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Development of a STEAM-based Papercraft Media 'Memoo!' to Enhance Fine Motor Skills in Early Childhood

Jazila Anaka Putri [1], Evi Selva Nirwana[2], Alimni[3]

[1] Universitas Islam Negeri Fatmawati Sukarno, Bengkulu, Indonesia ; jazilaaanaka@gmail.com
[2] Universitas Islam Negeri Fatmawati Sukarno, Bengkulu, Indonesia ; selvanirwana@gmail.com
[3] Universitas Islam Negeri Fatmawati Sukarno, Bengkulu, Indonesia ; alimni@mail.uinfasbengkulu.ac.id

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ABSTRACT

Fine motor development is a foundational aspect of early childhood learning, supporting skills such as writing, drawing, and object manipulation. Despite its importance, there is a lack of integrated learning media that stimulate fine motor skills through engaging, structured, and cognitively rich activities. This study introduces *Memoo!*, a STEAM-based papercraft medium designed to enhance fine motor skills in children aged 5–6. This research used a Research and Development (R&D) approach with the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). *Memoo!* was developed as a 3D cow-themed papercraft integrating STEAM elements—science exploration, engineering assembly, creative art, mathematical shape recognition, and early literacy. The media was validated by experts and tested on 14 children at TK IT Syuhada Bengkulu. Data collection involved expert validation checklists, teacher practicality questionnaires, and pretest-posttest observations of children's fine motor skills. Validation results showed high feasibility, with experts rating the media as suitable for early childhood use. Teachers reported ease of use and strong child engagement. Children demonstrated a statistically significant improvement in fine motor performance, with an average score increase of +8.86 points ($p < 0.05$) after using the media. Observed gains included better cutting, folding, pasting, and eye–hand coordination. The findings indicate that *Memoo!* is a valid, practical, and effective medium for developing fine motor skills through STEAM-based learning. Future studies are encouraged to expand the sample size and explore long-term effects in diverse educational contexts.

Corresponding Author:
Evi Selva Nirwana
Universitas Islam Negeri Fatmawati Sukarno, Bengkulu, Indonesia ; selvanirwana@gmail.com

1. INTRODUCTION

Fine motor development in early childhood plays a crucial role in preparing children for academic readiness. Skills such as writing, drawing, cutting, folding, and manipulating small objects rely heavily on the coordination of small muscles in the hands and fingers. These abilities are not only essential for

school-related tasks but also contribute to children's independence and cognitive development. Previous research indicates that stimulation of fine motor skills significantly enhances children's learning concentration, which is an important indicator of school readiness (Astuti et al., 2014). Therefore, providing appropriate stimulation during the early childhood period is essential to support optimal development.

Several studies highlight the importance of manipulative activities in strengthening fine motor coordination. For instance, Yulianti and Yuniarti (2022) found that children who lacked experience in drawing activities showed stiff coordination between their hands and fingers, indicating insufficient development of fine motor control. Similarly, research by Mayasri and Masliati (2023) revealed that sewing activities can improve finger flexibility and enhance eye–hand coordination, which are critical components of manipulative skills. These findings emphasize that structured and engaging activities are necessary to stimulate children's fine motor development effectively.

Despite the recognized importance of fine motor stimulation, developmental delays remain a common issue among preschool-aged children. Triwulandari (2022) reported that more than 50% of preschool children aged 4–6 years in Bogor Regency had not yet achieved age-appropriate standards for fine motor development. Many children struggled with manipulative tasks such as picking up small objects or stacking blocks. These delays were associated with limited learning stimulation, insufficient educational media, and restrictive parenting patterns that reduced opportunities for hands-on exploration.

Similarly, a quasi-experimental study involving children aged 4–5 years found that their average fine motor development score before intervention was categorized as "doubtful," with a mean score of 3.69 (Harmila et al., 2023). After receiving stimulation through puzzle-based learning activities, children showed significant improvement in their fine motor performance. This finding suggests that appropriate manipulative learning media play a critical role in supporting children's motor development. Without adequate stimulation, children may experience difficulties in developing the fine motor coordination necessary for academic and daily tasks.

Further evidence of fine motor developmental challenges was reported by Hantari et al. (2021), who observed that before the introduction of scientific play activities, approximately 25–40% of children at TK Aisyiyah 1 Talangpadang were categorized as "doubtful" or "undeveloped" in terms of fine motor skills. Following the intervention, 80% of the children reached the "developing as expected" category. Although the intervention showed positive results, the findings highlight the significant developmental delays present prior to the provision of appropriate learning stimulation.

The importance of early childhood education in supporting fine motor development is also reflected in research by Veri (2022). The study found that 33% of preschool-aged children who did not attend early childhood education programs (PAUD) demonstrated poor fine motor skills, whereas all children who participated in PAUD exhibited good fine motor development. These findings suggest that structured learning environments and appropriate educational media play a critical role in facilitating children's motor development.

In recent years, papercraft has emerged as a promising learning medium for stimulating fine motor skills in early childhood education. Papercraft activities typically involve cutting, folding, assembling, and pasting paper materials to create three-dimensional objects. These activities require precision, finger control, and coordination between visual perception and hand movement. As a result, papercraft can effectively stimulate the development of small muscle control in young children.

Empirical evidence supports the effectiveness of papercraft-based learning activities. Kuswanto and Ardiani (2022) reported that papercraft play therapy significantly improved fine motor development among preschool children aged 4–6 years. Their study showed that the level of fine motor development increased from 62% in the pretest to 90% after the intervention, with statistical analysis indicating significant results ($p = 0.001$). These findings demonstrate that structured papercraft activities can provide effective stimulation for developing fine motor coordination.

A case study conducted by Putri and Sulistyawati (2024) also demonstrated the effectiveness of papercraft media in improving children's motor skills. After nine therapy sessions lasting approximately 15 minutes each, preschool children showed measurable improvements in pinching, grasping, and controlling hand movements during cutting and folding activities. The study reported a shift in children's developmental status from "doubtful" to "age-appropriate," indicating that consistent and engaging papercraft activities can effectively stimulate motor development.

Similarly, an experimental study by Ifalahma et al. (2024) found that papercraft activities significantly improved fine motor development among children aged 4–5 years. Pretest and posttest analyses revealed that nearly half of the participants progressed from the "developing as expected" category to the "highly developed" category after participating in papercraft-based learning activities. The researchers concluded that manipulating paper materials provides effective stimulation for sensorimotor coordination and small muscle control.

Supporting these findings, a literature review conducted by Budiwaluyo and Muhid (2021) identified a consistent positive relationship between papercraft activities and fine motor development in early childhood. Most studies emphasized that manipulative actions such as cutting, folding, and pasting serve as effective stimuli for strengthening hand–finger coordination. Furthermore, a correlational study by Angelita et al. (2021) found that papercraft-based stimulation significantly contributed to improvements in precise movement control and visual–motor coordination among children aged 4–6 years.

Alongside the development of manipulative learning media, the STEAM approach (Science, Technology, Engineering, Art, and Mathematics) has gained increasing attention in early childhood education. The STEAM approach promotes interdisciplinary learning that integrates creativity, critical thinking, problem-solving, and exploration. Through hands-on activities and real-world problem-solving tasks, children are encouraged to experiment, design, and express their ideas creatively.

Several studies demonstrate the effectiveness of STEAM-based learning approaches. Salma et al. (2023) conducted a quasi-experimental study using STEAM-based loose parts media and found that the creativity of children aged 5–6 years in the experimental group was significantly higher than that of children in the control group. Through the use of loose materials such as paper, buttons, and wood, children were able to explore shapes and construct imaginative projects while integrating STEAM elements.

Similarly, research conducted in Boyolali found that STEAM-based loose parts learning significantly enhanced creativity and problem-solving skills among children aged 5–6 years (Kristiyani et al., 2024). Children used everyday materials such as stones, wooden pieces, cardboard, and recycled bottles to build creative constructions and experiment with different design ideas.

In addition, classroom action research conducted at TK Salsabila showed that the implementation of STEAM-based loose parts learning significantly improved children's fine motor development. The percentage of children categorized as "highly developed" increased from 10% in the pre-cycle stage to 58% in cycle II (Anita et al., 2022). Similarly, research conducted at TK Melati 1 PGRI Kebumen found that STEAM-based learning activities—such as color-mixing experiments, pattern construction, and creative exploration—significantly increased children's creativity scores from an average of 74.9 to 84.6 (Wuri Sasmita & Anti Isnaningsih, 2023).

Another study by Prahartiwi et al. (2025) demonstrated that STEAM-based experiential learning, which emphasizes direct play experiences rather than worksheet-based instruction, successfully enhanced creativity among children aged 5–6 years. Through simple science experiments, engineering constructions, artistic exploration, and mathematical games, children were able to actively explore their environment and express creative ideas in meaningful contexts.

Although previous studies have demonstrated the independent effectiveness of papercraft activities and STEAM-based learning approaches, few studies have attempted to systematically integrate these two approaches into a single learning medium. Most existing research applies papercraft primarily as a

manipulative activity to train motor coordination, while STEAM-based activities are often implemented through loose parts or experimental play without focusing specifically on fine motor development.

This gap indicates the need for innovative learning media that simultaneously integrate the manipulative benefits of papercraft with the interdisciplinary learning framework of STEAM. Such integration has the potential to stimulate not only children's fine motor skills but also their creativity, problem-solving ability, and exploratory learning.

Therefore, this study aims to develop Memoo!, a cow-themed papercraft learning medium embedded with the five STEAM components (Science, Technology, Engineering, Art, and Mathematics). The development process follows the ADDIE research and development model to ensure systematic design, validation, and implementation. The primary objective of this research is to produce a STEAM-based papercraft learning medium that is valid, practical, and effective for improving fine motor skills in early childhood.

2. METHODS

2.1 Participants

This study involved early childhood learners in Group B (ages 5–6 years) at TK IT Syuhada Bengkulu as the primary participants. A total of 14 children took part in the implementation phase, consisting of both boys and girls with varying levels of fine motor development. The classroom teacher acted as a facilitator during learning activities and also served as a respondent in the practicality assessment. Participant selection was conducted purposively based on age relevance, classroom availability, and institutional recommendation.

2.2 Design and Procedures

The research employed a Research and Development (R&D) approach guided by the ADDIE model, which consists of Analysis, Design, Development, Implementation, and Evaluation. The analysis stage identified classroom needs and fine motor developmental barriers. The design stage involved constructing the initial concept of Memoo!, preparing the papercraft layout, and designing evaluation instruments. During development, the media prototype was produced as a 3D papercraft integrated with STEAM elements and reviewed by content and media experts. The implementation phase was carried out through direct classroom use, allowing children to engage with the media in structured learning sessions. Finally, evaluation involved analyzing pretest–posttest results, expert validation scores, and teacher feedback.

2.3 Instrumentation

Research instruments consisted of: (1) observation rubrics for evaluating children's fine motor skills during pretest and posttest, (2) expert validation sheets for assessing media and material feasibility, and (3) teacher response and practicality questionnaires. Observations assessed indicators such as cutting, folding, pasting, hand control, and eye–hand coordination. Child interviews were conducted in a semi-structured format, designed to explore enjoyment, ease of use, and engagement while interacting with the media.

2.4 Validation and Reliability

Media validity was examined through expert evaluation involving a material specialist in early childhood education and a learning media expert. Assessment criteria included content accuracy, pedagogical suitability, visual appeal, practicality, and safety for children. Practicality testing was obtained from teacher questionnaires addressing ease of use, clarity of instructions, and classroom applicability. Reliability was reflected in the consistency of observation results across trial sessions and alignment between expert judgment and user feedback.

2.5 Data Analysis

Data were analyzed by comparing children's pretest and posttest scores to determine improvement in fine motor skills after using Memoo!. A paired mean comparison test was applied to examine statistically significant differences in performance before and after the intervention. Expert and teacher assessment scores were analyzed using descriptive statistics to determine media validity and practicality.

3. FINDINGS AND DISCUSSION

3.1 Findings

3.1.1 Development Process

The development of Memoo! followed the ADDIE R&D framework through five stages. The analysis phase identified low fine motor performance and limited manipulative learning media in the classroom. The design phase produced the initial papercraft layout integrating STEAM elements (Science exploration, Engineering assembly, Art coloring, mathematical shape recognition). The development resulted in a 3D manipulable cow papercraft. Implementation was carried out in learning sessions involving 14 children aged 5–6 years. Evaluation included expert validation, practicality testing with teachers, and pretest–posttest measurement of fine motor skills.

3.1.2 Validation Results

Expert validation showed that the media met feasibility standards for classroom implementation. Material experts judged alignment with developmental indicators, while media experts assessed visual clarity, safety, durability, and instructional readability. The validation score indicated that Memoo! fell into the highly feasible category for use in PAUD learning and was suitable for fine motor stimulation activities.

3.1.3 Limited Trial Results

A limited trial involving 14 children demonstrated positive engagement and successful task completion. Teachers reported that children were able to cut, fold, assemble, color, and manipulate the components with adequate guidance. Semi-structured interviews indicated that children perceived the activity as enjoyable and challenging in a positive way. Teacher practicality responses indicated that the media was easy to prepare, manageable in time, and classroom-friendly.

3.1.4 Effectiveness Testing

Fine motor outcomes were measured using pretest and posttest observation instruments administered to 14 participants. The analysis revealed a notable increase in performance following the intervention. The average pretest score of 58.64 (SD = 2.42) improved to 67.43 in the posttest (SD = 2.23). Score distribution also shifted upward, where the minimum score increased from 55 to 65, and the maximum score rose from 62 to 71. The overall mean gain of +8.79 points illustrates clear progress in children's abilities related to cutting, folding, pasting, and coordinating visual–motor movements.

Normality was verified using the Shapiro–Wilk test, and paired-sample t-test results confirmed that the improvement was statistically significant ($p < 0.05$). These findings indicate that Memoo! effectively promotes the development of fine motor skills in early childhood educational environments.

3.2 Discussion

The findings of this study demonstrate that the Memoo! learning medium effectively enhances fine motor development in early childhood. The improvement observed in children's ability to manipulate paper materials, coordinate finger movements, and control hand–eye coordination confirms that papercraft-based activities can serve as an effective tool for fine motor stimulation. These results align with previous studies indicating that structured manipulative activities significantly

improve children's motor dexterity and visual–motor integration. For instance, papercraft interventions involving cutting, folding, and pasting have been shown to increase fine motor skill achievement among preschool children (Kuswanto & Ardiani, 2022). Similar improvements have also been reported in learning interventions utilizing puzzles and other manipulative activities, which provide children with opportunities to strengthen finger control and coordination (Harmila et al., 2023).

Furthermore, the results support previous findings that papercraft-based play therapy can effectively stimulate the development of small muscle control in preschool-aged children. Studies have demonstrated that consistent engagement in papercraft activities leads to measurable improvements in pinching, grasping, and hand movement control (Putri & Sulistyawati, 2024). These manipulative experiences enable children to practice precise hand movements, which are essential for developing early academic skills such as writing and drawing. In addition, literature reviews on papercraft learning consistently highlight that cutting, folding, and assembling paper objects contribute positively to the development of fine motor coordination (Budiwaluyo & Muhid, 2021).

The effectiveness of Memoo! is also strengthened by the integration of the STEAM (Science, Technology, Engineering, Art, and Mathematics) learning approach. Through the Memoo! activities, children were not only engaged in physical manipulation of paper materials but were also encouraged to think critically through shape recognition, construction processes, color selection, and counting activities. This combination of physical and cognitive engagement reflects the principles of STEAM-based learning, which promotes interdisciplinary exploration and hands-on experimentation. Previous research has shown that STEAM learning environments that incorporate manipulative materials significantly enhance children's creativity, focus, and problem-solving abilities (Salma et al., 2023; Kristiyani et al., 2024).

Moreover, STEAM-based learning activities encourage children to explore and construct knowledge through direct experiences. Studies implementing STEAM approaches with loose parts and experiential learning have reported improvements in creativity, collaboration, and cognitive engagement among early childhood learners (Prahartiwi et al., 2025; Wuri Sasmita & Anti Isnaningsih, 2023). By integrating papercraft with STEAM elements, Memoo! provides a learning experience that simultaneously stimulates fine motor skills and higher-order thinking processes.

Despite these promising findings, several limitations should be acknowledged. The number of participants in this study was relatively small, consisting of only 14 children, which may limit the generalizability of the results. Additionally, the implementation period was relatively short, and the study was conducted within a single educational institution. Future studies involving larger and more diverse samples, as well as longer intervention periods, would provide stronger evidence regarding the scalability and long-term effectiveness of the Memoo! learning medium.

Nevertheless, the findings offer meaningful implications for early childhood education practice. Memoo! represents a simple, affordable, and classroom-ready learning medium that supports children's fine motor coordination while simultaneously fostering cognitive development and creative thinking. As a hands-on and engaging learning tool, Memoo! has strong potential to support project-based learning, exploratory play, and integrated STEAM activities within early childhood curricula.

4. CONCLUSION

The findings indicate that the STEAM-based Papercraft Memoo! is a valid, practical, and effective medium for improving fine motor skills in early childhood, supported by expert validation in the "very feasible" category (100%), positive practicality responses from teachers and children, and a significant post-test improvement of +8.86 points ($p < 0.05$). Its simple assembly steps, clear patterns, and suitability for independent or guided use make it accessible for classroom application. Despite strong results, the research was limited to 14 children in one school, suggesting the need for broader trials, expanded sample sizes, and exploration of additional developmental domains. Future refinement should include more color and shape variations, enriched activity features, and interactive guidance tools, while

teachers and institutions are encouraged to integrate Memoo! into STEAM-based learning as an engaging and meaningful resource for fine motor development.

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