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Learning Innovation: Application of Discovery Learning-Based Worksheets to Sharpen Students' Collaboration Skills on Hydroelectric Power Plants

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ABSTRACT

Purpose—In the 21st century, where education emphasizes the development of holistic competencies, collaboration skills have become an important aspect of preparing students to face the complex demands of the real-world environment. This study aims to analyze the effect of discovery learning on improving students' collaboration skills in studying alternative energy sources, mainly hydropower.

Methodology – This research employed a quasi-experimental design featuring a one-group pretest-posttest method, with 35 students at SMP IT Ibnu Abbas serving as participants. The sample was chosen using a random sampling approach, ensuring that every individual in the population had an equal chance of being selected. Information regarding students' collaboration skills was gathered through self-assessment using a questionnaire. The collected data were analyzed using descriptive statistical methods to provide an overview of the results and inferential statistics to test hypotheses and reach more detailed conclusions.

Findings—The results indicate a notable enhancement in students' collaboration abilities following the adoption of the discovery learning model, with the mean score increasing from 28.49 on the pre-test to 36.34 on the post-test. A paired sample t-test validated this change, yielding a significance level of 0.000. The N-Gain assessment also demonstrated a medium effectiveness level with an average score of 0.3255. The discovery learning model successfully improved collaboration skills through active exploration, discussion, and problem-solving, underscoring its potential to promote 21st-century competencies among students.

Significance – In addition, this approach provides a reference for implementing strategic steps to help high school students improve their collaborative skills, fostering essential non-academic achievements like teamwork and problem-solving for their future success

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INTRODUCTION

21st-century learning is characterized by a significant transformation in educational approaches, where learning methods that were once educator-centered are now shifting towards learner-centered learning. This shift is driven by the need to adapt the education system to the challenges of globalization (Junedi et al., 2020). In teaching and learning, the teacher is not just a conveyor of knowledge but also a facilitator who equips students by providing relevant 21st-century skills**.** Educational institutions are responsible for preparing young people who are adaptive to the times. Schools are expected to focus on knowledge transfer and encourage students to master the skills incorporated in the 4C concept of creativity, critical thinking, communication skills, and collaboration (Partono et al., 2021; Septikasari & Frasandy, 2018). These four abilities are considered important pillars in shaping competent individuals in the 21st century.

Collaboration is among the most important aspects of educational development. Collaboration is a process of cooperation and coordination and contains elements of positive dependence in groups that lead to achieving common goals (Dewi et al., 2022; Nurwahidah et al., 2021). An alternative viewpoint suggests that collaboration skills are characterized by a student's capability to engage in dialogue, share thoughts or concepts, and successfully inspire others to pursue a common goal in addressing issues, which can enhance critical thinking abilities (Hidayati, 2019; Lelasari et al., 2017; Robbins & Hoggan, 2019). From some of these opinions, it can be understood that collaboration involves learners working together in groups, supporting one another, and sharing duties to accomplish set objectives. This skill involves active interaction, mutual respect for opinions, and collective efforts in completing a particular task. However, the explanation of the importance of collaboration has not been fully realized in the world of education in Indonesia because the application of collaboration skills in education in Indonesia still faces challenges, such as low student involvement due to monotonous conventional learning methods and lack of innovative learning media (Octaviana et al., 2022; Ode et al., 2017). This is also relevant and occurs at SMP IT Ibnu Abbas, where the students' collaboration abilities appear insufficient, as indicated by initial observations revealing a scarcity of active engagement and limited group discussions during the science learning process. Most students prefer working alone, and the objectives of collaborative learning have yet to be completely realized.

The active participation of students in the science learning process is crucial for understanding and applying the natural phenomena around them. During this process, students develop observation and experimentation skills that focus primarily on cultivating scientific thinking and practical skills. Furthermore, students learn to conduct experiments collaboratively while identifying and utilizing equipment in the laboratory and their natural surroundings. With the enhancement of their mathematical skills, students are encouraged to foster their reasoning abilities through established principles, and this reasoning is conveyed through precise data management, leaving no room for doubt. Abdilah & Umiatin (2015) indicate that students retain 10% of what they read, 20% of what they hear, 30% of what they see, 50% of what they see and hear, 70% of what they say, and 90% of what they say and do. This implies that when a teacher relies solely on lectures, students will remember and grasp only 20% of the material, as they learn passively through listening. Conversely, if the teacher encourages students to engage in activities and report their findings, they will remember and understand up to 90% of the lesson (Hamid, 2011).

To answer these challenges, the discovery learning model presents a creative strategy that engages students in active exploration, discussion, and problem-solving. According to (Darmawan & Wahyudin, 2018), The discovery learning model is a method that positions students as active participants in their education. Discovery learning includes learning models and strategies that provide students with active and direct learning opportunities (Niman et al., 2024). Students are mainly responsible for solving various problems according to the material studied within the learning framework designed and presented by the teacher (Hosnan, 2014; Nababan et al., 2023). This process helps produce a deep understanding and improve students' memory of the material learned.

Meanwhile, Hanida et al. (2019) defined discovery learning as a cognitive model requiring teacher creativity to create a conducive and innovative learning situation. Through this approach, students are actively involved in discovering new knowledge so that learning becomes more meaningful and oriented towards

developing critical thinking skills and independent exploration (Manurung & Pappachan, 2025; Ramadhana et al., 2025)This learning model has several advantages that make it effective in the learning process. First, it improves students' problem-solving skills as they are trained to identify problems, find solutions, and evaluate the results. Secondly, discovery learning helps students to collaborate through the experience of working with others, which also increases self-confidence. Third, discovery learning motivates students to use their intuition and formulate hypotheses independently. Fourth, this model trains students to learn independently, giving them the skills to organize their learning process. Finally, students are encouraged to actively think and use their abilities to find solutions and draw conclusions from their learning (Hosnan, 2014).

Several studies have shown that discovery learning is efficacious in improving collaboration skills. Musni & Antrakusuma (2024) revealed that the application of Discovery Learning significantly improved collaboration skills, seen from the percentage increase from pre-cycle of 58.88%, then increased to 69.21% in cycle 1, and reached 73.33% in cycle 2. This increase shows consistent development as the learning process progresses. In addition, Hastuti et al. (2024) reported a significant difference between the control class and the experimental class in the application of Discovery Learning, which strengthens the evidence of the effectiveness of this model in improving collaboration skills. Furthermore, (Hertanti et al., 2023) noted a consistent increase in collaboration skills through Discovery Learning, from pre-cycle of 78.87%, from cycle 1 to 79.19%, and increasing more significantly in cycle 2 to 85%. This pattern of increase shows that students' collaboration skills are growing along with the continuous application of discovery learning. However, most of these studies have not explicitly examined the application of discovery learning in the context of alternative energy sources, especially in hydropower generation. Therefore, this research offers novelty by integrating discovery learning-based student worksheets with a problem-solving approach on the topic of hydropower generation that has not been widely researched before by being systematically designed to guide students through the learning stages starting from stimulation, problem formulation, data collection, data processing, to conclusion making. This worksheet allows students to play an active role in learning individually and in groups so that collaboration skills and concept understanding can develop simultaneously. A more comprehensive methodological approach, combined with observation and questionnaires on collaboration skills and analysis using the N-Gain test and paired-samples t-test, provides more holistic data on improving collaboration skills. Thus, this research not only enriches the literature on the application of discovery learning but also fills the research gap in the context of alternative energy, especially on hydropower generation.

METHODOLOGY

Research Design

This study employs a quantitative methodology utilizing a descriptive technique to evaluate the enhancement of students' collaboration skills following the implementation of the discovery learning model. The research framework was a pre-experimental design featuring a one-group pretest-posttest design approach. Collaboration skills are assessed using a pre-test followed by a post-test to evaluate the improvement resulting from implementing the learning model. This approach was selected due to its simplicity and relevance, and it is deemed more practical for achieving the research objectives, which include assessing the students' initial abilities, as shown in Table 1. Specifically, it examines students' learning process by employing the discovery learning model. However, this research methodology also presents a drawback, as no control class exists. Incorporating a control group would enhance the study's internal and external validity. Nonetheless, this method can still offer an initial indication of the effectiveness of the applied Treatment. The specifics of the research design utilized (Suharsimi, 2006) are presented in Table 1.

Table 1. Experimental Design

Pre-test	Experiment	Post-test
O_1	X	O_2

Explanation:

O_1 = Pre-test administered before the Treatment
X = Treatment uses a discovery learning model
O_2 = Post-test administered after the Treatment

Research Instrument

This research used a collaboration skills questionnaire as the data collection tool. This questionnaire contains 10 statements intended for students to complete to self-evaluate their collaboration skills throughout the learning process. Information about collaboration skills was gathered from the self-assessment responses provided by students via the questionnaire. The questionnaire is structured around five primary indicators representing key facets of collaboration skills: group contribution, problem-solving ability, teamwork capability, responsibility for task completion, and positive interactions and appreciation among group members. These five indicators were chosen to provide a comprehensive picture of students' collaboration skills during learning. Developing instruments and designing this research was carried out systematically to ensure that the instruments could sufficiently reflect students' collaboration skills, as described in Table 2.

Table 2. Collaboration Skills Indicator

No	Indicator	Number of Statements
1	Contribution	2
2	Problem-solving	2
3	Group work skills	2
4	Responsible for completing tasks	2
5	Positive interaction and respect between members	2

Data Collection Techniques

During the odd semester, this study was carried out at Ibnu Abbas Junior High School in November 2024. The research employed a quasi-experimental approach utilizing a one-group pretest-posttest design. Data collection involved two primary methods: observation and non-test assessments. Observations were conducted to assess learning requirements and pinpoint individual student characteristics. Simultaneously, non-test assessments were executed through the distribution of collaboration skills questionnaires administered twice, first prior to Treatment to evaluate students' initial abilities and then post-treatment to assess the changes in collaboration skills following the implementation of the discovery learning model.

The research sample was chosen through a random sampling method, focusing on class IX B at Ibnu Abbas Junior High School, which included 35 students. The primary tool for data collection was a questionnaire on collaboration skills comprising 10 statements. This questionnaire was intended for students to complete as a self-evaluation of their collaborative abilities during the learning experience. Data were analyzed using two statistical methods: descriptive and inferential. Descriptive statistics provided an overview of the data, while inferential statistics were used to determine differences in student collaboration skills before and after the research. By selecting a random sample from a single class, this study seeks to gain insight into the students' collaboration skills in that class and to examine any changes that occur following the Treatment.

Descriptive statistical analysis is used to describe or provide an overview of the data obtained, namely, the results of student collaboration on learning electricity, magnetism, and alternative energy table, finding the average value, variance, and standard deviation to describe the characteristics of the research variables (Sugiyono, 2016). The formulas that can be used are as follows. The average student score can be calculated using Equation 1.

$$M = \frac{\sum X}{N} \qquad (1)$$

Description:
M = average score
$\sum X$ = total score of learners

N = number of respondents

Standard deviation can be calculated using the formula equation 2.

$$s = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}} \quad (2)$$

Description:
s = standard deviation
x_i = learner score
$\bar{x}$ = average score
n = number of research subjects

Once all the data had been gathered, the N-Gain formula was utilized to assess the importance of the rise in student collaboration between the pre-test and post-test outcomes and examine the distribution and frequency of the data. This analysis aims to provide an overview of the increase in student collaboration before and after Treatment. The equation for calculating N-Gain is presented in equation 3.

$$g = \frac{S_{posttest} - S_{pretest}}{S_{maximal} - S_{pretest}} \quad (3)$$

The final score calculated using the formula above is then classified based on the category by Hake (1998), which divides the N-Gain results into three categories: high, medium, and low. The high category ($g > 0.7$) indicates a significant increase in collaboration skills, meaning that students experience a significant and practical improvement. The moderate category ($0.3 \leq g \leq 0.7$) indicates that the improvement of collaboration skills exists but at a moderate level. At the same time, the low category ($g < 0.3$) indicates that the improvement in students' collaboration skills is relatively small or even insignificant. Table 3 illustrates the range of values for each N-Gain category.

Table 3. N-Gain Indeks Value

N-Gain Score	Criteria
g ≥ 0,7	High
0,7 > g ≥ 0,3	Medium
g < 0,3	Low

Effect size is calculated to measure the magnitude of the impact caused by the application of student worksheets on student collaboration skills using the effect size calculation formula as follows.

$$d = \frac{(M_2 - M_1)}{\sqrt{\frac{SD_1^2 + SD_2^2}{2}}} \quad (4)$$

Description:
d = effect size
Mean 1 = pre-test mean score.
Mean 2 = post-test mean score
SD 1 = pre-test standard deviation
SD 2 = post-test standard deviation

The effect size values obtained were then interpreted into various categories based on Cohen's (1998) guidelines used to assess the magnitude of the difference between pre-test and post-test scores in a one-group pretest-posttest design. This measure divides effect size into three main categories. A small effect size (d = 0.2) suggests that the difference between the pre-test and post-test is minor, meaning that the changes that occur are insignificant despite the improvement. A moderate effect size (d = 0.5) indicates a noticeable, not overly dramatic, change. In contrast, a large effect size (d = 0.8) reflects a significant shift with a clear distinction

between the pre-test and post-test scores, demonstrating a strong influence of the provided Treatment. These classifications can be further examined in Table 4, which offers a detailed interpretation of the magnitude of change that occurred following the implementation of the learning model in this research.

Table 4. Categories for Interpreting Effect Size

Effect Size Value	Category
$d < 0,2$	Low
$0,2 \leq d < 0,5$	Medium
$d \geq 0,8$	High

FINDINGS

This section will present the research results in a structured and thorough manner. The first step is to use descriptive statistics to provide an initial understanding of the students' collaboration skills scores before and after applying the discovery learning model. Next, a normality test was conducted to verify whether the data distribution in the pre-test and post-test followed a typical distribution pattern. After ensuring that the data is usually distributed, hypothesis testing is carried out by applying a paired sample t-test to test whether there is a significant difference between students' pre-test and post-test scores. Finally, in the Effectiveness analysis section, the effect size calculation will be conducted to dig deeper and strengthen the findings of the t-test, thus providing a clearer understanding of the magnitude of the impact caused by the application of the learning model.

Descriptive Statistics

The results of the descriptive analysis indicate the variations in student scores before and after implementing the discovery learning model on the subject of alternative energy sources. Before implementing this model, the lowest score achieved by students was 20, whereas following the model's application, the minimum score rose to 32. Similarly, the highest score, which was 37 before the intervention, increased to 40 after introducing the discovery learning model. The mean score before the intervention was 28.49, while after the intervention, the average score of students grew to 36.34. This indicates a notable improvement in scores after applying this educational approach. The findings from the descriptive analysis are presented in Table 5.

Table 5. Description of Research Data

	N	Range	Minimum	Maximum	Mean	Std. Deviation
Pre-test	35	17	20	37	28,49	4,203
Postest	35	8	32	40	36,34	1,714
Valid N	35					

The following data, Figure 1, will clarify the comparison of pre-test and post-test scores. It illustrates the increase in the average score of students' collaboration skills.

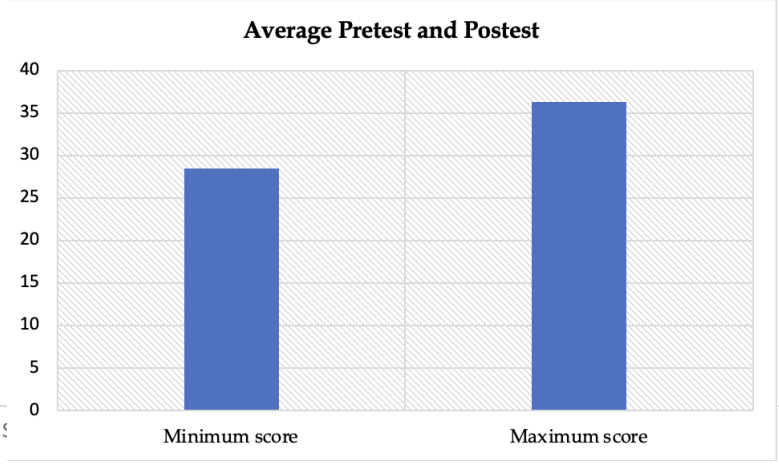

Figure 1. Average Score of Pretest and Posttest

Normality Test

A normality test was conducted to determine if the pre-test and post-test data followed a normal distribution. In this research, the Shapiro-Wilk test was utilized because the sample size was less than 50, consisting of only 35 students. The Shapiro-Wilk test was chosen because it offers more precise and reliable results for smaller sample sizes. The findings from the normality test indicate that the significance value recorded for the class prior to the intervention was 0.765, which is greater than 0.05, thus indicating that the pre-test scores are normally distributed. In contrast, after the Treatment, the significance value reached was 0.368, demonstrating that the significance is more significant than 0.05, thus confirming the normal distribution of the post-test scores. The results of the normality test can be found in Table 6.

Table 6. Normality Test Result

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pre-test	,098	35	,200*	,980	35	,765
Postest	,135	35	,107	,967	35	,368

Hypothesis Testing

The inferential test utilizing a paired sample t-test revealed a notable difference in students' pre-test and post-test scores. According to the data analysis, the significance value (Sig. 2-tailed) is 0.000. In line with the statistical decision-making criteria, if the Sig. (2-tailed) is less than 0.05, the null hypothesis (H_0) is to be rejected, while the alternative hypothesis (H_a) is accepted. Thus, based on these findings, there is a significant difference in the average scores of students' collaboration skills before and after implementing the discovery learning model in alternative energy education. The data from the paired sample t-test results are presented in Table 7.

Table 7. Paired Sample T-Test Result

	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
				Lower	Upper			
Pretest-Postest	-7,857	4,074	,689	-9,257	-6,458	-11,410	34	,000

Effectiveness Analysis

The effectiveness analysis revealed that using the discovery learning model significantly enhanced students' collaboration skills, reflected by an effect size (Cohen's d) 1.73. This Cohen's d value suggests substantial differences between students' pre-test and post-test scores. Cohen's (1988) criteria indicate that a value of 0.8 or greater signifies a strong effect, thus affirming the significant influence of the discovery learning model on students' collaboration skills. Additionally, this finding is supported by the N-Gain calculation, which indicates that most students (24 students) fall into the medium category regarding improvements in collaboration skills. In comparison, five students are categorized as high and six as low. This N-Gain categorization is based on Hake's theory (1998), which classifies the N-Gain value, namely the high category ($g > 0.7$), indicating a significant increase in collaboration skills, which means that students experienced a large and effective improvement. The moderate category ($0.3 \leq g \leq 0.7$) indicates that the improvement in

collaboration skills exists but at a moderate level. At the same time, the low category (g < 0.3) indicates that the improvement in students' collaboration skills is relatively small or even insignificant. This illustrates that although there was a significant improvement, the impact varied between students. Some factors that may have influenced this result include student engagement in group activities, students' initial abilities, and the quality of interactions within the group. Students who are more active and motivated in collaborative learning tend to show higher improvement. At the same time, other factors, such as group dynamics and interaction, also play an important role in strengthening the effectiveness of this model. The N-Gain table data can be seen in Table 8.

Table 8. N-Gain Test Result

Range	Category	Frequency
g ≥ 0,7	Tinggi	5
0,7 > g ≥ 0,3	Sedang	24
g < 0,3	Rendah	6

DISCUSSION

This research demonstrates that the discovery learning model substantially enhances students' collaboration abilities. Based on the descriptive analysis, there was an increase in the average score of students' collaboration skills from 28.49 in the pre-test to 36.34 in the post-test. These results can be evidence that applying the discovery learning model can improve collaboration skills. The decrease in the deviation score from 4.203 in the pre-test and 1.714 in the post-test shows that this model made the distribution of students' collaboration skills even more. In other words, the difference in scores between students with high and low collaboration skills was reduced after applying this model. Discovery learning can help reduce skill inequality between students with more thorough and complex learning.

The pre-test and post-test values in the normality test using Shapiro-Wilk showed that the values were normality distributed with a P value greater than 0.05 (p > 0.05). This proves there is no deviation of the data from the expected distribution results and can meet the requirements for conducting further statistical analysis tests. In testing the difference between the pre-test and post-test values, a paired sample t-test was used, and a p-value of 0.000, which can be said to be less than 0.05, was obtained. The low t-test results can describe the pre-test and post-test results that have a statistically significant difference. In other words, using the discovery learning model in the learning process provides positive results. It affects improving student collaboration results, as evidenced by the significant increase in student scores.

The results of the effect size calculation show that the discovery learning model greatly influences students' collaboration skills, as seen from Cohen's d value of 1.73. This shows that the difference between the pre-test and post-test scores is significant, meaning that discovery learning helps improve students' collaboration skills. This result is also supported by the N-gain calculation, which shows that 24 students are in the medium improvement category, 5 in the high category, and 6 in the low category. This grouping is based on the opinion of Hake (1998), who divides learning changes into three groups, namely high (g ≥ 0.7), medium (0.3 ≤ g < 0.7), and low (g < 0.3). Although most students showed improvement, these results can be influenced by several factors, such as how active students are in the discussion, the initial abilities of students, and how the group discussion process is carried out. Students who are more active in group discussions usually get higher N scores, while students with low N scores may have difficulty collaborating or be less motivated to participate optimally. In addition, students' initial abilities also affect how much change they experience. Students who already have better collaboration skills tend to experience faster improvement. The quality of interaction within the group is also an important factor; a group that is not solid or has ineffective communication can hinder the development of students' cooperation skills, resulting in a low N-gain.

This study supports the findings of (Kartikasari et al., 2018), which stated that discovery learning effectively improves collaboration skills in learning. The discovery learning model is oriented towards a scientific approach, which is one way to improve the ability to find themselves and investigate themselves in solving student problems in subjects (Dewi et al., 2020; Monalisa et al., 2022). This approach encourages

students to be active in finding solutions and develops their critical thinking skills, which are indispensable in a constantly evolving world full of new challenges. In the context of science, the application of the discovery learning model has the potential to strengthen students' understanding of scientific concepts that are often abstract and complex. Involving students directly in the discovery process, this model enhances collaboration skills, essential in achieving a common goal in a scientific project or task. Students learn to understand the material in depth and how to work together with classmates to achieve a greater goal. This is in line with Anisa and Astriani (2022), who revealed that the discovery learning model allows students to formulate the knowledge they gain in learning through a systematic, logical, critical, and analytical process. In addition, this model also reinforces individual responsibility for the group's success, where each member feels they have an equally important role in achieving the goal. This encourages students to share ideas, discuss solutions, and support each other in solving challenges faced together (Qureshi et al., 2023; Rahayu & Sumardi, 2024). Thus, the discovery learning model develops collaboration skills and teaches students to overcome challenges collectively, explore the material more practically, and improve critical thinking skills needed to solve problems in everyday life and the professional world. Applying this model in science learning allows students to learn in a more in-depth, thorough, and rewarding way that can later contribute to forming students' characters who are more independent and collaborative in dealing with problems in the future.

For teachers, this research can add knowledge that the discovery learning model positively influences students' collaboration skills, which are important in 21st-century learning. Teachers can use this discovery learning model to engage students in problem-based learning, which helps add collaboration and discussion skills to make the learning process more active. In addition, researchers can use the results of this study to determine the factors that influence the success of the teaching and learning process, such as students' motivation level and the external support they receive. Although this study has significant results, some limitations need to be considered, such as the relatively small number of samples and the lack of control class as a comparison in the research process, so the results do not fully represent the population. Further research that will be conducted is expected to use a control group and experimental group with a larger sample size in order to provide a more complex understanding of the effective use of the discovery learning model.

CONCLUSION

Discovery learning in this study improved students' collaboration skills significantly; this can be seen from the increase in the average score from 28.49 in the pre-test to 36.34 in the post-test, as well as a more even distribution of students after the application of discovery learning. Normally distributed data and t-test results with a significance value of 0.000 showed a significant difference between before and after learning. This study also tested N-Gain to determine the effectiveness during the learning process, with most students obtained in the medium group. Learning using discovery learning is essential in 21st-century education because, in addition to helping in understanding the material, it also helps students in the process of cooperation, discussion, and responsibility. This study confirms that discovery learning has great potential to be applied in the learning process.

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REFERENCES

Abdilah, H. S., & Umiatin, D. (2015). Pengembangan Miniatur Pembangkit Listrik Tenaga Air Sebagai Media Pembelajaran Fisika Sekolah Menengah Atas (SMA). *Prosiding Seminar Nasional Fisika (E-Journal) SNF2015*, *IV*. http://snf-unj.ac.id/kumpulan-prosiding/snf2015/

Anisa, V. M., & Astriani, D. (2022). Implementation of PhET simulation with discovery learning model to improve understanding of dynamic electricity concepts. *Jurnal Pijar Mipa*, *17*(3), 292–301. https://doi.org/10.29303/jpm.v17i3.3438

Darmawan, D., & Wahyudin, D. (2018). *Model Pembelajaran di Sekolah*. PT. Remaja Rosdakarya.

Dewi, A. P., Putri, A., Anfira, D. K., & Prayitno, B. A. (2020). Profil Keterampilan Kolaborasi Mahasiswa pada Rumpun Pendidikan MIPA. *Pedagogia Jurnal Ilmu Pendidikan*, *18*(01). https://doi.org/10.17509/pdgia.v18i1.22502

Dewi, N. L. R. A., Lasmawan, I. W., & Gadig, I. K. (2022). Pengembangan Instrumen Keterampilan Belajar Dan Berinovasi (4C) Pada Pembelajaran IPA Siswa Kelas V SD. *PENDASI: Jurnal Pendidikan Dasar Indonesia*, *6*(1), 65–74.

Hamid, S. M. (2011). *Metode Edutainment*. Diva Press.

Hanida, Neviyarni, & Fahrudin, F. (2019). Peningkatan Hasil Belajar Siswa Menggunakan Bahan Ajar Tematik Terpadu Berbasis Model Discovery Learning di Kelas IV Sekolah Dasar. *Jurnal Basicedu*, *3*(2), 716–724. https://doi.org/https://doi.org/10.31004/basicedu.v3i2.60

Hastuti, S. F., Sari, S. Y., Mufit, F., & Hufri. (2024). the Influence of the Discovery Learning Model on Students' Collaboration Ability at Sman 2 Padang. *Physics Learning and Education*, *2*(3), 127–135.

Hertanti, R., Azizah, K. R., Sari, P. P., & Melissa, M. M. (2023). *Guided Discovery Learning to Improve Students' Mathematics Representation and Collaboration at Senior High School 6 Yogyakarta*. *7*(2), 19–35. https://doi.org/10.30659/kontinu.7.2.p

Hidayati, N. (2019). Collaboration Skill Of Biology Students At Universitas Islam Riau, Indonesia. *International Journal of Scientific & Technology Research*, *8*(11), 208–2011.

Hosnan. (2014). *Pendekatan saintifik dan kontekstual dalam pembelajaran abad 21*. Ghalia Indonesia.

Junedi, B., Mahuda, I., & Kusuma, J. W. (2020). Optimalisasi Keterampilan Pembelajaran Abad 21 Dalam Proses Pembelajaran Pada Guru MTS Massaratul Mut'allimin Banten. *Transformasi: Jurnal Pengabdian Masyarakat*, *16*(1), 63–72. https://doi.org/https://doi.org/10.20414/transformasi.v16i1.1963

Kartikasari, D., Medriati, R., & Purwanto, A. (2018). Penerapan Discovery Learning Model dengan Pendekatan Saintifik untuk Meningkatkan Kemampuan Berpikir Kritis Siswa pada Konsep Kalor dan Perpindahan Kalor. *Jurnal Kumparan Fisika*, *1*(2), 1–7. https://doi.org/10.33369/jkf.1.2.1-7

Lelasari, M., Setyosari, P., & Ulfa, S. (2017). Pemanfaatan Social Learning Network Dalam Mendukung Keterampilan Kolaborasi Siswa. *ProsidingTEP & PDsTransformasi Pendidikan Abad 21*, 167–172.

Manurung, A. S., & Pappachan, P. (2025). The role of discovery learning in efforts to develop students' critical thinking abilities. *Journal of Education and Learning*, *19*(1), 46–53. https://doi.org/10.11591/edulearn.v19i1.21788

Monalisa, Q., Hakim, R., & Movitaria, M. A. (2022). Penggunaan Model Discovery Learning Berorientasi Pendekatan Scientific untuk Meningkatkan Hasil Belajar IPA Siswa Sekolah Dasar. *Jurnal Basicedu*, *6*(1), 852–858. https://doi.org/10.31004/basicedu.v6i1.2005

Musni, D. I., & Antrakusuma, B. (2024). Improving collaboration skills through implementing differentiated learning with a discovery learning model in junior high schools Article History. *Innovations in Science Education and Practice*, *1*(1), 18–24. https://doi.org/10.20961/isep.v1i1.1746

Nababan, D., Bakara, A., & Sihite, C. (2023). Penerapan Strategi Pembelajaran Discovery Learning Dalam Meningkatkan Keaktifan Belajar Peserta Didik. *Pediaqu:Jurnal Pendidikan Sosial Dan Humaniora*, *2*(2), 766–773.

Niman, E. M., Edison, A. Y., & Momang, B. (2024). The Effectiveness of the Discovery Learning Model on Student Learning Outcomes. *International Journal of Multidisciplinary Research and Analysis*, *7*(7), 3454–3458. https://doi.org/10.47191/ijmra/v7-i07-49

Nurwahidah, N., Samsuri, T., Mirawati, B., & Indriati, I. (2021). Meningkatkan Keterampilan Kolaborasi Siswa Menggunakan Lembar Kerja Siswa Berbasis Saintifik. *Reflection Journal*, *1*(2), 70–76. https://doi.org/10.36312/rj.v1i2.556

Octaviana, F., Wahyuni, D., & Supeno, S. (2022). Pengembangan E-LKPD untuk Meningkatkan Keterampilan Kolaborasi Siswa SMP pada Pembelajaran IPA. In *EDUKATIF : Jurnal Ilmu Pendidikan* (Vol. 4, Issue 2). Universitas Pahlawan Tuanku Tambusai. https://doi.org/10.31004/edukatif.v4i2.2332

Ode, N. M. Y., Bialangi, N., & Ischak, N. I. (2017). Pengaruh Pembelajaran Kolaboratif Terhadap Hasil Belajar Siswa Pada Materi Tata Nama Senyawa Kimia di SMA Negeri 1 Telaga Biru T . A 2015 / 2016. *Jurnal Entropi*, *12*(2), 157–164.

Partono, P., Wardhani, H. N., Setyowati, N. I., Tsalitsa, A., & Putri, S. N. (2021). Strategi Meningkatkan Kompetensi 4C (Critical Thinking, Creativity, Communication, & Collaborative). *Jurnal Penelitian Ilmu Pendidikan*, *14*(1), 41–52. https://doi.org/10.21831/jpipfip.v14i1.35810

Qureshi, M. A., Khaskheli, A., Qureshi, J. A., Raza, S. A., & Yousufi, S. Q. (2023). Factors affecting students' learning performance through collaborative learning and engagement. *Interactive Learning Environments*, *31*(4), 2371–2391. https://doi.org/10.1080/10494820.2021.1884886

Rahayu, F., & Sumardi, L. (2024). Meningkatkan Keterampilan Kolaborasi Peserta Didik Melalui Penerapan Model Discovery Learning Pada Pembelajaran Biologi Di SMAN 5 Mataram. *Jurnal Kependidikan*, *9*(1), 1–6.

Ramadhana, N., Qamariah, N., & Saphira, H. V. (2025). The Implementation of the Discovery Learning Model Using Higher Order Thinking Skills Booklet Media on Students' Critical Thinking Ability. *IJORER : International Journal of Recent Educational Research*, *6*(1), 33–42. https://doi.org/10.46245/ijorer.v6i1.725

Robbins, S., & Hoggan, C. (2019). Collaborative Learning in Higher Education To Improve Employability: Opportunities and Challenges. *New Directions for Adult and Continuing Education*, *163*, 95–108. https://doi.org/https://doi.org/10.1002/ace.20344

Septikasari, R., & Frasandy, R. N. (2018). Keterampilan 4C Abad 21 Dalam Pembelajaran Pendidikan Dasar. *Jurnal Tarbiyah Al-Awlad, Volume*, *VIII*(02), 107–117.

Sugiyono. (2016). *Metode Penelitian Kuantitatif, Kualitatif, dan R&D Cetakan ke-24*. Alfabeta.

Suharsimi, A. (2006). *Metodologi Penelitian*. Rineka Cipta.