Journal of Posthumanism
2025
Volume: 5, No: 3, pp. 743–755
ISSN: 2634-3576 (Print) | ISSN 2634-3584 (Online)
posthumanism.co.uk

DOI: https://doi.org/10.63332/joph.v5i3.783

Utilizing Natural Materials in Early Mathematics Education: Applying Bruner's Theory to Early Childhood Learning in Surakarta

Sudarti[1], Bambang Sumardjoko[2], Harsono[3], Sabar Narimo[4], Yan Surono[5]

Abstract

Early mathematics education is a fundamental aspect of children's cognitive development and plays a crucial role in their future academic success. However, conventional teaching methods in early childhood education (ECE) often rely on lectures and worksheets, lacking exploration and deep conceptual understanding. Bruner's learning theory (1966), which consists of enactive, iconic, and symbolic stages, provides an effective framework for early mathematics learning by emphasizing active engagement through concrete experiences before moving to abstraction. This study investigates the impact of nature-based early mathematics learning using Bruner's approach on the cognitive achievement of young children. A quasi-experimental research method with a one-group pretest-posttest design was employed. The participants consisted of 4–5-year-old children from a preschool in Surakarta, Indonesia. The findings revealed a Cronbach Alpha score of 0.732 and a significant improvement in children's cognitive abilities after implementing nature-based learning with Bruner's approach. These results suggest that integrating natural materials into early mathematics education can enhance children's understanding of mathematical concepts by providing richer and more meaningful sensory experiences. Additionally, this research contributes to the literature by exploring an alternative and innovative teaching strategy that leverages natural resources to support early childhood learning. The study has practical implications for educators, encouraging the adoption of nature-based learning to foster interactive and developmentally appropriate mathematics instruction. Future research should explore long-term effects and broader applications of this approach in different educational settings.

Keywords: *Bruner's Learning Theory, Cognitive Achievement, Early Mathematics Learning, Early Childhood Education, Natural Materialstechnology*

Introduction

Early mathematical understanding plays a crucial role in children's cognitive development and serves as a key factor in their future academic success (Ramani & Sigler, 2008; Cross et al., 2009; Jordan, Glutting, & Watkins, 2010). Children with a strong grasp of fundamental mathematical concepts are more likely to achieve higher academic performance in subsequent educational levels (Dunphy et al., 2014). However, international studies such as the Trends in International Mathematics and Science Study (TIMSS) indicate that Indonesian students'

[1] Doctoral Program of Education student, Universitas Muhammadiyah Surakarta (UMS), Surakarta, Indonesia, Email: sudarti360@gmail.com.
[2] Full Professor of Education, Facultyof Teacher Training and Science, Universitas Muhammadiyah Surakarta, Surakarta, Indonesia, Email: b131@ums.ac.id.
[3] Full Professor of Economic Education, Facultyof Teacher Training and Science UMS, Surakarta, Indonesia, Email: har152@ums.ac.id.
[4] Full Professor of Economin Education, Facultyof Teacher Training and Science UMS, Surakarta, Indonesia, Email: sn124@ums.ac.id.
[5] Doctor of Education, Department Teacher Training and Science, Assalaam Boarding School, Surakarta, Indonesia, Email: ysuro77@gmail.com.

mathematics proficiency remains below the global average (Mullis, Martin, Foy, & Arora, 2016) These findings highlight challenges in Indonesia's mathematics teaching approaches, particularly at the early childhood level, which may impact academic achievement in later stages of education.

Although several studies have emphasized the importance of using concrete media in early mathematics learning (Clements & Sarama, 2011; Gasteiger, H, & Benz, 2018), research specifically examining the effectiveness of natural materials in supporting Bruner's learning stages remains limited. Most previous studies have focused on the use of artificial teaching aids or digital technology, while the potential of utilizing natural resources available in children's surroundings has not been widely explored (Sutama, 2022). Therefore, further research is needed to analyze how natural materials can be optimally utilized to support Bruner's learning stages in early mathematics education (Widodo et. al. 2021)

This study introduces an innovative approach to early mathematics learning by utilizing natural materials as the primary medium in the application of Bruner's theory. This approach contributes new insights to educational literature by demonstrating how the exploration of natural materials can deepen and enhance young children's understanding of mathematical concepts in a more meaningful way. Additionally, this research provides practical guidance for educators in designing more interactive learning strategies that align with children's developmental characteristics. Therefore, this study is expected to contribute to improving the quality of early mathematics education in Indonesia while addressing the challenges identified in international studies such as TIMSS.

To date, early mathematics learning approaches in preschools have largely been dominated by conventional methods, such as lectures and practice exercises, which place little emphasis on exploration and deep conceptual understanding (Sarama & Clements, 2009). Several studies have highlighted the importance of using manipulative media in mathematics education to enhance conceptual comprehension (Clements & Sarama, 2011). However, research specifically evaluating the effectiveness of using natural materials as a learning medium in the context of early mathematics education remains limited.

Bruner's learning theory (1966) provides a structured approach to early mathematics education through three key stages: enactive (direct experience), iconic (visual representation), and symbolic (abstraction). This approach highlights the importance of active child engagement in the learning process, starting with concrete experiences before progressing to abstract thinking. Utilizing natural materials as learning media aligns with Bruner's principles, as it enables children to explore mathematical concepts firsthand through richer and more meaningful sensory experiences.

Method

This study employs a quasi-experimental design using a one-group pretest-posttest method. The research participants consist of 37 children aged 4–5 years from a preschool in Surakarta, Indonesia.

The treatment involved early mathematics learning based on Bruner's theory using natural materials, applied to Class A, which included students aged 4 to 5 years. After implementing the learning approach, the children's learning outcomes were compared to their pre-treatment scores. One of the advantages of this experimental design is the ability to directly compare pretest and posttest results within the same group, allowing for a more accurate measurement of the learning intervention's impact.

Research Design

This research design can be illustrated using a one-group pretest-posttest diagram.

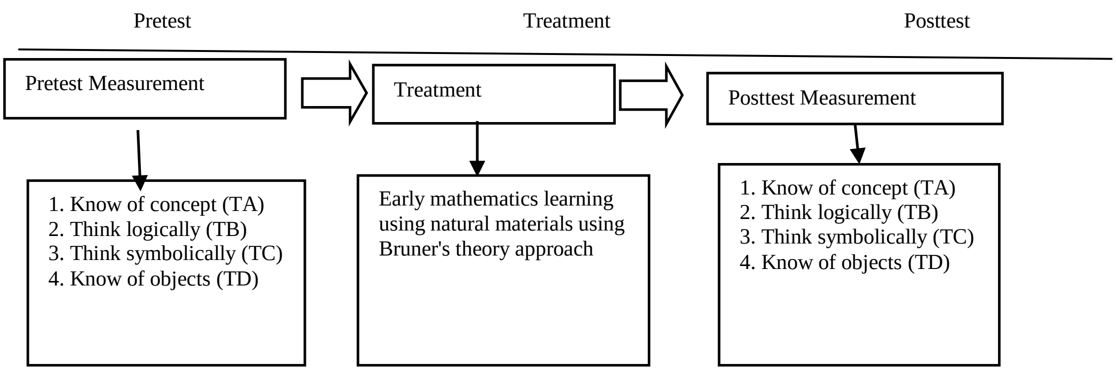

Figure 1. Research Design

The research design employed in this study is the one-group pretest-posttest design, which falls under the quasi-experimental method. This design allows researchers to measure changes in children's cognitive achievement before and after receiving the intervention, which involves early mathematics learning using natural materials based on Bruner's theory. During the pretest phase, an initial assessment is conducted to evaluate children's cognitive abilities before the intervention is applied. Subsequently, children participate in a structured learning process that emphasizes the exploration of natural materials, aligning with Bruner's enactive, iconic, and symbolic stages. After the learning period, a posttest is administered to assess improvements in children's mathematical understanding and skills. The advantage of this design is its ability to directly identify the impact of the intervention on the same subjects, even without a control group. However, its limitation lies in potential internal biases, such as history effects or maturation, which may influence the research outcomes.

Research Implementation Procedure

The research subjects are students from an early childhood education (PAUD) institution in Surakarta, Indonesia, with a sample taken from Group A, consisting of students aged 4–5 years. The research implementation procedure is presented in Figure 2.

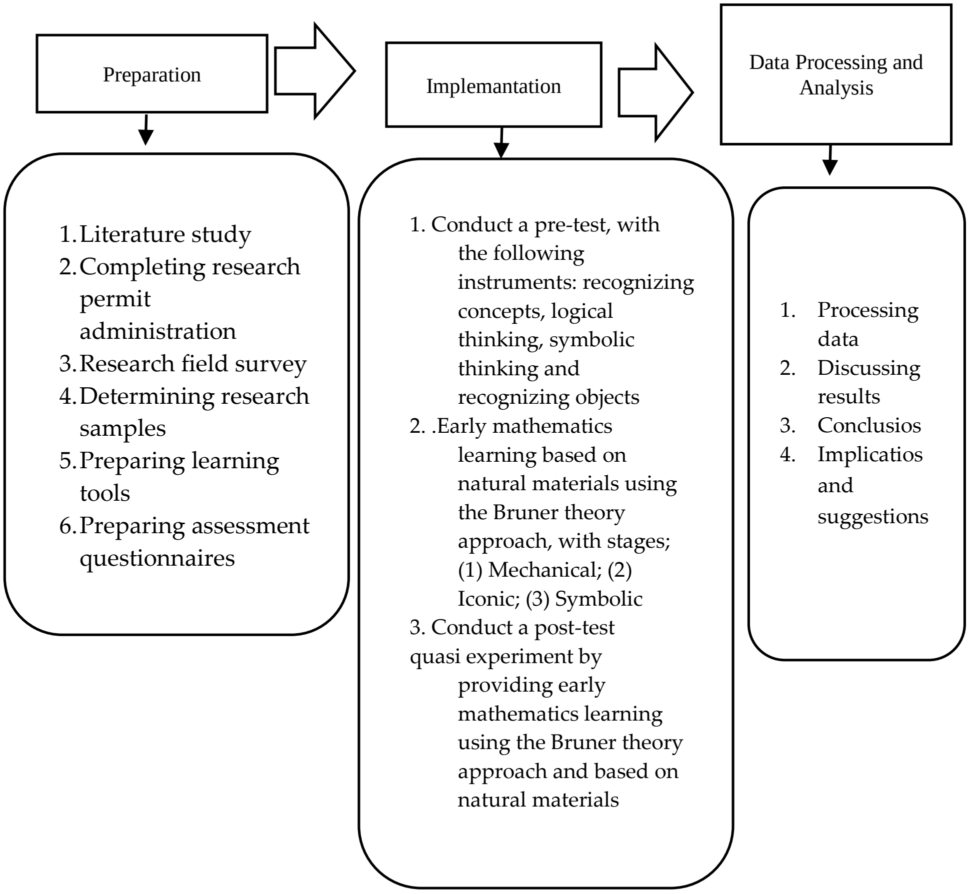

Figure 2. Research Implementation Procedure

Pretest to assess children's initial abilities. Implementation of early mathematics learning using natural materials based on Bruner's theory over several weeks. Posttest to measure children's final abilities.

Data Analysis. Data analysis was conducted using descriptive statistics and paired t-tests to compare pretest and posttest results. This study employs statistical analysis techniques, including descriptive statistical analysis, multiple linear regression analysis, classical assumption tests, and hypothesis testing to analyze the collected data (Ghozali, 2016).

The research instrument used is an early mathematics ability test, covering four aspects: understanding concepts, logical thinking, symbolic thinking, and object recognition. This instrument has been validated and tested for reliability.

Results or Findings

Validity Test; Based on the validity test results, the four instruments used in this study showed a significance level below 0.05. Consequently, the null hypothesis (H0) is rejected, indicating that all instruments meet the validity criteria and are deemed appropriate and suitable for use in the study..

Reliability Test; Reliability testing aims to assess the consistency of a questionnaire when used in repeated measurements. According to Imam Ghozali, a questionnaire is considered reliable if the coefficient value in the Cronbach's Alpha test exceeds 0.70.

Table 1. Reliability Levels

Reliability Coefficient	Criteria
> 0,9	Highly Reliable
0,7 – 0,9	Reliable
0,4 – 0,7	Moderately Reliable
0,2 – 0,4	Less Reliable
< 0, 2	No Reliable

Reliability Statistics	
Cronbach's Alpha	N of Items
.732	13

Table 2. Output Reliability Test Variable A, B, C, and D

Based on the test results, the questionnaire obtained a reliability score of 0.732. This value falls within the reliable category, indicating that the questionnaire meets reliability standards and demonstrates good consistency.

Pre-Test and Post-Test Difference Test

H0: There is no difference between the results before using natural materials with Bruner's theory approach and after using natural materials with Bruner's theory approach.

H1: There is a difference between the results before and after using natural materials with Bruner's theory approach.

Reject H0 if the significance value (test result significance level) is < 0.05.

The test was conducted using the Wilcoxon signed-rank test.

Test Statistics[a]				
	post_TA - pre_TA	post_TB - pre_TB	post_TC - pre_TC	post_TD - pre_TD
Z	-5.036[b]	-2.647[b]	-4.970[b]	-4.621[b]
Asymp. Sig. (2-tailed)	.000	.008	.000	.000
a. Wilcoxon Signed Ranks Test				
b. Based on negative ranks.				

Table 3. Output Wilcoxon Signed-Rank Test

Based on the table above, it is evident that among the four tested indicators, the concept recognition indicator has a significance value of < 0.05. Consequently, H0 is rejected, indicating a difference between the results before and after using natural materials with Bruner's theory approach.

Concept Recognition Indicator (TA)

The explanation of the differences in the concept recognition indicator is as follows:

Descriptive Statistics					
	N	Mean	Std. Deviation	Minimum	Maximum
pre_TA	37	14.92	2.203	9	19
post_TA	37	19.38	1.233	15	20

Table 4. Descriptive Statistics for Conceps Recognition (TA)

Based on the table 4, before using natural materials with Bruner's theory approach, the average respondent score for the concept recognition indicator was 14.92 out of 20. After using natural materials with Bruner's theory approach, the average score increased to 19.38 out of 20. The minimum score in the pre-test was 9, which increased to 19 out of 20 in the post-test. The maximum score in the pre-test was 19, which increased to 20 out of 20 in the post-test.

Logical Thinking Indicator (TB)

The explanation of the logical thinking indicator is as follows:

Descriptive Statistics					
	N	Mean	Std. Deviation	Minimum	Maximum
pre_TB	37	6.35	1.136	3	8
post_TB	37	7.05	.998	6	8

Table 5. Descriptive Statistics for Logical Thinking (TB)

For the descriptive analysis of the logical thinking indicator, the average score in the post-test increased compared to the pre-test. The pre-test average was 6.35, which then increased to 7.05

in the post-test.

The minimum score also showed an improvement in the post-test. In the pre-test, the minimum score was 3 points, which increased to 6 points in the post-test. Meanwhile, the maximum score remained the same for both pre-test and post-test at 8 points, which is the highest possible score.

Symbolic Thinking Indicator (TC)

The following is an explanation of the symbolic thinking indicator.

Descriptive Statistics					
	N	Mean	Std. Deviation	Minimum	Maximum
pre_TC	37	8.84	1.365	5	11
post_TC	37	11.22	1.294	9	16

Table 5. Descriptive Statistics for Symbolic Thinking (TC)

In the descriptive analysis of the symbolic thinking indicator, the post-test average showed an improvement compared to the pre-test. The pre-test yielded an average score of 8.84, which increased to 11.22 in the post-test.

The minimum score also showed progress, rising from 5 points in the pre-test to 9 points in the post-test.

Additionally, the maximum score increased as well. During the pre-test, the highest score recorded was 11 points, which later reached 16 points in the post-test, marking the highest possible score.

Object Recognition Indicator

The explanation of the object recognition indicator is as follows.

Descriptive Statistics					
	N	Mean	Std. Deviation	Minimum	Maximum
pre_TD	37	9.11	1.385	3	11
post_TD	37	11.11	1.295	9	12

Table 5. Descriptive Statistics for Object Recognition (TD)

In the descriptive analysis of the object recognition indicator, the post-test average showed an improvement compared to the pre-test. The pre-test resulted in an average score of 9.11, which increased to 11.11 in the post-test.

The minimum score also showed an increase, rising from 3 points in the pre-test to 9 points in the post-test.

Similarly, the maximum score improved. During the pre-test, the highest score recorded was 11 points, which increased to 12 points in the post-test, representing the highest possible score.

Discussion and Conclusion

The descriptive statistical analysis of the four indicators concept recognition (TA), logical thinking (TB), symbolic thinking (TC), and object recognition (TD) shows an improvement between the pre-test and post-test results in early mathematics learning using natural materials with Bruner's theory approach.

Thus, the implementation of early mathematics learning based on natural materials using Bruner's theory in Group A (ages 4-5 years) at a kindergarten in Surakarta, Indonesia, demonstrated positive progress. Therefore, the research hypothesis can be accepted.

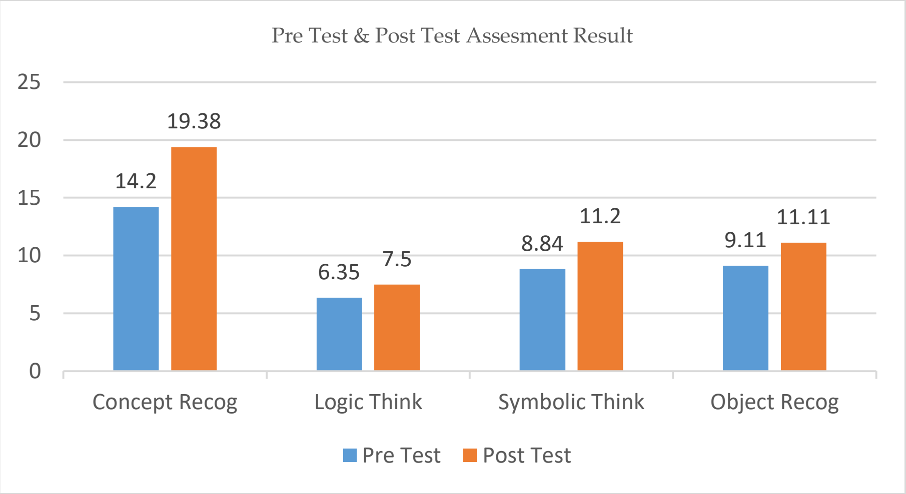

Figure 3. Diagram Pre test and Post Test Assesment Result

The use of natural materials in early childhood mathematics learning is highly effective, as incorporating real objects makes lessons more engaging compared to using worksheets. This aligns with the findings of Bassok et al. (Bassok et al, 2016, p. 14), which suggest that a worksheet-based pedagogical approach in preschool education is less appealing.

Bruner's theory enhances early mathematics learning by helping young learners gradually transition from concrete to abstract concepts, making it easier for them to understand. The implementation of Bruner's theory aligns well with early childhood education principles, as young children enjoy exploring their structured and diverse surroundings (Baroody, A. J., Clements, D., & Sarama, J., 2019).

Furthermore, early mathematical proficiency significantly influences the development of attitudes and competencies in other areas. A strong foundation in early mathematics supports the development of critical thinking skills (Sutama et al., 2022). Additionally, mathematical proficiency fosters independence (Widodo et al., 2022), enhances problem-solving abilities through reasoning and logical thinking (Novitasari et al., 2022), and contributes to the improvement of self-regulated learning (Naufal et al., 2022).

Stages of Early Mathematics Learning Based on Natural Materials with Bruner's Theory Approach

The teacher introduces natural materials that can be used as learning media for early mathematics. The selected materials must be safe for students and easily available around their homes.

- **Enactive Stage**: The teacher engages students in counting activities using natural materials.

- **Iconic Stage**: The teacher guides students to complete worksheets, where they count pictures of objects and write the corresponding numerical symbols.

- **Symbolic Stage**: The teacher assists students in writing numerical symbols that match the given examples.

Figure 4. Natural Material Used

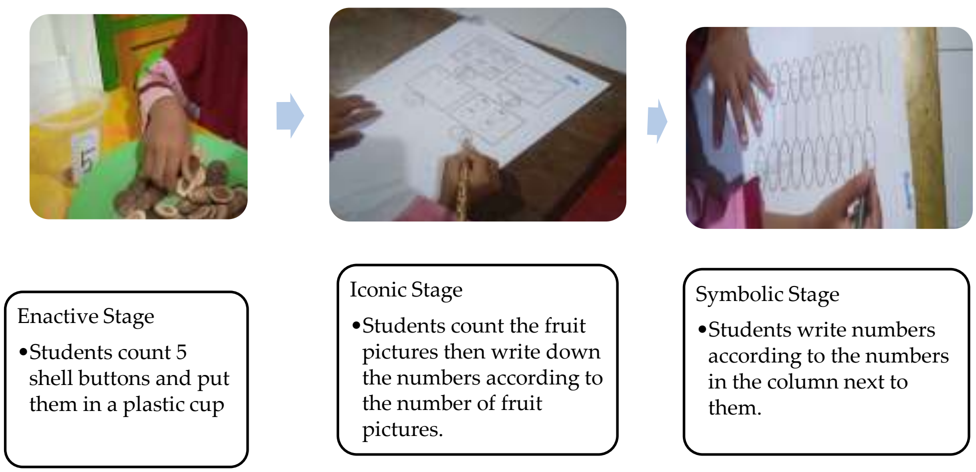

Figure 5. Stages Implementating The Bruner teory

Early Mathematics Learning Achievement Based on Natural Materials with Bruner's Theory Approach

This study examines the effectiveness of early mathematics learning by utilizing natural materials as learning media and applying Bruner's theory approach. The research instrument includes four key variables: (1) concept recognition (Variable A), (2) logical thinking (Variable B), (3) symbolic thinking (Variable C), and (4) object recognition (Variable B). Instrument validity and reliability tests were conducted to ensure measurement feasibility, with an r value of 0.3246 for a sample size of 37. Instrument validity was determined based on the following criteria:

- If $r_{calculated}$} > r_{table}, the instrument is considered valid.

- If $r_{calculated}$} < r_{table}, the instrument is considered invalid.

- Based on significance level alpha = 0,05:
  - If Sig. 2-tailed < 0.05, the instrument is valid.
  - If Sig. 2-tailed > 0.05, the instrument is invalid.

The paired t-test results indicate a significant improvement in children's early mathematics skills after implementing learning based on natural materials with Bruner's theory approach. This improvement was observed across all measured aspects, including concept recognition, logical thinking, symbolic thinking, and object recognition.

The discussion of research findings reveals that using natural materials as learning media makes mathematical concepts more concrete and easier to understand for young children. Bruner's theory approach, which consists of enactive, iconic, and symbolic stages, provides an effective learning structure for developing early mathematics understanding.

The learning stages implemented are as follows:

1.Enactive Stage: Children learn through direct experiences using natural materials as teaching aids.

2.Iconic Stage: Children understand concepts through images or visual representations of objects used in the enactive stage.

3.Symbolic Stage: Children begin to associate the learned concepts with mathematical symbols or notations.

The findings indicate that early mathematics learning based on natural materials is more engaging and effective compared to worksheet-based approaches. Bruner's theory helps children understand concepts progressively, from concrete to abstract, thereby enhancing their cognitive achievement.

Conclusion

The implementation of early mathematics learning using natural materials with Bruner's theory approach effectively enhances young children's cognitive achievement. Utilizing natural materials as learning media helps make mathematical concepts more concrete and meaningful. Bruner's theoretical approach provides a structured framework suitable for early mathematics education in young learners.

This study suggests that early childhood educators can adopt natural materials as an alternative medium for teaching foundational mathematical concepts. Future research could employ a more robust study design and incorporate a control group for further validation.

References

Al-Mutawah, M., Mahmoud, E., Thomas, R., Preji, N., & Alghazo, Y. (2022). Math and Science Integrated Curriculum: Pedagogical Knowledge-Based Education Framework. Hindawi Education Research International, 2022, 2984464. https://doi.org/10.1155/2022/298446

Balat, G. U., & Günşen, G. (2017). STEM Approach in the Preschool Period. Journal of Academic Social Research, 5(42), 337–348

Baroody, A. J., Clements, D., & Sarama, J. (2019). Teaching and Learning Mathematics in Early Childhood Programs (Handbook of early childhood care and education Section III of Curriculum in Early Childhood Care and Education. Wiley Blackwell Publishing. https://www.researchgate.net/publication/331148046_Teaching_and_Learning_Mathematics_in_

Early_Childhood_Programs

Beloglovsky, M., & Daly, L. (2015). Early learning theoris made visible (first). Minnesota: Redleaf Press

Bustang, Zulkardi, Darmawijoyo, Dolk, M., & van Eerde, D. (2013). Developing a local instruction theory for learning the concept of angle through visual field activities and spatial representations. International Education Studies, 6(8), 58–70. https://doi.org/10.5539/ies.v6n8p58

Chang, B. (2019). Reflection in learning. Online Learning Journal, 23(1), 95–110. https://doi.org/10.24059/olj.v23i1.1447

Chris Speldewinde & Coral Campbell.2022. Mathematics learning in the early years through nature playPages 813-830 | Received 09 Nov 2021, Accepted 25 Aug 2022, Published online: 08 Sep 2022

Clements, D. H., & Sarama, J. (2016). Math, science, and technology in the early grades. Future of Children, 26(2), 75–94. https://doi.org/10.1353/foc.2016.0013

Cross, C. T., Woods, T. A., & Schweingruber, H. (2009). Mathematics learning in early childhood: Paths toward excellence and equity. National Academies Press https://doi.org/10.1080/09669760.2022.2122026

Cui , Zhang & Leung,2019 .2019The Influence of Parental Educational Involvement in Early Childhood on 4th Grade Students' Mathematics Achievement.Early Education and DevelopmentPages 113-133 | Published online: 19 Nov 2019

Council, I. of M. and N. R. (2015). Child Development and Early Learning: A Foundation for Professional Knowledge and Competencies. In The National Academies of SCIENCES, ENGINEERING, MEDICINE. https://www.nap.edu/resource/19401/ProfKnowCompFINAL.pdf Crowe, A. R. (2010). 'What's Math Got to Do With It?': Numeracy and Social Studies Education.

Darling-Hammod, L., & Jossey-Bass. (2006). Powerful teacher education : Lessonsfrom exemplary programs. https://www.wiley.com/enie/Po

Dunphy, E., Shiel, T. D., & Shiel, G. (2014). Mathematics in Early Childhood and Primary Education (3–8 years) (Issue 17). https://www.researchgate.net/publication/327177097

Efriani, A., Ilma Indra Putri, R., & Aisyah, N. (2020). The Role of Teachers in Facing the Challenges of Beginning Mathematics. Pendidikan Anak Usia Dini, 4(1), 66–73. https://doi.org/10.29313/ga:jpaud.v4i1.5983

Efriani dkk.2022 .Developing a learning environment based on science, technology, engineering, and mathematics for pre-service teachers of early childhood teacher education Journ al on Mathematics EducationVolume 13, No. 2, 2022, pp. 275-288

Elfareta, N. J., & Murtiyasa, B. (2022). Analisis Kemampuan Komunikasi Matematis Materi Sistem Persamaan Linear Dua Variabel Dengan Penerapan Teori Bruner. AKSIOMA: Jurnal Program Studi Pendidikan Matematika, 11(3), 2523.

Evans, D. K., Glennerster, R., & Rogers, F. H. (2020). How to Improve Education Outcomes Most Efficiently ? A Comparison of 150 Interventions Using the New Learning-Adjusted Years of Schooling Metric. Center for Global Development, October. https://documents1.worldbank.org/curated/en/80190160331453012

Fauziddin, M., & Mufarizuddin, M. (2018). Useful of Clap Hand Games for Optimalize Cogtivite Aspects in Early Childhood Education. Jurnal Obsesi: Jurnal Pendidikan Anak Usia Dini, 2(2), 162. https://doi.org/10.31004/obsesi.v2i2.76

Gasteiger, H., & Benz, C. (2018). Enhancing and analyzing kindergarten teachers' professional knowledge for early mathematics education. The Journal of Mathematical Behavior, 33, 4–22. https://doi.org/10.1016/j.jmathb.2018.01.002

Ghozali.2016. Desain Penelitian Kuantitatif dan Kualitatif ,Akutansi,Bisnis dan Ilmu Sosial.Edisi : First. Publikasi Yoga Pratama : SSBN 978.602.0096.12.

Imam Ghozali.2018 .Aplikasi Analisis Multivaviate Dengan Program IBM SPSS 25 Edisi 9. Badan Penerbit Universitas Diponegoro. ISBN : 979-704-015-1

Jordan, N. C., Glutting, J., & Watkins, M. W. (2010). Validating a Number Sense Screening Tool for Use in Kindergarten and First Grade : Prediction of Mathematics Proficiency in Third Grade, 39(2), 181–195.

Kemdikbud, 2012. Modul Pasca UKA Guru SD Tentang Teori Belajar Matematika Kemdikbud: Jakarta.

Kurniasih, I., & Sani, B. (2014). Implementasi Kurikulum 2013 Konsep dan Penerapan. Kementrian Pendidikan Dan Kebudayaan, 1–162.

Kurniah, N., Andreswari, D., & Kusumah, R. G. T. (2019). Achievement of Development on Early Childhood Based on National Education Standard. Advances in Social Science, Education and Humanities Research, 295(ICETeP 2018), 351–354. https://doi.org/10.2991/icetep-18.2019.82

Mullis, I., Martin, M. O., Foy, P., & Hooper, M. (2015). Trends in International Mathematics and Science Study (TIMSS). Encyclopedia of Quality of Life and Well-Being Research, 6737–6739. https://doi.org/10.1007/978-94-007-0753-5_3063

Naufal dkk,2022 GeoGebra-Based Flipped Learning Model: An Alternative Panacea to Improve Students' Learning Independency in Online Mathematics Learning

Journal of Research and Advances in Mathematics Education, v7 n3 p178-195 Jul 2022

Piasta, S. B., Pelatti, C. Y., & Miller, H. L. (2014). Mathematics and Science Learning Opportunities in Preschool Classrooms. Early Education and Development, 25(4), 445–468. https://doi.org/10.1080/10409289.2013.817753

Permendikbud No. 137 Tahun 2014 tentang Standar Nasional PAUD.

Pramudiani dkk . 2011. A Concrete Situation For Learning Decimals. IndoMS. J.M.E Vol. 2 No. 2 July 2011, pp. 215-230

Rahayu,dkk Curiosity: A game-based early mathematics Mathematics Education, STKIP Muhammadiyah Pagaralam, South Sumatra, Indonesia2Mathematics Education, Universitas Sriwijaya, South Sumatra, Indonesia*Correspondence:ratuilma@unsri.ac.idReceived: 4January 2022| Revised: 19April 2022| Accepted: 14 June2022 | Published Online: 21 July 2022© The Author(s) 2022

Rahmawati, Y., & Euis Kurniati. (2005). Strategi Pengembangan Kreatifitas Pada Anak Usia TK. Depdikbud.

Rahmawati, Vijaya, E. S., Puslitjakdikbud, P. U., Development, P., Mathematics, C., & Pedagogy, M. (2015). International Science Achievement. 2016, 2015.

Ramani, G. B., & Siegler, R. S. (2008). Promoting Broad and Stable Improvements in Low-Income Children ' s Numerical Knowledge Through Playing Number Board Games, 79(2), 375–394.

Rusiyanti,dkk 2022 Developing RME-based lesson study for learning community in the learning environment ofhigh school mathematics teachers. Journal on Mathematics EducationVolume 13, No. 3, 2022, pp. 499-514http://doi.org/10.22342/jme.v13i3.pp499-

Susanto, A. (2011). Perkembangan Anak Usia DIni. Kencan

Sutama,dkk 2022. Collaborative mathematics learning management: Critical thinking skills in problem solving International Journal of Evaluation and Research in Education (IJERE) p-ISSN: 2252-8822, e-ISSN: 2620-5440

Widodo dkk,2021 Kemandirian Belajar Matematika Siswa Sekolah Dasar melalui Daring dengan Model Pembelajaran Flipped Classroom . September 2021Jurnal Basicedu 5(5):3902-3911 DOI:10.31004/basicedu.v5i5.1404

Zhang,dkk Chinese early childhood teachers' perspectives on mathematics education in play-based contexts Department of Education, Monash University, Melbourne, Australia https://orcid.org/0000-0002-5633-5673View further author information

Zulkardi, Z., Putri, R. I. I., & Wijaya, A. (2020). Two Decades of Realistic Mathematics. Springer International Publishing. https://doi.org/10.1007/978-3-030-20223- Developing a learning environment based on science, technology, engineering, and mathematics for pre-service teachers of early childhood teacher education