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Integrating Literacy and STEAM in Early Childhood Education in Indonesia: A Quasi-Experimental Study of Module Effectiveness.

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Abstract
The integration of literacy and STEAM (Science, Technology, Engineering, Arts, and Mathematics) in early childhood education has become increasingly important in supporting the goals of Indonesia's Kurikulum Merdeka Belajar. However, practical learning resources that effectively combine these domains remain limited in preschool settings. This study aimed to evaluate the effectiveness of a Literacy and STEAM Learning Module developed using the ADDIE instructional design model. A quasi-experimental research design was employed involving four teachers and 60 preschool children from two preschools in Indonesia. Each school provided one treatment class and one control class, with 15 children in each classroom. Teachers in the treatment group participated in a one-week training program before implementing the module over a 12-week period, while the control group continued conventional instructional practices. Data were collected through a performance-based assessment instrument designed to measure children's literacy and STEAM competencies using an assessment-for-learning approach. The findings revealed a significant difference in post-test scores between the treatment and control groups ($t = 2.13$, $p < .001$). Significant improvements were also found within the treatment group ($t = -15.37$, $p < .001$). These results indicate that the module effectively enhanced preschoolers' literacy and STEAM competencies while promoting active, play-based, and culturally responsive learning. The study provides empirical support for integrating literacy and STEAM in early childhood education and offers a scalable resource for curriculum innovation in Indonesia...
Keywords: Literacy, STEAM Education, Early Childhood Education, Learning Module, Quasi-Experimental Study.

INTRODUCTION

Literacy and STEAM have often been treated as distinct domains of learning. Literacy is commonly understood as the ability to read and write, whereas STEAM (Science, Technology, Engineering, Arts, and Mathematics) is regarded as an interdisciplinary approach to fostering 21st-century skills. Yet, in early childhood education, literacy extends beyond reading and writing alone (Wohlwend, 2015; Snow, 2006). It encompasses communication, numeracy, and problem-solving, as well as the ability to interpret and apply knowledge to everyday experiences. Literacy is deeply connected to language development, involving both receptive (understanding) and expressive (conveying) abilities that underpin emergent literacy (Johnson et al., 2025). By ages 5 - 6, children are expected to comprehend multi-step instructions, recall increasingly complex sentences, and interpret values, while also expressing ideas through complete sentences, storytelling, symbolic recognition, and early pre-reading activities (Ismail et al., 2025; Geiger, 2024).

Contemporary perspectives emphasise literacy as a social, interactive, and multimodal process. Scholars highlights the importance of linguistically rich environments that nurture literacy from the earliest stages (Benard, 2024; Kim & Yim, 2024; Wang et al., 2024). Children construct meaning through storytelling, play, songs, and oral dialogue. Play-based approaches have been shown to support early literacy, with picture books, role-play, and dialogic interaction enhancing communication and conceptual development (Ataee, 2024; Lunga, 2022). Technology also plays a growing role, as interactive literacy applications, when scaffolded by adults can improve phonological awareness and alphabet knowledge (Naeem & Khan, 2024; Kulju & Makinen, 2021). Furthermore,

literacy is increasingly recognised as central to social-emotional growth (Dermirdis, 2025; Gunawardena & Koivula, 2024; Espinosa, 2002). Scholars argue that literacy fosters empathy, emotional expression, and identity development through storytelling and reflective dialogue (Trigos-Carrillo & Urrea-Hernández, 2024; Batini et al., 2021; Gunawardena & Brown, 2021).

Parallel to these developments, STEAM has gained global traction as an interdisciplinary approach in early childhood education. It positions children as active participants in inquiry and exploration, enabling them to create projects that reflect real-world problems and themes. STEAM is widely implemented in developed countries where it is regarded as foundational for creativity, problem-solving, and collaboration (Leavy et al., 2023; Belbase et al., 2022). Structured and exploratory play within STEAM settings has been shown to enhance creativity and critical thinking in preschoolers (Erol et al., 2023; Tee, 2022), while child-centred designs tailored to developmental stages foster self-confidence and collaboration (Apriyansyah, 2024). Symbolic representation through diagrams, models, and mathematical symbols also supports comprehension and knowledge transfer for children still developing abstract reasoning (Kampeza & Delserieys, 2024; Zadlo-Treder, 2021). Beyond cognitive skills, STEAM strengthens social-emotional development by encouraging teamwork, perseverance, and empathy (Dignam & Taylor, 2024; Nho & Thiep, 2024).

The integration of literacy and STEAM is increasingly acknowledged as essential for holistic development, yet its implementation remains uneven (Sun & Saleh, 2024; Leavy et al., 2023). Literacy forms the foundation for learning in mathematics, science, and other disciplines, but in practice many programmes continue to emphasise STEAM in isolation, neglecting its meaningful connections with literacy (Makuvire et al., 2025; García-Silva et al., 2024; Shernoff, 2024). Research consistently shows that early literacy experiences are closely tied to later competencies in problem-solving, creativity, and scientific reasoning (Ramulumo, 2024; Bauer & Booth, 2019). This underscores the urgency of adopting integrated approaches that nurture both domains simultaneously rather than treating them as parallel strands.

In Indonesia, research and practice on literacy and STEAM remain scarce (Ellizah et al., 2020; Maulidiyah et al., 2023). The previous Curriculum 2013 reinforced a fragmented approach by teaching literacy and STEAM as separate subjects. However, the introduction of the *Kurikulum Merdeka Belajar* in 2021 represents a significant policy shift, combining literacy and STEAM into a single integrated domain delivered through play-based learning (Faiz & Faridah, 2022; Andriani et al., 2024; Dini, 2022). Within this framework, children are expected to interpret symbols and narratives, communicate through multimodal forms, demonstrate curiosity through exploration, and develop critical, creative, and collaborative thinking skills. However, the translation of these goals into practice has been challenging. Teachers are provided only with broad guidelines and significant autonomy to design their own modules (Puspitasari & Patonah, 2024), leaving many uncertain about how to operationalise interdisciplinary integration effectively (Suharni et al., 2025). The scarcity of teacher-friendly resources further exacerbates these difficulties (Alias et al., 2013; Utomo et al., 2020). At the same time, the rapid push toward artificial intelligence in education risks diverting attention from developmentally appropriate, play-based methods for young learners (Bakhadirov et al., 2024). Without stronger support systems, practical tools, and clear models of integration, the ambitious aims of the *Kurikulum Merdeka Belajar* risk remaining aspirational rather than achievable (Suharni et al., 2025).

In response to these challenges, there is an urgent need for practical, teacher-friendly models that support the integration of literacy and STEAM in Indonesian early childhood education. A module-based approach provides a promising pathway by offering structured yet adaptable guidance that aligns with the developmental needs of young children while accommodating diverse classroom contexts. Such modules can serve as concrete resources that bridge the gap between curriculum policy and classroom practice, thereby enabling the intended benefits of literacy and STEAM integration to be translated into meaningful learning experiences. Against this backdrop, the present study seeks to evaluate the effectiveness of a Literacy and STEAM Activity Module with the dual aim of strengthening teachers' pedagogical practices and enhancing children's holistic learning outcomes, particularly in communication, critical thinking, creativity, and collaboration. Specifically, the study tests the following hypotheses, (i) H_{01} There is no significant difference in literacy and STEAM achievement between the treatment group and the control group at post-test, and (ii) H_{02} There is no significant difference between pre-test and post-test literacy and STEAM achievement scores within both the treatment and control groups.

2. Literature Review

The curriculum is a fundamental pillar of education, serving as a framework that directs teaching and learning towards clearly defined goals. It outlines objectives, content, materials, and pedagogical methods, while also acting as a benchmark for evaluating educational success (Masut et al., 2025). In Indonesia, the centrality of the curriculum is reflected in the Regulation of the Minister of Education and Culture, which has consistently revised the national curriculum to enhance its quality and relevance. Since its inception in 1947, the curriculum has undergone eleven revisions, with major reforms including the Competency-Based Curriculum (2004), Curriculum 2006, Curriculum 2013, and the latest is *Kurikulum Merdeka Belajar* (2021).

Unlike Curriculum 2013 that often criticised for being overly teacher-centred, *Kurikulum Merdeka Belajar* redefines the teacher's role as a facilitator, granting children more autonomy to explore knowledge from multiple sources (Pratiwi, 2025; Kurniawan, 2023). This shift reflects a broader pedagogical emphasis on active, creative, and play-based learning designed to cultivate 21st-century competencies. Importantly, the curriculum provides teachers with flexibility to innovate and adapt learning to children's interests, talents, and developmental stages (Citrawati, 2024; Nihayah, 2023). Its implementation has been supported by pioneer schools tasked with modelling best practices. A distinctive feature of *Kurikulum Merdeka Belajar* is its strong focus on project-based learning, with instructional design guided by three core elements, namely (i) religious and moral values, (ii) personal identity, and (iii) literacy and STEAM.

The prominence of literacy and STEAM in the new curriculum reflects their shared role in promoting holistic child development. Traditionally, literacy was narrowly defined as the ability to read and write. However, in early childhood contexts, it is increasingly conceptualised as a multidimensional construct that includes oral communication, symbolic understanding, problem-solving, and meaning-making in everyday interactions (Karnita et al., 2025). STEAM, by contrast, integrates science, technology, engineering, art, and mathematics in an interdisciplinary framework aimed at fostering creativity, critical thinking, and collaborative problem-solving (Alkhatib, 2025; Belbase et al., 2022). Although their disciplinary foci differ, literacy and STEAM converge in their commitment to inquiry, representation, and communication, suggesting rich potential for integration in early learning settings.

Literacy research has increasingly moved beyond a narrow cognitive lens towards social-constructivist approaches that situate literacy as interactive, relational, and multimodal. Scholars emphasises that literacy development begins long before formal schooling and is shaped by children's linguistic and social environments (Bjorklund, 2022; Nation et al., 2022; Salminen, 2021). Play-based and dialogic approaches have been found to enhance communication and conceptual understanding (Bainazarova, 2025; Lunga, 2022), while digital tools offer opportunities to accelerate early literacy skills such as phonological awareness (Akhtar, 2025; Naeem & Khan, 2024). Yet scholars also caution against overreliance on digital platforms, warning that excessive focus on technology may neglect critical social-emotional dimensions such as empathy and storytelling (John & Bates, 2024). These debates highlight the tension between cognitive and social-emotional priorities, and between traditional and digital modalities in early literacy.

A similar evolution is evident in the literature on STEAM. Globally, STEAM has gained prominence for its capacity to position children as active participants in inquiry-based, project-driven learning (Su et al., 2025; Ng et al., 2022). Structured exploration has been shown to strengthen children's creativity and critical thinking, while enabling them to grasp abstract concepts through hands-on engagement (Agustini et al., 2024; Suharni et al., 2024). However, scholars caution against standardised, prescriptive models of STEAM. Scholars argue for child-centred and context-sensitive approaches that take into account children's interests, developmental readiness, and classroom realities (Yulianti et al., 2025; Suharni et al., 2024). Furthermore, while symbolic and visual representations such as models and diagrams can enhance conceptual learning (Monteira et al., 2022), STEAM should not be reduced to the acquisition of technical knowledge. Instead, it also cultivates collaboration, perseverance, and socio-emotional competencies that are vital for lifelong learning (Papadopoulou, 2024).

Taken together, literacy and STEAM highlight important intersections that remain underexplored. Both domains emphasise multimodality, inquiry, and representation: storytelling in literacy aligns with documentation practices in STEAM projects, while symbol recognition in early reading parallels pattern recognition in mathematics. Yet, despite these synergies, research has largely treated literacy and STEAM in isolation. Literacy studies typically foreground communication and meaning-making (Barnes et al., 2025; Burnett & Merchant, 2021), whereas STEAM studies emphasise inquiry and problem-solving (Su et al., 2025; Johnston et al., 2025). Few studies have attempted to integrate these perspectives into a coherent pedagogical framework. This gap points to the need for practical, teacher-friendly models that operationalise the integration of literacy and STEAM in early childhood settings, particularly within the context of *Kurikulum Merdeka Belajar*. Such models can serve as a bridge between curriculum policy and classroom practice, equipping teachers with structured yet flexible resources to foster children's communication, creativity, critical thinking, and collaboration.

3. Methodology

This study adopted a quasi-experimental research design with a quantitative and qualitative approach, which is appropriate for enabling the researchers to examine the effects between two comparative conditions, (i) pre-intervention with the literacy and STEAM activity module against post-intervention, and (ii) control group against treatment group. The quantitative approach was also chosen due to its ability to permit numerical data collection to study causal links and variations and gives the researcher control over the variables.

3. .1 Research Participants

The study was conducted in two preschools located in Pekanbaru, Riau Province, Indonesia. The sample comprised four teachers and 60 preschool children. Detailed demographic information on the participants is

presented in Table 1. All teachers were female and possessed more than five years of professional experience in early childhood education. In line with Indonesian national standards, each classroom accommodated a maximum of 15 preschool children.

Table 1. Participant's Information

Kindergarten	Group	Gender		Total
		Boy	Girl	
Preschool A	Treatment Group	8	7	15
	Control Group	7	8	15
Preschool B	Treatment Group	6	9	15
	Control Group	8	7	15
Grand Total				**60**

3.2 Research Instruments

Two instruments were employed in this study, namely (i) the Literacy and STEAM Performance-Based Assessment, and (ii) the Literacy and STEAM Activity Module. The Literacy and STEAM Performance-Based Assessment was developed based on the learning objectives outlined in the *Kurikulum Merdeka Belajar*, specifically targeting the literacy and STEAM domains. The instrument comprised 60 items designed to evaluate children's achievement in classroom-based literacy and STEAM activities. An assessment for learning approach was adopted, whereby teachers rated children's performance as they completed the activities. A five-point rating scale was used, (i) 1 = unable to perform the task; (ii) 2 = able to perform with substantial assistance; (iii) 3 = able to perform with minimal assistance; (iv) 4 = able to perform independently; and (v) 5 = able to perform independently with high proficiency. To ensure validity, the instrument underwent a content validation process. Three experts in early childhood education, each with a doctoral qualification and a minimum of ten years' professional experience, were appointed to review the instrument. Their feedback and recommendations were incorporated into revisions before the instrument was finalised for use in data collection.

The Literacy and STEAM Activity Module served as the intervention tool. It provided structured lesson plans and activities integrating literacy and STEAM concepts, implemented in the treatment group classrooms. Developed using the ADDIE Model (Analysis, Design, Development, Implementation, and Evaluation), the module was carefully aligned with the *Kurikulum Merdeka Belajar*, which emphasises differentiated instruction, project-based learning, 21st-century technological skills, and the values of *Pancasila*. Each topic in the module was organised around four components, namely (i) a thematic focus integrating literacy and STEAM elements, (ii) an activity guide, (iii) an exploration guide, and (iv) an evaluation and collaboration guide.

The module also included daily lesson plans and structured activities tailored to the developmental needs of preschool learners. Activities featured games, puzzles, and interactive tasks designed to strengthen literacy and STEAM skills through a playful, child-centred approach. For example, in the topic *"Knowing the Plants Around You"*, children were encouraged to name familiar plants while simultaneously recognising letters and words from their environment. In this way, the module offered teachers practical pedagogical guidance while promoting holistic learning experiences that fostered curiosity, creativity, and foundational literacy skills. To ensure contextual relevance and comprehensive coverage, input from multiple stakeholders was incorporated during the development process. Furthermore, eight experts in early childhood education, all holding doctoral qualifications, evaluated the content of the module. Their recommendations were integrated into the revisions to enhance quality and validity before the module was used in the effectiveness study.

3.3 Ethical Considerations

Ethical approval for this study was granted by the Faculty of Education, Universiti Kebangsaan Malaysia, and written permission was obtained from the headteachers of the participating preschools. Informed consent was secured from teachers and guardians of all participating children, with assurances of confidentiality, voluntary participation, and the right to withdraw at any time. To minimise disruption, the researchers coordinated with school administrators to align the study schedule with existing timetables, and the final plan was reviewed and agreed upon by the teachers.

3.4 Data Collection and Analysis

Prior to the intervention, two teachers from the treatment group received training on how to use the Literacy and STEAM Activity Module. The training, conducted over one full day, ensured that teachers had a clear understanding of the module's structure and strategies for effective classroom implementation. A second training session was then organised for all teachers from both the treatment and control groups. The purpose of this session was to provide guidance on the use of the assessment form, ensuring consistency in how teachers from both groups

recorded and evaluated preschoolers' performance. In both training sessions, teachers were given opportunities to ask questions and clarify any uncertainties to ensure accurate implementation and data collection.
Following the training, the intervention phase was carried out over a period of 12 weeks. During this time, the treatment group implemented the Literacy and STEAM Activity Module in their daily learning activities, while the control group continued using conventional teaching methods. Throughout the intervention, teachers from both groups were required to complete the assessment form regularly for monitoring purposes. To support this process, the researcher maintained regular communication with teachers, providing prompt assistance whenever needed to address any challenges. At the end of the 12 weeks, all assessment forms were collected and the data were entered into Statistical Package for Social Sciences for analysis.
Inferential statistical analyses were conducted to examine the effectiveness of the intervention. Paired samples *t*-tests were performed to compare the pre-test and post-test scores within each group (treatment and control) in order to determine whether there were significant improvements in preschooler's literacy and STEAM achievement over time. In addition, independent samples *t*-tests were conducted to compare the mean scores of the treatment group and the control group at both the pre-test and post-test stages. These analyses were carried out to test the hypothesis that there would be a significant difference in literacy and STEAM achievement between children who received the Literacy and STEAM Activity Module and those who were taught using conventional methods. All statistical analyses were conducted using Statistical Package for Social Sciences version 27.0, with the level of statistical significance set at $p < .05$.

4. Results

An independent samples t-test was conducted to examine differences in literacy and STEAM achievement scores between the treatment and control groups at both the pre-test and post-test stages. In addition, paired samples t-tests were carried out to determine any significant differences in literacy and STEAM achievement scores within each group, by comparing their respective pre-test and post-test results. Based on the results of the average scores obtained from the two class groups show, there is a significant difference between the pupil's literacy and STEAM achievement depending on the implementation of the module. For the treatment group, the mean pre-test score was 62.20. and the mean post-test score was increased to 89.26. Meanwhile the control group's mean pre-test score was 59.00 and the mean post-test score was increased to 76.86. Table 2 shows that while both groups showed improvement from pre-test to post-test, the experimental group demonstrated a larger increase in mean scores compared to the control group, suggesting a positive impact of the literacy and STEAM module on preschooler's learning outcomes.

Table 2. Comparison of the mean scores of the experimental and control groups

Group	Test	Mean Score	Mean Differences
Treatment Group	Pre-test	62.20	27.99
	Post-test	89.26	
Control Group	Pre-test	59.00	26.22
	Post -test	76.86	

4.1 Differences in preschooler's literacy and STEAM scores before and after the intervention within the treatment group and the control group

A paired samples *t*-test was conducted to examine the differences between pre-test and post-test scores within the treatment and control groups . For the treatment group, the pre-test mean score was 62.20 (SD = 5.78), while the post-test mean score increased to 89.26 (SD = 5.81). The results indicated a statistically significant improvement, $t(28) = -15.37$, $p < .001$. This large increase of 27.06 points suggests that the intervention had a strong and meaningful effect on children's literacy and STEAM-related competencies. For the control group, the pre-test mean score was 59.00 (SD = 11.26), and the post-test mean score rose to 76.86 (SD = 8.62). The paired samples *t*-test also showed a statistically significant improvement, $t(28) = -5.73$, $p < .001$. However, the overall gain of 17.86 points was notably smaller compared to the treatment group. Taken together, the findings reveal that although both groups demonstrated significant progress over time, the magnitude of improvement was much greater for the treatment group. This provides strong evidence that the Literacy and STEAM Activity Module was more effective in enhancing children's competencies than the conventional instructional approach used in the control group. These findings led to the rejection of the null hypothesis. Table 3 presents the results of the paired samples t-test analyses.

Table 3. A Paired Samples t-test Analyses for Pre- and Post- Test Scores

Group	Test	M	SD	*t*	*df*	*p*
Treatment Group	Pre-test	62.20	5.78			
	Post-test	89.26	5.81	-15.37	28	.000
Control Group	Pre-test	59.00	11.26			
	Post-test	76.86	8.62	-5.73	28	.000

4.2 Differences in preschooler's literacy and STEAM scores before and after the intervention between the treatment group and the control group

The effectiveness of the Literacy and STEAM Activity Module was examined using an independent samples *t*-test to compare the mean scores of the treatment and control groups at both the pre-test and post-test stages. At the pre-test stage, the treatment group recorded a mean score of 62.20 (SD = 5.77), while the control group recorded a mean score of 59.00 (SD = 11.26). The independent samples *t*-test revealed a statistically significant difference between the two groups, $t(28) = 2.13$, $p < .05$. Although this result indicates that the treatment group entered the intervention with slightly higher initial literacy and STEAM-related skills, the effect size was small (Cohen's $d \approx 0.34$), suggesting that the pre-test difference was not practically substantial.

At the post-test stage, both groups showed improvement. However, the treatment group demonstrated substantially higher performance, achieving a mean score of 89.26 (SD = 5.81), compared to 76.86 (SD = 8.62) for the control group. The independent samples *t*-test revealed a statistically significant difference, $t(28) = 2.13$, $p < .05$. The effect size was large (Cohen's $d \approx 1.62$), indicating a meaningful and educationally significant impact of the intervention. Overall, the results indicate that while the treatment group began with a modest advantage at pre-test, the intervention had a clear and substantial impact on children's outcomes. The gain in scores for the treatment group an increase of more than 27 points was markedly greater than that of the control group. These findings provide strong empirical support for the effectiveness of the Literacy and STEAM Activity Module in enhancing preschool children's literacy and STEAM-related competencies compared to traditional teaching approaches. These findings led to the rejection of the null hypothesis. Table 4 presents the results of the independent samples t-test analyses.

Table 4. An Independent Samples t-test Analyses for Treatment and Control Group

Test Time	Group	M	SD	*t*	*df*	*p*
Pre-test	Treatment Group	62.20	5.7719			
	Control Group	59.00	11.2567	2.13	28	0.00
Post-test	Treatment Group	89.26	5.8121			
	Control Group	76.86	8.6178	2.13	28	0.00

5. Discussion

The findings of this study demonstrate that the Literacy and STEAM Activity Module had a significant positive effect on preschooler's achievement in literacy and STEAM-related learning. Both the treatment and control groups showed improvement from pre-test to post-test, indicating that classroom learning activities, regardless of approach, contribute to preschooler's developmental progress (Aloizou, 2025; Pellas, 2025; Iqbal & Mehmood, 2024). However, the treatment group recorded a substantially larger mean gain compared to the control group, suggesting that the integration of literacy and STEAM principles provided added value beyond conventional instruction. The paired samples t-tests confirmed significant improvements within both groups, yet the larger mean difference observed in the treatment group underscores the module's effectiveness in enhancing learning outcomes.

Further evidence from the independent samples t-test revealed significant differences in post-test performance between the treatment and control groups, reinforcing the conclusion that the module was more effective than conventional teaching methods. This finding supports the view that integrated and cross-disciplinary pedagogies can provide enriched learning opportunities in early childhood settings (Kumar, 2025; Thompson, 2024). By combining literacy with STEAM activities, the module encouraged children to make connections across subject areas, promoting creativity, problem-solving, and higher-order thinking, all of which are increasingly recognised as essential for 21st-century education (Ouafa, 2025; Violy, 2024).

These findings contribute to a growing body of literature that advocates for STEAM-based approaches in early childhood education. Previous studies have highlighted the benefits of experiential, inquiry-based, and interdisciplinary learning in fostering engagement and deepening understanding (Kausar et. al., 2024; Krogh & Morehouse, 2020). The results of this study extend these insights by showing that embedding literacy within

STEAM activities can strengthen foundational literacy skills while simultaneously cultivating interest in science, technology, engineering, arts, and mathematics. Such an approach not only enriches early learning experiences but also addresses the challenge of preparing young children for future academic and life demands (Rohman, 2024; Shih, 2024).

The practical significance of this study lies in its potential to inform early childhood teachers and curriculum developers. By bridging a gap in existing teaching materials, the Literacy and STEAM Activity Module provides a flexible yet structured resource that supports teacher adaptability in the classroom. Its context-sensitive design also aligns with broader educational reforms in Indonesia, such as the *Kurikulum Merdeka Belajar*, which emphasises creativity, collaboration, and contextualised learning (Agustin & Kurniawaty, 2025). These results therefore highlight the importance of designing innovative teaching resources that are both pedagogically sound and responsive to local educational contexts.

Nevertheless, some limitations should be acknowledged. The study was conducted with a relatively small sample, drawn from two kindergartens in Pekanbaru, which may limit the generalisability of the findings to other regions or educational contexts. The duration of the intervention was also relatively short, and longer-term studies would be valuable to assess the sustainability of the observed gains (Bastianello, 2025; Ramsden, 2025; Watts, 2024). Future research should explore the impact of the module across diverse settings, with larger samples and extended timeframes, as well as examine how teacher training, classroom resources, and home support may interact with such interventions.

In sum, this study provides empirical evidence that the Literacy and STEAM Activity Module enhances preschoolers' literacy and STEAM learning outcomes more effectively than conventional teaching methods. The results underscore the potential of integrated pedagogical approaches to advance holistic early childhood education in Indonesia and highlight the need for practical, research-informed innovations that equip young learners with skills relevant to the demands of the 21st century.

6. Conclusion

This study examined the effectiveness of a Literacy and STEAM Activity Module in improving preschooler's literacy and STEAM-related competencies within the context of Indonesia's *Kurikulum Merdeka Belajar*. Using a quasi-experimental design, the findings provide robust evidence that the module significantly enhanced pupil's outcomes, underscoring its potential as a developmentally appropriate and contextually relevant resource for early childhood classrooms. By addressing a notable gap in instructional materials, the module supports teacher adaptability and enriches children's learning experiences, thereby contributing to broader efforts to promote holistic and integrated early childhood education. The implications of this study extend beyond local practice. They highlight the potential of literacy and STEAM integration as a framework for advancing early learning in resource-constrained contexts, while also aligning with international calls for curricula that prepare young children for the demands of the 21st century. Future research should investigate the long-term effects of literacy and STEAM implementation, replicate the study across more diverse educational settings, and explore how sustained professional development can strengthen teachers' capacity to deliver integrated learning. Such work would provide deeper insight into how context-sensitive innovations can drive systemic improvements in early childhood education.

7. Suggestion

Based on the findings of this study, several recommendations can be made. First, early childhood educators are encouraged to adopt integrated Literacy and STEAM modules as they have been shown to enhance children's learning outcomes, particularly in communication, problem-solving, and creativity. Second, teacher training programmes should emphasise the use of interdisciplinary and play-based approaches, ensuring that teachers are confident in implementing STEAM activities alongside literacy instruction. Third, policymakers and curriculum developers may consider embedding Literacy–STEAM integration more explicitly into early childhood curricula, providing resources and structured guidelines for effective classroom application. Finally, future research should extend the use of the module across diverse educational settings and age groups to validate its effectiveness and ensure scalability within different contexts.

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