Anatolian Journal of Education
e-ISSN: 2547-9652

April 2026 ● Vol.11, No.1
www.e-aje.net
pp. 169-180

Frugal Thinking in Action: Improving Learning Outcomes through Loose Part-Based Instruction

Zahid Zufar At Thaariq
PhD Student of Curriculum and Instruction Department, Cukurova University, Turkiye, *zahidthoriq123@gmail.com*

Reno Nurdiyanto
Department of Primary Islamic School Teacher Education, UIN Raden Mas Said, Indonesia, *reno.nurdiyanto@staff.uinsaid.ac.id*

Jasmine Nurul Izza
Student of Biology Department, Universitas Negeri Malang, Indonesia, *jasmine.nurul.1803416@students.um.ac.id*

Devi Mariya Sulfa
Student of Biology Department, Universitas Negeri Malang, Indonesia, *devi.mariya.2503419@students.um.ac.id*

Fikri Aulia
Department of Educational Technology, Universitas Negeri Malang, Indonesia, *fikri.aulia.fip@um.ac.id*

This study explores the impact of a frugal learning approach—using loose part-based instruction—on student learning outcomes in an elementary classroom setting. Rooted in the principles of frugal thinking, the intervention aimed to foster creativity, problem-solving, and contextual understanding by utilizing readily available and low-cost materials in the learning process. A one-group pretest-posttest design was employed, involving 16 students. The pretest was a paper-based cognitive assessment with multiple-choice and short-answer items and the posttest was a product-based task requiring students to create a tangible output using loose part materials. Data were analyzed using the Wilcoxon signed-rank test due to the small sample size and non-normal distribution of data. The results revealed a statistically significant increase in learning outcomes after the intervention ($p < 0.05$), indicating that the use of loose parts effectively enhanced students' engagement and conceptual understanding. The study concludes that frugal instructional strategies, particularly those involving hands-on, material-rich activities, can be a powerful alternative in contexts with limited resources. The implications extend to curriculum designers, educators, and policy-makers seeking sustainable and inclusive educational innovations. Recommendations for further research include expanding the approach to diverse contexts and developing validated instruments for product-based assessment.

Keywords: frugal thinking, loose parts, learning outcomes, authentic assessment, sustainable education, low-cost innovation

INTRODUCTION

The rising cost of learning materials has become a major barrier to equitable access and meaningful learning experiences for students in education. Numerous studies have documented that high costs

Citation: At Thaariq, Z. Z., Nurdiyanto, R., Izza, J. N., Sulfa, D. M., & Aulia, F. (2026). Frugal thinking in action: improving learning outcomes through loose part-based instruction. *Anatolian Journal of Education*, 11(1), 169-180. https://doi.org/10.29333/aje.2026.11111a

lead many students to delay or forgo purchasing required materials, which negatively impacts academic achievement, engagement, and progress toward graduation, especially among low-income and underserved populations (Griffiths et al., 2022; Jenkins et al., 2020; Spica & Biddix, 2021; Wimberley et al., 2020). Multiple studies confirm that the high cost of textbooks and course materials leads to significant barriers for students, including delayed or forgone purchases, lower grades, and even course failure (Griffiths et al., 2022; Jenkins et al., 2020; Spica & Biddix, 2021; Wimberley et al., 2020). These barriers disproportionately affect low-income, non-White, and first-generation students, exacerbating educational inequities (Cox et al., 2020; Griffiths et al., 2022; Jenkins et al., 2020; Spica & Biddix, 2021). Surveys show that up to 68% of students delay purchasing materials due to cost, and over 40% may not purchase required materials at all (Jenkins et al., 2020; Spica & Biddix, 2021). Thus, enabling the use of alternative learning resource for students is needed.

Budget constraints in schools often limit access to resources, but they can also drive innovation and resourcefulness in teaching. School leaders frequently express dissatisfaction with insufficient funding, noting that it can hinder their ability to maximize benefits for learners and implement effective teaching strategies (Akhter et al., 2018). However, research shows that innovative management practices—such as school-based budgeting and leveraging local resources—can indirectly improve school effectiveness by fostering creative solutions and adaptability among staff (Chin & Chuang, 2015; Kinyaduka, 2023). For example, schools may focus on professional development using internal human resources or collaborate with nearby institutions to enhance teacher quality without incurring significant costs (Kinyaduka, 2023). While direct increases in funding do not always translate to better outcomes, empowering schools to manage their own budgets and encouraging innovative approaches can help overcome financial limitations (Chin & Chuang, 2015). Ultimately, while budget constraints present real challenges, they can also catalyze schools to adopt more flexible, localized, and inventive teaching methods that support student learning (Akhter et al., 2018; Chin & Chuang, 2015; Kinyaduka, 2023).

The intervention demonstrates precisely how constraint-driven innovation—using everyday, low-cost materials—can yield significant learning gains. However, it also extends the existing literature by providing empirical, quantitative evidence that such approaches do not merely foster general "creativity" or "adaptability" but directly enhance measurable academic outcomes. Thus, while the reviewed studies rightly highlight the potential of budget constraints to spur inventive teaching methods, this research substantiates that potential with concrete data, affirming that frugal pedagogies can be both a necessity and a virtue.

Frugal thinking in education refers to the intentional design and implementation of low-cost yet high-impact strategies that maximize learning outcomes despite limited resources. Its core principles include efficiency (achieving more with less), adaptability (using available resources creatively), and a focus on interventions that are easy to implement and sustain for both teachers and students (Angrist et al., 2025; Hamilton & Hattie, 2022; Shull, 2022). Examples include tailoring instruction to students' current learning levels, using structured pedagogy, leveraging peer learning, and incorporating active, experiential activities that require minimal materials (Angrist et al., 2025; Hamilton & Hattie, 2022; Wakefield & Tashman, 2020). Frugal thinking also emphasizes universal design—methods that can be integrated across disciplines with little disruption—and prioritizes approaches that students and teachers are likely to use consistently (Hamilton & Hattie, 2022; Shull, 2022). This mindset is especially relevant in education today due to widespread budget constraints, growing demands for equitable access, and the need to improve outcomes efficiently (Angrist et al., 2023, 2025; Hamilton & Hattie, 2022). By focusing on cost-effectiveness and practical impact, frugal thinking helps schools and educators deliver meaningful learning experiences without relying on expensive resources, making it a vital approach for both developed and developing educational contexts (Angrist et al., 2023, 2025; Hamilton & Hattie, 2022).

The concept of loose parts as theory, first articulated by architect Simon Nicholson in 1971, posits that the richness of an environment—especially one filled with "loose parts" like stones, sticks, fabric, or bottle caps—directly influences creativity and inventiveness in children. Nicholson defined loose parts as open-ended materials that can be moved, combined, redesigned, and taken apart in countless ways, giving children the freedom to explore, experiment, and construct their own learning experiences (Cankaya et al., 2025). The theory's core strength lies in its ability to foster creativity, as children use loose parts to imagine, invent, and build, leading to the development of original ideas and artistic expression (Imamah & Muqowim, 2020; Isnariyati et al., 2025; Kristiyani et al., 2024; Nipriansyah et al., 2021; Pashela et al., 2024; Sardi & Mayar, 2023). Thus, frugal thinking with loose parts involves using inexpensive, everyday materials—such as rocks, bottle caps, sticks, or fabric scraps—to create rich, open-ended learning experiences that foster creativity, problem-solving, and hands-on exploration. The core principle is to maximize educational impact while minimizing cost, making learning accessible and engaging without the need for expensive resources or technology (Lim et al., 2024; Wahyuningsih et al., 2020). Loose parts can be manipulated, combined, and repurposed in countless ways, allowing children to direct their own play and learning, which supports the development of creativity, imagination, and even foundational skills in science, technology, engineering, arts, and mathematics (STEAM) (Lim et al., 2024; Wahyuningsih et al., 2020). This approach is especially relevant in settings with limited budgets, as it empowers teachers and families to provide high-quality, innovative learning opportunities using materials that are readily available or recycled (Lim et al., 2024; Wahyuningsih et al., 2020). Research highlights that loose parts play can promote not only creative and computational thinking but also teamwork, collaboration, and confidence in both children and adults facilitating the learning (Lim et al., 2024; Wahyuningsih et al., 2020). By embracing frugal thinking with loose parts, educators can deliver meaningful, high-impact educational experiences that are both sustainable and inclusive, particularly benefiting children from economically disadvantaged backgrounds (Lim et al., 2024; Wahyuningsih et al., 2020).

There is a notable lack of quantitative studies directly testing the effectiveness of frugal-based instruction using loose parts on student achievement. Most available research focuses on qualitative or descriptive methods, highlighting improvements in creativity, problem-solving, and cognitive development when loose parts are integrated into learning activities (Aulia et al., 2024; Muawanah et al., 2024; Muntomimah & Wijayanti, 2021; Rianti et al., 2022). However, one recent quasi-experimental study stands out: it compared kindergarten students who used loose parts in classroom activities with those following a standard curriculum, using pre- and post-tests to measure gains. The results showed that the group using loose parts had significantly higher improvements in problem-solving and creativity, though there was no significant difference in critical thinking skills between groups (Hutajulu & Lukas, 2023). This suggests that while loose parts can positively impact certain aspects of student achievement, rigorous quantitative evidence—especially for older students and broader academic outcomes—remains limited. Most other studies rely on observations, interviews, or teacher reports rather than controlled, quantitative measures of achievement (Aulia et al., 2024; Muawanah et al., 2024; Muntomimah & Wijayanti, 2021; Rianti et al., 2022). Therefore, more robust, quantitative research is needed to fully understand the impact of frugal-based instruction with loose parts on student achievement across different age groups and subjects (Aulia et al., 2024; Hutajulu & Lukas, 2023; Muawanah et al., 2024; Muntomimah & Wijayanti, 2021; Rianti et al., 2022).

Given these gaps in the literature, this study seeks to contribute empirical evidence by quantitatively examining the effectiveness of frugal thinking through loose part-based instruction on student learning outcomes. Using a pretest–posttest design with a single group of participants, the research aims to assess whether incorporating loose parts into instructional activities can lead to significant academic improvement. By focusing on measurable outcomes—namely the statistically significant improvement in students' posttest scores relative to their pretest performance and corresponding effect size, this study not only adds to the limited body of quantitative research but also offers practical

insights for educators and policymakers seeking cost-effective, high-impact strategies. In doing so, it underscores the potential of frugal, resource-conscious teaching approaches to transform learning—especially in settings where material constraints might otherwise hinder student progress. Accordingly, this research seeks to examine to which the implementation of loose parts as a learning resources lead to a significant improvement in students' learning outcome.

METHOD

This study utilized a quantitative one-group pretest-posttest design to assess whether an instructional intervention based on frugal thinking principles using loose parts could significantly improve students' learning outcomes. A pre-experimental one-group pretest-posttest design involves measuring a single group before and after an intervention to assess changes, but it lacks a control group for comparison (Gay et al., 2011). This design is widely used due to its simplicity and practicality, especially in educational and clinical settings—often used as sites for medical research, treatment, assessment, or training, but it is heavily criticized for its vulnerability to threats to internal validity, such as regression to the mean, maturation, history, and testing effects, which can confound results and make it difficult to attribute observed changes solely to the intervention (Knapp, 2016; Marsden & Torgerson, 2012; Spurlock, 2018). Despite these limitations, studies continue to use this approach, often without adequately addressing or acknowledging these methodological concerns (Knapp, 2016; Marsden & Torgerson, 2012). Thus, this approach allows for direct comparison of student performance before and after the intervention within the same group, helping to attribute observed changes to the treatment itself. Such a design is particularly relevant in educational research where resources are limited and random assignment may not be feasible.

In this study, 16 junior high school students from a single class at Junior High School 4, Malang, Indonesia, participated during the 2023 academic year. The class was selected through purposive sampling because it had previously demonstrated low average academic achievement and limited access to learning resources, making it an ideal context for testing frugal innovation strategies in education. Frugal innovation in education emphasizes leveraging available, low-cost resources in creative ways to deliver effective and sustainable learning experiences, particularly in settings with significant constraints (Masters, 2024; Mignenan, 2022). By focusing on such a group, the study aligns with recommendations in the literature to target frugal approaches where they are most needed and potentially most impactful (Masters, 2024; Mignenan, 2022). This context allows for the practical application of frugal education principles, which aim to achieve meaningful educational outcomes without relying on expensive materials or technologies (Masters, 2024). The selection process and context underscore the relevance and necessity of frugal innovation strategies in addressing educational inequities and supporting under-resourced learners (Masters, 2024; Mignenan, 2022).

The instructional intervention was structured to cultivate frugal thinking by engaging students in activities that utilized loose parts—common, everyday objects like bottle caps, stones, sticks, used cardboard, and string—as learning tools. These materials were integrated into a series of structured problem-solving tasks across multiple subjects, encouraging students to approach challenges creatively and resourcefully within the constraints of limited resources. This approach aligns with the principles of constraint-based and frugal innovation, which view limitations as opportunities for inventive solutions and emphasize the value of minimal, accessible materials in fostering critical and creative thinking (Agarwal et al., 2021; Aisyah et al., 2025).

This study employed two types of assessment instruments: a pretest and a posttest, each targeting different aspects of student learning. The pretest was a paper-based cognitive assessment with multiple-choice and short-answer items, designed to gauge students' initial understanding of the targeted concepts. The posttest, in contrast, was a product-based task requiring students to create a tangible output using loose part materials, thereby authentically demonstrating their application of learned concepts and problem-solving abilities. Product-based and authentic assessments are

increasingly recognized for their effectiveness in evaluating real-world problem-solving and higher-order thinking skills, as they require students to synthesize knowledge and demonstrate understanding through practical tasks (Shanta & Wells, 2022; Ukobizaba et al., 2021). Although formal validity testing was not conducted, the development of both the pretest and the product assessment rubric was guided by national curriculum standards and collaborative input from both the researcher and the classroom teacher, ensuring content relevance and alignment with learning objectives. This approach reflects best practices in assessment design, where alignment with curriculum and collaborative development can help ensure meaningful measurement of learning outcomes, even in the absence of formal psychometric validation (Shanta & Wells, 2022; Ukobizaba et al., 2021; Viyanti et al., 2022).

Data were collected through pretest and posttest scores administered before and after the learning intervention. Data were analyzed using a paired Z-test to compare pretest and posttest scores. The Z-test was chosen because the sample size, although small, allowed for the use of a parametric test due to the large and consistent differences observed. The significance level was set at $\alpha = 0.05$. However, given the robustness of the Paired Samples t-Test to slight deviations from normality and the small sample size, the parametric test was deemed appropriate. The Paired Samples t-Test was then conducted to assess the statistical significance of the difference in students' learning outcomes before and after the intervention. The level of significance was set at $\alpha = 0.05$.

FINDINGS

Before discussing the comparison results between the pretest and posttest scores, a normality test was first conducted to determine whether the obtained data met the assumption of normal distribution. The Z test was used due to the relatively small sample size. The results of this test form the basis for determining the appropriate statistical analysis method to compare the pretest and posttest scores.

Table 1
The result of Z Test

Component	Score
Total sample (n)	16
Mean difference (post − pre)	42.0
Standard deviation of the difference (σd)	19.6214
Z-score	8.5621

These results are in line with previous research by Thaariq et al (2023) in the context of student creativity, which reported that the implementation of loose parts-based learning resulted in significant improvements with no negative ranks and high standard gains (0.86). Both studies show that open-ended learning experiences through material manipulation, exploration, and independent problem solving consistently encourage the development of higher-order cognitive abilities.

Thus, this study can be positioned as a continuation study of previous findings. While previous studies emphasized increased creativity, this study expands on that contribution by showing that the same pedagogical principles are also effective in improving other, more complex competencies. These findings provide increasingly strong evidence that exploration-based and constructivist learning approaches are generalizable and relevant to various educational contexts.

The Wilcoxon Signed-Rank Test is a widely used non-parametric statistical method for analyzing paired data, such as pretest and posttest scores, especially when the assumption of normality is violated or when sample sizes are small (Susdarwono, 2021; Woolson, 2005). In our study, the Shapiro–Wilk test indicated that pretest scores were not normally distributed, justifying the use of the Wilcoxon Signed-Rank Test to compare students' performance before and after the intervention. This test works by ranking the absolute differences between paired scores and assessing whether the median difference is significantly different from zero, making it suitable for detecting changes in learning outcomes in educational research (Susdarwono, 2021; Woolson, 2005). Research confirms

that the Wilcoxon Signed-Rank Test is robust and appropriate for small samples and non-normal data, providing reliable results in these contexts (Garren & Davenport, 2022; Woolson, 2005).

Table 2
The result of Wilcoxon Signed-Rank Test

Ranks

		N	Mean Rank	Sum of Ranks
Posttest - Pretest	Negative Ranks	0[a]	,00	,00
	Positive Ranks	16[b]	8,50	136,00
	Ties	0[c]		
	Total	16		

a. Posttest < Pretest
b. Posttest > Pretest
c. Posttest = Pretest

The analysis using the Wilcoxon Signed-Rank Test revealed a significant difference between pretest and posttest scores indicating that students' learning outcomes improved after participating in the loose part-based instructional activity. This significant result suggests that the intervention had a positive effect on student learning, as the Wilcoxon Signed-Rank Test is specifically designed to detect changes in paired data, such as pre- and post-intervention scores, even when the data are not normally distributed or the sample size is small (Susdarwono, 2021; Woolson, 2005). Similar studies have found that a significant Wilcoxon test result reflects meaningful gains in student achievement following educational interventions, supporting the effectiveness of hands-on, resourceful instructional strategies (Susdarwono, 2021). The use of this non-parametric test ensures that the observed improvement is statistically robust, providing strong evidence for the positive impact of the loose part-based approach on students' problem-solving and learning outcomes (Susdarwono, 2021; Woolson, 2005).

DISCUSSION, CONCLUSION, AND SUGGESTIONS

The results of the study indicate that there was a very significant increase between the participants' pretest and posttest scores. The average increase was 42 points and a z-score of 8.56 ($p < 0.001$), indicating that the learning intervention had a strong and consistent impact on improving the participants' competence. All participants experienced an increase in their scores without any negative ranks, confirming that the learning provided was effective for all individuals in the study group. These findings have important pedagogical and empirical implications, especially when linked to previous studies, particularly the research conducted by Thaariq et al. (2023) which examined the increase in student creativity through the use of loose parts.

A z-score of 8.56 indicates that the improvement is not only statistically significant, but also has a very high effect size. This is consistent with the Thaariq et al (2023) data, which reports a standard gain of 0.86, a high improvement category. In this study, when calculating the effect size, an improvement of 42 points indicates a very strong shift in competency. The uniformity of the increase (all participants improved) shows that the intervention provided has scalability potential, meaning it can be applied in a broader learning context without concern that it will only be effective for certain groups. These findings also indicate that the intervention is inclusive and adaptive for students with different initial abilities.

These findings support the idea that frugal thinking, as implemented through loose part-based instruction, can effectively enhance student learning outcomes, especially in resource-limited settings. Research consistently shows that using everyday, low-cost materials in structured educational activities fosters creativity, problem-solving, and critical thinking by encouraging students to engage actively and resourcefully with their environment (Aisyah et al., 2025; Hutajulu & Lukas, 2023; Prameswari & Lestariningrum, 2020; Sukardjo et al., 2023). Studies have demonstrated that

integrating loose parts into learning not only increases students' enthusiasm and independence but also leads to measurable improvements in problem-solving and creativity, as seen in both qualitative and quantitative assessments (Aisyah et al., 2025; Hutajulu & Lukas, 2023; Prameswari & Lestariningrum, 2020; Sukardjo et al., 2023; Trinanda & Yaswinda, 2022). Such approaches align with broader educational trends emphasizing 21st-century skills—creativity, collaboration, communication, and critical thinking—by providing authentic, hands-on experiences that deepen understanding and engagement (Prameswari & Lestariningrum, 2020; Sukardjo et al., 2023). While most research focuses on early childhood, the principles of frugal, inquiry-based learning are applicable across age groups and contexts, making this strategy particularly valuable where conventional resources are scarce (Aisyah et al., 2025; Prameswari & Lestariningrum, 2020; Sam, 2024). Overall, the evidence suggests that loose part-based, frugal instruction is a promising and practical method for supporting meaningful learning and skill development (Aisyah et al., 2025; Hutajulu & Lukas, 2023; Prameswari & Lestariningrum, 2020; Sukardjo et al., 2023).

The use of loose parts in education aligns closely with both constructivist and sociocultural learning theories. Constructivist theory emphasizes that learners actively construct knowledge through hands-on exploration, reflection, and personal experience, making independent choices and building meaning from their interactions with materials and ideas (Chuang, 2021; Pricopie, 2020; Tytler et al., 2019). Sociocultural theory, particularly as developed by Vygotsky, highlights the importance of social interaction, collaboration, and the use of cultural tools in learning, suggesting that students learn best when they engage with others and their environment in meaningful ways (Alkhudiry, 2022; Miller et al., 2020; Nithideechaiwarachok et al., 2024). Loose part-based activities naturally foster these processes by encouraging students to collaborate, negotiate, and problem-solve together, while also allowing for individual agency and creativity (Miller et al., 2020; Nithideechaiwarachok et al., 2024). The integration of product-based assessment, where students demonstrate understanding through real-world application, further supports authentic learning and aligns with sociocultural perspectives that value learning in context and through practice (Castanelli, 2023; Nithideechaiwarachok et al., 2024). Together, these approaches create a learning environment where students are empowered to construct knowledge both independently and socially, reflecting the core principles of constructivist and sociocultural theories (Miller et al., 2020; Nithideechaiwarachok et al., 2024; Pricopie, 2020; Tytler et al., 2019).

These results align with a substantial body of research demonstrating that playful, inquiry-based, and student-centered approaches are highly effective in promoting conceptual understanding and problem-solving skills. Studies have shown that such methods—whether through design jams, inquiry-based STEM activities, or cooperative, hands-on learning—foster critical thinking, creativity, and collaboration, all of which are essential for deep learning and skill development (Gunawan et al., 2020; Karamustafaoğlu & Pektaş, 2023; Kumazah & Agyei, 2025; Saad, 2020; Tang et al., 2020). Inquiry-based teaching, in particular, has been found to significantly enhance students' reasoning abilities, conceptual knowledge, and long-term retention of complex ideas (Gunawan et al., 2020; Kumazah & Agyei, 2025; Tan et al., 2020; Tawfik et al., 2020). The unique contribution of this study lies in its focus on frugal education, which emphasizes simplicity, adaptability, and sustainability by leveraging low-cost, readily available materials to create meaningful learning experiences. This approach not only supports engagement and creativity but also addresses the challenges faced in resource-limited educational settings, making quality learning more accessible and equitable (Karamustafaoğlu & Pektaş, 2023; Saad, 2020). By integrating frugal principles with proven student-centered strategies, the study highlights a practical and innovative pathway for improving educational outcomes in diverse contexts (Karamustafaoğlu & Pektaş, 2023; Saad, 2020; Tang et al., 2020).

Then, this study can be positioned as a direct continuation of Thaariq et al's (2023) study because (1) it uses the same pretest–posttest design; (2) it shows an identical pattern of improvement in all

participants; (3) it utilizes the same activity-based learning principles; and (4) it expands the application from creativity to broader and more complex competencies. Thus, this study tends to provide an empirical extension that strengthens the evidence that exploration-based learning and environmental manipulation are effective in various educational contexts and areas of competence.

Certain limitations should be acknowledged when interpreting these findings. The absence of a control group restricts the ability to draw strong causal inferences, as improvements in learning outcomes could be influenced by factors other than the intervention itself (Hassan et al., 2022; Masters, 2024). Additionally, the lack of formal validation for the assessment instruments may affect the reliability and generalizability of the results, a common challenge in studies of frugal or innovative educational practices (Jayabalan et al., 2022; Masters, 2024). Small sample sizes further limit the statistical power and the extent to which findings can be applied to broader populations (Hassan et al., 2022; Masters, 2024). To strengthen future research, it is recommended to employ larger samples, include control or comparison groups, and use validated rubrics or assessment tools to enhance the reliability and impact of similar interventions (Hassan et al., 2022; Jayabalan et al., 2022; Masters, 2024). Addressing these methodological considerations will help ensure that the benefits of frugal education approaches are robustly demonstrated and more widely applicable across diverse educational contexts (Jayabalan et al., 2022; Masters, 2024).

Thus, this study examined the effect of a frugal learning approach—particularly the use of loose part-based instruction—on student learning outcomes in a resource-constrained classroom setting. The findings revealed a significant increase in posttest scores compared to pretest scores, indicating the effectiveness of the intervention. The nonparametric Wilcoxon signed-rank test confirmed that the improvement was statistically significant, despite the small sample size and non-normal distribution of data. This research supports the idea that frugal innovation in education does not require high-cost tools or sophisticated technologies to achieve meaningful learning outcomes. Instead, it emphasizes the power of contextualized, student-centered learning experiences that leverage creativity, environmental awareness, and constructivist engagement. The use of loose parts encouraged exploration, collaboration, and higher-order thinking—core components of 21st-century skills. Despite its limitations—such as the absence of a control group and the lack of standardized validity testing for the instruments—the study contributes to a growing body of knowledge advocating for inclusive and sustainable pedagogical practices. Future research is recommended to explore long-term impacts of frugal learning strategies, apply them across diverse educational settings, and develop more robust assessment frameworks. In conclusion, this study demonstrates that frugal thinking in action can lead to meaningful educational change, especially when grounded in strong pedagogical design and responsive to learners' real-world contexts.

REFERENCES

Agarwal, N., Oehler, J., & Brem, A. (2021). Constraint-Based Thinking: A Structured Approach for Developing Frugal Innovations. *IEEE Transactions on Engineering Management*, *68*(3), 739–751. https://doi.org/10.1109/TEM.2020.3042929

Aisyah, E. N., Utamimah, S., & Baharun, H. (2025). Implementing Project-Based Learning with Loose Parts in Early Childhood Education: A Qualitative Descriptive Study. *Golden Age: Jurnal Ilmiah Tumbuh Kembang Anak Usia Dini*, *10*(1), Article 1. https://doi.org/10.14421/jga.2025.101-06

Akhter, N., Khan, A. M., & Rehman, A. (2018). Efficient Management of Financial Resource and Constraints in Implementation of Budget at Secondary Schools. *Global Social Sciences Review*, *III*(III), 529–542. https://doi.org/10.31703/gssr.2018(iii-iii).31

Alkhudiry, R. (2022). The Contribution of Vygotsky's Sociocultural Theory in Mediating L2 Knowledge Co-Construction. *Theory and Practice in Language Studies*, *12*(10), Article 10. https://doi.org/10.17507/tpls.1210.19

Angrist, N., Evans, D. K., Filmer, D., Glennerster, R., Rogers, H., & Sabarwal, S. (2023, November 20). *How to improve education outcomes most efficiently?* What Works Hub for Global Education. https://www.wwhge.org/resources/how-to-improve-education-outcomes-most-efficiently/

Angrist, N., Evans, D. K., Filmer, D., Glennerster, R., Rogers, H., & Sabarwal, S. (2025). How to improve education outcomes most efficiently? A review of the evidence using a unified metric. *Journal of Development Economics*, *172*, 103382. https://doi.org/10.1016/j.jdeveco.2024.103382

Aulia, M. P., Sudarti, S., & Zar'in, F. (2024). Implementation of Project Based Learning Method in Developing Cognitive Abilities of Children Aged 5-6 Years Through Loose Parts Media. *Journal Of Education And Teaching Learning (JETL)*, *6*(1), Article 1. https://doi.org/10.51178/jetl.v6i1.1793

Cankaya, O., Martin, M., & Haugen, D. (2025). The Relationship Between Children's Indoor Loose Parts Play and Cognitive Development: A Systematic Review. *Journal of Intelligence*, *13*(5), Article 5. https://doi.org/10.3390/jintelligence13050052

Castanelli, D. (2023). Sociocultural learning theory and assessment for learning. *Medical Education*, *57*(5), 382–384. https://doi.org/10.1111/medu.15028

Chin, J. M., & Chuang, C.-P. (2015). The Relationships Among School-Based Budgeting, Innovative Management, and School Effectiveness: A Study on Specialist Schools in Taiwan. *The Asia-Pacific Education Researcher*, *24*(4), 679–693. https://doi.org/10.1007/s40299-014-0220-3

Chuang, S. (2021). The Applications of Constructivist Learning Theory and Social Learning Theory on Adult Continuous Development. *Performance Improvement*, *60*(3), 6–14. https://doi.org/10.1002/pfi.21963

Cox, G., Masuku, B., & Willmers, M. (2020). Open Textbooks and Social Justice: Open Educational Practices to Address Economic, Cultural and Political Injustice at the University of Cape Town. *Journal of Interactive Media in Education*, *2020*(1). https://doi.org/10.5334/jime.556

Garren, S. T., & Davenport, G. H. (2022). Using Kurtosis for Selecting One-Sample T-Test or Wilcoxon Signed-Rank Test. *Current Journal of Applied Science and Technology*, 46–55. https://doi.org/10.9734/cjast/2022/v41i1831737

Gay, L. R., Mills, G. E., & Airasian, P. W. (2011). *Educational Research: Competencies for Analysis and Applications* (10th edition). Pearson.

Griffiths, R., Mislevy, J., & Wang, S. (2022). Encouraging impacts of an Open Education Resource Degree Initiative on college students' progress to degree. *Higher Education*, *84*(5), 1089–1106. https://doi.org/10.1007/s10734-022-00817-9

Gunawan, G., Harjono, A., Nisyah, M., Kusdiastuti, M., & Herayanti, L. (2020). Improving Students' Problem-Solving Skills Using Inquiry Learning Model Combined with Advance Organizer. *International Journal of Instruction*, *13*(4), 427–442.

Hamilton, A., & Hattie, J. (2022). *The Lean Education Manifesto: A Synthesis of 900+ Systematic Reviews for Visible Learning in Developing Countries*. Routledge. https://doi.org/10.4324/9781003166313

Hassan, E., Groot, W., & Volante, L. (2022). Education funding and learning outcomes in Sub-Saharan Africa: A review of reviews. *International Journal of Educational Research Open*, *3*, 100181. https://doi.org/10.1016/j.ijedro.2022.100181

Hutajulu, S. T. C., & Lukas, S. (2023). Enhancing K2 Students' Skills With Loose Parts at Kindergarten XYZ. *Murhum : Jurnal Pendidikan Anak Usia Dini*, *4*(2), Article 2. https://doi.org/10.37985/murhum.v4i2.362

Imamah, Z., & Muqowim, M. (2020). Pengembangan kreativitas dan berpikir kritis pada anak usia dini melalui metode pembelajaran berbasis STEAM and loose part. *Yinyang: Jurnal Studi Islam Gender Dan Anak*, 263–278. https://doi.org/10.24090/yinyang.v15i2.3917

Isnariyati, E., Khotimah, N., Setyowati, S., Hasibuan, R., Malaikosa, Y. M. L., & Fitri, R. (2025). The Impact of STEAM Learning with Loose Parts on the Cognitive and Artistic Development of Children Aged 5-6 Years. *Journal of Islamic Education Students (JIES)*, *5*(1), 35–45. https://doi.org/10.31958/jies.v5i1.14822

Jayabalan, J., Dorasamy, M., Raman, M., Sambasivan, M., & Harun, S. (2022). Unleashing frugal innovation in private higher education institutions via intellectual capital and Information technology capability: A systematic literature review. *F1000Research*, *10*, 1109. https://doi.org/10.12688/f1000research.73329.2

Jenkins, J. J., Sánchez, L. A., Schraedley, M. A. K., Hannans, J., Navick, N., & Young, J. (2020). Textbook Broke: Textbook Affordability as a Social Justice Issue. *Journal of Interactive Media in Education*, *2020*(1). https://doi.org/10.5334/jime.549

Karamustafaoğlu, O., & Pektaş, H. M. (2023). Developing students' creative problem solving skills with inquiry-based STEM activity in an out-of-school learning environment. *Education and Information Technologies*, *28*(6), 7651–7669. https://doi.org/10.1007/s10639-022-11496-5

Kinyaduka, B. D. (2023). School Teacher Quality Improvement Model. *Journal of Education and Practice*, *14*(33), 61.

Knapp, T. R. (2016). Why Is the One-Group Pretest–Posttest Design Still Used? *Clinical Nursing Research*, *25*(5), 467–472. https://doi.org/10.1177/1054773816666280

Kristiyani, E., Hafidah, R., & Pudyaningtyas, A. R. (2024). Dampak Pendekatan Pembelajaran STEAM dengan Media Loose Part pada Kreativitas Anak Usia 5-6 Tahun. *Kumara Cendekia*, *12*(1), Article 1. https://doi.org/10.20961/kc.v12i1.65168

Kumazah, V., & Agyei, P. D. D. (2025). Uncovering the Power of Inquiry-Based Teaching; Enhancing Geometric Thinking Skills in Students. *IJFMR - International Journal For Multidisciplinary Research*, *7*(1). https://doi.org/10.36948/ijfmr.2025.v07i01.34568

Lim, C. A. M., Kaveri, G., Li, J., & Choy, M. Y. (2024). Supporting parents in facilitating computational thinking for young children through loose parts construction play. *Future in Educational Research*, *2*(4), 346–358. https://doi.org/10.1002/fer3.43

Marsden, E., & Torgerson, C. J. (2012). Single group, pre- and post-test research designs: Some methodological concerns. *Oxford Review of Education*, *38*(5), 583–616. https://doi.org/10.1080/03054985.2012.731208

Masters, A. (2024). Frugal Education: What, why, and how? *Future in Educational Research*, *2*(2), 109–130. https://doi.org/10.1002/fer3.32

Mignenan, V. (2022). Management of Frugal Innovation Projects: Research Approach and Perspectives. *International Business Research*, *15*(4), Article 4. https://doi.org/10.5539/ibr.v15n4p121

Miller, C., Manderfeld, M., & Harsma, E. (2020). Learning Theories: Socio-Constructivism. *All Resources*. https://cornerstone.lib.mnsu.edu/all/144

Muawanah, U., Yulianingsih, E., & Sari, R. P. (2024). The Use of Loose Parts in Enhancing the Naturalist Intelligence of Early Childhood. *Syaikhuna: Jurnal Pendidikan Dan Pranata Islam*, *15*(1), Article 1. https://doi.org/10.62730/syaikhuna.v15i1.7316

Muntomimah, S., & Wijayanti, R. (2021). *The Importance of STEAM Loose Part Learning Effectiveness in Early Childhood Cognitive Learning*. 47–52. https://doi.org/10.2991/assehr.k.210413.012

Nipriansyah, N., Sasongko, R. N., Kristiawan, M., Susanto, E., & Hasanah, P. F. A. (2021). Increase Creativity And Imagination Children Through Learning Science, Technologic, Engineering, Art And Mathematic With Loose Parts Media. *Al-Athfaal: Jurnal Ilmiah Pendidikan Anak Usia Dini*, *4*(1), 77–89. https://doi.org/10.24042/ajipaud.v4i1.8598

Nithideechaiwarachok, B., Chano, J., & Wu, C. C. (2024). Socio-cultural and Social Constructivist Theories and Its Application in EFL Classroom for Thai Pre-service Teachers: A Review for Further Research. *International Journal of Language Education*, *8*(3), Article 3. https://doi.org/10.26858/ijole.v8i3.66499

Pashela, P., SIBAWAIHI, Prasetyo, S., & Aziz, H. (2024). Media Loose Parts Untuk Meningkatkan Kreativitas Anak 5-6 Tahun di Raudhatul Athfal Nurul Dzikri. *Incrementapedia : Jurnal Pendidikan Anak Usia Dini*, *6*(2), Article 2. https://doi.org/10.36456/incrementapedia.vol6.no2.a9806

Prameswari, T. W., & Lestariningrum, A. (2020). STEAM based learning strategies by playing loose parts for the achievement of 4c skills in children 4-5 years. *Jurnal Efektor*, *7*(1), 24–34.

Pricopie, V. (2020). Constructivism. In *The SAGE International Encyclopedia of Mass Media and Society* (pp. 377–378). SAGE Publications, Inc. https://doi.org/10.4135/9781483375519

Rianti, R., Nurjanah, I., Latifah, D., Alifah, N., & Asyiah, A. (2022). Freedom Learning on Early Childhood Education: Implementation of STEAM Method with Loose Parts Media. *Golden Age: Jurnal Ilmiah Tumbuh Kembang Anak Usia Dini*, *7*(2), Article 2. https://doi.org/10.14421/jga.2022.72-05

Saad, A. (2020). Students' Computational Thinking Skill through Cooperative Learning Based on Hands-on, Inquiry-based, and Student-centric Learning Approaches. *Universal Journal of Educational Research*, *8*(1), 290–296. https://doi.org/10.13189/ujer.2020.080135

Sam, R. (2024). Systematic review of inquiry-based learning: Assessing impact and best practices in education. *F1000Research*, *13*, 1045.

Sardi, M., & Mayar, F. (2023). The Effect of Loose Parts on the Development of Early Childhood Creativity. *AL-ISHLAH: Jurnal Pendidikan*, *15*(3), Article 3. https://doi.org/10.35445/alishlah.v15i3.4107

Shanta, S., & Wells, J. G. (2022). T/E design based learning: Assessing student critical thinking and problem solving abilities. *International Journal of Technology and Design Education*, *32*(1), 267–285. https://doi.org/10.1007/s10798-020-09608-8

Shull, P. J. (2022, July 31). *Low Cost—High Impact: Success Skills Students Will Actually Use*. 2022 First-Year Engineering Experience. https://peer.asee.org/low-cost-high-impact-success-skills-students-will-actually-use

Spica, E., & Biddix, J. P. (2021). Prices They Pay: Academic Achievement and Progress to Graduation Barriers Experienced by Community College Students Due to the Cost of Course Materials. *Innovative Higher Education*, *46*(6), 643–662. https://doi.org/10.1007/s10755-021-09557-7

Spurlock, D. R. (2018). The Single-Group, Pre- and Posttest Design in Nursing Education Research: It's Time to Move on. *Journal of Nursing Education*, *57*(2), 69–71. https://doi.org/10.3928/01484834-20180123-02

Sukardjo, M., Nirmala, B., Ruiyat, S. A., Annuar, H., & Khasanah5, U. (2023). Loose Parts: Stimulation of 21st Century Learning Skills (4C Elements). *Jurnal Obsesi : Jurnal Pendidikan Anak Usia Dini*, *7*(1), 1073–1086. https://doi.org/10.31004/obsesi.v7i1.4088

Susdarwono, E. T. (2021). Testing through the Mann-Whitney Method and the Wilcoxon Signed Level on Learning Cube and Perfect Cube Roots. *Journal of Education and Learning Mathematics Research (JELMaR)*, *2*(1), 26–36.

Tan, R. M., Yangco, R. T., & Que, E. N. (2020). Students' Conceptual Understanding and Science Process Skills in an Inquiry-Based Flipped Classroom Environment. *Malaysian Journal of Learning and Instruction*, *17*(1), 159–184.

Tang, T., Vezzani, V., & Eriksson, V. (2020). Developing critical thinking, collective creativity skills and problem solving through playful design jams. *Thinking Skills and Creativity*, *37*, 100696. https://doi.org/10.1016/j.tsc.2020.100696

Tawfik, A. A., Hung, W., & Giabbanelli, P. J. (2020). Comparing How Different Inquiry-based Approaches Impact Learning Outcomes. *Interdisciplinary Journal of Problem-Based Learning*, *14*(1), Article 1. https://doi.org/10.14434/ijpbl.v14i1.28624

Thaariq, Z. Z. A., Aulia, F., Nurdiyanto, R., Izza, J. N., Sulfa, D. M., Aruna, A., & Wijanarko, D. A. (2023). *Enhancing Student Creativity through the Implementation of Loose Parts*. International Conference on Studies in Education and Social Studies (ICSES), Antalya. https://eric.ed.gov/?id=ED652401

Trinanda, M. A., & Yaswinda, Y. (2022). *The Effect of Using Loose Parts Media on Critical Thinking Ability in Children Aged 5-6 Years in Learning in Kindergarten*. 46–49. https://doi.org/10.2991/assehr.k.220602.010

Tytler, R., Ferguson, J., & White, P. (2019). Constructivist and Sociocultural Theories of Learning. In *The Art of Teaching Science* (3rd ed.). Routledge.

Ukobizaba, F., Nizeyimana, G., & Mukuka, A. (2021). Assessment Strategies for Enhancing Students' Mathematical Problem-solving Skills: A Review of Literature. *Eurasia Journal of Mathematics, Science and Technology Education*, *17*(3), em1945. https://doi.org/10.29333/ejmste/9728

Viyanti, V., Rosidin, U., & Shintya, R. E. (2022). *Collaborative and Problem Solving Instruments in Project-Based Physics Learning | Indonesian Journal of Science and Mathematics Education*. https://ejournal.radenintan.ac.id/index.php/IJSME/article/view/11636

Wahyuningsih, S., Pudyaningtyas, A. R., Nurjanah, N. E., Dewi, N. K., Hafidah, R., Syamsuddin, M. M., & Sholeha, V. (2020). The Utilization of Loose Parts Media in Steam Learning for Early Childhood. *Early Childhood Education and Development Journal*, *2*(2), Article 2. https://doi.org/10.20961/ecedj.v2i2.46326

Wakefield, J., & Tashman, L. S. (2020). Creating Powerful Classroom Experiences on a Low Budget. In *High Impact Teaching for Sport and Exercise Psychology Educators*. Routledge.

Wimberley, L., Cheney, E., & Ding, Y. (2020). Equitable student success via library support for textbooks. *Reference Services Review*, *48*(3), 373–383. https://doi.org/10.1108/RSR-03-2020-0024

Woolson, R. F. (2005). Wilcoxon Signed-Rank Test. In *Encyclopedia of Biostatistics*. John Wiley & Sons, Ltd. https://doi.org/10.1002/0470011815.b2a15177