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Augmented Reality and Learning Motivation in Achieving 21st Century Skills: The Mediating Role of Immersive Learning Experiences

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ABSTRACT

In response to the increasing demands for 21st-century competencies, this study adopts an explanatory quantitative research design to investigate the mediating role of Immersive Learning Experiences (ILE) in the relationship between Augmented Reality (AR) and Learning Motivation (LM) toward the acquisition of 21st-Century Skills (CS). Using a quantitative explanatory design with Partial Least Squares Structural Equation Modeling (PLS-SEM), this study analyzes data from Generation Z students (aged 17–25) enrolled at the Ministry of Transportation's maritime campus in Sumatra to evaluate this relationship. The results show that AR has a significant positive effect on ILE ($\beta = 0.603$; $t = 3.878$; $p < 0.001$), while its direct effect on 21st-Century Skills (CS) is negative and insignificant ($\beta = -0.225$; $t = 1.461$; $p = 0.144$). ILE, in turn, significantly influenced CS ($\beta = 0.599$; $t = 4.928$; $p < 0.001$) and significantly mediated the effect of AR on CS ($\beta = 0.361$; $t = 2.924$; $p = 0.003$). Meanwhile, Learning Motivation (LM) did not show a significant direct or indirect effect on CS through ILE. This finding highlights that ILE plays a significant mediating role in linking AR to 21st-century skills, while LM did not show a comparable influence. This suggests that intrinsic factors such as motivation are crucial, with technology-enhanced learning environments playing a more dominant role in developing 21st-century skills. The limited mediation effect of ILE in the LM–CS pathway may stem from the inherently cognitive–affective nature of motivation, which may require different pedagogical support. Future research is recommended to incorporate moderator variables such as digital literacy and adopt a longitudinal design to assess the sustained impact of immersive learning on skill development.

Keywords: Augmented Reality; Immersive Learning Experience; Learning Motivation; 21st Century Skills.

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1. INTRODUCTION

Digital technology has revolutionized higher education, particularly through the integration of immersive technologies such as augmented reality (AR). Understanding abstract concepts and immersive learning experiences support the mastery of 21st-century skills such as creativity, critical thinking, collaboration, and digital literacy (Lima et al., 2022; Rizki et al., 2025). AR enables more contextual, interactive, and in-depth learning environments, which are believed to enhance student participation and learning experiences. Research indicates that the use of augmented reality (AR) can improve learning outcomes (Akçayır & Akçayır, 2017). However, its impact on

the development of 21st-century skills remains insufficiently understood, particularly in the context of higher education.

One of the critical components in the learning process is learning motivation, which represents the internal drive that encourages students to actively engage in educational activities. AR is believed to enhance learning motivation by capturing attention, increasing the relevance of the content, and offering enjoyable and meaningful learning experiences (Amores-Valencia et al., 2023; Prasetya et al., 2024). This aligns with the preferences of the digital generation, which demands more visual, interactive, and flexible learning approaches. Nevertheless, the relationship between AR and learning motivation is often indirect and should be examined further through conceptual approaches that incorporate mediating variables such as immersive learning experience. In this context, immersive learning experience serves as a crucial bridge between technology and learning outcomes. According to Self-Determination Theory Ryan & Deci, (2000), suggests that when basic needs such as competence, autonomy, and social relatedness are met, intrinsic motivation increases. Therefore, this conceptual approach emphasizes the importance of exploring the role of immersive technology in promoting relevant learning outcomes and motivation.

Immersive learning means that students feel cognitively, affectively, and behaviourally engaged during the learning process. AR allows the learning environment to be customized to meet individual learning needs. This enables students to interact directly with digital objects or simulations that resemble real-world situations, thereby increasing the relevance of the material they are learning. Previous studies have shown that immersive learning improves student learning outcomes and engagement (Lampropoulos & Kinshuk, 2024; Lin et al., 2024), enhances the flexibility and interactivity of learning activities (Lu et al., 2020), student engagement and motivation (Reis, 2025), visualization, interaction, as well as learning and teaching outcomes (Suhail et al., 2024). However, few studies have explicitly positioned immersive learning as a mediating variable in the relationship between AR, learning motivation, and 21st-century skill acquisition leaving a research gap that must be addressed systematically.

Ideally, higher education institutions should provide their students with both theoretical and practical knowledge. AR has emerged as an innovative solution by combining learning motivation, modern skills, and creating engaging and interactive learning experiences (Zuo & Li, 2025). Some studies have only used short-term or experimental approaches, failing to consider the long-term and contextual dimensions of AR use, particularly in higher education settings in developing countries (Akinradewo et al., 2025; Zhang et al., 2025). Specifically, in the context of maritime higher education in Indonesia, the implementation of AR faces significant challenges, including limited digital infrastructure, lack of instructor readiness, and minimal integration of AR into curricula The maritime education environment demands practical and contextual competencies, making AR a promising solution for delivering more hands-on and immersive learning. Yet, little research has examined the effectiveness of AR in enhancing 21st-century skills in Indonesian maritime institutions, particularly from the perspective of students' motivational and psychological aspects. From a theoretical perspective, integrating Flow Theory with Self-Determination Theory provides a strong foundation to understand how full engagement in learning through AR can improve both motivation and learning outcomes (Arifitama & Rahman, 2024; Oliveira et al., 2018). This theory can be combined with Self-Determination Theory to enhance our understanding of the role of AR and immersive learning.

Based on the above considerations, this study aims to evaluate the mediating role of immersive learning experience in the relationship between augmented reality, learning

motivation, and 21st-century skill acquisition among students in maritime higher education institutions. The results of this study are expected to contribute theoretically by developing a conceptual framework based on immersive technology, and practically by offering insights into innovative instructional approaches.

2. THEORETICAL SUPPORT

2.1 Immersive Learning Experience

Immersive learning experiences, also known as immersive learning experiences, are learning methods that directly involve participants in the learning context through virtual or simulated environments created by technologies such as Virtual Reality (VR) and Augmented Reality (AR). This method enhances student engagement, understanding, and retention (Radianti et al., 2020). Immersive learning provides a more realistic and active contextual experience compared to conventional learning (Jensen & Konradsen, 2018), improving motivation, cognitive engagement, and the attainment of modern skills such as problem solving and creativity (Czok et al., 2023), increases a sense of presence and intrinsic motivation (Makransky & Lilleholt, 2018). Additionally, this variable has the potential to mediate the relationship between learning technology and learning outcomes.

However, immersive learning experiences are complex phenomena influenced by interactivity, instructional design, and cultural context (Anwar et al., 2025; Mike, 2019). To make learning more relevant and emotionally meaningful, recent research also emphasizes the importance of incorporating local values (Ahdhianto et al., 2025; Liamruk et al., 2025). According to the conceptual model developed by Yang et al. (2023) emotional experiences play a crucial role in enhancing motivation and learning outcomes. This method is derived from Kolb's Experiential Learning theory (Experiential & Cycle, 2012; Kolb, 1984) and Cognitive Load (Sweller, 1988). These theories emphasize the importance of managing cognitive load and concrete experiences during the learning process. Therefore, interactive learning is a method that may enhance the effectiveness of learning in the computer and internet era.

In this study, immersive learning experiences are positioned as a mediating variable that bridges the relationship between learning technologies such as Augmented Reality (AR) or Virtual Reality (VR) and 21st-century skills. This is based on the idea that interactive learning not only provides an authentic learning context but also enhances the desire to learn and a sense of presence, which in turn impacts learning outcomes (Makransky & Petersen, 2021). Furthermore Han & Fung (2024) found that engaging learning experiences for mediators enhance the influence of technology use on the development of skills such as creativity, problem-solving, and collaboration. Therefore, understanding this mediating role is crucial for comprehending how technology integration indirectly impacts engagement and learning experiences.

2.2 Augmented Reality (AR)

Augmented Reality (AR) is a technological innovation that provides a more immersive and contextual learning experience by integrating virtual objects into the real world in real-time and interactively. In education, AR has been proven to enhance student engagement, help them visualize abstract concepts, and encourage them to learn. The use of AR-based games and simulations can increase student active participation and learning outcomes, according to research conducted by (Anil & Batdi, 2023; Krüger et al., 2022). Additionally, AR supports 21st-century education by fostering critical thinking (Anwar et al., 2025), enhancing team collaboration (Anwar et al., 2025), and sharpening digital literacy (Ramadan et al., 2024). Furthermore, this

technology enables learning tailored to individual learning styles. AR as an educational medium is a new pedagogical approach that leverages affective, cognitive, and social aspects in the learning process. Thus, AR emerges as an innovative strategy with the potential to transform conventional learning paradigms into more adaptive and experience-based approaches.

Theoretically, the effectiveness of AR in education is explained by Flow Theory, which emphasizes full engagement when students feel challenged and in control of their activities, and Self-Determination Theory, which highlights the role of AR in fulfilling basic psychological needs to trigger intrinsic motivation (Belda-Medina, 2022; Buchner & Zumbach, 2018). According to studies conducted by Czerkawski & Berti (2021); Wang (2025), instructional AR has the ability to generate learning that is not only engaging but also meaningful. By combining these two concepts, we can use a robust theoretical framework to create AR-based learning experiences where flow (cognitive engagement) and Self-Determination Theory (internal motivation) reinforce each other. Therefore, AR designed using this theory-based methodology not only improves students' academic performance but also enhances their social engagement (Schaper & Pares, 2022) and emotional engagement during the learning process (Koumpouros, 2024). The integration of these two theories forms an important conceptual framework for designing AR, where optimal cognitive engagement (flow) and intrinsic motivation (SDT) reinforce each other to create meaningful and effective learning experiences.

2.3 Learning Motivation

One important factor in effective learning is student motivation, especially in the digital age, where students must participate actively and independently. In modern education, student motivation no longer comes from internal drives. Instead, it is now seen as the result of meaningful, interactive, and personalized interactions between students and their learning environment. Previous studies have shown that students with high motivation tend to demonstrate greater perseverance, interest, and engagement in learning activities, contributing to the development of critical thinking skills, collaboration, and technological literacy (Chen et al., 2024; Stavropoulou et al., 2025). Echnology-based learning, such as Augmented Reality (AR), can enhance student motivation by offering a more realistic and engaging learning context (Amores-Valencia et al., 2022; Zuo & Wenling, 2025).

Self-Determination Theory provides a theoretical foundation for understanding how learning motivation emerges in learning environments that support basic psychological needs (Alivernini et al., 2023; Ojo et al., 2024). This theory explains that intrinsic motivation will naturally grow when students have social connections, feel free to choose their learning methods, and feel capable of completing tasks. AR-based learning designed in this way encourages students to participate in activities and actively explore and acquire new knowledge. Studies by Bureau et al. (2022); David & Weinstein (2024); Wang et al. (2024), show that technology-based learning aligned with SDT principles can significantly enhance engagement and learning outcomes. Thus, within the framework of the relationship between AR and the acquisition of 21st-century skills, learning motivation acts as an internal driver that strengthens the effectiveness of experience-based learning. Therefore, measuring learning motivation is an important element in evaluating how effectively immersive learning experiences facilitate the mastery of essential skills for this century.

2.4 21st Century Skills

Critical thinking, communication, creativity, collaboration, digital literacy, and problem-solving and innovation skills are all important skills referred to as 21st-century skills (Adeoye & Jimoh, 2023; Herlinawati et al., 2024). Most people believe that these skills are crucial for producing graduates who are flexible, adaptive, and competitive in the era of digital transformation and globalization. Various international organizations such as the Partnership for 21st Century Learning and the Organization for Economic Co-operation and Development emphasize that the learning process in universities should not only focus on cognitive aspects. They also stress the development of practical and contextual soft skills. Studies Papanastasiou et al. (2019); Uzoma & Emetarom (2020) found that technology-based learning methods such as Augmented Reality (AR) can help people learn skills through active and real interactions. Meanwhile, studies by (Buditjahjanto & Irfansyah (2023); Indarta et al. (2025); Liu et al. (2023) show that the integration of AR media in vocational learning has been proven to enhance creativity, collaboration, and academic performance among students. Therefore, the acquisition of 21st-century skills is a strategic dimension that can be facilitated through innovative, immersive, and instructionally integrated learning approaches.

Conceptually, the acquisition of 21st-century skills can be explained through the constructivist approach and experiential learning theory (Kolb, 1984), in which learning is considered an active process that is formed from direct experience, reflection, and real-world application (Pamungkas et al., 2020; Trongtorsak et al., 2021). In this context, immersive technologies such as AR play a role as a mediator of learning experiences that encourage exploration, visualization of abstract concepts, and deep social interaction. A study conducted by Bacca et al. (2015); Crogman et al. (2025) shows that the use of digital visualization such as AR in higher education can result in meaningful learning while enhancing students' understanding of technology, analytical skills, and collaborative abilities. Additionally, the use of AR in conjunction with instructional design based on Self-Determination Theory enables an increase in intrinsic motivation. This is a crucial foundation for developing sustainable skills in the 21st century (Wang et al., 2024). Therefore, 21st-century skills are not merely the result of academic content but also the outcome of a learning approach that uses experience-based technology to connect emotions, cognition, and social context. Based on the explanation above, the hypotheses development for this research are as follow:

H1: The use of Augmented Reality (AR) has a positive effect on immersive learning experiences.

H2: Learning motivation has a positive effect on immersive learning experiences.

H3: Immersive learning experiences have a positive effect on the achievement of 21st-century skills.

H4: The use of Augmented Reality (AR) has a direct effect on the acquisition of 21st-century skills.

H5: Learning motivation has a direct impact on the acquisition of 21st-century skills.

H6: Immersive learning experiences mediate the relationship between the use of AR and the acquisition of 21st-century skills.

H7: Immersive learning experiences mediate the relationship between learning motivation and the acquisition of 21st-century skills.

3. METHODS

This quantitative study aims to investigate the effects of Augmented Reality (AR) and students' desire to acquire 21st-century skills, with immersive learning experience serving as a mediating variable. Data were collected from primary sources via the distribution of a questionnaire, administered both online and offline to purposively selected individuals. The instrument employed a five-point Likert scale (1 = strongly disagree to 5 = strongly agree) to gauge respondents' perceptions of each indicator.

Validity and reliability tests were conducted to ensure the research instrument was accurate and consistent. Confirmatory Factor Analysis (CFA) was used at the external analysis stage of the model to test construct validity. The SEM-PLS method was employed. Each metric was considered valid if the pooling factor had a value of at least 0.70. However, values between 0.60 and 0.70 are acceptable in the initial stages of instrument development (Hair et al., 2019). Furthermore, the Average Variance Extracted (AVE) value was examined. The AVE value must be greater than 0.50 to ensure that the latent variable has the ability to explain more than 50% of the variance in its indicators. The Fornell–Larcker Criterion and the Heterotrait-Monotrait Ratio (HTMT) were used to test discriminant validity; the required HTMT value is 0.85. The reliability value is considered adequate if Cronbach's Alpha ≥ 0.70 and CR ≥ 0.70, indicating internal consistency between indicators in measuring the same construct.

Instrument reliability was assessed using Cronbach's Alpha, Composite Reliability (CR), and rho_A, with all values required to exceed 0.70 to ensure internal consistency. Once the outer model met the criteria, the inner model was tested by examining VIF (< 3.3), R^2, f^2, and Q^2 values. Hypotheses were tested using bootstrapping with 5,000 subsamples, considering results significant if $t > 1.96$ and $p < 0.05$. Mediation analysis evaluated the role of Immersive Learning Experience as a mediator between Augmented Reality, learning motivation, and 21st-century skills; mediation was deemed significant if the indirect effect was significant and categorized as full or partial based on the direct path's significance. To improve the accuracy of data interpretation and the reliability of the findings, demographic information such as age, gender, and study program was collected, and bias control strategies such as ensuring respondent anonymity, using neutral language in survey items, and randomizing question order were implemented.

The survey items were adapted from established, validated sources. The AR construct was based on Gandolfi & Ferdig (2025) emphasizing spatial presence (physical), engagement/involvement (self), and ecological validity/realism (social) within a simulation framework. Learning motivation was operationalized according to Self-Determination Theory (Ryan & Deci, 2000), encompassing autonomy, competence, and relatedness. Immersive learning experience was measured by emotional engagement, concentration, and flow (Arifitama & Rahman, 2024; Oliveira et al., 2018). The 21st-century skills variable focused on Learning and Innovation Skills critical thinking, creativity, collaboration, and communication following the (Partnership for 21 st Century Skills, 2015).

Participants were Generation Z students (aged 17–25) enrolled at the Ministry of Transportation's maritime campus in Sumatra who had experienced AR in formal instruction. Using purposive sampling, inclusion criteria required respondents to be (1) active Nautical Technology majors and (2) participants in AR-based learning. Following Hair et al. (2019), a minimum sample size of 5–10 times the number of indicators was applied; with 14 indicators, at least 110 respondents were deemed necessary to ensure valid and representative results. Structural Equation Modeling–Partial Least Squares (SEM-PLS) was employed to examine (a) the

influence of AR and learning motivation on immersive learning experience, (b) the influence of immersive learning experience on 21st-century skills, and (c) the mediating role of immersive learning experience in the relationships between AR, learning motivation, and 21st-century skill acquisition, as shown in Table 1.

Table 1. Measurements of Variables

No.	Variable	Dimension	Source	Measurement Scale
1.	Augmented Reality (AR)	1. Spatial Presence (Physical), 2. Engagement / Involvement (Self), 3. Ecological Validity/Realism (Social)	(Gandolfi & Ferdig, 2025)	Likert Scale 1–5
2	Learning Motivation	1. Autonomy 2. Competence 3. Relatedness	(M. Ryan and L. Deci, 2000)	Likert Scale 1–5
3	Immersive Learning Experience	1. Emotional Engagement 2. Concentration 3. Experience 4. Flow during Learning	(Arifitama & Rahman, 2024; Oliveira dos Santos et al., 2018)	Likert Scale 1–5
4	21st Century Skills	1. Critical Thinking, 2. Creativity, 3. Collaboration 4. Communication,	(Partnership for 21 st Century Skills, 2015).	Likert Scale 1–5

When data for exogenous and endogenous variables are gathered from the same respondents at the same time, bias often occurs (Memon et al., 2023). Therefore, the Full Collinearity Test (Variance Inflation Factor/VIF), introduced by Kock (2015), is a test that combines collinearity between constructs to detect common method bias. The general rule is that if all VIF values are < 3.3 or, more conservatively, < 3.0, then the data is considered free of common method bias. The VIF values can be found in this Table 2.

Table 2. Common Method Bias

	VIF
AR -> CS	1.581
AR -> ILE	1.198
ILE -> CS	2.466
LM -> CS	1.869
LM -> ILE	1.198

4. RESULT AND DISCUSSION

The following is the Fornell-Larcker Criterion, as shown in Table 3.

Table 3. Fornell-Larcker Criterion.

	AR	CS	ILE	LM
Augmented Reality (AR)	0.954			
21st Century Skills	0.479	0.970		
Immersive Learning Experience	0.774	0.626	0.800	
Learning Motivation	0.855	0.517	0.715	0.943

All constructs in the model have AVE values that meet convergent validity. Augmented Reality has an AVE root of 0.954, 21st Century Skills 0.970, Immersive Learning Experience 0.800, and Learning Motivation 0.943. This shows that the indicators in each construct are able to explain the variance of the construct well and the model is suitable for further analysis, as shown in Figure 1.

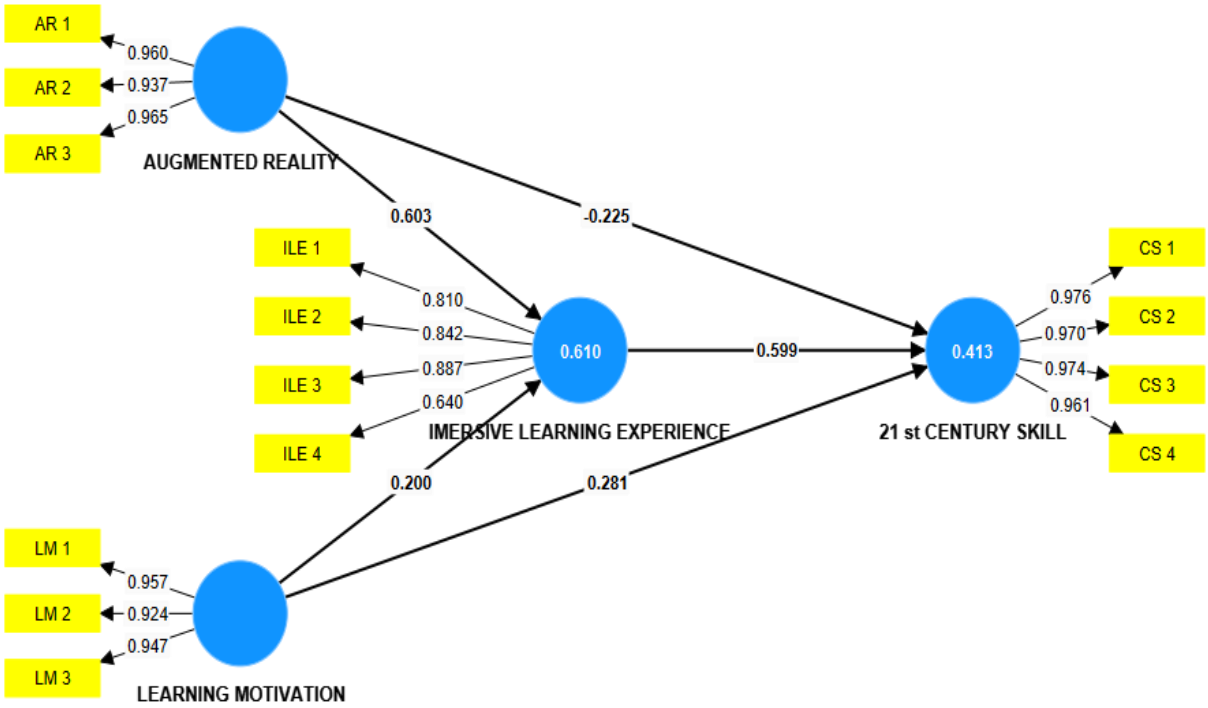

Figure 1. Research Model

Figure 1 shows good convergent validity and that the research instruments have measured the constructs consistently and accurately. The path estimation results show that augmented reality has a significant model relationship with immersive learning experience (0.603) and 21st Century Skills (-0.225). On the other hand, learning motivation also has a significant model relationship with immersive learning experience (0.200) and 21st Century Skills (0.281). Meanwhile, the mediation path between immersive learning experience and 21st Century Skills is (0.599), indicating a large partial mediation role. These findings reinforce concepts from learning ecology theory and cognitive engagement theory, where technology-based learning environments can enhance immersive learning experiences, ultimately fostering the development of 21st-century skills. Thus, this research is not merely descriptive in nature but also makes a theoretical contribution to the development of understanding of the mediating role of learning experiences

in digital learning contexts.

In the local context, these findings suggest that implementing AR in maritime higher education settings in Indonesia can be an effective strategy for enhancing students' critical, collaborative, communicative, and creative skills. Students who experience AR-based learning tend to experience increased concentration, emotional engagement, and learning flow, which are key elements in facilitating active learning in maritime vocational fields. This supports the digital transformation policy in the vocational education sector initiated by the Ministry of Transportation and the Ministry of Education, Culture, Research, and Technology, as shown in Table 4.

Table 4. Outer Loading

	AR	**CS**	**ILE**	**LM**
AR 1	0.960			
AR 2	0.937			
AR 3	0.965			
CS 1		0.976		
CS 2		0.970		
CS 3		0.974		
CS 4		0.961		
ILE 1			0.810	
ILE 2			0.842	
ILE 3			0.887	
ILE 4			0.640	
LM 1				0.957
LM 2				0.924
LM 3				0.947

The results of Table 4 outer loading show that all indicators in the construct in the model have a good contribution in explaining each construct. In the Augmented Reality (AR) construct, all indicators have strong outer loading values, namely AR1 at 0.960, AR2 at 0.937, and AR3 at 0.965, all of which are above 0.70, thus meeting the convergent validity requirements. The 21st Century Skills (CS) construct also shows very good results, with CS1 at 0.976, CS2 at 0.970, CS3 at 0.974, and CS4 at 0.961, indicating that these indicators strongly represent the construct. For Immersive Learning Experience (ILE), three indicators have high loadings: ILE1 0.9810, ILE2 0.842, and ILE3 0.887, while ILE4 is 0.640, which, although the lowest, is still acceptable. Meanwhile, the Learning Motivation (LM) construct has indicators with very strong outer loadings: LM1 0.957, LM2 0.924, and LM3 0.947. Overall, these results indicate that the measurement model meets the criteria for convergent validity, and all indicators are sufficiently strong in explaining their respective constructs, as shown in Table 5.

Table 5. Composite Reliability

	Composite reliability (rho_c)
Augmented Reality (AR)	0.968
21st Century Skills	0.985
Immersive Learning Experience	0.875
Learning Motivation	0.960

Table 5 composite reliability shows that all constructs have very good internal reliability, with values above 0.70. Augmented Reality (0.968), 21st Century Skills (0.985), Immersive Learning Experience (0.875), and Learning Motivation (0.960) show strong measurement consistency. These results ensure that the model is feasible to use in structural analysis and support the validity of the research conclusions, as shown in Table 6.

Table 6. R-Square

	R-Square
21st Century Skills	0.413
Immersive Learning Experience	0.610

The results of the R-square analysis indicate that the model has good predictive ability. The R-square value for 21st Century Skills is 0.413, which means that 41.3% of the variation in 21st century skills can be explained by the constructs in the model, especially Augmented Reality and Immersive Learning Experience. Meanwhile, the R-square value for Immersive Learning Experience of 0.610 indicates that 61% of the mediation in Immersive Learning Experience can be explained by the influence of Augmented Reality and Learning Motivation. These values indicate that the model has a fairly strong explained variance and is worthy of being used in further structural analysis to support the conclusions of the study, as shown in Table 7.

Table 7. Effect Size

	21st Century Skills	**Immersive Learning Experience**
Augmented Reality (AR)	0.019	0.251
21st Century Skills		
Immersive Learning Experience	0.238	
Learning Motivation	0.035	0.028

Table 7, explains that Augmented Reality (AR) has a weak effect size on 21st Century Skills (0.019) and moderate results on Immersive Learning Experience (0.251). Then Immersive Learning Experience only has a moderate effect on 21st Century Skills (0.238). Meanwhile, Learning Motivation has a weak effect on Immersive Learning Experience (0.028) and 21st Century Skills (0.035). Overall, this shows that the contribution of Immersive Learning Experience as a mediation pathway to 21st Century Skills is moderate (0.238). This means that the immersive learning experience plays a fairly important role in explaining how the indirect effects of Augmented Reality and Learning Motivation flow to the mastery of 21st Century Skills, although the direct contribution of the two independent variables to these skills is relatively weak.

The insignificant results, such as the direct effect of AR on CS and the influence of learning motivation on ILE and CS, require more critical analysis. One possible cause is that AR technology has not been fully integrated into the curriculum as a systemic pedagogical approach, so its effect on skill mastery is not optimal. Furthermore, the characteristics of Generation Z, which are more responsive to visual and contextual learning experiences than individual intrinsic motivation, may explain the weak influence of learning motivation in this model. Therefore, these findings open up opportunities to develop new theoretical models that incorporate contextual factors, such as institutional support, digital infrastructure readiness, and lecturer pedagogical factors in increasing the effectiveness of AR. The direct effect hypothesis is examined by looking at the t-statistic value generated by the internal model. Table 8 displays the results of the direct effect hypothesis test. The results indicate that the research hypothesis can be accepted if the t statistic

is greater than 1.96. In PLS research, simulation is used to evaluate hypothetical relationships. The bootstrap method is used on the research sample to reduce the problem of unusual research data.

Table 8. Inner Model

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (O/STDEV)	P Values
Augmented Reality -> 21st Century Skills	-0.225	-0.239	0.154	1.461	0.144
Augmented Reality -> Immersive Learning Experience	0.603	0.577	0.155	3.878	0.000
Immersive Learning Experience -> 21st Century Skills	0.599	0.598	0.122	4.928	0.000
Learning Motivation -> 21st Century Skills	0.281	0.292	0.148	1.901	0.057
Learning Motivation -> Immersive Learning Experience	0.200	0.230	0.158	1.265	0.206

Based on Table 8 (Inner Model), it can be interpreted that Augmented Reality (AR) has a positive and significant influence on Immersive Learning Experience with an original sample of 0.603, t-statistic 3.878, and p-value 0.000. This shows that AR contributes strongly to forming an immersive learning experience. However, AR actually has a negative and insignificant influence on 21st Century Skills (original sample -0.225; t-statistic 1.461; p-value 0.144), so AR does not directly support mastery of 21st century skills. Furthermore, Immersive Learning Experience shows a positive and significant influence on 21st Century Skills with an original sample value of 0.599, t-statistic 4.928, and p-value 0.000. This indicates the important role of immersive learning experience as a mediator in the relationship between AR and 21st century skills. Meanwhile, Learning Motivation has a positive but insignificant influence on both 21st Century Skills (0.281; t-statistic 1.901; p-value 0.057) and Immersive Learning Experience (0.200; t-statistic 1.265; p-value 0.206). Overall, these results confirm that the main pathway supporting the development of 21st Century Skills occurs through the mediation of Immersive Learning Experience, not through the direct influence of AR or Learning Motivation, as shown in Table 9.

Table 9. Indirect Effect

	Original Sample (O)	Sample Mean (M)	Standard deviation (STDEV)	T statistics (O/STDEV)	P values
AR -> ILE -> CS	0.361	0.347	0.124	2.924	0.003
LM -> ILE -> CS	0.120	0.134	0.095	1.259	0.208

In Table 9 (Indirect Effect), it can be seen that the indirect path from Augmented Reality (AR) through Immersive Learning Experience (ILE) to 21st Century Skills (CS) has an original sample of 0.361 with a t-statistic of 2.924 and a p-value of 0.003. This shows that the indirect effect of Augmented Reality on 21st Century Skills through the mediation of Immersive Learning Experience is significant, so it plays an important role in channelling the influence of AR to support 21st century skills. On the other hand, the indirect path from Learning Motivation through Immersive Learning Experience to 21st Century Skills has an original sample of 0.120, a t-statistic of 1.259, and a p-value of 0.208. This means that the indirect effect of Learning Motivation on 21st

Century Skills through Immersive Learning Experience is not significant, so the mediation of Immersive Learning Experience on this path does not provide a significant contribution in bridging the influence of Learning Motivation on 21st century skills. Overall, these results confirm that the mediating role of Immersive Learning Experience is stronger and more meaningful in the relationship between AR and 21st Century Skills compared to Learning Motivation.

The results of the study indicate that Immersive Learning Experience (ILE) plays an important role as a mediator in the relationship between Augmented Reality (AR) and 21st Century Skills (CS). The indirect effect of AR on CS through ILE is 0.361 with a p-value of 0.003, which means significant. This finding is supported by the argument that immersive learning experiences are the main pathway that bridges AR-based technology in supporting the mastery of 21st century skills (Jantanukul, 2024; Liamruk et al., 2025). AR is able to create an interactive and contextual learning environment so that students find it easier to develop critical thinking skills, creativity (Kelechi & Nnaji, 2024), and increase collaboration (Silva et al., 2021). This is in line with the literature stating that immersive technology is effective in strengthening the transfer of knowledge and skills in 21st century learning.

On the other hand, the indirect path from Learning Motivation through Immersive Learning Experience to 21st Century Skills showed insignificant results with a p-value of 0.208. This means that learning motivation does not contribute much indirectly to the mastery of 21st century skills through immersive learning experiences. Although learning motivation is important to trigger engagement in learning, these results indicate that without the support of technological factors such as Augmented Reality, motivation alone is not enough to meaningfully influence skill development. Several study results show the importance of integrating technological and pedagogical aspects in creating effective learning for the 21st century (Pasalidou et al., 2025; Zambri et al., 2022).

Contextual factors and the learning environment seem to be more dominant in mediating this relationship. Overall, these findings confirm that learning designs that combine immersive technologies such as Augmented Reality with pedagogical strategies that encourage active learning experiences are essential to support the development of 21st century skills. The mediating role of Immersive Learning Experience is more effective in the Augmented Reality pathway than Learning Motivation, indicating that the success of 21st-century learning depends more on the quality of the learning environment and interactive experiences than on internal motivational drives alone. Therefore, educational institutions need to pay attention to investing in learning technology and designing immersive learning experiences so that students' mastery of skills can be optimally improved. For further research, it is recommended that the model be developed by adding moderator variables, such as self-regulated learning or digital literacy technology, to see how these factors can strengthen or weaken the relationship between variables. In addition, future research can also use a longitudinal approach to measure the long-term impact of AR-based immersive learning on 21st-century skills, thereby providing a more complete picture of the effectiveness of this learning model.

5. CONCLUSION AND SUGGESTIONS

The results of this study indicate that Immersive Learning Experience (ILE) does not have a significant mediating role in enhancing the influence of Augmented Reality (AR) on the mastery of 21st-century skills. In contrast, the mediating role of ILE in the learning motivation pathway is significant. These results provide a theoretical contribution to the development of research on

how learning and technology interact in the 21st century, specifically by confirming that, compared to intrinsic motivation alone, technology-based learning experiences play a greater role in enhancing creative, critical, collaborative, and communicative skills. Practically, these findings suggest that immersive technologies such as AR should be incorporated into learning design not only as an instructional innovation, but also as a strategic necessity to prepare students to be proficient in the digital age.

These findings have political implications: higher education institutions, particularly in the maritime vocational field, need to start developing curricula that make use of augmented reality (AR) structuredly in teaching and learning. This can be done by developing competency-based AR modules, training teachers on how to use immersive technology, and having enough digital infrastructure. In the local context, these findings suggest that implementing AR in maritime higher education settings in Indonesia can be an effective strategy for enhancing students' critical, collaborative, communicative, and creative skills. Students who experience AR-based learning tend to experience increased concentration, emotional engagement, and learning flow, which are key elements in facilitating active learning in maritime vocational fields. This supports the digital transformation policy in the vocational education sector initiated by the Ministry of Transportation and the Ministry of Education, Culture, Research, and Technology.

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