Journal, 11* (2), 290-302. http://dx.doi.org/10.2139/ssrn.3649324

Sırakaya, M., & Alsancak Sırakaya, D. (2022). Augmented reality in STEM education: A systematic review. *Interactive Learning Environments*, *30*(8), 1556-1569. https://doi.org/10.1080/10494820.2020.1722713

Suherman, S., Zaman, A. M., & Farida, F. (2021). Fostering of mathematical critical thinking ability using ARCS model and students' motivation. *JTAM (Jurnal Teori Dan Aplikasi Matematika)*, *5(1)*, 134. https://doi.org/10.31764/jtam.v5i1.3798