Jurnal Tarbiyatuna
Vol. 16 No. 1 (2025) pp. 61 - 79
pISSN: 2085-0889 | eISSN: 2579-4981
Journal Homepage: *https://journal.unimma.ac.id/index.php/tarbiyatuna/index*

The Development of the IPAER Learning Model for Improving Critical Thinking Skills in Elementary Education

Nasyariah Siregar[1*], Syahrial[2], Sofyan[3] Bunga Ayu Wulandari[4]
[1]Universitas Jambi, Indonesia
**email: nasyariahsiegar@uinjambi.ac.id*

DOI: *https://doi.org/10.31603/tarbiyatuna.v16i1.13882*

Check for updates

Article Info:
Submitted: 21/04/2025
Revised: 29/05/2025
Published: 30/06/2025

ABSTRACT

Critical thinking has become a key focus in modern education as a response to contemporary challenges. However, field observations show that students' ability to recognize and evaluate IPAS (Science and Social Sciences Integration) content remains relatively low, indicating underdeveloped critical thinking skills. These skills can be nurtured through effective classroom instruction. In reality, many existing learning models fail to fully accommodate students' cognitive needs. To address this gap, this study aims to develop the IPAER learning model. Employing the ADDIE research and development framework, consisting of analysis, design, development, implementation, and evaluation, this study collected data through observations, interviews, response questionnaires, and critical thinking tests. The findings indicate that the IPAER model is highly valid, with validation scores of 90.25% for content, 92.22% for language, 93.68% for instructional design, and 94.61% for educational technology. The model also demonstrated high practicality, with a score of 94%. Its effectiveness was evidenced by significant improvements in students' critical thinking skills, as shown by a t-test result of $p < 0.001$ and high N-gain scores of 0.7604 (limited trial) and 0.7638 (large-scale trial). These results contribute to the advancement of innovative learning models that foster higher-order thinking in elementary education.

Keywords: *IPAER learning model; critical thinking; IPAS; elementary education*

ABSTRAK

Berpikir kritis telah menjadi fokus utama dalam pendidikan modern sebagai respons terhadap tantangan kontemporer. Namun, pengamatan lapangan menunjukkan bahwa kemampuan siswa untuk mengenali dan mengevaluasi konten IPAS (Integrasi Sains dan Ilmu Sosial) masih relatif rendah, yang menunjukkan keterampilan berpikir kritis yang kurang berkembang. Keterampilan ini dapat dipupuk melalui instruksi kelas yang efektif. Pada kenyataannya, banyak model pembelajaran yang ada gagal untuk sepenuhnya mengakomodasi kebutuhan kognitif siswa. Untuk mengatasi kesenjangan ini, penelitian ini bertujuan untuk mengembangkan model pembelajaran IPAER. Dengan menggunakan kerangka kerja penelitian dan pengembangan ADDIE, yang terdiri dari analisis, desain, pengembangan, implementasi, dan evaluasi, penelitian ini mengumpulkan data melalui observasi, wawancara, kuesioner respons, dan tes berpikir kritis. Temuan menunjukkan bahwa model IPAER sangat valid, dengan skor validasi

90,25% untuk konten, 92,22% untuk bahasa, 93,68% untuk desain instruksional, dan 94,61% untuk teknologi pendidikan. Model tersebut juga menunjukkan kepraktisan yang tinggi, dengan skor 94%. Efektivitasnya dibuktikan dengan peningkatan signifikan dalam keterampilan berpikir kritis siswa, sebagaimana ditunjukkan oleh hasil uji-t $p < 0,001$ dan skor N-gain yang tinggi, yaitu 0,7604 (uji coba terbatas) dan 0,7638 (uji coba skala besar). Hasil ini berkontribusi pada kemajuan model pembelajaran inovatif yang mendorong berpikir tingkat tinggi dalam pendidikan dasar.
Kata-kata Kunci: model pembelajaran IPAER; berpikir kritis; IPAS; pendidikan dasar

1. INTRODUCTION

The development of science and technology requires a paradigm shift in the world of education, especially in equipping students with 21st-century skills. One of the skills that is a global priority is the ability to think critically (Syarifah et al., 2018; Vong & Kaewurai, 2017). Critical thinking skills are the stages of high-level thinking that students need in solving problems (Wahyuningtyas & Widiyono, 2024). Critical thinking skills are not only needed in academic contexts but are also crucial in daily life (Ennis, 2018). Therefore, learning that encourages students to think analytically, evaluate, and make responsible decisions is an urgent need at the elementary school level (Loyens et al., 2023). One of the learnings that has great potential to develop critical thinking skills is IPAS (natural and social sciences), which are the two main subjects in the *Merdeka* curriculum (Mabrur et al., 2024). The characteristics of social science learning, which are based on problem solving, are strategic in improving critical thinking skills (Kemendikbud, 2022).

However, the results of observations and interviews show that students' critical thinking skills in science subjects are relatively low. Many teachers use conventional models that are oriented towards memorizing concepts and practicing questions. So this limits students' space to think reflectively and open (Jabarullah & Hussain, 2019). In line with this, Surianto & Umaimah, (2024) emphasize that the learning model is able to develop students' abilities and attitudes. This results in students' critical thinking skills not developing. Teachers and students need a learning model that systematically leads to the development of critical thinking skills. This presentation was strengthened from national assessments and local studies showing that most students were only able to answer questions at the LOTS level, such as grasping, understanding, and students had difficulty answering HOTS questions that required analytical thinking and evaluation (Borihantanachot et al., 2024).

The above problems encourage the need to develop a learning model that can foster and train students' critical thinking skills in IPAS learning. One alternative is to develop the IPAER learning model (identifying, planning, acting, evaluating, and reflecting). This model is designed so that students are actively involved through the stages of identifying problems, planning solutions, taking action, evaluating processes and results, and reflecting on the learning done. Each stage of the IPAER learning model is aligned with the main components of critical thinking, such as analysis, inference, reasoning, and evaluating arguments (Facione, 2015). The IPAER learning model is a renewal of the merger of the PBL and PjBL models.

Previous research conducted by Yu & Zin, (2023) A systematic review of 20 articles on the PBL model shows that the PBL model is able to improve students' critical thinking skills. However, this study emphasizes the importance of further exploration of the effectiveness of PBL adaptation in various educational contexts. Other research was conducted by Imron et al., (2024) The PJBL model is proven to have a deep understanding of the material being taught. Finally, research conducted by Avendano et al., (2018) prove that the PBL learning model treats students fairly and develops students' abilities even if they are not complete. However, this development is not intended for the elementary school level, so further research is needed to design a learning model aimed at the elementary school level.

Progress is always linked to change, and every change leads to the creation of a novelty or Novelty (Houston & Manrique, 2024). So that the IPAER learning model is the right alternative, through the merger of the PBL and PjBL models. In addition, the IPAER learning model also pays attention to students' initial abilities and connects them with initial understanding. This is what distinguishes IPAER from the PBL and PjBL models. The novelty of the IPAER model lies in the systematic structure of five stages that explicitly direct students through the overall critical thinking. This is confirmed by Abrami et al. (2015) that structured learning can significantly improve critical thinking skills. This model is contextual with the characteristics of IPAS learning and the demands of 21st-century skills today. The following is a comparison table of the stages of the PBL, PjBL, and IPAER models. To further illustrate this distinction, Table 1 presents a comparative overview of the stages involved in the PBL, PjBL, and IPAER learning models.

Table 1. Differences in the stages of PBL, PjBL, and IPAER models

No	Model PBL	Model PjBL	Model IPAER
1	Student orientation on the problem	Project determination	Identification
2	Organizing students to learn	Planning of solution steps	Planning
3	Guiding individual and group investigations	Preparation of the project implementation schedule	Action
4	Develop and present works	Project completion with facilities and monitoring	Evaluation
5	Analyze and evaluate the problem-solving process	Preparation of reports and presentation/publication of results	Reflection
6		Evaluation of project processes and outcomes	

Empirically, (Wijnia et al., 2024; L. Zhang & Ma, 2023) showed that the incorporation of PBL and PjBL elements through a structured reflective approach provided a structured and significant improvement in students' critical thinking skills and learning outcomes compared to the use of a single model. Through consideration of the need for contextual and integrative science learning, as well as the demands of 21st-century skills, the IPAER learning model becomes an appropriate and adaptive solution to be implemented at the elementary school level.

2. METHOD

This research is a research and development, referring to the ADDIE model (Branch, 2009). This model was chosen to produce an IPAER learning model to improve students' critical thinking skills in elementary school science learning. Refer to the views Branch, (2009); Zulkarnaini et al., (2022) that the ADDIE model is a systematic framework that includes analysis to evaluation, to encourages continuous improvement. The main focus is on the needs of students and implementation in a real context (Wang & Hou, 2024). This model supports the development of teaching materials, strategies, and learning media in a structured manner.

The subjects of this study were fifth-grade students at SDN 131/IV and SDN 28/IV in Jambi City. Using a one-group design, the participants were selected through purposive sampling based on specific criteria, including comparable initial abilities, the same curriculum, and similar school facilities and accreditation levels. Data were collected through observation sheets, interviews, questionnaires, and a set of critical thinking test items. All instruments used in this research underwent a validation process, resulting in a feasibility score of 93.68%, which falls into the "very feasible" category. To ensure that the test items aligned with higher-order thinking skills (HOTS), a structured question grid was developed as a reference. The details of the HOTS-oriented test item specifications are presented in Table 2.

Table 2. HOTS Question Grids

No	Question Indicator	Material	Cognitive Level (HOTS)	Question
1	Analyze the impact of forest fires on human life and the environment.	Forest fires	C4 (Analyzing)	2
2	Analyze why cities feel hotter due to human activities.	Temperature change & urbanization	C4 (Analyzing)	4
3	Analyze the cause of fish death due to pollution.	Water pollution	C4 (Analyzing)	5
4	Analyze the impact of climate change on the surrounding environment.	Climate change	C4 (Analyzing)	8
5	Analyze the importance of disaster evacuation drills for students.	Disaster evacuation drill	C4 (Analyzing)	11

No	Question Indicator	Material	Cognitive Level (HOTS)	Question
6	Analyze the relationship between river pollution and community health issues.	Pollution and health	C4 (Analyzing)	19
7	Evaluate how to persuade friends about the importance of recycling plastic.	Environmental pollution & waste	C5 (Evaluating)	1
8	Evaluate solutions to prevent abrasion and its impacts.	Coastal abrasion	C5 (Evaluating)	7
9	Evaluate the contents of a disaster readiness bag based on family needs.	Earthquake disaster mitigation	C5 (Evaluating)	10
10	Evaluate actions to take during an aftershock in an open area.	Aftershock mitigation	C5 (Evaluating)	12
11	Evaluate the impact of river pollution on residents.	River water pollution	C5 (Evaluating)	14
12	Evaluate the decision to cut down trees for development.	Tree logging	C5 (Evaluating)	15
13	Evaluate citizens' attitudes in maintaining river cleanliness.	Human-induced environmental change	C5 (Evaluating)	16
14	Evaluate the impact of various citizen attitudes towards rivers.	Community environmental responsibility	C5 (Evaluating)	18
15	Evaluate the factory's decision to recycle waste based on a graph.	Waste recycling	C5 (Evaluating)	20
16	Create long-term solutions for human-wildlife conflict due to deforestation.	Deforestation	C6 (Creating)	3
17	Create a disaster mitigation plan with peers.	Natural disasters	C6 (Creating)	6
18	Create an inclusive earthquake evacuation strategy.	Earthquake evacuation simulation	C6 (Creating)	9
19	Create a safety guide for aftershocks.	Disaster safety education	C6 (Creating)	13
20	Create a neighborhood action plan based on river data.	River environmental data	C6 (Creating)	17

This research stage refers to the ADDIE stages, namely analysis, design, development, implementation, and evaluation. The learning needs of science and science in elementary schools were analyzed at the analysis stage by researchers, observation of teaching and learning activities in the classroom, and interviews with teachers. The results of the analysis showed that students had poor critical thinking skills, and there was no integrated learning model that was in accordance with the characteristics of science subjects. Based on these findings, the design stage is focused on designing the IPAS curriculum. The researchers created learning scenarios for three main encounters during this stage, as well as learning materials, additional media, and techniques to evaluate critical thinking abilities.

In addition, the development stage is complemented by the manufacture of initial products such as test instruments, teaching aids, learning media, and draft IPAER models. After being validated by experts, the product is then improved according to the feedback received. Two elementary schools in Jambi City, namely SDN 131/IV and SDN 28/IV, participated in the limited trial at the implementation stage. The implementation was carried out for three weeks, and each school underwent three learning meetings. "Concern for the Environment and Natural Disasters" is the trial material, which includes student worksheets (LKPD), learning videos, and direct implementation of the IPAER model. With the help of researchers, grade V teachers in both schools acted as facilitators.

Finally, the evaluation stage is carried out to find out how effective the learning model is. This assessment uses a pretest and a posttest to measure critical thinking skills. To determine the significance of the increase in scores, the test result data was evaluated descriptively and quantitatively, and using a statistical test (paired t-test). To evaluate the implementation process and reaction to the IPAER learning model used, a qualitative evaluation was also carried out through the analysis of observation and interview data. The following presents the ADDIE model research flow (Mohammad Basir et al., 2025).

3. RESULTS AND DISCUSSION

This research aims to develop an IPAER learning model for elementary school students. The development of the IPAER model is based on the results of needs analysis in the field (Jayanti et al., 2025). The development of this model is against the background of students' low critical thinking skills in social studies learning (Mabrur et al., 2024; Tang et al., 2025). In addition, these findings are reinforced by Yaldiz & Bailey, (2019) which shows that students have difficulty in analyzing, evaluating information, and solving problems logically. Of course, these findings reinforce the need for a learning model that focuses on developing higher-level thinking skills (HOTS) (Atef et al., 2025; Kwangmuang et al., 2021)One of which is the ability to think critically (Aarti & Gandhimathi, 2025; Srirat et al., 2025).

Referring to this context, the IPAER model was developed as an alternative solution designed as an alternative solution and was designed systematically based on the real needs of Basic education. The syntax of IPAER learning consists of identifying, planning, actioning, evaluating, and reflecting. The syntax of the IPAER learning model was formed from the results of modification and merger between the syntax of the problem-based learning (PBL) and project-based learning (PjBL) models, resulting in a new syntax. Each stage in this IPAER model can encourage active student participation and has been proven to be effective in improving students' critical thinking skills.

This model was developed based on the theory of learning constructivism. Constructivism is based on the idea that knowledge and meaning are actively constructed by learners (Duchesne et al., 2022) and cognitive theory, which emphasizes the importance of interaction with the social environment to encourage intellectual growth. Furthermore, this model also refers to the 3C3R theory (Marzano & Brown, 2009), which emphasizes between learning materials, authentic contexts, and high cognitive tasks that involve reasoning and reflection. This IPAER learning model goes through the validation stage first before going to the user trial stage.

Validation of learning models is very important for the developed product to be feasible to implement and function according to its purpose (Joseph et al., 2025; Kalkbrenner, 2021; Suartama et al., 2024). The IPAER learning model has gone through the validation stage of educational instruments, materials, languages, and technology (Rasyid et al., 2024). Validation is an important stage because it ensures that the IPAER learning model is not only innovative, but will continue to be in accordance with the pedagogical and psychological principles of elementary school students' development (Walzer et al., 2025; Wulandari et al., 2018). The following is a summary of the results of validation by experts.

The feasibility validation of the IPAER learning model was carried out by involving experts in the fields of education, learning design, and technology integration to ensure the model meets academic and practical standards. This validation process focused on assessing the content relevance, pedagogical suitability, clarity of language, and technological feasibility of the model. Each aspect was rated using a structured validation instrument, and the results were analyzed quantitatively. The compiled data from these assessments are presented in Figure 2, which illustrates the extent to which the IPAER model is considered valid and appropriate for implementation in elementary science learning.

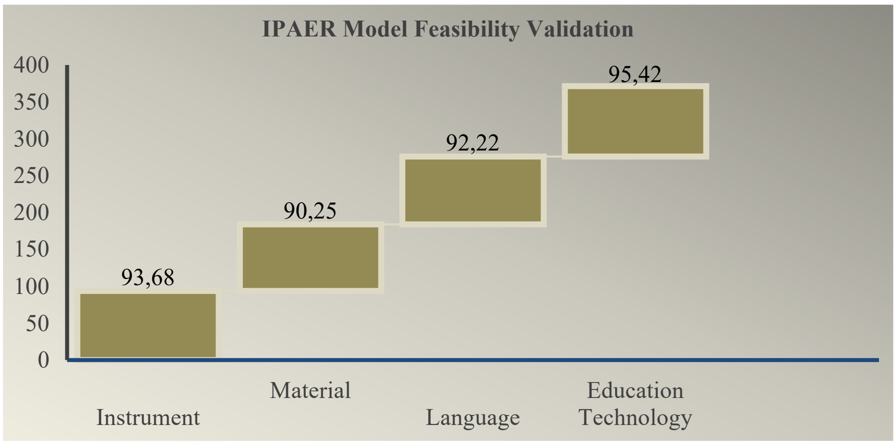

Figure 2. Results of Feasibility Validation of IPAER Learning Model

Referring to the Figure 2 above, it can be seen that the results of the validation of the feasibility of the IPAER learning model are in the category of valid and very feasible to be used in learning. Instrument validation 93.68 with the "very feasible" category, material validation 90.25 with the "very feasible" category, language validation 92.22 with the “very feasible” category, and educational technology validation 95.42 with the “very feasible” category. The results of the validation are in line with Martínez-Pascual et al. (2025) the obtained score of 91.39% indicating that the developed model was declared valid. Next, Devi & Rusdinal (2023) the value of validation aspects of educational technology (digital learning media) reaches about 96%, indicating that the digital media, which is validated by declared suitable for use in learning. So does research Laksana (2024), reinforcing the importance of using comprehensive validation instruments in the aspect of educational products.

Thus, the IPAER learning model is declared valid and suitable for use in the learning process. This validation not only guarantees the technical quality of the IPAER learning model but also provides a scientific basis for the implementation stage. The high validation score in each validation aspect shows that IPAER learning is not only in accordance with the needs of IPAS learning, but also has the potential to be adapted to other subjects.

After the learning model is declared valid, the IPAER learning model goes through the trial stage. The trial was carried out to determine the response and practicality of the learning model based on users, namely, teachers and students (Kalkbrenner, 2021; Sari et al., 2023; Wahyuni & Yerimadesi, 2021). One of the criteria for the quality of a development product is practicality. Practicality means involving users as third parties in assessing the product that has been designed (Nieveen & Plomp, 2013). In line with the expression, Siswanto & Susanti, (2019) the design of the learning model must meet the applicable and practical requirements. Teacher and student responses reinforce the argument that the practicality of a model is determined not only by the technical ease of its application, but also by the extent to which it provides a meaningful and relevant learning experience for students (Duan et al., 2025). The results of the practicality test by the teacher showed that the syntax of the IPAER model was considered very clear and easy to follow. Student and teacher activity guides in each phase, Identifying, Planning, Actioning, Evaluating, dan Reflecting, arranged in a concise and logical manner.

The teacher stated that each phase provides a specific direction for the roles of teachers and students, making it easier to carry out learning activities. This is in accordance with the findings of Reddy et al. (2019), which states that a learning model that is equipped with explicit instruction and supported by real practices can improve the quality of learning implementation in the classroom and strengthen teachers' competence in delivering material. Furthermore, students' responses to the application of the IPAER model also showed high enthusiasm and involvement in the learning process. This view is in line with the opinion of Ainley (2017), which emphasizes the importance of students' emotional and cognitive involvement in generating interest in learning and strengthening concepts. The following is a summary of the results of the teacher and student trial at the one-to-one trial, small group trial, and field trial (Branch, 2009). Figure 3 presents a summary of these responses, reflecting the model's potential to support meaningful and engaging science learning experiences.

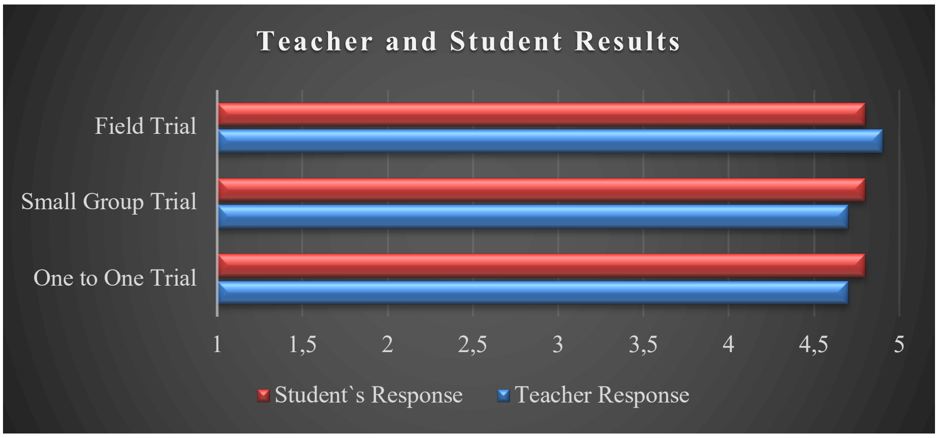

Figure 3. Results of Teacher and Student`s Responses

Based on Figure 3 above, it can be seen that the results of the teacher's and students' responses from the stage one to one trial, small group trial, and field trial in the category "Very practical". Results of teacher responses in one-to-one trial, i.e., 4.7, and students' 4.8. Next, the response of the teacher stage small group trial 4.7 and the students 4.8. Finally, the stage field trial Teacher response was 4.9 and students' 4.8. This high response value shows that the IPAER model is considered not only easy to understand, but also suitable for application in the context of learning in elementary schools. In line with the expression, Allanta & Puspita, (2021) the response rate of a device or learning model can be seen from how much the device can facilitate teaching and learning activities effectively and efficiently, and is easy to use by teachers in the implementation of learning. These results are reinforced by the findings (Ashraf et al., 2025; Marini et al., 2025; Yulianti & Wulandari, 2021), which state that innovative learning models designed based on students' needs and characteristics are able to increase active participation and provide a fun and meaningful learning experience.

Lastly, the IPAER learning model is not only feasible and practical to use, but also effective in improving the critical thinking skills of elementary school students. The use of the IPAER model is one of the efforts to realize education that is in line with the stages of student development. In accordance with Piaget's cognitive theory, which emphasizes the importance of providing education that is tailored to the child's level of cognitive development (Ibda, 2015), and reinforced by the theory of constructivism, which states that understanding is formed through active interaction with the environment. Teachers use initial assessments at the identification stage to help students recognize learning objectives and challenges related to real-world situations, such as environmental issues and natural disasters. Collaborative planning is carried out by students to create problem-solving techniques based on readings and information sources to help facilitate the planning stage.

The Actioning stage involves exploratory activities such as discussions and simulations that encourage active participation and the development of students' critical thinking skills. At this stage, the teacher is the facilitator. Evaluating is done to assess the effectiveness of learning, while reflecting provides space for students to reflect on their learning process and outcomes. The findings of the study show that teachers consistently integrate the principles of 3C3R (Content, Context, Connection, Researching, Reasoning, Reflecting) in each IPAER syntax, so that students are able to identify problems appropriately, plan solutions, carry out actions participatively, and conduct independent evaluation and reflection. Students show improvements in logical, critical, and reflective thinking. Implicitly, the IPAER model can be an effective approach in IPAS learning because it encourages contextual, collaborative, and problem-solving-based learning that is relevant to students' real lives, while developing high-level thinking skills systematically.

The IPAER learning model is designed to train students' critical thinking skills through a constructivist and collaborative approach, which emphasizes the process of inquiry and discovery, both in the form of concepts and experiments, In line with this approach, motivation theory also states that when students have confidence in the possibility of success, then their motivation to learn will increase. (Williams, 2017). Align with expressions McDonald, (1961) that motivation has a positive impact on success in communication and collaboration. Therefore, building interest and desire to learn is a priority in the early stages, in accordance with the concept that high student attention can create a deep curiosity (Primamukti & Farozin, 2018). Figure 4 provides an overview of the implementation results in the field.

Figure 4. Field Implementation

Based on Figure 4 above, it can be seen that students take a role in the learning process. The implementation of the IPAER model groups students into several learning groups so that students collaboratively solve problems and work on projects (Boakye-

Yiadom et al., 2025; Novalia et al., 2025). This shows that the IPAER learning model is not only able to improve students' critical thinking skills, but also students' motivation and involvement to learn. This is reinforced by the results of N-Gain students' critical thinking skills. The data consists of Pre-test, post-test, N-Gain value, N-Gain percentage, and category. The average N-Gain from the data table above is 0.76 with a high category. Theoretically, the calculation of NGain refers to the formula Hake, (1998) which states that the value of $G \geq 0.70$ is categorized as high, while the range between 0.30–0.70 is categorized as moderate. The following is a summary of the results N-Gain students' critical thinking skills. In line with the research conducted García-Martínez et al., (2023) Problem-Based Learning (Problem-Based Learning), which also emphasizes syntax similar to IPAER, significantly affects the improvement of critical thinking skills with a moderate category of 0.47. This shows that learning models that emphasize investigative activities, collaboration, and reflection, as applied in the IPAER model, are indeed effective in encouraging the achievement of more meaningful learning outcomes. To support the theoretical explanation and reinforce the effectiveness of the IPAER learning model, the following figure presents the N-Gain results of students' critical thinking abilities after implementation. This visual representation highlights the improvement in students' performance before and after using the model, confirming its positive impact on higher-order thinking skills. The data is summarized in Figure 5.

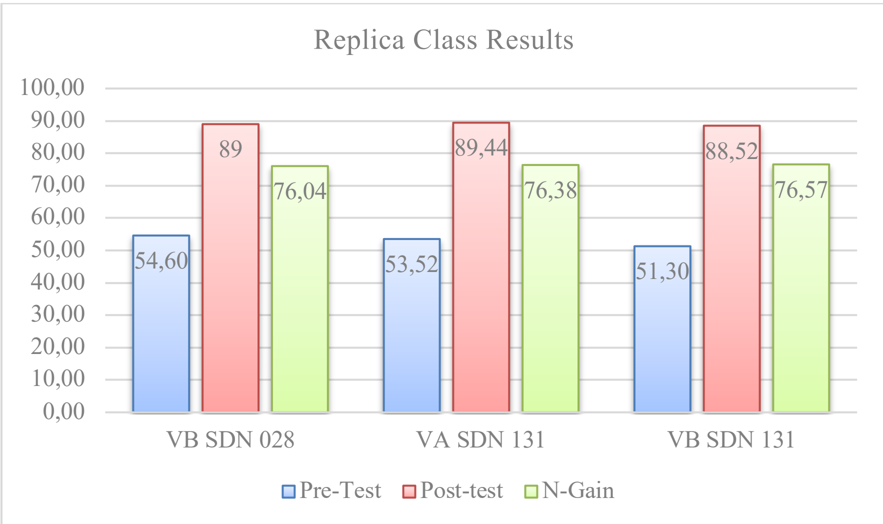

Figure 5. N-Gain Results of Students' Critical Thinking Ability

The figure 5 above shows that the IPAER model has a significant impact on improving students' critical thinking skills. The results of the pretest and posttest of the three different classes show a large difference in pretest and posttest scores. In the VB class, SDN 028 got a pretest score of 54.60, while the VA and VB classes in the broad trial class got lower scores, namely 53.52 and 51.30. Turning to the increased posttest score, it shows that the application of the IPAER model is able to encourage a significant increase in material mastery. The effectiveness of the IPAER model is reflected in the high and consistent N-Gain values of the three classes. N-Gain is a pending indicator in measuring the effectiveness of learning interventions, which in this case describes the extent to which students experience learning improvement relative to the maximum potential that can be achieved. In the VB class, SDN 028, which is a limited trial class, received the smallest N-Gain score of 76.04% in the high and effective category. Meanwhile, in the extensive trial, there was an increase in the acquisition of N-Gain scores in the VA class, with a score of 76.38 and VB of 76.57, a very small increase in value. All three grades fall into the high category, which means that most students experience improved learning after participating in learning with the IPAER model.

These findings are in line with international research conducted by (Andriani et al., 2023) The PJBL model has been proven to improve students' HOTS abilities in elementary school science subjects. In addition, a study from (Rati et al., 2023) shows that the HOTS-oriented PjBL model is recommended to improve 4C skills and elementary school science learning outcomes. Further He et al., (2020) emphasized that learning that adopts HOTS has been proven to be able to improve students' critical thinking skills. Nevertheless, a more methodical and precise syntax structure of IPAER is just as important as its success with HOTS orientation. In addition to helping students complete project assignments or problems, the five phases of IPAER, i.e., identify, plan, act, evaluate, and reflect, also help students think critically about how to think. This distinguishes IPAER from PBL, which prioritizes problem-solving without systematically exploring the student's initial knowledge, and PjBL, which concentrates on the final product without providing a clear procedure for in-depth evaluation and reflection. Thus, by combining metacognitive reflection and emphasizing the relationship between initial understanding and the learning process, IPAER not only supports the findings of previous research but also enhances students' critical thinking skills. Based on this research, IPAER can be a more focused alternative paradigm to help the development of HOTS of elementary school students.

Students' critical thinking skills can be measured through HOTS questions (Higher Order Thinking Skills) (Luvia Ranggi et al., 2021), which refers to various taxonomies and cognitive theories (Özelçi & Çalışkan, 2019). There are six levels of cognitive domains, ranging from knowledge, understanding, application, analysis, synthesis, to evaluation (Suyadi, 2022; M. Zhang et al., 2024). In line with the previous presentation, the syntax of the IPAER learning model can facilitate students' critical thinking skills. Not only that, the IPAER learning model also motivates students to be actively involved in the learning process. Based on the observation process during learning, students are seen to be able to analyze a mistake, analyze the given problem, and be able to create solutions (Moch. Syakroni et al., 2021; Risdiani et al., 2023). This is also tested through HOTS-based test questions to test students' critical thinking skills.

4. CONCLUSION

This study was conducted in two elementary schools in Jambi City, namely SDN 131/IV and SDN 28/IV, with the aim of developing the IPAER learning model as an effort to improve students' critical thinking skills, which were found to be low in science learning. The model was validated by four experts in the fields of elementary education, instrument evaluation, materials, and implementation tools, based on the stages of the ADDIE model, and the results showed it to be in the "highly feasible" category. This evaluation demonstrates the model's alignment with both theoretical and contextual demands of 21st-century education, particularly in fostering critical thinking. The trial results also indicated that the IPAER model is highly practical for classroom use; teachers reported that its syntax was easy to follow and supported students' flow of thinking, while students showed enthusiasm and active engagement during the learning process. Empirically, the model proved to be effective, as indicated by a significant increase in students' critical thinking skills from pretest to posttest scores at both schools. The scientific strength of the IPAER model lies in its systematic and explicit syntactic structure, which includes concept identification, action planning, implementation, evaluation, and reflection. This structure is in line with constructivist theory and reflective learning principles, both of which have been proven in various studies to successfully develop higher-order thinking skills. Therefore, the IPAER model is important for improving the quality of science and social science (IPAS) learning processes and outcomes in elementary schools, not only in terms of content, but also in instructional design. Further research is recommended to implement and refine the IPAER model across various science-related subjects at the elementary level to examine its adaptability and effectiveness. This study contributes to the development of learning models in elementary science (IPAS) education, especially those that emphasize critical pedagogy and higher-order thinking skills. Future development may focus on integrating digital learning tools or adapting the IPAER model to meet diverse student needs in inclusive classrooms.

5. REFERENCES

Abrami, P. C., Bernard, R. M., Borokhovski, E., Waddington, D. I., Wade, C. A., & Persson, T. (2015). Strategies for Teaching Students to Think Critically: A Meta-Analysis. *Review of Educational Research*, *85*(2), 275–314. https://doi.org/10.3102/0034654314551063

Acesta, A., Sumantri, M. S., & Fahrurrozi. (2020). Development of Natural Science Learning Models Based on Multiple Inteligences to Improve Higher Order Thinking Skills in Elementary Schools. *Journal of Physics: Conference Series*, *1477*(4), 0–6. https://doi.org/10.1088/1742-6596/1477/4/042036

Ainley, M. (2017). Interest: Knowns, Unknowns, and Basic Processes. In P. A. O'Keefe & J. M. H. (Eds.) (Eds.), *The Science of Interest* (pp. 3–24). Springer International

Publishing. https://doi.org/10.1007/978-3-319-55509-6

Allanta, T. R., & Puspita, L. (2021). Analisis keterampilan berpikir kritis dan self efficacy peserta didik: Dampak PjBL-STEM pada materi ekosistem. *Jurnal Inovasi Pendidikan IPA*, *7*(2), 158–170. https://doi.org/10.21831/jipi.v7i2.42441

Andriani, R., Dewi, K., Qurotul A'eni, E., & Wijaya, T. T. (2023). Pengaruh Model Pembelajaran Berbasis Proyek Untuk Meningkatkan Kemampuan HOTS IPA Di Sekolah Dasar. *Jurnal Penelitian Ilmu Pendidikan*, *16*(1), 60–71. https://doi.org/https://doi.org/10.21831/jpipfip.v16i1.55982

Arthi, M. P., & Gandhimathi, S. N. S. (2025). Research trends and network approach of critical thinking skills in English Language Teaching – A bibliometric analysis implementing R studio. *Heliyon*, *11*(2), e42080. https://doi.org/10.1016/j.heliyon.2025.e42080

Ashraf, M. H., Özpolat, K., Yalcin, M. G., & Shah, P. (2025). A project-based learning approach to supply chain mapping education. *International Journal of Management Education*, *23*(2). https://doi.org/10.1016/j.ijme.2024.101128

Atef, N., Mansour, Y., & Sabry, H. (2025). Impact of lecture hall's background noise on undergraduates' higher order thinking skills: A field study. *Ain Shams Engineering Journal*, *16*(1), 103238. https://doi.org/10.1016/j.asej.2024.103238

Avendano, L., Renteria, J., Kwon, S., & Hamdan, K. (2018). Bringing equity to underserved communities through STEM education: implications for leadership development. *Journal of Educational Administration and History*, *51*(1). https://doi.org/https://doi.org/10.1080/00220620.2018.1532397

Boakye-Yiadom, F., Donkor, E. K., & Mensah, R. O. (2025). Exploring the role of project-based learning in higher education to promote indigenous knowledge through sculpture students' engagement with Ghanaian Adinkra symbols. *Discover Global Society*, *3*(1). https://doi.org/10.1007/s44282-024-00135-8

Borihantanachot, O., Mangkhang, C., Phujeenaphan, P., & Nantasri, C. (2024). Developing Learning Innovation of Digital Open Badge in Social Studies to Enhance Citizenship Characteristics of Secondary School Students. *Journal of Curriculum and Teaching*, *13*(4), 55–70. https://doi.org/10.5430/jct.v13n4p55

Branch, R. M. (2009). Instructional Design: The ADDIE Approach. In *Encyclopedia of Evolutionary Psychological Science*. Springer ScienceþBusiness Media. https://doi.org/10.1007/978-3-319-19650-3_2438

Cerovac, M., & Keane, T. (2024). Early insights into Piaget's cognitive development model through the lens of the Technologies curriculum. *International Journal of Technology and Design Education*, *35*(1), 61–81. https://doi.org/10.1007/s10798-024-09906-5

Devi, M. Y., & Rusdinal, R. (2023). Validation of Digital Learning Media to Improve the Basic Literacy Skills of Low-Grade Elementary School Students. *Jurnal Obsesi : Jurnal Pendidikan Anak Usia Dini*, *7*(1), 119–129. https://doi.org/10.31004/obsesi.v7i1.3713

Duan, M., Geng, Z., Gao, L., Zhao, Y., Li, Z., Chen, L., Kuosmanen, P., Qi, G., Gong, F., & Yu, G. (2025). An interpretable machine learning-assisted diagnostic model for Kawasaki disease in children. *Scientific Reports*, *15*(1), 1–12. https://doi.org/10.1038/s41598-025-92277-1

Duchesne, S., Mcmaugh, A., & Mackenzie, E. (2022). *Educational Psychology For Learning and Taeching (7th ed.)* (7th ed.). Cengage Learning Australia Pty Limited.

Ennis, R. H. (2018). Critical Thinking Across the Curriculum: A Vision. *Topoi*, *37*(1), 165–184. https://doi.org/10.1007/s11245-016-9401-4

Facione, P. a. (2015). Critical Thinking : What It Is and Why It Counts. In *Insight assessment* (Issue ISBN 13: 978-1-891557-07-1.).

Fatimah, I. (2020). The development of physics learning tools in vocational high school based constructivism approach using learning cycle 5E model. *Journal of Physics: Conference Series*, *1481*(1). https://doi.org/10.1088/1742-6596/1481/1/012120

García-Martínez, I., Fernández-Batanero, J. M., Fernández-Cerero, J., & León, S. P. (2023). Analysing the Impact of Artificial Intelligence and Computational Sciences on Student Performance: Systematic Review and Meta-analysis. *Journal of New Approaches in Educational Research*, *12*(1), 171–197. https://doi.org/10.7821/naer.2023.1.1240

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, *66*(1), 64–74. https://doi.org/10.1119/1.18809

Houston, N., & Manrique, F. (2024). Designing an effective educational toy: incorporating design-thinking and user-centered design in the design classroom. *Discover Education*, *4*(11). https://doi.org/10.1007/s44217-025-00402-z

Ibda, F. (2015). Perkembangan Kognitif: Teori Jean Piaget. *Intelektualita*, *3*(1), 242904.

Imron, A., Muarifah, S., Oktradiksa, A., & Romdhoni, A. (2024). Cultivating Social Character through Project-Based Learning in Islamic Elementary Schools in Semarang. *Jurnal Tarbiyatuna*, *15*(1), 28–42. https://doi.org/10.31603/tarbiyatuna.v15i1.10166

Jabarullah, N. H., & Hussain, H. I. (2019). The Effectiveness of Problem-Based Learning in Promoting Critical Thinking Skills in Elementary Education. *Journal of Educational Research*, *4*(112), 515–530. https://doi.org/https://doi.org/10.1080/00220671.2018.1563034

Jayanti, T., Wuryandani, W., Edi, S., & Tribrata, J. P. (2025). Optimizing Pancasila Education Through Modern Teaching Materials : A Need Analysis for Effective Learning. *Al-Ishlah: Jurnal Pendidikan*, *17*(1), 1534–1549. https://doi.org/10.35445/alishlah.v17i1.6248

Joseph, V., Shaharudin, S. M., Hamid, N. A., & Rajak, N. A. (2025). Development and Evaluation of the Bvee Kit for Teaching Circle Topics: A Validity and Usability Study in Form 2 Mathematics. *International Journal of Information and Education Technology*, *15*(2), 230–235. https://doi.org/10.18178/ijiet.2025.15.2.2236

Kalkbrenner, M. T. (2021). A Practical Guide to Instrument Development and Score Validation in the Social Sciences: The Measure Approach. *Practical Assessment, Research and Evaluation*, *26*, 1–18.

Kemendikbud. (2022). Ilmu Pengetahuan Alam dan Sosial (IPAS) SD-SMA. *Merdeka Mengajar*.

Kwangmuang, P., Jarutkamolpong, S., Sangboonraung, W., & Daungtod, S. (2021). The development of learning innovation to enhance higher order thinking skills for students in Thailand junior high schools. *Heliyon*, *7*(6), e07309. https://doi.org/10.1016/j.heliyon.2021.e07309

Laksana, D. N. L. (2024). Validation Instruments for Local Culture-Based Learning Media. *Journal of Education Technology*, *8*(2), 264–274. https://doi.org/10.23887/jet.v8i2.74446

Loyens, S. M. M., van Meerten, J. E., Schaap, L., & Wijnia, L. (2023). Situating Higher-Order, Critical, and Critical-Analytic Thinking in Problem- and Project-Based Learning Environments: A Systematic Review. In *Educational Psychology Review* (Vol. 35, Issue 2). Springer US. https://doi.org/10.1007/s10648-023-09757-x

Luvia Ranggi, N., Yokhebed, Ramli, M., & Yuliani, H. (2021). Meta-Analysis of the Effectiveness of Problem-Based Learning towards Critical Thinking Skills in Science Learning. *Journal of Physics: Conference Series*, *1842*(1). https://doi.org/10.1088/1742-6596/1842/1/012071

Mabrur, Huda, N., & Utami, S. (2024). The Effectiveness of Project-Based Learning Assisted by Digital Technology to Improve Problem-Solving and Critical Thinking Skills in SMKN 3 Sampang Students. *Journal of Indonesian Social Scincem*, *5*(9), 2450–2457. https://doi.org/http://dx.doi.org/10.59141/jiss.v5i10.1468

Marini, A., Safitri, D., Niladini, A., Zahari, M., Dewiyani, L., & Muawanah, U. (2025). Developing a website integrated with project-based learning: Evidence of stimulating creativity among elementary school students in Indonesia. *Social Sciences and Humanities Open*, *11*(February), 101402. https://doi.org/10.1016/j.ssaho.2025.101402

Martínez-Pascual, D., Catalán, J. M., Lledó, L. D., Blanco-Ivorra, A., & García-Aracil, N. (2025). A deep learning model for assistive decision-making during robot-aided rehabilitation therapies based on therapists' demonstrations. *Journal of NeuroEngineering and Rehabilitation*, *22*(1). https://doi.org/10.1186/s12984-024-01517-4

McDonald, F. J. (1961). Motivation and the communication processes. *Audiovisual Communication Review*, *9*(5), 57–67. https://doi.org/10.1007/BF02769478

Moch. Syakroni, Endang Suprapti, & Junaidi Fery Efendi. (2021). Peningkatan Berpikir Kritis dan Kreatif pada Pelajaran Matematika ditinjau dari Jenjang Satuan Pendidikan. *Jurnal Absis: Jurnal Pendidikan Matematika Dan Matematika*, *4*(1), 414–428. https://doi.org/10.30606/absis.v4i1.972

Mohammad Basir, M. F., Mohd Hairon, S., Ibrahim, M. I., Wan Mohamad, W. M. Z., Mohd Fuzi, N. M. H., Rosli, A. S., Abdul Rahman, M. S., & Rosedi, A. (2025). Development and Validation of Rabies Health Education Module (RaHEM) for Dog Owners in Kelantan, Malaysia: An ADDIE Model. *Journal of Epidemiology and Global Health*, *15*(1), 12. https://doi.org/10.1007/s44197-025-00355-4

Nieveen, N., & Plomp, T. (2013). Educational Design Research Educational Design Research. *Netherlands Institute for Curriculum Development: SLO*, 1–206.

Novalia, R., Marini, A., Bintoro, T., & Muawanah, U. (2025). Project-based learning: For higher education students' learning independence. *Social Sciences and Humanities Open*, *11*(April), 101530. https://doi.org/10.1016/j.ssaho.2025.101530

Özelçi, S. Y., & Çalışkan, G. (2019). What is critical thinking? A longitudinal study with teacher candidates. *International Journal of Evaluation and Research in Education*, *8*(3), 495–509. https://doi.org/10.11591/ijere.v8i3.20254

Piaget, J. (1973). To understand is to invent: the future of education. In *The Viking Press*.

Primamukti, A. D., & Farozin, M. (2018). Utilization of interactive multimedia to improve learning interest and learning achievement of child. *Jurnal Prima Edukasia*, *6*(2), 111–117. https://doi.org/10.21831/jpe.v6i2.19183

Rasyid, R., Agustang, A. T. P., Aryuni, V. T., Maru, R., Mufiana, I., & Soamole, H. (2024). Validity of Environmental Education E-Module Based on Education for Sustainable Development Using Flipcreator Platform to Develop Environmental Awareness in Geography Education Students at Khairun University. *Journal of Applied Science, Engineering, Technology, and Education*, *6*(2), 105–117. https://doi.org/10.35877/454RI.asci3093

Rati, N. W., Arnyana, I. B. P., Dantes, G. R., & Dantes, N. (2023). HOTS-Oriented e-Project-Based Learning: Improving 4C Skills and Science Learning Outcome of Elementary School Students. *International Journal of Information and Education Technology*, *13*(6), 959–968. https://doi.org/10.18178/ijiet.2023.13.6.1892

Reddy, L. A., Glover, T., Kurz, A., & Elliott, S. N. (2019). Assessing the Effectiveness and Interactions of Instructional Coaches: Initial Psychometric Evidence for the Instructional Coaching Assessments–Teacher Forms. *Assessment for Effective Intervention*, *44*(2), 104–119. https://doi.org/10.1177/1534508418771739

Risdiani, Srifariyati, Raharjo, & Rohman, A. (2023). The Application of Mentimeter to Improve Critical Thinking Skills in Al Islam dan Muhammadiyah (AIK) Course. *Jurnal Tarbiyatuna*, *14*(1), 63–74. https://doi.org/https://doi.org/10.31603/tarbiyatuna.v14i1.9000

Robert J. Marzano, & John L. Brown. (2009). *The Art and Science of Teaching*. ASCD.

Sari, N., Prasetyawati, Y., Sukmaningthias, N., & Simarmata, R. H. (2023). Development of E-Worksheet Based on Realistic Mathematics Education to Support Mathematical Literacy Skills of Junior High School Students. *E3S Web of Conferences*, *400*. https://doi.org/10.1051/e3sconf/202340003006

Sireerat, K., Seki, N., Foxton, R., Liao, S. R., Akiyama, M., Sangouam, S., & Morio, I. (2025). A study of critical thinking skills among Thai dental students: From disposition to skills assessment. *Journal of Dental Sciences*, *20*(3), 1622–1628. https://doi.org/10.1016/j.jds.2025.02.005

Siswanto, S., & Susanti, E. (2019). Manajemen Pengembangan Kurikulum Sekolah Inklusi. *Tadbir : Jurnal Studi Manajemen Pendidikan*, *3*(2), 113. https://doi.org/10.29240/jsmp.v3i2.927

Suartama, I. K., Yasa, I. N., & Triwahyuni, E. (2024). Instructional Design Models for Pervasive Learning Environment: Bridging Formal and Informal Learning in Collaborative Social Learning. *Education Sciences*, *14*(12). https://doi.org/10.3390/educsci14121405

Surianto, M. A., & Umaimah, U. (2024). Social Responsibility Model based on The Thoughts of KH Ahmad Dahlan at Muhammadiyah Schools. *Jurnal Tarbiyatuna*, *15*(1), 70–84. https://doi.org/10.31603/tarbiyatuna.v15i1.10936

Suyadi. (2022). Learning Taxonomy of Islamic Education: The Development of Aql and the Brain in Quran from a Neuroscience Perspective. *Millah: Journal of Religious*

Studies, *21*(2), 361–410. https://doi.org/10.20885/millah.vol21.iss2.art3

Syarifah, T. J., Usodo, B., & Riyadi, R. (2018). Higher Order Thingking (Hot) Problems To Develop Critical Thinking Ability and Student Self Efficacy in Learning Mathematics Primary Schools. *Social, Humanities, and Educational Studies (SHEs): Conference Series*, *1*(1), 917–925. https://doi.org/10.20961/shes.v1i1.23676

Tang, M., Wijaya, T. T., Li, X., Cao, Y., & Yu, Q. (2025). Exploring the determinants of mathematics teachers' willingness to implement STEAM education using structural equation modeling. *Scientific Reports*, *15*(1), 1–15. https://doi.org/10.1038/s41598-025-90772-z

Theodoridis, T., & Kraemer, J. (1995). *Constructivism in Education*.

Vong, S. A., & Kaewurai, W. (2017). Instructional model development to enhance critical thinking and critical thinking teaching ability of trainee students at regional teaching training center in Takeo province, Cambodia. *Kasetsart Journal of Social Sciences*, *38*(1), 88–95. https://doi.org/10.1016/j.kjss.2016.05.002

Wahyuni, Z. A., & Yerimadesi, Y. (2021). Praktikalitas E-Modul Kimia Unsur Berbasis Guided Discovery Learning untuk Siswa Sekolah Menengah Atas. *Edukatif : Jurnal Ilmu Pendidikan*, *3*(3), 680–688. https://edukatif.org/index.php/edukatif/article/view/420

Wahyuningtyas, I. N., & Widiyono, A. (2024). The Effect of STEM-Based Discovery Learning Model on Critical Thinking Skills of Elementary School Students on Fraction Topics in the Context of Islamic Education. *Jurnal Tarbiyatuna*, *15*(2), 139–157. https://doi.org/https://doi.org/10.31603/tarbiyatuna.v15i2.12632 Article

Walzer, S., Barthel, C., Pazouki, R., Marx, H., Ziegler, S., Koenig, P., Kugler, C., & Jobst, S. (2025). Teaching in the Digital Age-Developing a Support Program for Nursing Education Providers: Design-Based Research. *JMIR Formative Research*, *9*. https://doi.org/10.2196/66109

Wang, Y., & Hou, Y. (2024). Expansion of Innovative Diffusion and Communication Strategies of Chinese Opera Culture Based on ADDIE Modeling. *Applied Mathematics and Nonlinear Sciences*, *9*(1), 1–12. https://doi.org/10.2478/amns-2024-1315

Wijnia, L., Noordzij, G., Arends, L. R., Rikers, R. M. J. P., & Loyens, S. M. M. (2024). The Effects of Problem-Based, Project-Based, and Case-Based Learning on Students' Motivation: a Meta-Analysis. *Educational Psychology Review*, *36*(1), 1–38. https://doi.org/10.1007/s10648-024-09864-3

Williams, M. K. (2017). John Dewey in the 21st century. *Journal of Inquiry and Action in Education*, *9*(1), 91–102.

Wulandari, T., Suharno, S., & Triyanto, T. (2018). The Teaching Material Development of Problem Based Learning: Improving students' civic knowledge. *Journal of Education and Learning (EduLearn)*, *12*(4), 725–730. https://doi.org/10.11591/edulearn.v12i4.9377

Yaldiz, N., & Bailey, M. (2019). The Effect of Critical Thinking on Making the Right Decisions in the New Venture Process. *Procedia Computer Science*, *158*, 281–286. https://doi.org/10.1016/j.procs.2019.09.053

Yu, L., & Zin, Z. M. (2023). The critical thinking-oriented adaptations of problem-based learning models: a systematic review. *Frontiers in Education*, *8*(1). https://doi.org/10.3389/feduc.2023.1139987

Yulianti, Y. A., & Wulandari, D. (2021). Flipped Classroom : Model Pembelajaran untuk Mencapai Kecakapan Abad 21 Sesuai Kurikulum 2013. *Jurnal Kependidikan: Jurnal Hasil Penelitian Dan Kajian Kepustakaan Di Bidang Pendidikan, Pengajaran Dan Pembelajaran*, *7*(2), 372. https://doi.org/10.33394/jk.v7i2.3209

Zhang, L., & Ma, Y. (2023). A study of the impact of project-based learning on student learning effects: a meta-analysis study. *Frontiers in Psychology*, *14*(July), 1–14. https://doi.org/10.3389/fpsyg.2023.1202728

Zhang, M., Gou, J., Zhang, F., & Zhang, X. (2024). Assessment of Higher-order Thinking Skills in Conversation Situation. *Procedia Computer Science*, *242*, 845–852. https://doi.org/10.1016/j.procs.2024.08.210

Zulkarnaini, Megawati, C., Astini, D., & Syahputra, I. (2022). Penggunaan Model ADDIE dalam Pengembangan Bahan Ajar. *BAKTIMAS: Jurnal Pengabdian Masyarakat*, *4*(2), 77–80. https://doi.org/https://doi.org/10.32672/btm.v4i2.4782