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Loose Parts-Based STEAM Approach: An Effective Strategy to Develop Problem-Solving and Critical Thinking in Kindergarten Children

Iswatini[1], Achmad Buchori[2], Aryo Andri Nugroho[3]
[1] Universitas PGRI Semarang; omahsawah83@gmail.com
[2] Universitas PGRI Semarang;achmadbuchori@upgris.ac.id
[3] Universitas PGRI Semarang;aryoandrinugroho@upgris.ac.id

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ABSTRACT

This study investigates the effectiveness of loose parts-based learning media integrated with the STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach in enhancing problem-solving and critical thinking skills among early childhood learners. A quasi-experimental design with a one-group pretest-posttest and control group was applied to 26 children aged 5–6 years at TK Al Mubarok Bolo, Demak, Indonesia. The experimental group engaged in STEAM activities utilizing loose parts, while the control group received conventional instruction. Data were collected through observation sheets and performance rubrics, then analyzed using paired sample t-tests and independent sample t-tests. Findings revealed significant improvements in problem-solving and critical thinking in the experimental group compared to the control group ($p < 0.05$). This research contributes novelty by addressing both skills simultaneously in early childhood through the innovative integration of loose parts and STEAM pedagogy. The results highlight the potential of this approach as an adaptable and effective strategy for fostering 21st-century learning competencies in early childhood education.

Corresponding Author:
Iswatini
Universitas PGRI Semarang; omahsawah83@gmail.com

INTRODUCTION

Early childhood (0–6 years) is a group in a phase of rapid and unique growth and development, requiring appropriate stimulation approaches in accordance with their developmental stages (Syarnubi, Syarnubi, Ahmad Syarifuddin, 2023). Early Childhood Education (PAUD) serves as a platform for nurturing children from birth to six years old through care, guidance, and education, in order to prepare them for the next stage of schooling, as stipulated in Law No. 20 of 2003 on the National Education System. The national education goals, as stated in Article 3, emphasize the development of learners to become individuals who are faithful, devoted, noble in character, healthy, knowledgeable, competent, creative, independent, democratic, and responsible.

In the 2021/2022 academic year, TK Al Mubarok Bolo, Demak Regency, implemented limited face-to-face learning in accordance with the Circular Letter of the Head of the Demak Regency Office of Education and Culture regarding the tightening of health protocols. The institution applies a learning center model which includes preparation, blocks, faith-based learning (imtaq), natural materials, and physical movement centers for Kindergarten A, as well as preparation, art, role play, and cooking centers for Kindergarten B. However, observations revealed that children's abilities in

simple problem-solving and critical thinking had not yet developed optimally—for instance, children had difficulty mentioning numerical symbols or showed little interest in asking questions during learning activities.

One approach that has the potential to address this issue is the use of loose parts-based learning media within the STEAM (Science, Technology, Engineering, Art, and Mathematics) framework. Loose parts are open-ended materials that can be combined, separated, moved, and modified according to children's imagination, and can be obtained from the surrounding environment at little to no cost (Nurjanah, N., & Novita, 2020). The attractive, open-ended, and movable characteristics of loose parts enable children to create without limits and stimulate Higher Order Thinking Skills (HOTS) such as critical thinking (Puspita, 2019)(Siantajani, 2020)(Wahyuningsih, 2019). Nevertheless, the study by Mastuinda, Zulkifli, and Febrialismanto (2020) found that teachers' perceptions of loose parts in early childhood education were still low (58.60%, in the "less favorable" category), indicating the need for more effective mentoring (Bhertia, 2022).

The STEAM approach is considered aligned with the demands of 21st-century skills, which require children to have critical thinking, creativity, collaboration, and communication skills (Bybee, 2023)(Muniroh, M, F., Roshayanti, 2019)(Tritiyatma, 2017). Previous studies have demonstrated the effectiveness of STEAM-based learning in developing critical thinking skills in children aged 5–6 years (Reswari, 2021) and in supporting problem-solving skills (Rahman, 2019). However, the implementation of loose parts-based STEAM at TK Al Mubarok has not been optimal, especially in linking learning to children's real-life experiences in a contextual manner (Helista, 2019)(Imaduddin, 2017).

Based on these conditions, this study focuses on examining the effectiveness of loose parts-based learning media within the STEAM approach in improving problem-solving and critical thinking skills of TK Al Mubarok Bolo students. This research is expected to provide theoretical contributions to the development of innovative media in early childhood education, as well as practical contributions for teachers in designing enjoyable, contextual, and stimulating learning activities that foster children's higher-order thinking skills

Problem-Solving

Problem-solving ability in early childhood is an essential part of cognitive development that needs to be stimulated from an early age. Piaget emphasized that cognitive development occurs through structured stages, where children build sensorimotor schemas from birth that serve as the foundation for interacting with their environment. This structure gradually develops through continuous interaction until children are able to think logically at later stages of development Zelazo, in (Azizah, M, Nuryatmawati, A. M., & Dimyati, 2021). According to Washington in (Azizah, M, Nuryatmawati, A. M., & Dimyati, 2021), habituating children to work on tasks related to real-life situations is the essence of problem-solving ability. This ability is defined as the skill or potential that enables children to solve problems and apply solutions in daily life (Gunantara, G., Suarjana, M., & Riastini, 2020).

Problem-solving activities require children to identify appropriate steps to overcome existing gaps, applying concepts and rules they have previously learned (Ernawulan, 2018). In the context of early childhood education, this skill includes eight indicators, ranging from grouping objects by color or shape to answering questions relevant to the learning material (Yesi Ratna Sari, M. Thoha B. S. Jaya, 2018).

Learning Effectiveness

Learning effectiveness is defined as the success of the learning process in achieving predetermined objectives. Effective learning is characterized by optimal learning time, active student participation, alignment of material with learners' abilities, and the creation of a positive learning atmosphere (Widodo, 2015). Effectiveness can be measured through the achievement of cognitive

learning outcomes obtained from tests, which also reflect mastery of concepts and skills (Yesi Ratna Sari, M. Thoha B. S. Jaya, 2018).

Learning Media and Loose Parts

Learning media play an important role in facilitating effective communication and interaction between teachers and students, thereby creating a conducive learning environment (Arsyad, 2011)(Munadhi, 2014). One medium particularly relevant for early childhood education is *loose parts*, which refers to open-ended materials that can be combined, separated, moved, redesigned, and reused in various ways (Nurjanah, N., & Novita, 2020). Loose parts can include natural materials, plastics, metals, wood and bamboo, threads and fabrics, glass and ceramics, as well as recycled packaging (Damayanti, D., 2020). The characteristics of loose parts being attractive, open-ended, and easily movable—can stimulate children's creativity and critical thinking (Puspita, 2019)(Siantajani, 2020)(Wahyuningsih, 2019).

STEAM Approach

The STEAM (Science, Technology, Engineering, Art, and Mathematics) approach emphasizes the development of 21st-century skills such as critical thinking, creativity, collaboration, and communication (Bybee, 2023). In early childhood learning, STEAM is highly relevant because it is contextual, utilizes the child's surrounding environment, and encourages exploration through engaging activities (Muniroh, M, F., Roshayanti, 2019)(Tritiyatma, 2017). STEAM facilitates children in identifying questions, understanding the characteristics of science, technology, and art, and connecting them to real-world problems. Research by Reswari (2021) shows that STEAM-based learning can enhance higher-order thinking skills (HOTS) in early childhood. This aligns with the findings of Rahman (2019), who emphasized the importance of problem-solving as a core 21st-century skill (Reswari, 2021)(Rahman, 2019).

Critical Thinking

Critical thinking is one of the higher-order thinking skills (HOTS) that involves the ability to ask questions, gather facts, construct arguments, and make sound decisions. Lewis & Smith in (Ikaningtyas Purnamasari, Dewanti Handayani, S. S., & Formen, 2020) explain that critical thinking involves the reorganization and expansion of information stored in memory to achieve goals or find solutions. Santrock (Reswari, 2021) emphasizes that critical thinking requires effective manipulation and transformation of memory (Santrock, 2007). This process can be fostered through consistent stimulation, enabling children to become accustomed to solving problems and making independent decisions (Siantajani, 2020).

METHODS

This study employed a quantitative method, which is a process of discovering knowledge using numerical data as an analytical tool to address the research questions Kasiram in (Kuntjojo, 2008). Quantitative methods are based on the philosophy of positivism, applied to examine a specific population or sample, with data collection using research instruments and statistical data analysis to test the established hypotheses (Sugiyono, 2019). This research falls under the category of quasi-experimental design, in which the researcher does not have full control to manipulate subjects. The assignment of treatment and control groups was conducted randomly based on pre-existing groups. Experimental research is considered the most scientific among research types because it allows the researcher to manipulate treatments to observe their effects on the studied variables (Yusuf, 2014).

The research design used was a *One Group Pretest–Posttest Design*, an experimental design carried out on a single group selected randomly without testing for initial stability and equivalence. Measurements were taken before (pretest) and after (posttest) the intervention, allowing the researcher to compare results and identify changes resulting from the treatment.

The study was conducted at TK Al Mubarok Bolo, Demak Regency, involving students aged 5–6 years during the period of November to December 2021. The research population comprised all TK Al Mubarok Bolo students aged 5–6 years. The sample was selected using purposive sampling

(criterion-based sampling), consisting of two learning groups: TA 3 as the experimental group and TA 4 as the control group, both sharing similar characteristics.

The independent variable in this study was loose parts-based learning media within the STEAM approach, measured using a learning observation sheet. The dependent variables consisted of problem-solving skills (Y1) and critical thinking skills (Y2), assessed using a student activeness rubric. The research instruments included observation sheets to record the implementation of learning and assessment rubrics to measure student skills.

Data collection techniques included observation to examine learning implementation, tests in the form of pretests and posttests to measure problem-solving and critical thinking skills before and after the treatment, and documentation to complement the research data. According to Sugiyono, data collection can be conducted through observation, interviews, questionnaires, and documentation, or a combination of these methods to obtain comprehensive results (Sugiyono, 2022).

The data obtained consisted of quantitative and qualitative data. Quantitative data were derived from pretest and posttest scores, while qualitative data were obtained from observations of learning implementation and student activities. Data analysis was conducted both quantitatively and qualitatively. Qualitative data were used to support quantitative findings through descriptive accounts of the learning process, whereas quantitative data were analyzed using the paired sample *t*-test to determine the differences in learning outcomes before and after the treatment in the experimental group. The paired sample *t*-test was employed to assess the extent to which the independent variable influenced the dependent variables partially, with a significance level of α = 0.05, where a sig value < 0.05 indicates a statistically significant difference.

FINDINGS AND DISCUSSION

This study was conducted at TK Al Mubarok Bolo, Demak Regency, involving two groups of students aged 5–6 years: TA 3 as the experimental group and TA 4 as the control group. The implementation of loose parts-based learning media with the STEAM approach was carried out in the experimental group for one month, from November 1 to November 27, 2021. The purpose of this treatment was to examine the effectiveness of loose parts-based learning media in improving children's problem-solving and critical thinking skills.

Measurements were taken twice, before (pretest) and after (posttest) the treatment. The mean scores from these measurements are presented in Table 1.

Table 1. Mean Pretest and Posttest Scores

Variable	Group	N	Mean Pretest	Mean Posttest	Difference
Problem-Solving Skills (Y1)	Experimental	13	37.69	80.00	+42.31
	Control	13	38.08	72.31	+34.23
Critical Thinking Skills (Y2)	Experimental	13	35.77	84.23	+48.46
	Control	13	37.31	75.00	+37.69

Based on Table 1, both groups experienced an increase in scores for both variables, but the increase in the experimental group was higher than in the control group. The improvement in problem-solving skills scores for the experimental group was +42.31, compared to +34.23 in the control group. Similarly, the improvement in critical thinking skills scores in the experimental group was +48.46, compared to +37.69 in the control group.

The normality test using the Shapiro Wilk test showed that all pretest and posttest data had significance values greater than 0.05, indicating that the data were normally distributed. The homogeneity test using Levene's Test also showed significance values greater than 0.05 for all variables, meaning the data between the experimental and control groups were homogeneous.

Descriptive analysis indicated that the implementation of loose parts in STEAM facilitated children in building knowledge through structured and contextual play activities. These activities

encouraged students to actively engage in problem-solving and questioning, thereby significantly enhancing higher order thinking skills (HOTS) in the experimental group.

Furthermore, the paired sample *t*-test was used to determine the differences between pretest and posttest results within each group. The results are presented in Table 2.

Table 2. Results of the Paired Sample t-Test

Variable	Group	t-count	Sig. (2-tailed)	Description
Problem-Solving Skills (Y1)	Experimental	-13.291	0.000	Significant
	Control	-8.930	0.000	Significant
Critical Thinking Skills (Y2)	Experimental	-18.959	0.000	Significant
	Control	-13.155	0.000	Significant

Based on Table 2, both the experimental and control groups showed significant differences between pretest and posttest scores for both variables ($p < 0.05$). However, the score differences in the experimental group were greater than in the control group, indicating that the loose parts media in STEAM had a stronger effect on improving problem-solving and critical thinking skills.

The independent sample *t*-test was then used to compare posttest scores between the experimental and control groups. The results are presented in Table 3.

Table 3. Results of the Independent Sample t-Test (Posttest)

Variable	t-count	Sig. (2-tailed)	Mean Difference	Description
Problem-Solving Skills (Y1)	-3.149	0.004	-7.69	Significant
Critical Thinking Skills (Y2)	-3.090	0.005	-9.23	Significant

Based on Table 3, there were significant differences between the experimental and control groups in the posttest for problem-solving skills ($p = 0.004$) and critical thinking skills ($p = 0.005$). The average scores in the experimental group were higher than those in the control group, confirming that the use of loose parts-based learning media within the STEAM approach is more effective than the teaching method applied in the control group.

Overall, the results of this study indicate that loose parts-based learning media combined with the STEAM approach can significantly enhance children's problem-solving and critical thinking skills. The greater improvements observed in the experimental group compared to the control group suggest that this learning model is highly recommended for implementation in early childhood education (Lestariningrum, A., & Wijaya, 2020).

The results of this study show a significant improvement in the problem-solving and critical thinking skills of children in the experimental group after the implementation of loose parts-based STEAM media. This finding is consistent with previous studies stating that the application of STEAM in children aged 5–6 years significantly enhances cognitive development, particularly creativity and problem-solving ability (Farida, N., Ningsih, R. W., & Ndruru, 2023). Similarly, research by Novita Ananda, demonstrated the effectiveness of loose parts–STEAM in improving the creativity of early childhood learners (Novita Ananda, S., Astuti, W., & Widodo, 2023).

The implementation of loose parts provides open-ended and enjoyable exploratory experiences while naturally fostering problem-solving, as explained in the theoretical review that this medium enriches early childhood education in a concrete and creative manner. The STEAM approach itself, according to Huda, promotes children's holistic thinking in real-world contexts and serves as an important investment in early childhood education (Huda, 2023).

Furthermore, Hayati & Zurianti, state that the application of STEAM with loose parts media can enhance exploration and problem-solving in early childhood (Hayati, Z., & Zurianti, 2024). Other studies also reinforce that the use of loose parts improves creativity, communication, collaboration, and critical thinking within the framework of 21st-century skills (Wahyuni, D., & Nuraini, 2023).

Research focusing on STEAM in early childhood education also supports these findings. For instance, Motimona & Maryatun concluded that the implementation of STEAM in the *Kurikulum Merdeka* is effective in improving the cognitive competencies of early childhood learners (Motimona, M., & Maryatun, 2023). Kurinci, further emphasized that the STEAM method plays a significant role in the cognitive development of preschool children. In addition, the effectiveness of STEAM in building cooperative skills has been demonstrated by pre-experimental research conducted on children aged 5–6 years (Kurinci, 2022).

Reinforcing the evaluation results on the media, qualitative research on the application of loose parts in early childhood education shows that this medium stimulates creativity through the freedom to explore, supports problem-solving, and fosters socio-emotional interaction at the same time. Overall, these findings are consistent with empirical evidence that the integration of loose parts media within the STEAM approach creates transformative learning: enhancing cognitive abilities, critical thinking, creativity, and collaboration in early childhood. This confirms that such a learning approach is not only academically effective but also holistic in developing children's potential (Wulandari, F., & Setyaningrum, 2023).

CONCLUSION

This study confirms that the integration of loose parts-based learning media with the STEAM approach significantly improves the problem-solving and critical thinking skills of children aged 5–6 years at TK Al Mubarok Bolo, with the experimental group achieving higher gains than the control group ($p < 0.05$). These findings highlight the model's potential to foster creativity, exploration, and independent problem-solving, aligning closely with the competencies required in 21st-century education. The novelty of this research lies in the combined application of loose parts and STEAM principles in early childhood settings, addressing both cognitive and creative development simultaneously. However, the study's scope is limited by its single-institution sample and short intervention period, which may restrict generalizability. Future research should involve a larger and more diverse sample, extend the intervention duration, and examine additional 21st-century skills such as collaboration and communication to provide a more comprehensive picture of the model's long-term effects.

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