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Development of a Madurese Local Wisdom–Based Learning Model Using a STEAM Integrative Approach to Improve Creativity and Innovation of Indonesian Elementary School Students

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Abstract

Creativity and innovation are essential competencies for elementary school students; however, learning practices in many Indonesian elementary schools remain teacher-centered and provide limited opportunities for creative and innovative activities. In addition, local cultural values that can support contextual learning are often underutilized. Therefore, this study aims to develop a learning model grounded in Madurese local wisdom that employs STEAM as an integrative instructional approach to enhance students' creativity and innovation at the elementary school level. This study used a research and development method with the ADDIE model, consisting of analysis, design, development, implementation, and evaluation stages. The effectiveness of the developed model was tested using a one-group pretest–posttest design. Data were collected through observations, interviews, questionnaires, documentation, pretest–posttest instruments, and product-based assessments. Students' creativity was measured using Torrance indicators (fluency, flexibility, originality, and elaboration), while innovation was assessed through indicators of idea adaptation, simple implementation, usefulness, and initiative appropriate to elementary students' developmental levels. Quantitative data were analyzed using descriptive statistics, N-Gain, and paired-sample t-tests, while qualitative data were analyzed through data reduction, display, and verification. The results indicate that the developed learning model is valid, practical, and effective. Students' creativity increased from 57.3 to 86.6, and innovation increased from 55.8 to 84.1, with moderate-to-high N-Gain scores. The model supports contextual and culture-based learning by strengthening creativity, innovation, and STEAM-related competencies while preserving Madurese local wisdom.

Keywords: STEAM Approach; Madurese local wisdom; Creativity; Innovation; Elementary education

Introduction

Creativity and innovation are core competencies required for elementary school students (Zain 2017) to face the challenges of the 21st century (Rusmansyah et al. 2019). At the basic education level, these competencies support students' ability to generate ideas, solve contextual problems, and adapt knowledge to new situations (Aisyah 2023). However, empirical studies indicate that instructional practices in many elementary schools remain dominated by teacher-centered approaches (Abariyah et al. 2023), textbook-driven activities (Saputri, El Khoiri, and Muniroh 2022), and uniform tasks

(Wang 2025) that emphasize factual recall rather than creative exploration (Bhardwaj 2023) and innovative problem solving (Kvale, S. 2015). As a result, opportunities for students to develop creativity and innovation in authentic learning contexts are limited.

Several learning models have been implemented to foster creativity and innovation in elementary education (Zain 2017), including project-based learning (Nurahman et al. 2025), inquiry-based learning (Oryan et al. 2023), and interdisciplinary approaches (Dumitru et al. 2018). These models have been shown to encourage active learning and collaboration (Lovegreen 2020); however, their implementation often lacks contextual relevance to students' cultural backgrounds. Learning activities are frequently designed using generic or externally developed contexts (Biddix and Collom 2023), which may reduce students' engagement and limit the meaningful application of creative ideas in real-life situations (Baddane and Ennam 2024). This limitation is particularly evident in culturally diverse settings such as Indonesia, where local values and traditions remain underutilized as instructional resources (Lestari et al. 2024).

The integration of local wisdom (Daluti Delimanugari et al. 2025) into learning has been widely recognized as an effective strategy for creating meaningful and contextual learning experiences (Hasan 2020). Local wisdom provides culturally grounded knowledge, values, and practices (Rahmi Nasution and Supriatin 2023) that can stimulate inquiry (Menzie-Ballantyne and Ham 2022), strengthen character education (Shaari and Hamzah 2018), and support higher-order thinking skills (Silor and Silor 2025). Studies in various regions of Indonesia have demonstrated that local wisdom based learning can enhance students' engagement, creativity, critical thinking, and cultural awareness. Nevertheless, most existing studies focus on specific subjects or limited instructional materials, rather than on the systematic development of a learning model that explicitly targets creativity and innovation at the elementary level.

One instructional approach that has gained global attention for fostering creativity and innovation is STEAM (Science, Technology, Engineering, Arts, and Mathematics) (Bedewy and Lavicza 2023). STEAM emphasizes interdisciplinary learning (Alghamdi 2023), problem solving (Jami'ul Amil, Ismail, and Narawi 2024), and creative design (Devy Rinjani, Rois, and Adha Al-Giffari 2025) through project-based activities (Siswoyo, Wijaya, and Efendi 2025). Research has shown that STEAM learning can enhance students' imagination, creativity, collaboration, and problem-solving skills

(Marín-Marín et al. 2021). However, STEAM implementation in elementary schools is often adapted from Western educational contexts and tends to overlook the integration of local cultural values. Consequently, STEAM learning may become conceptually abstract and disconnected from students' lived experiences.

In the Indonesian context, STEAM has increasingly been promoted as an innovative approach to support holistic competence development in elementary education (Djam'an 2025). Previous studies report that STEAM learning contributes positively to cognitive (Boeckx 2014), affective (Biddix and Collom 2023), and psychomotor development, as well as to the development of 4C skills (Silor and Silor 2025). Despite these benefits, research on STEAM-based learning models that are systematically integrated with local wisdom remains limited, particularly in relation to students' creativity and innovation at the elementary level.

Madura possesses rich local wisdom that can serve as a meaningful foundation for contextual STEAM learning (Mutik Nur Fadhilah 2025). Madurese cultural values (Prastyo et al. 2025) such as diligence, solidarity, devotion, and respect, as well as traditional practices including batik production (Anna, Cahyadi, and Alfa 2025), local crafts, and agricultural activities, naturally involve elements of science, technology, art, and mathematics (Yasir and Wulandari 2020). Integrating these cultural elements into STEAM-oriented learning has the potential to enhance creativity and innovation while simultaneously strengthening students' cultural identity and character. However, there is a lack of empirically validated learning models that integrate STEAM with Madurese local wisdom in a structured and pedagogically sound manner.

Based on these considerations, a clear research gap can be identified: the absence of a structured, validated, and contextually grounded learning model that integrates STEAM as an instructional approach with Madurese local wisdom to specifically enhance creativity and innovation among elementary school students. This study seeks to address this gap by developing and evaluating a learning model grounded in Madurese local wisdom that employs a STEAM integrative approach. The proposed model is expected to provide a practical and theoretically grounded solution for teachers in designing culturally relevant learning experiences that foster creativity, innovation, and character development in elementary education.

Methods

This study employed a research and development (R&D) design to develop a learning model grounded in Madurese local wisdom that employs STEAM as an integrative instructional approach to enhance elementary students' creativity and innovation. The ADDIE model was adopted because it provides a systematic and iterative framework for developing, validating, implementing, and evaluating instructional products (Branch 2009).

The development procedures of this study followed the ADDIE framework, which consists of five systematic stages: Analysis, Design, Development, Implementation, and Evaluation. The ADDIE framework was adopted to ensure that the learning model was developed through a structured, iterative, and evidence-based process. The overall flow of the development procedures is presented in Figure 1.

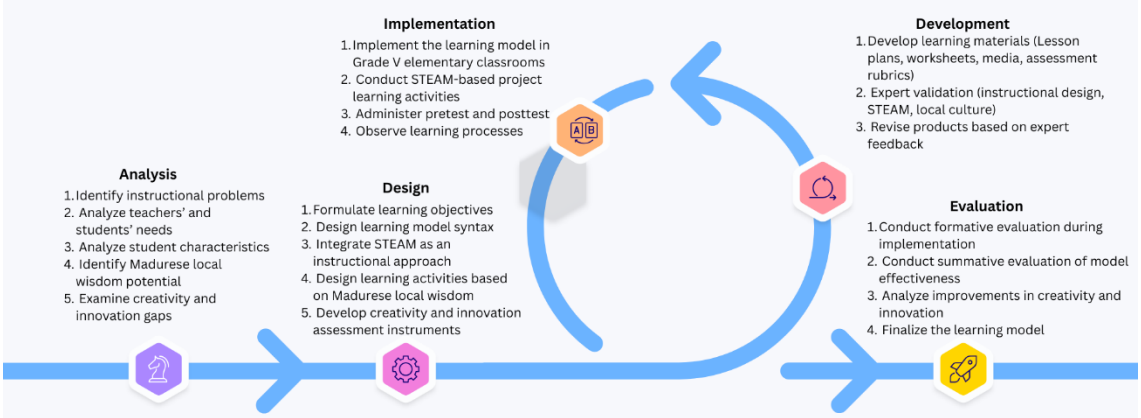

Figure 1

Flowchart of the ADDIE-Based Development Process

Source : Personal Document

First, Analysis

The analysis stage aimed to identify instructional problems, student characteristics, and the potential of Madurese local wisdom to support creativity and innovation in elementary education. A needs analysis was conducted in five elementary schools across Pamekasan and Sampang Regencies through teacher interviews, classroom observations, and questionnaires.

The findings revealed that learning activities were predominantly textbook-based, with limited interdisciplinary instruction and minimal integration of STEAM elements and local cultural content. Teachers consistently reported difficulties in designing

creative, project-based learning activities and in assessing students' creativity and innovation. These results indicate that the identified instructional problems were not confined to a single school, but reflected broader regional conditions in Madura. Novelty at this stage: the identification of creativity and innovation gaps in elementary learning based on a regional Madurese context, rather than a single-school setting.

Second, Design

Based on the analysis results, the learning model was designed by formulating learning objectives, instructional syntax, learning activities, media, and assessment strategies. In this stage, STEAM was positioned as an instructional approach integrated within the learning model, while Madurese local wisdom served as the contextual foundation of learning activities. Indicators of creativity and innovation were systematically embedded into each phase of the learning process. Novelty at this stage: the systematic alignment of STEAM instructional processes with Madurese cultural practices to explicitly support creativity and innovation development.

Third, Development

The development stage focused on producing learning components, including lesson plans, student worksheets (LKPD), teacher guides, learning media, and assessment rubrics. These products were validated by experts in instructional design, STEAM education, and Madurese local culture. Revisions were carried out based on expert feedback to ensure pedagogical feasibility, cultural relevance, and content validity. Novelty at this stage: the development of culture-based STEAM learning instruments that were validated across pedagogical, instructional, and cultural dimensions.

Fourth, Implementation

The learning model was implemented in a Grade V elementary classroom through STEAM-based project learning activities. These activities included natural dye experiments and batik motif design, which integrated scientific concepts, engineering processes, artistic creativity, and mathematical reasoning within Madurese cultural contexts. To examine the effectiveness of the developed model, a one-group pretest and posttest design was employed to measure changes in students' creativity and innovation before and after implementation.

Fifth, Evaluation

Evaluation was conducted through both formative and summative procedures. Formative evaluation was carried out during the implementation stage to refine learning activities and instructional strategies. Summative evaluation focused on assessing the effectiveness of the learning model based on improvements in students' creativity and innovation outcomes. The results of this stage were used to finalize the learning model.

The research instruments used in this study consisted of a creativity test and an innovation assessment rubric, as well as qualitative data collection tools. Students' creativity was measured using a creativity test based on Torrance's indicators, including fluency, flexibility, originality, and elaboration (Torrance 2011). Innovation was assessed through a performance-based rubric that measured students' ability to adapt ideas, implement solutions, demonstrate usefulness, and show initiative or risk-taking appropriate to the elementary school level (Miller 2015). In addition, observation sheets and interview guides were used to capture learning processes and student engagement, while expert validation questionnaires were employed to evaluate the pedagogical quality, cultural relevance, and feasibility of the developed learning model. Creativity and innovation data were analyzed using descriptive statistics, N-Gain, and paired-sample t-tests to determine improvement after model implementation.

Result

First, Product Development of the Learning Model

This study resulted in a learning model grounded in Madurese local wisdom that employs STEAM as an integrative instructional approach to enhance elementary students' creativity and innovation. Developed through the ADDIE stages, the model comprises a conceptual framework describing learning syntax and principles, lesson plans (RPM) that integrate STEAM activities with Madurese cultural contexts, project-based student worksheets (LKPD), learning media related to Madurese batik practices, and assessment rubrics for creativity and innovation. Madurese local wisdom is integrated both as cultural values, such as perseverance, cooperation, and respect, and as cultural practices, particularly batik-making, which functions as the main project context to support contextual, meaningful, and interdisciplinary STEAM learning activities.

Second, Model Validity

Model validity was assessed through expert validation involving specialists in instructional design, STEAM education, and Madurese local culture. The validation focused on content relevance, theoretical foundation, learning syntax, cultural integration, and assessment instruments.

Table 1. Expert Validation Results

Aspect Evaluated	**Mean Score (5-point scale)**	**Category**
Theoretical foundation	4.7	Very valid
Learning syntax	4.6	Very valid
STEAM integration (as approach)	4.8	Very valid
Cultural relevance	4.9	Very valid
Assessment instruments	4.6	Very valid
Overall validity	4.7	Very valid

Source: personal document

These results indicate that the developed learning model meets validity requirements and is theoretically and pedagogically sound.

Third, Expert Suggestions and Product Revision

Expert feedback highlighted the need to simplify the language used in student worksheets to align with elementary students' cognitive levels, clarify the descriptors used in the creativity and innovation assessment rubrics, incorporate explicit cultural reflection activities, and provide a user guide for teachers. All expert suggestions were systematically accommodated during the revision process, resulting in a refined and improved version of the learning model prior to classroom implementation.

Fourth, Model Practicality

Model practicality was examined through limited implementation involving teachers and students. Observation data and teacher questionnaires showed that the model was easy to use, contextually meaningful, and feasible within regular classroom conditions. Teachers reported that STEAM-based projects grounded in batik practices helped make abstract science and mathematics concepts more concrete and engaging.

Fifth, Model Effectiveness

The effectiveness of the learning model was evaluated using a one-group pretest–posttest design focusing on creativity (Y1) and innovation (Y2).

Table 2. Summary of Creativity (Y1) and Innovation (Y2) Scores

Variable	Pretest Mean	Posttest Mean	N-Gain	Category
Creativity (Y1)	68.5	84.7	0.71	High

Innovation (Y2)	65.2	82.3	0.68	Medium–High

Observational and documentation data supported these findings. Students actively generated design ideas, experimented with natural and synthetic dyes, collaborated in groups, and linked batik-making processes with STEAM elements.

Sixth, Hypothesis Testing Results

Paired-sample t-test analysis showed significant differences between pretest and posttest scores.

Table 3. Hypothesis Testing Results

Variable	t-value	Sig. (p)	Result
Creativity (Y1)	3.842	0.001	Significant
Innovation (Y2)	3.117	0.004	Significant

Source: *Personal Document*

These results confirm that the developed learning model effectively improved students' creativity and innovation.

Seventh, Graphical Representation of Results

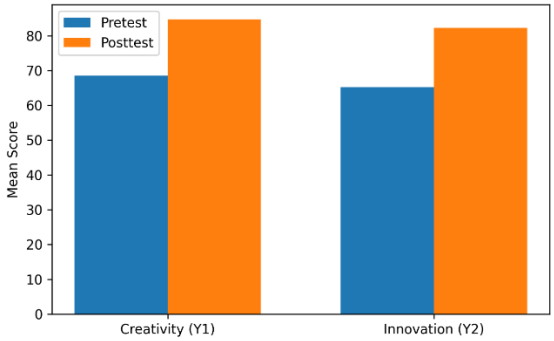

Figure 2.

Comparison of Pretest and Posttest Scores for Creativity and Innovation

Source: *Personal Document*

Figure 2 presents a side-by-side comparison of students' pretest and posttest mean scores for creativity (Y1) and innovation (Y2). The figure shows a consistent increase in both variables after the implementation of the learning model. The creativity mean score increased from 68.5 to 84.7, while the innovation mean score increased from 65.2 to 82.3. This visual evidence confirms the effectiveness of the developed learning model in improving students' creativity and innovation.

Overall, the findings demonstrate that the developed learning model is valid, practical, and effective. By integrating STEAM as an instructional approach with Madurese local wisdom, the model provides a contextual and culturally responsive

learning framework that supports the development of creativity, innovation, collaboration, and cultural appreciation among elementary school students.

Discussion

This study demonstrates that the learning model grounded in Madurese local wisdom and employing STEAM as an integrative instructional approach effectively enhances elementary students' creativity and innovation. This conclusion is strengthened by the rigor of the research process, which systematically followed the ADDIE development stages and was supported by multiple sources of data, including needs analysis across several schools, expert validation, classroom implementation, observations, interviews, documentation, and pretest–posttest assessments (Branch 2009). The convergence of evidence from these stages reinforces the credibility of the findings and confirms that the results are not incidental but emerge from a structured and iterative development process.

The main finding of this study is that creativity (Torrance 2011) and innovation (Miller 2015) improved significantly after the implementation of the developed learning model. This improvement can be interpreted as the result of meaningful learning experiences (Carney and Levin 2013) that connected interdisciplinary STEAM activities with students' cultural context (Hsiao et al. 2025). By engaging students in Madurese batik-based projects, abstract concepts in science, technology, engineering, arts, and mathematics were transformed into concrete and culturally familiar learning experiences. This supports theoretical perspectives on contextual (Setiaji et al. 2025) and experiential learning (Aghasafari, Needles, and Malloy 2025), which argue that knowledge becomes more meaningful when embedded in learners' lived experiences (Pantaleo 2024).

From a creativity perspective (Wang 2025), the learning activities facilitated idea generation, experimentation, and refinement, aligning with Torrance's view that creativity develops through iterative processes involving fluency, flexibility, originality, and elaboration (Torrance 2011). Innovation emerged as students transformed creative ideas into functional and aesthetic products, confirming the conceptual relationship between creativity as idea generation and innovation as idea implementation (Torres-Rivera et al. 2025). The findings thus support theories that position innovation (Miller 2015) as the applied dimension of creativity (Torrance 2011) within problem-based

(Jelodari, Zenouzagh, and Hashamdar 2025) and project-oriented learning environments (Lu, Lo, and Syu 2022).

The integration of Madurese cultural values such as perseverance, cooperation, and respect further strengthened the learning process (Nurahman et al. 2025). These values were not treated merely as learning content (De Souza 2018), but functioned as pedagogical drivers (Luo and Tang 2026) that shaped collaboration (Fadhilah and Nurahman 2021), persistence (Schunk and DiBenedetto 2018), and reflective practices during learning (Tri Astuti, M.Fahmi Maulana, and Siti Rohmah 2025). This finding extends ethnopedagogical (Septiwima, Hadriani, and Gata 2022) and culturally responsive learning theories by providing empirical evidence that local wisdom can function as a structural component of instructional design, rather than as a supplementary element (Tiwuk et al. 2025).

In terms of novelty, this study contributes to the literature by developing a structured learning model that integrates local wisdom with STEAM as an instructional approach within a validated R&D framework. Unlike previous studies that focus either on STEAM implementation or on local wisdom integration in isolation, this study combines both dimensions systematically and evaluates their effectiveness in enhancing creativity and innovation at the elementary level. The inclusion of a multi-school needs analysis further strengthens the general relevance of the model, indicating that the identified instructional problems and proposed solution reflect broader regional conditions rather than a single-school case.

Theoretically, this study reinforces constructivist (Torres-Rivera et al. 2025), experiential (Aghasafari et al. 2025), and culturally responsive learning theories by demonstrating that STEAM-based learning (Pransiska, Rozimela, and Hadiyanto 2025) becomes more effective when grounded in ethnocultural practices (Pingge and Aingu 2021). Practically, the findings suggest that teachers can design interdisciplinary (Li 2025) and innovative learning experiences (Tang et al. 2025) without detaching instruction from local cultural identity (Siswoyo et al. 2025). Overall, the discussion confirms that positioning STEAM as an instructional approach within a culturally grounded learning model provides a meaningful pathway for developing creativity and innovation in elementary education contexts.

Conclusion

This study concludes that integrating STEAM as an instructional approach with Madurese local wisdom provides an effective pathway for enhancing creativity and innovation among elementary school students. In line with the research objectives, the developed learning model demonstrates that culturally grounded and interdisciplinary learning experiences can support the development of essential 21st-century skills at the elementary level.

The main contribution of this study lies in the development of a structured and validated learning model that systematically integrates local cultural practices into STEAM-oriented learning. The findings indicate that embedding science, technology, engineering, arts, and mathematics within familiar cultural contexts enables students to engage more meaningfully with scientific inquiry, problem solving, and creative production. From a theoretical perspective, this study strengthens constructivist, experiential, and culturally responsive learning frameworks by showing that STEAM learning becomes more effective when grounded in ethnocultural practices.

Practically, the findings have important implications for elementary school science education. The developed model provides teachers with a concrete instructional reference for designing science learning activities that are contextual, interdisciplinary, and culturally relevant. By using local cultural practices as learning contexts, science concepts can be taught in a more concrete and meaningful manner, thereby increasing student engagement and supporting creativity and innovation.

Despite these contributions, this study has limitations. The effectiveness testing was conducted in a limited instructional setting and focused primarily on creativity and innovation outcomes. Future research is recommended to involve broader implementation across different regions, examine long-term impacts on students' scientific understanding, and explore the integration of digital technologies within culture-based STEAM learning. Such studies would further strengthen the generalizability and contribution of culture-based STEAM approaches to elementary education.

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Declaration of Conflicting Interests

The authors declare that there is no potential conflict of interest with respect to the research, authorship, and/or publication of this article.

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