The Effectiveness of Steam Digitalization in Slow Pedagogy: Building Early Childhood Literacy Through Malay Culture

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Abstract: Developing early childhood literacy requires innovative and contextual learning approaches that integrate technology **and** local cultural values. This study aims to analyze the effectiveness of STEAM digitalization within a slow pedagogy framework to enhance literacy skills among early childhood learners by incorporating Malay cultural elements into the learning process. The proposed solution is the implementation of a digitalized STEAM-based learning model supported by interactive multimedia, designed to create meaningful, engaging, and culturally relevant learning experiences.This research employed a quantitative experimental design involving two groups of early childhood students: an experimental group receiving instruction through digitalized STEAM-based slow pedagogy and a control group using conventional teaching methods. The study involved 60 children selected through purposive sampling. Data were collected using literacy performance tests, observation sheets, and teacher assessments. The findings indicate that the implementation of STEAM digitalization in slow pedagogy significantly improved children's literacy achievement. Results of the paired sample t-test show a significant difference between pre-test and post-test scores in the experimental group ($t = 8.412$; $p < 0.05$), demonstrating the effectiveness of the approach. Furthermore, the independent sample t-test revealed a significant difference between the experimental and control groups ($t = 2.132$; $p < 0.05$). The study concludes that STEAM digitalization combined with slow pedagogy is an effective strategy for enhancing early childhood literacy while promoting Malay cultural identity. It is recommended that culturally grounded and interactive digital STEAM resources be integrated into early childhood education to foster sustainable and meaningful literacy development.

Keywords: Early childhood literacy; Slow pedagogy; STEAM digitalization

Introduction

Early childhood education is crucial for instilling critical thinking, creativity, and literacy skills in children. Conventional learning methods must be adapted to more contextual and relevant innovations in line with globalization and technological advancements. STEAM-based learning (Science, Technology, Engineering, Arts, and Mathematics) is an approach that is gaining increasing attention. This approach combines various disciplines to provide more interactive and meaningful learning experiences for children ((Huda et al., 2024). However, adapting learning to local values and cultural contexts when implementing STEAM in early childhood education often presents challenges. Therefore, strategies are needed to integrate local culture into the curriculum so that children not only acquire skills relevant to the modern era but also remain connected to their cultural identity and values. Slow pedagogy is one useful learning approach to address this issue because it gives children more time to think, explore, and deeply understand concepts. This approach is also implemented internationally (Sulaiman et al.,

2024).This is done without placing the child under excessive academic pressure.

This learning model can improve children's literacy in a more natural and developmentally appropriate way by combining slow-learning pedagogy, STEAM, and local culture. Digitalization is also crucial to this model, as technology can be used as a tool to enhance children's learning experiences, but it does not replace direct interaction and culturally based exploration (Bastian & Firdaus, 2024)

Furthermore, implementing contextual and culturally based STEAM learning can help address challenges in early childhood learning, particularly in adapting materials to local values and their environment (Motimona & Maryatun, 2023). Early childhood has distinct learning characteristics that make it easier for them to grasp concepts when they are connected to their daily lives and familiar culture. Children can learn in a more enjoyable and meaningful way by incorporating folktales, traditional games, and local arts (Gandana et al., 2023). This also helps build cultural identity at an early age, providing a better understanding of Malay cultural heritage.

The STEAM learning model, based on slow-paced pedagogy and local culture, is still under-implemented in the Indonesian education system (Wahyuningsih et al., 2019). Most learning approaches still focus on delivering material based on the national curriculum, without considering children's unique needs and local contexts (Afiana et al., 2021). Nevertheless, slow-paced teaching allows children to better understand fundamental concepts in mathematics, science, art, and technology. Furthermore, this model allows children to learn at their own pace, preventing them from feeling rushed or overwhelmed by rigorous academic objectives.

The novelty of this study lies in the development of an integrated STEAM learning model for early childhood education that uniquely combines slow pedagogy with localized Malay cultural elements, a combination that has not been addressed in previous research. While earlier studies have examined STEAM, cultural-based learning, or slow-paced instruction separately, this research bridges all three components into a single pedagogical framework supported by concrete teaching tools such as lesson plans, activity worksheets, and authentic assessment instruments. In contrast to existing studies that mostly focus on Javanese, Sundanese, or Balinese cultural contexts, this study introduces a culturally specific learning design rooted in Malay heritage pantun, traditional games, folklore, and arts positioning it as a culturally responsive and context-driven innovation. Furthermore, the study moves beyond conceptual exploration by implementing and validating the model in real classroom settings, making it not only theoretically original but also practically applicable for early childhood educators.

Based on observations and several previous studies, researchers are interested in conducting further research on the influence of implementing the model digitalization of STEAM based on slow pedagogy integrated with Malay culture to improve early childhood literacy(Fauziddin & Ningrum, 2024) The purpose of this study is to analyze the implementing the model digitalization of STEAM based on slow pedagogy integrated with Malay culture to improve early childhood literacy. It is that this model will improve children's literacy and serve as a reference for other schools adapting STEAM learning methods that are more contextual, culturally based, and relevant to the needs of 21st-century education.

Method

This study uses the (R&D) method with a quantitative approach. This type of research is experimental evaluation research focusing on measuring the effectiveness of STEAM digitalization in slow pedagogy to build early childhood literacy through Malay culture. The research was conducted at PAUD in Riau Province. The implementation of STEAM-based digital learning integrated with Malay cultural values aimed to improve literacy skills by providing contextual and interactive learning experiences. The study took place in February 2025 during the even semester of the 2025/2025 academic year. The location was chosen because the selected PAUD institutions had already implemented early literacy programs, making them suitable for testing the integration of digital STEAM and slow pedagogy.

The population in this study consisted of all early childhood students enrolled in selected PAUD institutions in Riau Province that integrate Malay culture into their learning process. A total of 60 students participated in the study, drawn from four early childhood education classes. Sampling was carried out using a purposive sampling technique, with the consideration that the students were in similar stages of early literacy development and possessed relatively equal learning abilities. Two classes, comprising 30 students in total, were selected as the research sample. Data collection techniques included early literacy assessments in the form of pre-tests and post-tests to measure the improvement in literacy skills after the implementation of STEAM-based digital learning. In addition, observations and documentation were used to capture students' engagement, interaction, and responses throughout the learning process.

The data analysis techniques in this study focused on measuring the improvement of early childhood literacy skills. Individual scores from the pre-test and post-test were collected and analyzed to evaluate the effectiveness of STEAM-based digital learning within the framework of slow pedagogy. The gain in literacy skills was calculated using the normalized gain (N-gain) formula to determine the magnitude of improvement. Before conducting hypothesis testing, normality and homogeneity tests were carried out to ensure the data met the statistical requirements. A paired sample t-test was then used to analyze the difference between pre-test and post-test scores.

Furthermore, the relationship between the implementation of STEAM digitalization in slow pedagogy and the improvement of early childhood literacy was analyzed by comparing the pre-test and post-test scores. The collected data were transformed into interval scale scores to facilitate statistical testing. The improvement in literacy was measured using the normalized gain (N-gain) analysis, followed by hypothesis testing using a paired sample t-test. The statistical results showed a significant effect, indicating that the integration of STEAM digitalization within slow pedagogy, enriched by Malay cultural contexts, effectively enhanced early literacy skills in children.
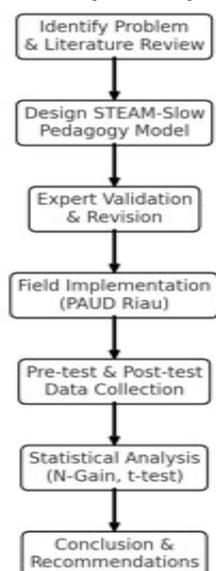

Figue 1. Research flow

Result and Discussion

Literacy Skills

The Literacy Skills instrument, consisting of descriptive questions related to early childhood literacy integrated with Malay cultural contexts, was validated by three expert validators. The instrument then underwent empirical validation and reliability testing, resulting in a Cronbach's Alpha score of 0.87, which indicates a very high level of reliability. The results of the study can be observed from the comparison of literacy achievement scores between the control and experimental groups, as presented in Figure 2.
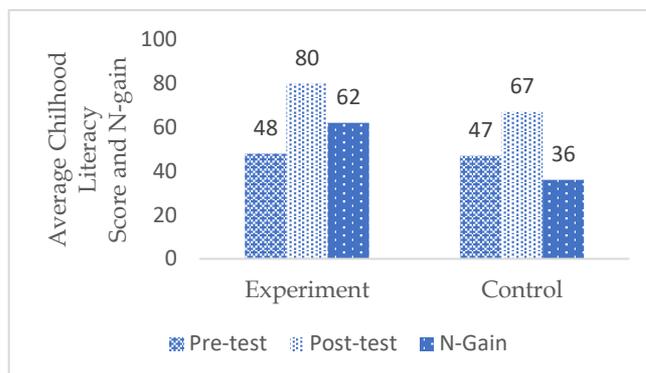

Figure 2. Average Score of Childhood Literacy and N-gain

The literacy scores of early childhood after treatment with the application of STEAM digitalization in slow pedagogy in the experimental class. The comparison of the average post-test literacy scores of children based on each indicator in the control class and experimental class is presented in Figure 3.
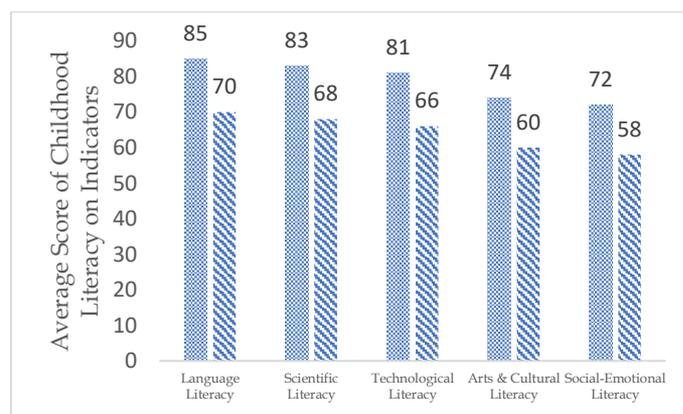

Figure 3. Average Score of Childhood Literacy for Each

Indicator of Experimental and Control Classes Normality, homogeneity, and t-tests were conducted to test the hypothesis regarding the effect of implementing STEAM digitalization in slow pedagogy on improving early childhood literacy, and the results are presented in Table 1.

Table 1. Data Analysis of Childhood Literacy

Class	N-Gain Score	Normality Test	Homogeneity Test	t-test
		Shapiro-Wilk		Sig
Experiment	62	0.12*	0.09**	0.00***
Control	36	0.11*		

Note: Shapiro-Wilk, sig > 0.05*, Levene, sig > 0.05**,
Independent sample t-test, sig < 0.05***.

STEAM Digitalization

The results of this study show that the implementation of STEAM digitalization within the framework of slow pedagogy with the inclusion of Malay cultural content has a significant impact on improving early childhood literacy. This approach not only integrates technology but also embeds local cultural contexts, making the learning process more relevant and meaningful. These findings are in line with the study by(Suharni et al., 2025)which noted that the integration of STEAM into the Merdeka Belajar curriculum helps strengthen children's literacy, although teachers face challenges such as limited technical knowledge and time constraints.

These findings align with recent studies emphasizing the effectiveness of digital STEAM approaches in early childhood education. Sumardi, (2025) demonstrated that the use of digital STEAM-inquiry learning modules significantly improves children's numeracy and conceptual literacy compared to conventional methods. Similarly, Hermita et al., (2012) reported that STEAM-based media integrated with Malay culture were well-received by teachers and significantly enhanced children's engagement in learning activities. This reflects growing evidence that culturally contextualized digital tools offer dual benefits: improving literacy skills while strengthening local identity (Sumardi, 2025).

This approach has proven to be highly effective because it enables children to learn through direct, hands-on experiences and project-based explorations. The STEAM-based activities assisted by digital tools were designed to meet the developmental needs of early childhood learners, using age-appropriate interactive games, educational videos, and simulations (Noviyanti et al., 2023). For instance, children were introduced to Malay folk stories and symbols through digital storytelling applications, which enhanced their ability to comprehend, interpret, and retell narratives. These tools helped make learning more engaging, context-driven, and aligned with their cognitive and social development stages.

Moreover, the slow pedagogy approach provided ample time for children to fully grasp new concepts at their own pace without the pressure of rushed instruction. By giving learners sufficient space to reflect and explore, this model facilitated a holistic literacy development process that includes not only reading and writing skills but also cultural literacy, numeracy, scientific reasoning, and digital fluency. The combination of cultural integration and digital learning tools strengthened the quality of the learning experience, creating a balanced pathway between modern education and traditional values (Maulidul et al., 2024).

The integration of interactive digital media also enhanced children's opportunities to develop critical thinking, creativity, and problem-solving skills from an early age (Sevval et al., 2025). Through project-based STEAM activities, children were exposed to tasks such as recognizing patterns in traditional Malay textiles, experimenting with local materials for simple science projects, and creating digital artwork based on cultural motifs. This supports the idea that early literacy should go beyond reading and writing to embrace creativity, analytical thinking, and cross-disciplinary understanding.

Literacy Skills

Wulandari & Komariah, (2024) demonstrated early childhood literacy is best understood as a multidimensional construct that develops well before formal reading, encompassing oral language, vocabulary growth, print awareness, narrative understanding, symbolic thinking, and emergent digital competences. Within a slow-pedagogy frame, literacy emerges through rich, repeated, and meaningful interactions rather than accelerated drills, and is strengthened when children can explore texts, images, and symbols at their own pace(Carlsen & Clark, 2022). In digitally infused environments, carefully curated tools can extend these interactions by scaffolding attention, turn-taking, and language expansion while respecting developmental needs. International policy reviews likewise stress that digital tools should enrich not replace human interaction, and that ECEC settings need intentional designs to balance benefits and risks. Such guidance positions early literacy as cognitive, social, and cultural practice that can be responsibly supported by technology.

A slow pedagogy approach is particularly aligned with emergent literacy because it privileges time for observation, dialogue, and reflection, enabling children to revisit stories, symbols, and representations until meaning consolidates (Nuragnia et al., 2021).Research in early years settings shows that when educators slow down routines, follow children's interests, and create unhurried spaces for inquiry, language and narrative skills deepen alongside confidence to communicate ideas. Leadership studies on slow pedagogy further document how teams re-design timetables, environments, and assessments to protect children's time for meaning-making with texts and media. This is critical for literacy practices that integrate listening, speaking, viewing, and representing core domains often compressed by "accelerated childhood." In this study, slow pedagogy legitimizes extended exploration of Malay stories and symbols in digital form, ensuring depth over (Rodrigues-Silva & Alsina, 2023).

STEAM digitalization complements this stance by widening the text types children encounter (data displays, diagrams, procedural videos, interactive simulations) and by engaging multiple modalities that underpin literacy growth, (Suziyani & Kamariah, 2024). Experimental evidence from comparative trials indicates that digital STEAM-inquiry modules can raise literacy outcomes particularly mathematical and conceptual literacies relative to conventional instruction, because children question, test, and explain ideas with media that provide immediate feedback. Systematic reviews also show that emerging technologies (e.g., AR/VR, intelligent tutors) can strengthen motivation, vocabulary, and explanatory talk when used with sound pedagogy. In your context, STEAM tasks tied to Malay cultural artifacts (motifs, architecture, materials) give authentic purposes for describing, labeling, counting, and narrating key behaviors in early literacy.

Putri & Taqiudin, (2022) reported that STEAM and literacy by inviting children to plan, narrate, record, and review their own stories, blending images, audio, and text. Empirical work shows that interactive storytelling environments can enhance early reading, writing, and listening comprehension by motivating children to rehearse language and structure narratives collaboratively. Visual-literacy scholarship adds that interpreting and composing images is not ancillary but central to contemporary literacies; children learn to "read" patterns, icons, and diagrams that also appear in STEAM contexts. In your design, recording a retelling of a Malay folktale, annotating a songket pattern, or labeling parts of a rumah Melayu within an app are not just cultural tasks they are literacy events that mobilize vocabulary, syntax, and discourse (Hassan et al., 2018).

Realizing these literacy benefits at scale requires attention to teacher capacity, equity, and policy.Cross-national analyses warn that implementation quality depends on professional learning, access to devices/connectivity, and clear guidance for safe, developmentally appropriate digital use in ECEC. Studies of preschool STEAM implementation identify material supports and training as decisive factors for translating intentions into day-to-day literacy practice (Handiyani & Abidin, 2023). Recent OECD and UNESCO reports therefore call for whole-system strategies that pair investment in infrastructure with curricula and safeguards that keep interactional quality at the center. For your setting, this means coupling digital STEAM materials on Malay culture with coaching, family partnerships, and simple evaluation routines that monitor growth in vocabulary, narrative, and multimodal expression.

Conclusion

The application of the STEAM digitalization model through a slow pedagogy approach, integrated with Malay cultural content, can improve the early childhood literacy skills of students. There is a positive relationship between the implementation of digital STEAM-based learning and the enhancement of children's abilities in literacy skills. By combining interactive digital media with local cultural values, this learning model effectively supports the development of holistic literacy skills in early childhood education in Riau Province.

Author Contributions
Conceptualization; S.; methodology.; S. M. E.; validation; L. L.V. F; formal analysis; L. L. V. F.; investigation.; S; resources; L. L.V. F; data curation: S.; writing—original draft preparation. S. M. E.; writing—review and editing: L. L. V. F.; visualization: S. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest
The authors declare no conflict of interest.

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