Jurnal Pijar MIPA
https://jurnalfkip.unram.ac.id/index.php/JPM

ISSN 1907-1744 (Print)
ISSN 2460-1500 (Online)

The Effect of the JIRE Collaborative Learning Model Based on Phylearn Media on Students Learning Outcomes in the Topic of Heat and Temperature in School

Nursuciani Radja Ilato[1], Nova Elysia Ntobuo[2], Dewa Gede Eka Setiawan[1*], Lukman Samatowa[1], Wahyu Mu'zizat Mohamad[1], Muhammad Yunus[1]

[1]Physics Education Study Program, Universitas Negeri Gorontalo, Gorontalo, Indonesia
[2]Science Education Study Program, Universitas Negeri Gorontalo, Gorontalo, Indonesia
[*]e-mail: dewaeka@ung.ac.id

Received: July 10, 2025. Accepted: August 9, 2025. Published: August 13, 2025

Abstract: Collaborative learning has the potential to address these challenges by promoting problem-solving through collective participation within groups. This research investigates the effect of the Jire Collaborative Learning model integrated with Phylearn media on students' learning outcomes regarding heat and temperature. The study was motivated by low student achievement, primarily attributed to conventional teaching methods to engage students in active participation. This quasi-experimental research employed a one-group pre-test-post-test design involving 25 seventh-grade students at SMP Negeri 4 Monano. The Jire Collaborative model emphasizes active student collaboration, while Phylearn provides interactive multimedia support to help visualize abstract scientific concepts. The findings reveal a significant improvement in students' cognitive performance (levels C2-C4) after the intervention, indicating that the integrated approach effectively improves conceptual understanding. This influence is demonstrated by the difference in students' learning outcomes before and after applying the JIRE model, where the average pre-test score of 46.4 increased to 81.05 in the post-test. The t-test results indicate that this difference is statistically significant, with a significance value of 2.10, less than 0.05. These findings confirm a significant difference between students' pre-test and post-test scores after applying the JIRE collaborative learning model, indicating that this model effectively improves students' learning outcomes. These results suggest that technology-supported collaborative learning is a promising strategy for improving the quality of science education at the junior high school level.

Keywords: Jire Collaborative; Learning Outcomes; Phylearn Media.

Introduction

Education is one of the efforts to enlighten the life of a nation and is a key determinant of national progress. A nation's advancement depends on the skills and knowledge of its citizens. Therefore, the quality of education must be continuously improved [1][2]. Learning activities created by teachers should facilitate interactions among students, between students and teachers, and between students and various learning resources to ensure high-quality education. According to [3], students cannot acquire essential values in learning if teachers rely solely on lecturing methods. Students should be allowed to interact with others, especially their classmates and the community. Knowledge gained should be applicable daily to improve the quality of life. Consequently, learning should be closely related to the natural and social environment. Real-life contextual problems from society can be discussed in the classroom and solved by encouraging students to develop creative ideas [4][5].

Generally, low student achievement is influenced by ineffective teaching processes, less engaging teaching models, and limited student involvement, all of which negatively impact learning outcomes [6]. Thus, there is a need for enjoyable and engaging learning models. Subjects involving formulas and calculations, such as science, are often perceived as boring by students [7]. Collaborative learning has the potential to address these challenges by promoting problem-solving through collective participation within groups [8]. It is not difficult to implement, as humans naturally live in social environments where they coexist, need one another, and are interdependent. Cooperative collaboration has long been practised in daily life within communities [9][10]. In collaborative learning, strategies involve students working in groups with structured activities and goals, requiring active cooperation to achieve meaningful learning outcomes [11].

One type of collaborative learning is the jigsaw model, which fosters active student engagement in schools. This model is rooted in 'getting better together,' which provides a broader learning opportunity and a conducive environment for students to acquire and develop knowledge, attitudes, values, and social skills helpful in society [12][13]. Although the jigsaw model has many strengths, every learning model has limitations. This study aims to enhance the collaborative model by maximizing its strengths and minimizing its weaknesses. The JIRE (Jigsaw Revisi) collaborative model addresses these concerns by encouraging students to engage in learning activities based on their respective competencies [14]. Considering the importance of media in the teaching-learning process, teachers must pay close attention to selecting appropriate media that support and facilitate learning. Effective media

How to Cite:
N. R. Ilato, N. E. Ntobuo, D. G. E. Setiawan, L. Samatowa, W. M. Mohamad, and M. Yunus, "The Effect of the JIRE Collaborative Learning Model Based on Phylearn Media on Students Learning Outcomes in the Topic of Heat and Temperature in School", *J. Pijar.MIPA*, vol. 20, no. 5, pp. 992–997, Aug. 2025. https://doi.org/10.29303/jpm.v20i5.9631

selection enhances learning outcomes' efficiency, attractiveness, and quality [15][16].

Observations and interviews at SMP Negeri 4 Monano revealed that teachers still predominantly use direct instruction and lecture methods. This results in teacher-centered learning, where students passively receive content without actively participating. As a result, it raises problems regarding students' low understanding of physics concepts, and their engagement is minimal, leading to poor academic performance. Newly gained knowledge should reduce complexity and offer a comprehensive map of problems and solutions [14].

Experts have carried out various developments in learning models and learning media, which can be proposed as solutions to the problems in this research. Among them are the JIRE collaborative learning model, which has proven effective in improving student outcomes [17], and the Phylearn media for teaching heat and temperature concepts in science, which has been deemed suitable for classroom use. Based on these developments, this study seeks to test the practicality and effectiveness of the Phylearn media by integrating it with the JIRE collaborative learning model.

Research Methods

This study employs a quantitative research approach using an experimental method. The specific method applied in this study is a single-group experimental design, where only the experimental class was used as the research sample without any control or comparison group. The rationale for using this method is to examine the influence of the JIRE collaborative learning model assisted by Phylearn Media in improving students' learning outcomes.

The research design utilized is the One-Group Pre-test–Post-test Design, which involves three main steps: Administering a pre-test to measure students' understanding of physics concepts as the dependent variable before the treatment. Next, providing the experimental treatment to the subjects by implementing the JIRE collaborative learning model supported by Phylearn media. After the treatment, a post-test was administered to measure students' conceptual understanding of physics.

The population in this study includes all seventh-grade students of SMP Negeri 4 Monano during the 2024/2025 academic year, consisting of one class with 25 students. The sample was selected using the total sampling technique, in which the entire population was taken as the sample [18]. Thus, all 25 students from one class served as the research subjects. The instruments used in this study to collect data include pre-test-post-test question sheets, teaching modules, instructional materials, student worksheets, and the Phylearn learning media.

This study employed a pre-test as the initial test and a post-test as the final test to assess learning outcomes. These were used to determine student achievement differences before and after implementing the JIRE collaborative model. Operationally, learning outcomes in this study refer to Bloom's Taxonomy, which comprises six cognitive levels: remembering (C1), understanding (C2), applying (C3), analyzing (C4), evaluating (C5), and creating (C6). This study focuses on three cognitive aspects: C2, C3, and C4.

Conducting research requires both measurement and evaluation. Therefore, an appropriate measurement tool known as a research instrument is essential. According to [19], a research instrument is a tool used to measure observed natural or social phenomena, specifically research variables. The instruments used in this study to collect data on those variables were the pre-test and post-test. The pre-test-post-test method is highly recommended for evaluating the effectiveness and progress of a learning process, as it offers concise and efficient assessment [20].

The pre-test is administered before learning to assess students' initial knowledge and evaluate instructional effectiveness. The post-test, given after the lesson, assesses students' understanding of the material after completing the learning activities. Finally, data analysis was conducted after all data were collected using several statistical tests: normality test, paired t-test, and N-Gain analysis.

Results and Discussion

The study's results provide an overview of the data regarding from The Effect of Implementing the JIRE Collaborative Learning Model Based on Phylearn Media on Students' Learning Outcomes in the Topic of Heat and Temperature in School. This research was conducted at SMP Negeri 4 Monano. The study involved a single sample group (One Group), and data were collected after the students received treatment using the JIRE collaborative learning model.

The research aimed to obtain data on students' learning outcomes, which were gathered after implementing the treatment on one Group of participants. Following the intervention, the researcher performed data analysis using several theoretically based techniques to draw conclusions that could support the research hypothesis. The data analysis includes results from the normality test, paired t-test, N-Gain analysis, and assessment of students' learning outcomes.

Based on the test results obtained from the pre-test and post-test questions, a comparative analysis of students' learning outcomes in the experimental class can be observed in Table 1.

Table 1. Average Scores Pre-test and Post-test

	Average Score	
Class	Pre-test	Post-test
Experimental	46.4	81.05

The percentage comparison of students' learning outcomes at each cognitive level in the pre-test and post-test is illustrated as follows in Figure 1. Based on the diagram in Figure 1, the differences in scores for each cognitive criterion from C2 to C4 reveal notable gains. For the C2 criterion, the pre-test score was 36.80%, while the post-test score increased to 84.80%, resulting in a difference of 48%, higher than the differences observed in C3 and C4. For the C3 criterion, the pre-test score was 54.4%, increasing to 88.8% on the post-test, with a difference of 34.4%. In the C4 criterion, students scored 44.8% on the pre-test and 78.4% on the post-test, with a gain of 33.6%. This data shows a noticeable difference between the pre-test and post-test results in each cognitive category. The comparison between the pre-test and post-test results shows a significant improvement across all cognitive domains [21]. The following section provides a more detailed comparison of the learning improvement in each cognitive domain.

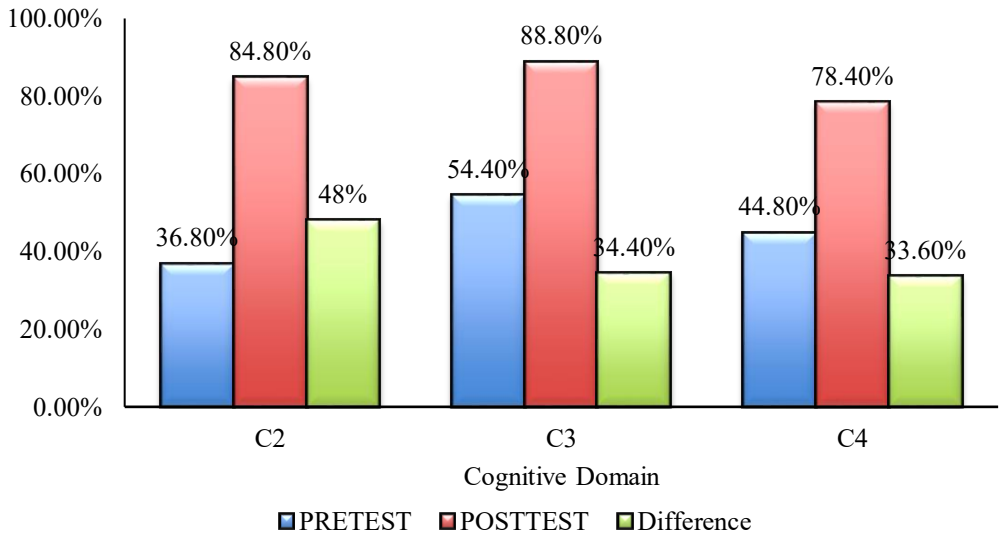

Figure 1. Cognitive Analysis Diagram One Group

Normality Test Results

One of the methods used to perform a normality test in research is the Kolmogorov-Smirnov test. The normality test aims to determine whether the data are typically distributed. In this study, the normality of the data was assessed using the Kolmogorov-Smirnov test based on the results of the pre-test and post-test data. The statistical results of the normality test can be seen in the following Table 2.

Table 2. Normality Test Results

Class	Fi	K	Description
Experimental	0.479	0.26	Normally Distributed

Based on Table 2, since the value of Fi > K at a significance level of 0.05, it can be concluded that the data from the experimental class are normally distributed [22][23].

Paired t-Test Results

The paired t-test was conducted to determine whether the implementation of physics learning using Phylearn media significantly affected the seventh-grade students at SMP Negeri 4 Monano. This test aims to investigate the causal relationship between the treatment applied to a variable and its observed effect, as presented in Table 3.

Table 3. Paired t-test Analysis of Students' Learning Outcomes

Class	$t_{calculated}$	t-(α/2;dk	Description
Experimental	-6.73	2.10	H1 Accepted

Based on Table 3, where the hypotheses are H0 = μ1 – μ2 = 0, H1 = μ1 – μ2 ≠ 0 Hα with significance level α, it is concluded that the actual difference between the two means is not equal to zero. Thus, the paired t-test on the objective questions resulted in H_1 being accepted, indicating a statistically significant difference between the pre-test and post-test mean scores [24].

N-Gain Analysis Results

The gain analysis was conducted to determine the improvement in students' learning outcomes based on the pre-test and post-test results. The N-Gain scores of students' learning outcomes are presented in Table 4.

Table 4. N-Gain Analysis of Students' Learning Outcomes

Test	Ideal Score	Max Score	Min Score	Average	<g>	
					Score	Category
Pre-test	100	50	30	46.4	0.68	Moderate
Post-test	100	90	60	81.05		

Based on Table 4, learning supported by the Phylearn media improved learning outcomes, as indicated by the higher average post-test score than the pre-test. The normalized gain score obtained from the data is 0.68, which falls into the moderate category. Each item indicator was analyzed by comparing the cognitive-level scores from the pre-test and post-test within the JIRE Collaborative Learning Model supported by the Phylearn media [25].

This study was conducted at SMP Negeri 4 Monano during the 2024/2025 academic year using the Phylearn learning media. This study aimed to examine the effect of the JIRE collaborative learning model supported by Phylearn media in improving students' learning outcomes on the topic of heat and temperature. It aimed to shift the learning process from a teacher-centered approach to a more student-centered one, allowing students to be more active and engaged. In a teacher-centered approach, all activities are directed by the teacher, which limits students' opportunities to develop their abilities according to their learning styles. Before the research was conducted, the instruments used had been

validated by expert validators. This validation process aimed to refine the instruments based on the criteria listed in the validation sheet.

This study was carried out over approximately one month at SMP Negeri 4 Monano. It used a single class (One Group), which served as the experimental class, applying the JIRE collaborative learning model integrated with Phylearn media. This class's students received pre-tests and post-tests to measure learning outcomes before and after the treatment. The One-Group design was intended to provide a more accurate estimate and evaluate the results' consistency [26]. The intervention implemented was the JIRE collaborative learning model integrated with Phylearn to observe whether it significantly improved students' learning outcomes [27].

The study was conducted over three meetings, each consisting of two class periods (2 x 40 minutes). The first meeting covered the topic of temperature, the second addressed heat, and the third focused on heat transfer. Before beginning instruction, the teacher distributed learning materials to ensure students could actively follow the activities. The teacher provided an introduction and motivation during instruction and then delivered the material. Students were then guided to work on worksheets in groups, with the class divided into five teams.

The research data were collected through objective tests consisting of 15 multiple-choice questions targeting the cognitive domains C2 (understanding), C3 (applying), and C4 (analyzing). These tests were given before and after the instructional intervention. Based on the data shown in Graph 4.1, which presents the percentage comparison of learning outcomes for C2 to C4 in the One Group, it was found that the C3 domain had the highest post-test performance compared to C2 and C4. This may be due to students finding it easier to grasp content in the C3 domain. These results suggest that the JIRE collaborative learning model effectively enhances learning outcomes, particularly in the C3 domain. According to Bloom's theory, the goal of education should always address three domains inherent in students: the cognitive (thinking), affective (attitudes/values), and psychomotor (skills) domains. The cognitive domain encompasses mental activities such as understanding (C2), applying (C3), and evaluating (C4). This domain can be assessed through tests derived from school material. The results of this study demonstrate that the JIRE model positively influenced students' learning outcomes. These findings align with research from [14], which concluded that using the revised jigsaw model (JIRE) improved the learning outcomes of university physics students.

Improved learning outcomes can be seen from the post-test scores in the One Group. The highest average was found in the C3 domain with a score of 88.8, followed by C2 with 84.8 and C4 with 78.4. This may be because many students find recalling and explaining information in the C4 domain difficult. The research involved statistical analysis using normality tests, paired t-tests, and N-Gain analysis. All data were thoroughly analyzed for the One Group. The Kolmogorov-Smirnov test showed that the data were normally distributed. A non-parametric test would have been applied if the data had not been normally distributed. However, a parametric test (paired t-test) was used since normality was confirmed. As shown in Table 4, the paired t-test resulted in the acceptance of H_1, indicating a significant difference between pre-test and post-test scores. Since the hypothesis testing had already been explained in Chapter III, repeating it here would be redundant.

N-Gain scores for C2, C3, and C4 are in the appendix. Some respondents had low N-Gain scores because they had already mastered the pretest and posttest material, resulting in no significant improvement. For example, one respondent scored 80 on both the pre-test and post-test, while another met the minimum passing grade in both tests but showed a decrease in the post-test. This may be due to the limited number of sessions (only three meetings). If this intervention were implemented over a more extended period, the improvement in learning outcomes might be more apparent. Teaching problem-solving in just three sessions cannot be considered sufficient for all students, given that each learner has a different pace of understanding. Some grasp concepts quickly, while others require more time. Additionally, although some N-Gain scores appear negative, it does not necessarily indicate a lack of understanding. Rather, the time provided to teach more complex questions was insufficient [28][29]. Despite this, the study still expects meaningful improvement in student outcomes.

The advantages of the JIRE collaborative learning model include improved student confidence, greater student participation, enhanced learning motivation, faster and more effective understanding of the material, consistency in group answers, peer teaching, and strengthened social relationships among group members. The drawbacks of the JIRE model include difficulties in distributing material evenly among students, especially when group sizes are uneven. In such cases, more than one student in a group may work on the duplicate content. Another drawback is the varying pace at which students complete tasks; some may finish early, while others still need more time.

Conclusion

Based on the results of the study and data analysis, it can be concluded that the use of the JIRE collaborative learning model significantly affects students' learning outcomes in the topic of heat and temperature in Grade VII. The implementation of the JIRE collaborative model was proven to influence student achievement. This influence is demonstrated by the difference in students' learning outcomes before and after applying the JIRE model, where the average pre-test score of 46.4 increased to 81.05 in the post-test. The t-test results indicate that this difference is statistically significant, with a significance value of 2.10, less than 0.05. These findings confirm a significant difference between students' pre-test and post-test scores after applying the JIRE collaborative learning model, indicating that this model effectively improves students' learning outcomes.

Author's Contributions

Nursuciani Radja Ilato: Conceptualization, writing-original draft preparation, methodology; Nova Elysia Ntobuo: Conceptualization, formal analysis, methodology; Dewa Gede Eka Setiawan: Writing-review and editing, curation, writing-original draft preparation; Lukman Samatowa: Formal analysis; Wahyu Mu'zizat Mohamad: Methodology; Muhammad Yunus: Writing-review and editing.

Acknowledgements
The author would like to express sincere gratitude to all parties who contributed to the implementation of this research, especially the principal and teachers of SMP Negeri 4 Monano, the academic supervisors, and all students who participated in this study. Special thanks are also extended to Universitas Negeri Gorontalo for the support and facilities provided throughout the research process.

References

[1] U. A. Charlyn, D. E. Gberevbie, and G. U. Osimen, "Fostering National Development in Nigeria: The Interplay Between Education and Social Orientation," 2025. https://doi.org/10.36941/jesr-2025-0048

[2] W. Ibrahim, W. Ibrahim, T. Zoubeidi, S. Marzouk, A. Sweedan, and H. Amer, "An online management system for streamlining and enhancing the quality of learning outcomes assessment," *Educ. Inf. Technol.*, vol. 27, no. 8, pp. 11325–11353, 2022. https://doi.org/10.1007/s10639-022-10918-8

[3] S. S. B. Sani, "Exploring teachers' approaches to science practical work in lower secondary schools in Malaysia," Ph.D. dissertation, Open Access Te Herenga Waka-Victoria Univ. Wellington, 2014.

[4] Y. Wang, J. Zhu, Z. Xu, X. Dai, K. Chen, and Y. Wang, "Social support, oral health knowledge, attitudes, practice, self-efficacy and oral health-related quality of life in Chinese college students," *Sci. Rep.*, vol. 13, no. 1, p. 12320, 2023. https://www.nature.com/articles/s41598-023-39658-6

[5] J. Nilimaa, "New examination approach for real-world creativity and problem-solving skills in mathematics," *Trends High. Educ.*, vol. 2, no. 3, pp. 477–495, 2023. https://doi.org/10.3390/higheredu2030028

[6] T. Ngoc Tuong Nguyen and D. Thi Kim Oanh, "Cooperative learning and its influences on student engagement," *Cogent Educ.*, vol. 12, no. 1, p. 2513414, 2025. https://doi.org/10.1080/2331186X.2025.2513414

[7] K. Utha, B. H. Subba, B. B. Mongar, N. Hopwood, and K. Pressick-Kilborn, "Secondary school students' perceptions and experiences of learning science and mathematics: the case of Bhutan," *Asia Pac. J. Educ.*, vol. 43, no. 2, pp. 350–367, 2023. https://doi.org/10.1080/02188791.2021.1901652

[8] A. Nankhantee, "Combining inquiry-based learning and collaborative learning: a new model for improving students' teamwork and problem-solving skills," *J. Educ. Educ. Dev.*, vol. 12, no. 1, pp. 13–38, 2025. https://doi.org/10.22555/joeed.v12i1.1296

[9] J. C. Mugabekazi, J. Mukanziza, P. Nizeyimana, and P. Manirahari, "Integrating collaborative learning strategies in the curriculum: enhancing critical thinking and communication skills in primary education," *Eur. J. Educ. Stud.*, vol. 12, no. 3, 2025. http://dx.doi.org/10.46827/ejes.v12i3.5848

[10] S. H. Hosseini, "The well-living paradigm: reimagining quality of life in our turbulent world," *Discov. Glob. Soc.*, vol. 1, no. 1, p. 19, 2023. https://doi.org/10.1007/s44282-023-00022-8

[11] E. E. Barkley, P. K. Cross, and C. H. Major, *Collaborative Learning Techniques*. San Francisco: Jossey-Bass, 2015.

[12] Z. Widyanto, R. I. Qomarrullah, and S. Tebai, "The Implementation of the Jigsaw-Type Cooperative Learning Model to Enhance Students' Motivation and Participation in Physical Education," *ACTIVE: J. Phys. Educ. Sport Health Recreat.*, vol. 14, no. 2, pp. 679–685, 2025. https://doi.org/10.15294/active.v14i2.28474

[13] T. M. Bhuttah, Q. Xusheng, M. N. Abid, and S. Sharma, "Enhancing student critical thinking and learning outcomes through innovative pedagogical approaches in higher education: The mediating role of inclusive leadership," *Sci. Rep.*, vol. 14, no. 1, p. 24362, 2024. https://www.nature.com/articles/s41598-024-75379-0

[14] N. E. Ntobuo, "Development of the Revised Jigsaw Collaborative Learning Model (JIRE) in Basic Physics II Courses at the Department of Physics, Universitas Negeri Gorontalo," 2018.

[15] E. Perez, S. Manca, R. Fernández-Pascual, and C. Mc Guckin, "A systematic review of social media as a teaching and learning tool in higher education: A theoretical grounding perspective," *Educ. Inf. Technol.*, vol. 28, no. 9, pp. 11921–11950, 2023. https://doi.org/10.1007/s10639-023-11647-2

[16] S. R. H. Intiana, A. A. Prihartini, F. Handayani, and K. Faridi, "Learning Media Based on Development of ICT (Information Communication Technology) in Increasing Student Motivation and Learning Outcomes in Indonesian Language Subject," *BULLET: J. Multidisiplin Ilmu*, vol. 3, no. 3, pp. 410–419, 2024.

[17] N. E. Ntobuo, L. M. K. Amali, D. D. Paramata, and M. Yunus, "The Effect of Implementing the Android-Based Jire Collaborative Learning Model on Momentum and Impulse Materials to Improve Student Learning Outcomes," *J. Penelit. Pendidik. IPA*, vol. 9, no. 2, pp. 491–497, 2023. https://doi.org/10.29303/jppipa.v9i2.2924

[18] Sugiyono, "*Research and Development Methods"*. Bandung: Alfabeta, 2015.

[19] Sugiyono, "*Quantitative, Qualitative, and R&D Research Methodology"*, 24th ed. Bandung: Alfabeta, 2016.

[20] M. Costa, "Choosing the Right Assessment Method: Pre-Test/Post-Test Evaluation," Boston Univ., Cabrillo College SLO Website, Revised 4/23/2024.

[21] A. Akmam, R. Afrizon, I. Koto, D. Setiawan, R. Hidayat, and F. Novitra, "Integration of cognitive conflict in generative learning model to enhancing students' creative thinking skills," *Eurasia Journal of Mathematics, Science and Technology Education*, vol. 20, no. 9, p. em2504, 2024. doi: https://doi.org/10.29333/ejmste/15026.

[22] N. Gusasi, "The Effect Of Jire's Collaborative Learning Model Based On Smart Apps Creator On Student Learning Outcomes And Students' character On Physics Learning At Small High School In Bone Bolango District," *European Journal of Humanities and Educational Advancements*, vol. 3, no. 9, pp. 72–79, 2022. [Online]. Available: https://www.scholarzest.com

[23] Y. A. Kebede, F. K. Zema, G. M. Geletu, and S. A. Zinabu, "Cooperative Learning Instructional Approach and Student's Biology Achievement: A Quasi-Experimental Evaluation of Jigsaw Cooperative Learning Model in Secondary Schools in Gedeo Zone, South Ethiopia," *Sage Open*, vol. 15, no. 1, p. 21582440251318883, 2025. doi: https://doi.org/10.1177/21582440251318

[24] D. K. Wardani and S. Widyawati, "Paired t-test analysis to determine the effect of smart paperboard learning media on student learning outcomes," *Al-Fikru: Jurnal Pendidikan Dan Sains*, vol. 5, no. 2, pp. 281–290, 2024. doi: https://doi.org/10.55210/al-fikru.v5i2.1870.

[25] K. N. Chee, N. Yahaya, and N. H. Ibrahim, "An evaluation of the learning effectiveness of a formulated ideal social collaborative mobile learning environment application towards cognitive level in biology," *International Journal of Mobile Learning and Organisation*, vol. 12, no. 2, pp. 162–189, 2018. doi: https://doi.org/10.1504/IJMLO.2018.090850

[26] N. K. Muflikah and I. Sucahyono, "The Effectiveness of Applying the Guided Discovery Learning Model on Student Learning Outcomes in the Topic of Work and Energy in Grade X Senior High School," *J. Inov. Pendidik. Fis.*, vol. 8, no. 2, pp. 747–750, 2019.

[27] L. A. C. Urbina, "The Impact of Collaborative Learning Strategies on 9th-Grade Biology Students' Learning Outcomes," *Online Submission*, 2025. [Online]. Available: https://eric.ed.gov/?id=ED672441.

[28] A. Triyono *et al.*, "The level of effectiveness of tps and conventional methods judging from students' geometry learning results using the N-Gain Test," *AlphaMath: Journal of Mathematics Education*, pp. 142–156, 2024. doi: https://doi.org/10.30595/alphamath.v10i1.21530.

[29] A. A. Aziz, I. N. H. Adam, J. Jasmis, S. J. Elias, and S. Mansor, "N-Gain and System Usability Scale Analysis on Game Based Learning for Adult Learners," in *2021 6th IEEE International Conference on Recent Advances and Innovations in Engineering (ICRAIE)*, vol. 6, pp. 1–6, Dec. 2021. doi: https://doi.org/10.1109/ICRAIE52900.2021.9704013.