Education and Human Development Journal Vol. **11** No.**1**, 69–80 (2026)
doi: 10.33086/ehdj.v11i1.8525

EHDJ | Education and Human Development Journal

ARTICLE

Improving Elementary Students' Mathematical Understanding and Independent Learning Through the Puzzle Learning Media

Yanti Setiawati, Nuril Huda *, Muhajir, and Soubar Isman

Master's Program In Educational Technology Faculty Of Educational Sciences And Literature, Universitas Dr. Soetomo Surabaya, Surabaya, Indonesia

*Corresponding author: nuril.huda@unitomo.ac.id

(Received: 01 December 2025; Accepted: 07 January 2026; Published: 30 April 2026)

Abstract

Integrating digital learning media in primary education has become increasingly important to enhance student engagement and academic achievement, particularly in subjects that students often perceive as difficult, such as mathematics. Interactive technologies such as Smartboards provide dynamic visual and interactive learning environments that can potentially improve students' interest and learning outcomes. This study aims to examine the effect of interactive Smartboard media on students' learning interest and mathematics achievement among fourth-grade students at SDN Kebun 2 Kamal. The research employed a quasi-experimental design with a quantitative approach. The sampling technique used was saturation sampling, involving the entire population of 50 students from classes IV-A and IV-B. The research instruments consisted of a mathematics learning achievement test and a questionnaire measuring students' learning interest. Data were analyzed using IBM SPSS version 21, including tests of validity, homogeneity, normality, and an independent samples t-test. The findings reveal a statistically significant improvement in both students' interest and learning outcomes after the implementation of Smartboard-based instruction, with a significance value of 0.000 ($p < 0.05$). The results indicate that the use of Smartboard media effectively enhances students' engagement and academic performance in mathematics. Therefore, Smartboard technology can be recommended as an alternative instructional medium to support the achievement of learning competencies in elementary mathematics education

Keywords: Learning independence; Learning Media; Puzzle; Understanding Learning.

1. Introduction

Mathematics is widely recognized as a discipline that plays a crucial role in the development of logical, analytical, and problem-solving abilities. [1] asserts that proficiency in mathematics extends beyond routine cognitive engagement, functioning as a fundamental basis for higher-level intellectual development. Furthermore, [2] emphasizes that a solid understanding of mathematics supports

 ISSN 2541-0156 (print), 2599-0292 (online).

the advancement of science and technology, both of which constitute essential components of modern life. However, [3] indicates that the abstract characteristics of mathematical concepts demand deep conceptual comprehension, which often presents substantial challenges for elementary school students. These difficulties are particularly evident in specific topics such as geometry, fractions, and basic mathematical operations, as noted by [4].

Developing learning independence in mathematics is therefore essential for addressing these challenges. [5] and [6] highlight that learning autonomy encourages students to take initiative in confronting academic difficulties and to explore diverse strategies for problem-solving. In contrast, [7] identifies limited independence and low self-confidence as indicators of excessive dependence on teachers during the learning process. In this context, [8] proposes that effective time management, the ability to recognize stages in problem-solving, and accountability for learning outcomes are important indicators of students' autonomous learning. Moreover, [9], [10], and [11] argue that the use of educational media plays a significant role in enabling students to experiment with various solution strategies, strengthening their confidence, and enhancing intrinsic motivation. Similarly, [12] and [13] emphasize that the integration of learning media enables students not only to manage their learning time efficiently and solve problems independently, but also to actively engage in constructing, connecting, and deepening their understanding of knowledge.

Conceptual understanding serves as a criterion for success in mathematics learning. [14] asserts that students who understand the concept can apply the information in various contexts and enhance their responses. In addition, [15] also describes learning understanding as the ability to assimilate, integrate, and connect new concepts with existing knowledge and experiences. [16] emphasizes that the educational process should prioritize the synthesis of ideas, the construction of meaning, and the practical application of concepts in real-world contexts. For example, [17] shows that learning understanding is a substantial predictor of academic achievement in elementary school. [18], [19] assert that students with deep understanding can express information in their own terms, provide application examples, and solve related challenges. [20] argues that students who do not understand the concept often make repeated mistakes and have difficulty connecting concepts.

One potential approach to addressing these challenges is the use of learning resources that are aligned with students' cognitive levels and learning characteristics. In this regard, [21] emphasizes that interactive and engaging instructional media can effectively stimulate students' interest and motivation in the learning process. Among various instructional tools, puzzles represent a learning medium that not only provides entertainment but also promotes the development of logical thinking skills [22].

In the context of mathematics learning, puzzles function as strategically valuable instructional tools. According to [23], puzzle-based activities encourage active student engagement through processes of strategic exploration and knowledge integration, which in turn contribute to improved conceptual understanding. Furthermore, [24] argues that puzzles provide learners with opportunities to identify problem-solving steps, select appropriate strategies, and regulate their own learning pace independently. Such conditions support the development of learning autonomy by giving students greater control over the management of their learning processes. In addition, [25] states that puzzle-based learning environments create active, enjoyable, and meaningful learning experiences. Through these activities, students engage in visual reasoning, systematic problem-solving, and collaborative interaction, all of which facilitate a deeper internalization and understanding of mathematical concepts.

Several studies have proven the benefits of using puzzles. First of all, [26] showed that learning comprehension can be improved through puzzle media, with 70% of students achieving classical mastery. [27] also found that 85% of students successfully completed the task using the "nested summation" idea after using the puzzle. Again, [28] also stated that students' learning independence increased

dramatically, with an average post-test score of 92.67 compared to a pre-test score of 34. [29], in their quasi-experimental study published in the Journal of Science Education Research, found that puzzle-based learning media significantly improved mathematical problem-solving abilities, particularly in geometry material requiring conceptual understanding and spatial analysis.

Previous studies have demonstrated that puzzle-based learning can enhance students' conceptual understanding and promote independent learning. However, most of these studies tend to examine only a single dimension of learning outcomes, such as conceptual comprehension, learning independence, or problem-solving ability. Only a limited number of studies have attempted to integrate the two key aspects—conceptual understanding and independent learning of elementary school students—within a single research framework. Moreover, the majority of previous investigations have focused on specific mathematical topics, such as geometry or multi-step addition, thereby restricting the application of puzzles as a pedagogical tool to particular content areas. Consequently, a research gap remains, particularly regarding how the simultaneous integration of puzzle-based learning media can enhance both conceptual understanding and learning independence among elementary school students within a broader instructional context. This study seeks to address this gap by examining the potential of puzzle media as an effective pedagogical approach to improving conceptual understanding while simultaneously fostering students' independent learning attitudes.

Preliminary observations at SDN Petapan 2 indicate that mathematics instruction is still predominantly conducted using conventional teaching methods. In such settings, students are not actively engaged in the learning process, which leads to confusion when they encounter problems that differ from previously practiced examples. As a result, many students experience difficulties in understanding fundamental concepts, particularly fractions and basic mathematical operations, and they demonstrate limited ability to learn independently. In response to these issues, the present study was conducted to overcome students' conceptual barriers and enhance their learning autonomy through the use of puzzle-based learning media. The findings of this study are expected to contribute to improving the quality of mathematics instruction at SDN Petapan 2 and to support the development of a generation of independent learners capable of facing future academic challenges. Based on the discussion above, this study investigates whether the use of puzzle learning media significantly improves (1) students' conceptual understanding and (2) learning independence compared with conventional instructional approaches.

2. Methods

2.1 Research Design

This research uses a two-group pre-test and post-test design with a quantitative methodology and a quasi-experimental framework. This methodology was chosen because of its ability to explain the treatment effects on the variable being investigated. Besides that, this study also uses a dual sampling procedure, starting with saturation sampling to ensure the representation of student characteristics.

2.2 Research Subjects

There are 60 students in classes V-C and V-D at Petapan 2 Primary School who participated in this study. Each class consists of 30 children carefully selected based on academic criteria and classroom arrangement. The selection of research subjects for this study was made to ensure that the research results are more controlled and it accurately represents the field setting.

2.3 Research Instruments

There are two types of research instruments: a test of mathematical concept understanding and a learning independence questionnaire. The concept understanding test is designed to assess students'

ability to understand mathematical concepts both before and after therapy. The exam questions are based on the concept knowledge indicators from the elementary school curriculum. The learning independence questionnaire was designed to determine students' level of independence during the learning process. This questionnaire was created using a Likert scale and addresses topics such as time management, learning initiative, self-confidence, and responsibility for learning outcomes.

The experimental group received an intervention involving the use of puzzle-based media in mathematics instruction, whereas the control group continued to receive instruction through conventional teaching methods. The implementation of puzzle-based learning was carried out systematically, with each session conducted for approximately 30 minutes during the core learning phase. The intervention was administered six times over a period of three weeks. The puzzle activities employed in this study were designed around key mathematical concepts, including number-based puzzles, geometric shape puzzles, and logical reasoning puzzles. These activities were intended to support students' conceptual understanding while simultaneously encouraging the development of learning independence.

The effectiveness of puzzle-based learning media in improving students' conceptual understanding and independent learning was evaluated by comparing the post-intervention learning outcomes of the experimental group with those of the control group. This comparison enabled the study to determine the extent to which the integration of puzzle media contributed to improvements in both cognitive understanding and students' autonomous learning behaviours.

2.4 Data collection techniques

The research instrument underwent an initial trial to confirm its quality. The item and questionnaire validity coefficients ranged from 0.62 to 0.81, and the Cronbach's Alpha reliability was 0.89. The sample was determined using cluster random sampling, and external factors were controlled by standardizing the schedule and learning materials. Data analysis includes homogeneity tests, normality tests, and independent samples t-tests, which were performed using IBM SPSS version 21. This research aims to determine the significant differences between the experimental group and the control group in terms of arithmetic understanding and learning autonomy of elementary school students.

3. Results and Discussion

3.1 Results

The purpose of this study is to examine how the use of puzzle media affects students' knowledge of mathematical concepts and their learning independence in fifth-grade students at Petapan 2 Primary School. The independent samples T-test statistical test was used to evaluate the results of the experimental group using puzzle media against the control group using conventional techniques.

Table 1. Examining the Mean Understanding learning Scores of Students Statistically

Group Statistics

	Class	N	Mean	Std. Deviation	Std. Error Mean
Understanding	Experiment Class	30	82.20	8.360	1.526
Learning	Control Class	30	59.00	21.494	3.960

The experimental and control groups differed significantly in their understanding of mathematical learning, according to statistical analysis using an independent samples t-test. The experimental group had an average learning comprehension score of 82.20, compared to the control group's score

of 59, a difference of 23.2 points. The comparison of the test score results for the experimental and control classes is as follows:

Figure 1. Comparison of Post-test scores for understanding learning test in the experimental and control groups.

The graph in Figure 1 illustrates a comparison of understanding learning test scores between the experimental and control groups, with the experimental group achieving an average score of 82.2, while the control group only achieved an average score of 59. The following table shows the results of the independent samples t-test:

Table 2. Understanding Learning variable results from an independent samples T-test

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Learning Interest	Equal variances assumed	27.909	.000	5.510	58	.000	23.200	4.211	14.771	31.629
	Equal variances not assumed			5.510	37.578	.000	23.200	4.211	14.673	31.727

The results of Levene's test for equality of variances indicate an F value of 27.909 with a significance level of 0.000, suggesting that the assumption of homogeneity of variances is violated and that the variances between the groups are unequal. Accordingly, the subsequent analysis was conducted under the assumption of unequal variances. The results of the independent samples t-test reveal a t-value of 5.510 with 37.578 degrees of freedom (df) and a Sig. (2-tailed) value of 0.000, indicating a highly statistically significant difference between the two groups. Furthermore, the mean difference

is supported by a 95% confidence interval ranging from 14.673 to 31.727, which strengthens the robustness and reliability of the findings. The results of the hypothesis testing using the independent samples t-test on learning independence are presented in Table 3.

Table 3. Examining the Mean Independence Learning Scores of Students Statistically

Group Statistics					
	Class	N	Mean	Std. Deviation	Std. Error Mean
Understanding Learning	Experiment Class	30	54.93	8.233	1.503
	Control Class	30	41.43	12.662	2.312

Independent samples t-tests showed a significant difference between the experimental and control groups in terms of students' learning independence. The experimental group using puzzle media scored an average of 54.93, while the control group only scored 41.43, a difference of 13.5 points. This difference indicates that students who learn using puzzle media have a higher level of learning independence compared to children who learn using traditional techniques. The comparison of the test score results for the experimental and control classes is as in the Graph in Figure 2.

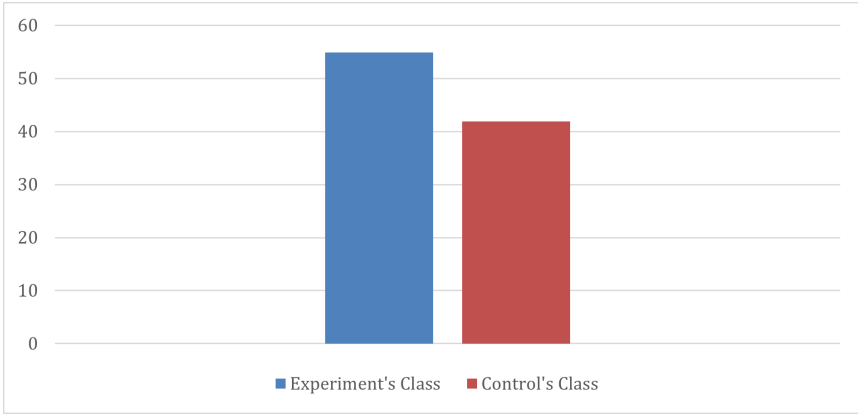

Figure 2. Comparison of Posttest scores for learning independence test in the experimental and control groups.

The graph in Figure 2 illustrates a comparison of learning independence test scores between the experimental and control groups, with the experimental group achieving an average score of 54.9, while the control group only achieved an average score of 41.9. The difference in results indicates that the intervention used in the experimental group had a positive impact on students' learning independence. Table 4 presents the results of the independent samples t-test:

Table 4. Learning Independence variable results from an independent samples T-test

Independent Samples Test									
	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper

Learning Interest	Equal variances assumed	11.594	.001	4.896	58	.000	13.500	2.757	7.980	19.020
	Equal variances not assumed			4.896	49.804	.000	13.500	2.757	7.961	19.039

The significance value (Sig. 2-tailed) is 0.000, which is substantially lower than the predetermined threshold of = 0.05, indicating the presence of a statistically significant difference between the compared groups. The results of Levene's test for equality of variances show an F-value of 11.594 with a significance level of 0.000, suggesting that the assumption of homogeneity of variances is violated and that the variances between the groups differ. However, the analysis remains statistically valid because the independent samples t-test was conducted using the unequal variances assumption. The test results show a t-value of 4.89 with 58 degrees of freedom (df). In addition, the % confidence interval, ranging from 7.980 to 19.020, further supports the robustness of the findings. These results provide empirical evidence that the use of puzzle media has a significant and positive impact on improving students' independent learning 2,776.

3.2 Discussion

This study demonstrates that puzzle-based learning media significantly improves students' learning comprehension and learning independence at Petapan 2 Primary School. The experimental group achieved an average comprehension score of 82.20, whereas the control group obtained a mean score of 59.00, resulting in a difference of 23.2 points. Similarly, the experimental group demonstrated a higher level of learning independence, with an average score of 54.93 compared with 41.43 in the control group, representing a difference of 13.5 points. The results of the independent samples t-test further confirm the statistical significance of these differences (p-value = 0.000, <0.05). These findings indicate that puzzle-based learning media contributes substantially to both cognitive outcomes and students' autonomous learning behaviors. In the context of this study, puzzles function not merely as instructional tools but also as pedagogical media that integrate cognitive engagement and affective involvement within mathematics learning.

The findings of this study are consistent with previous empirical research. For instance, [30] reported that puzzle-based learning media can enhance students' focus and conceptual understanding. Similarly, [31] argue that puzzle-based educational games can increase learning motivation while simultaneously fostering learning independence. Furthermore, [32] concluded that puzzles, as interactive instructional media, enhance student participation in the learning process and directly influence learning outcomes. In addition, [33] highlighted that puzzles contribute to the development of critical thinking skills as well as independent learning indicators, including time management and problem-solving strategies. Supporting these findings, [34] emphasized the consistent contribution of puzzle-based activities to improving mathematics learning outcomes.

Further empirical evidence has been provided by [35], who demonstrated through a quasi-experimental approach that puzzle-based learning strategies significantly improve student academic achievement. Likewise, [29] showed that puzzle-based learning effectively enhances students' mathematical problem-solving skills, particularly in geometry. At the primary education level, [36] found that puzzle-based learning promotes student engagement, creativity, and critical thinking. From a constructivist learning perspective, [37] further demonstrated that instructional approaches incorporating puz-

zles significantly enhance students' mathematical problem-solving abilities. Moreover, [38] revealed that puzzle-based cooperative learning methods, which emphasize collaboration and independent problem-solving, contribute to improved mathematics learning outcomes.

The theoretical foundation supporting these findings can be explained through the constructivist learning paradigm. According to Piaget and Vygotsky, learning is a process in which individuals actively construct knowledge through direct experience and interaction with their environment [39]. Within this framework, puzzles enable students to explore, experiment, and discover solutions independently, thereby facilitating deeper conceptual understanding [40]. Constructivist theory emphasizes the active involvement of learners in the knowledge construction process, which is closely associated with the development of autonomous learning skills [40]. Puzzle-based learning aligns with these principles because it enables students to connect abstract mathematical concepts with concrete experiences while simultaneously fostering a sense of responsibility for their own learning process.

The significance of these findings can also be interpreted within the framework of student-centred learning. As emphasized by [41], learning media should be adapted to students' characteristics in order to achieve optimal learning outcomes. In this study, puzzles functioned as an effective medium within a student-centered learning approach, allowing students at Petapan 2 Primary School to actively engage in the learning process from the initial exploration stage to the final evaluation stage. In line with this argument, [42] emphasize that interactive media, such as puzzles, facilitate students' understanding of complex concepts, enable them to relate learning content to their personal experiences, and accommodate diverse learning styles. In this context, puzzle-based learning not only improves academic outcomes but also promotes an adaptive, creative, and enjoyable learning environment.

The effectiveness of puzzles in improving students' comprehension and self-directed learning skills is particularly relevant at the elementary education level. Puzzle-based activities require active engagement, sequential problem-solving, and independent task completion, making them highly suitable for young learners. Moreover, puzzles accommodate variations in students' abilities, create an engaging and supportive learning atmosphere, and strengthen logical reasoning as well as spatial analysis skills. These characteristics make puzzle-based media an effective pedagogical tool for elementary mathematics instruction.

From an educational perspective, the primary implication of this study is that puzzles can function as a bridge between abstract mathematical concepts and students' real-life experiences. Through puzzle-based activities, students develop logical reasoning, spatial analysis abilities, and independent learning habits that are essential for understanding more complex mathematical concepts in subsequent stages of learning. Consequently, the use of appropriately designed puzzle media is not only relevant for improving immediate learning outcomes but also for strengthening students' long-term cognitive foundations and cultivating positive learning dispositions.

Overall, the findings of this study indicate that puzzle-based learning media play a significant role in supporting students' conceptual understanding and independent learning development. Supported by a strong theoretical foundation in constructivist and student-centered learning theories, puzzle-based instruction represents a meaningful pedagogical innovation for addressing challenges in elementary mathematics education, particularly those related to the comprehension of abstract concepts and the development of autonomous learning skills.

4. Conclusion

Below is a proofread and academically strengthened version of your discussion section, written in clearer, more coherent, and more formal language appropriate for a Q1 Scopus-indexed journal.

The results of the independent samples t-test revealed a significance value of 0.000, which is lower than the threshold of 0.05. This finding indicates that the use of puzzle-based learning media has a statistically significant effect on the learning outcomes of fifth-grade students at Petapan 2 Primary School, particularly in terms of conceptual understanding and learning independence. The findings suggest that puzzle-based activities not only support students' comprehension of mathematical concepts but also encourage the development of independent learning behaviors. From a theoretical perspective, this study provides empirical evidence that game-based learning media can simultaneously integrate cognitive and affective dimensions within the instructional process. In addition to functioning as visual instructional aids, puzzles also stimulate intrinsic motivation and foster students' self-directed learning abilities. The interactive and problem-solving nature of puzzle-based learning encourages students to actively engage with learning materials while constructing their own understanding. From a practical standpoint, these findings provide pedagogical guidance for educators to systematically integrate puzzle-based activities into mathematics instruction in order to enhance classroom interactivity, student engagement, and active learning participation. Nevertheless, several limitations should be acknowledged. This study was conducted within a single educational institution and focused on a specific subject area, which may limit the generalizability of the findings. Future research is therefore recommended to expand the scope of investigation by involving different educational levels, such as secondary and higher education, as well as broader disciplinary contexts including language, arts, and social sciences. Furthermore, interdisciplinary approaches may provide deeper insights into the potential of puzzle-based learning as an innovative instructional strategy. Such efforts would contribute to the advancement of educational practices and support the transformation of learning toward a more holistic and integrative educational paradigm.

The independent sample T-test revealed a significance value of 0.000, which is below 0.05. This shows that the use of puzzle media substantially affects the educational outcomes of 5th-grade students at SDN Petapan 2 Bangkalan, particularly in terms of concept understanding and independent learning. Puzzles have demonstrated the ability to enhance the understanding of mathematical concepts and encourage independent learning in children. This research argues that game-based media can simultaneously encompass cognitive and emotional aspects. Puzzles serve as efficient visual aids while encouraging intrinsic motivation and independent learning skills.

This study offers guidance for educators to systematically integrate puzzles into mathematics teaching, ultimately enhancing student engagement and participation. Additionally, these findings provide recommendations to curriculum policymakers to consider incorporating game-based media, such as puzzles, into new learning methodologies. As a result, the curriculum can better meet students' needs in developing critical thinking skills, fostering independent learning, and enhancing intrinsic motivation.

This study has its limitation that lies in its narrow scope, as it was conducted at only one university and within specific disciplines. Therefore, further research is recommended to expand the focus to secondary and higher education levels, as well as other fields such as language, arts, or social sciences. Interdisciplinary studies will enhance the understanding of puzzles as a new educational approach while simultaneously advancing learning reforms toward a more comprehensive paradigm.

References

[1] T. Zachariades, C. Sakonidis, and S. Zoitsakos. "The impact of advanced mathematics in teaching school mathematics through secondary teachers' reflections on students' reasoning". In: *The Journal of Mathematical Behavior* 80 (Dec. 2025), p. 101277. DOI: 10.1016/J.JMATHB.2025.101277.

[2] B. Xu, X. Ma, Y. Zhang, and X. Wu. "How does mathematical literacy affect creative thinking? Independent effects and differential impacts across proficiency groups". In: *Acta Psychol. (Amst).* 260 (Oct. 2025), p. 105509. DOI: 10.1016/J.ACTPSY.2025.105509.

[3] O. Fitzmaurice, N. O'meara, and P. Johnson. "Highlighting the Relevance of Mathematics to Secondary School Students – Why and How". In: *European Journal of STEM Education* 6.1 (2021). DOI: 10.20897/ejsteme/10895.

[4] L. H. Muhaimin and D. Juandi. "The Role Of Learning Media In Learning Mathematics: A Systematic Literature Review". In: *Journal of Mathematics and Mathematics Education* 13.01 (2023). DOI: 10.20961/jmme.v13i1.74425.

[5] T. N. Sipayung, Imelda, T. Y. E. Siswono, and Masriyah. "An analysis of students learning independence in mathematics based on google classroom". In: *Journal of Physics: Conference Series*. IOP Publishing Ltd, Jan. 2022. DOI: 10.1088/1742-6596/2157/1/012037.

[6] A. Tusaadia, A. Abdillah, M. Mahsup, V. Mandailina, and S. Syaharuddin. "Learning Independence Towards Mathematics Learning Outcomes Based on Education Level". In: *Indonesian Journal Of Educational Research and Review* 5.3 (Dec. 2022), pp. 577–587. DOI: 10.23887/ijerr.v5i3.52312.

[7] L. Henschel, D. Kügler, and M. Reuter. "FastSurferVINN: Building resolution-independence into deep learning segmentation methods—A solution for HighRes brain MRI". In: *Neuroimage* 251 (May 2022), p. 118933. DOI: 10.1016/J.NEUROIMAGE.2022.118933.

[8] R. Novalia, A. Marini, T. Bintoro, and U. Muawanah. "Project-based learning: For higher education students' learning independence". In: *Social Sciences and Humanities Open* 11 (Jan. 2025). DOI: 10.1016/j.ssaho.2025.101530.

[9] S. Johanes, A. R. G. Nesna, and K. Tamrin. "The Application of Dick and Carey Learning Design toward Student's Independence and Learning Outcome". In: *1st International Conference on Educational Sciences and Teacher Profession (ICETeP 2018)*. 2019. URL: http://creativecommons.org/licenses/by-nc/4.0/.

[10] M. Maisyaroh, J. Juharyanto, B. B. Wiyono, A. M. Nawi, M. A. Adha, and I. Lesmana. "Unveiling the nexus of leadership, culture, learning independence, passion trend-based learning, and teacher creativity in shaping digital student skills". In: *Social Sciences & Humanities Open* 9 (Jan. 2024), p. 100884. DOI: 10.1016/J.SSAHO.2024.100884.

[11] M. Ainley, S. Hidi, and D. Berndorff. "Interest, learning, and the psychological processes that mediate their relationship". In: *J. Educ. Psychol.* 94.3 (2002), pp. 545–561. DOI: 10.1037/0022-0663.94.3.545.

[12] N. Khasanah and S. Isman. "Enhancing Elementary Students' Creativity and Understanding through Audio-Visual Learning Media". In: *Education and Human Development Journal* 10.2 (2025), pp. 163–172. DOI: 10.33086/ehdj.v10i2.7794.

[13] C. O. Nja et al. "Learning space, students' collaboration, educational outcomes, and interest: Exploring the physical, social and psychological mediators". In: *Heliyon* 9.4 (Apr. 2023), e15456. DOI: 10.1016/J.HELIYON.2023.E15456.

[14] W. Hidayat and U. Aripin. "The improvement of students' mathematical understanding ability influenced from argument-driven inquiry learning". In: *J. Phys. Conf. Ser.* 1157.3 (Mar. 2019). DOI: 10.1088/1742-6596/1157/3/032085.

[15] J. Jahari. "Preparing Teachers in the Era of 'Independence Learning' in Indonesia". In: *International Journal of Psychosocial Rehabilitation* 24 (2020). URL: https://id.wikipedia.org/wiki/Industri_4.0.

[16] Moh Ghoizi Eriyanto, M.V. Roesminingsih, Soedjarwo, and Ivan Kusuma Soeherman. "The Effect of Learning Motivation on Learning Independence and Learning Outcomes of Students in the Package C Equivalence Program". In: *IJORER : International Journal of Recent Educational Research* 2.4 (July 2021), pp. 455–467. DOI: 10.46245/ijorer.v2i4.122.

[17] A. Triwiratman, T. Nusantara, and I. Hitipeuw. "Level of Learning Independence in Elementary School Students: The Influence of Self-Efficacy, Motivation, and Peer Interaction". In: (2023). URL: https://jurnaldidaktika.org705.

[18] R. N. Alexandrovna. "Development of Independence among Future Primary School Teachers by Applying Interactive Learning Methods". In: *J. Educ. Elearn. Res.* 5.2 (2018), pp. 118–121. DOI: 10.20448/journal.509.2018.52.118.121.

[19] L. Listiana, A. Bin Jamaluddin, A. Bahri, and N. H. Romadhon. "The influence of self-efficacy, learning attitude, and learning independence on students' metacognitive awareness and skills". In: *Journal of Pedagogical Research* 9.4 (Sept. 2025), pp. 19–34. DOI: 10.33902/JPR.202534836.

[20] M. G. Azar et al. "A General Theoretical Paradigm to Understand Learning from Human Preferences". In: *International Conference on Artificial Intelligence and Statistics*. Vol. 238. 2024. URL: https://proceedings.mlr.press/v238/gheshlaghi-azar24a.html.

[21] C. M. Amerstorfer and Clara. "Student Perceptions of Academic Engagement and Student-Teacher Relationships in Problem-Based Learning". In: *Front. Psychol.* 12 (Oct. 2021). DOI: 10.3389/fpsyg.2021.713057.

[22] O. Alika and E. H. Radia. "Development of Learning Media Based on Cross Puzzle Game in Science Learning to Improve Learning Outcomes". In: *Jurnal Penelitian Pendidikan IPA* 7.2 (Apr. 2021), pp. 173–177. DOI: 10.29303/jppipa.v7i2.667.

[23] A. Oktaviani and A. Elmojahed. "The Use of Puzzle Learning Media to Improve Student Learning Outcomes in Science Subjects for Class IV". In: *Tekno-Pedagogi : Jurnal Teknologi Pendidikan* 13.2 (2023). DOI: 10.22437/teknopedagogi.v13i1.38459.

[24] M. Maghfiroh and L. Nadhirotul. "Boosting Early Reading Skills with Alphabet Puzzle Media: The Effectiveness of Positive Reinforcement". In: *PSIKOSTUDIA: Jurnal Psikologi* (2024). DOI: 10.30872/psikostudia.v13i4.

[25] A. Siti Rohimah, D. Afriyuni Yonanda, and R. Rachmadtullah. "The Effect Of Puzzle Media-Assisted Problem-Based Learning Model On Student Learning Outcomes". In: *Jurnal Elementaria Edukasia* 7.4 (2024), pp. 3455–3462. DOI: 10.31949/jee.v7i4.13152.

[26] K. Tey, A. Ali, and T. S. Rusli. "Strategi Pembelajaran Aktif Dengan Media Puzzle Untuk Meningkatkan Pemahaman Siswa Terhadap Siklus Makhluk Hidup". In: *Jurnal Riset Pendidikan Dasar (JRPD)* (Mar. 2025), pp. 124–133. DOI: 10.30595/jrpd.v6i1.26158.

[27] T. Bagoes, P. Sanjoyo, R. P. Sriwijayanti, and A. Anjarwati. "Penerapan Media Pembelajaran Puzzle Menggunakan Game Based Learning 'Penjumlahan Bersusun' Kelas II SDN Mayangan IV". In: *INNOVATIVE: Journal Of Social Science Research* 4 (Feb. 2024). DOI: https://doi.org/10.31004/innovative.v4i2.10066.

[28] G. Gumilar. "Efektifitas Penggunaan Media Puzzle Matematika Materi Bilangan Pecahan Terhadap Kemandirian Belajar Siswa Kelas 2 SD". In: *EMTEKA: Jurnal Pendidikan Matematika* 5.1 (2024).

[29] Hidayatulloh and Noerhasmalina. "The Effectiveness of Puzzle Game-Based Learning Media in Improving Mathematics Science Problem Solving Skills". In: *Jurnal Penelitian Pendidikan IPA* 11.3 (Mar. 2025), pp. 946–953. DOI: 10.29303/jppipa.v11i3.10625.

[30] Ahmat Sobirin et al. "Pengaruh Model Jigsaw Melalui Media Puzzle Pada Pelajaran Matematika Dengan Materi Pecahan Untuk Meningkatkanhasil Belajar Siswa Kelas IV SD 067257 Medan Amplas". In: *Pendas : Jurnal Ilmiah Pendidikan Dasar* 10.2 (June 2025).

[31] I. Lailatur Rohmah, H. Wakhyudin, H. Nuroso, and E. Tri Haryani. "Peningkatan Hasil Belajar Matematika Menggunakan Model Problem Based Learning Berbantuan Media Puzzle Pecahan Pada Siswa Kelas II C di SDN Sarirejo". In: *Didaktik : Jurnal Ilmiah PGSD FKIP Universitas Mandiri* 9.2 (2023). DOI: https://doi.org/10.36989/didaktik.v9i2.1258.

[32] A. Octaviana, R. P. Kurniawati, and S. Chasanah. "Penerapan Model Pembelajaran Problem Based Learning (PBL) Berbantuan Media Puzzle Untuk Meningkatkan Hasil Belajar Pendidikan Pancasila Siswa Kelas II SDN 01 Manisrejo". In: *Pendas : Jurnal Ilmiah Pendidikan Dasar* 9.3 (2024). URL: https://job.uho.ac.id/index.php/journal/article/view/8.

[33] S. Rabiyanti, M. Ridwan, and Z. Zainuddin. "The Effect of Puzzle-Based Learning Media on Students' Critical Thinking in Mathematics Lessons at SDN Kolor II". In: *Electronic Journal of Education, Social Economics and Technology* 5.2 (Oct. 2024), pp. 432–437. DOI: 10.33122/ejeset.v5i2.206.

[34] F. Anam, R. Hasanah, M. Firdaus, A. Purnomo, and M. Noviyanti. "Learning Puzzle Model Contribution to Improve Math Subjects Learning Outcomes". In: *Journal of Physics: Conference Series*. IOP Publishing Ltd, Feb. 2021. DOI: 10.1088/1742-6596/1779/1/012048.

[35] D. H. Patacsil. "Games and Puzzles as Teaching Strategies in Mathematics". In: *Asian Journal of Multidisciplinary Studies* 4.2 (2021). URL: www.preservearticles.com.

[36] D. I. A Mageed. "The Mathematization of Puzzles or Puzzling Mathematics Innovative Teaching of Mathematics". Sept. 2024. DOI: 10.20944/preprints202409.0609.v1.

[37] B. Çibukçiu. "The impact of constructivist methods on students' mathematical problem-solving". In: *Discover Education* 4.1 (Dec. 2025). DOI: 10.1007/s44217-025-00475-w.

[38] B. Puput, W. Hidayat, and Apdoludin. "Mathematics Learning Outcomes Through Puzzle-Based Student Teams Achievement Division". In: *Academia Open* 10.2 (2025). URL: https://acopen.umsida.ac.id/index.php/acopen/article/view/12042.

[39] V. Nikolay and P. S. Ingrid. *Piaget and Vygotsky in XXI century*. Vol. 4. Springer Nature Switzerland AG, 2022. DOI: https://doi.org/10.1007/978-3-031-05747-2.

[40] M. M. Fontes, L. C. Morgado, P. Pestana, D. Pedrosa, and J. P. Cravino. "Viewing puzzles as two-faced: theoretical and practical implications for Puzzle-based Learning". In: *Think. Skills Creat.* 52 (June 2024), p. 101470. DOI: 10.1016/J.TSC.2024.101470.

[41] A. G. S. Zaky, W. Wahono, and I. Sifak. "Contextual Based Learning Media Development to Train Creative Thinking Skill in Primary School". In: *IJORER : International Journal of Recent Educational Research* 2.4 (July 2021), pp. 468–476. DOI: 10.46245/ijorer.v2i4.124.

[42] J. C. Tu, C. H. Yang, C. Y. Liang, and H. Y. Chen. "Exploring the Impact of Puzzle Games for the Elderly from Experiential Learning". In: *Think. Skills Creat.* 45 (Sept. 2022), p. 101107. DOI: 10.1016/J.TSC.2022.101107.