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THE EFFECTIVENESS OF THE STEAM-PROKSI MODEL ON LOGICAL, CREATIVE, AND INNOVATIVE THINKING SKILLS IN ELEMENTARY SCHOOL NATURAL AND SOCIAL SCIENCE LEARNING

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Abstract
This study aims to describe the implementation of the STEAM-PROKSI (Student Innovation Creativity and Synergy Project) model in IPAS Phase B learning and evaluate its impact on the development of logical, creative, and innovative thinking skills in elementary school students. The research approach used is a mixed method, which combines descriptive qualitative and quasi-experimental approaches. A qualitative approach was used to explore the learning process, student experience, and teacher and student perception of the application of the STEAM-PROKSI model, with a case study method carried out in two elementary schools in Moga District, Pemalang Regency. Qualitative data collection techniques include observation during the learning process, in-depth interviews with teachers and students, and documentation of student projects. Qualitative data analysis was carried out using the Miles and Huberman model, which includes data reduction, data presentation, and conclusion/verification, with the validity of the data guaranteed through source and method triangulation techniques. Meanwhile, the quantitative approach uses a quasi-experimental design with two groups: the experimental group using the STEAM-PROXI model and the control group using the conventional approach. The instrument used was a high-level thinking skill test before and after treatment to measure the improvement of students' logical, creative, and innovative thinking skills. The results of the study show that the application of the STEAM-PROXSI model is able to create a meaningful and contextual learning experience, as well as encourage students to develop high-level thinking skills through project activities that are integrated with real life. Despite challenges in time planning, resource availability, and the implementation of a cross-disciplinary approach, overall the implementation of this model was considered effective. These findings recommend STEAM-PROKSI as an alternative innovative learning model in supporting the implementation of the Independent Curriculum, especially in science subjects at the elementary school level.
***Keywords**: STEAM-PROKSI, IPAS, Thinking Skills, Elementary school*

INTRODUCTION

Teaching Natural and Social Sciences (IPAS) at the elementary school level is currently facing complex challenges. It is not enough to just deliver conceptual material, social studies learning is required to cultivate high-level thinking skills or Higher Order Thinking Skills (HOTS), which includes logical, creative, and innovative thinking skills. These skills are essential to form learners who are able to cope with the dynamics of the 21st century, which are characterized by the complexity of problems, the need for cross-disciplinary problem-solving, and adaptive skills in the face of social and technological change (Ananiadou & Claro, 2009; Trilling & Fadel, 2009).

However, in practice in the field, social studies learning is still often conventional teacher-centered, memorization-based, and lacks exploratory activities. Teachers use more structured lecture methods and written activities, so students have fewer opportunities to think critically, collaborate, or relate learning to their real experiences (Herianingtyas et al., 2024; Suryaningsih & Astuti, 2021). As a result, students do not get adequate stimulation to develop logical thinking skills in analyzing cause and effect, think creatively in generating new ideas, or think innovatively in solving contextual problems.

Data from *the Programme for International Student Assessment* (PISA) shows that the high-level thinking skills of Indonesian students are still relatively low. In 2018, the average science literacy score of Indonesian students only reached 396, and mathematics literacy was 379, both far below the OECD average of 489. Most Indonesian students are only able to solve problems at a low level (Level 1A or below), which does not require deep reasoning or complex thinking skills (OECD, 2019). This condition does not show a significant improvement in PISA 2022. Indonesian students' mathematics scores actually dropped to 366, science literacy to 383, and reading literacy reached 359, all three remaining below the OECD average of around 472, 485, and 476, respectively (OECD, 2023). More than 60% of Indonesian students are still at basic level in all three assessment domains, which shows limitations in understanding and applying concepts in real-life contexts. Meanwhile, only a small percentage of students are able to achieve high levels (Level 5 or 6) who demonstrate critical and complex reasoning skills. This data confirms that most Indonesian students have not been able to develop logical, creative, and innovative thinking skills optimally, so learning innovations are needed that can encourage high-level thinking skills in a contextual and applicative manner, as mandated by the Independent Curriculum.

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Previous research has shown that the creative thinking skills of elementary school students in Indonesia are still at an alarming level. One of the important indicators in creative thinking is thinking flexibility, which is the ability to see a problem from various points of view and move from one strategy to another flexibly. However, the results of the research conducted by Suryaningsih et al., (2025) revealed that most students have not been able to show such flexibility of thinking. Students tend to be fixated on one way of thinking or a single strategy in solving problems, and have difficulty when asked to find other alternative solutions (Suyanto et al., 2012). In addition, the ability to produce original ideas is also relatively low. When faced with open problems that demand creativity, many students are only able to deliver conventional answers that are repetitive and lack an element of novelty.

Meanwhile, the Independent Curriculum, which is now the national policy of education in Indonesia, emphasizes the importance of contextual, thematic, and cross-disciplinary learning to form the Pancasila Student Profile. This curriculum demands a learning model that provides space for exploration, collaboration, and strengthening students' character as lifelong learners (Kemdikbud, 2022). This certainly demands a shift from traditional learning models to innovative learning models that are able to stimulate HOTS and connect with students' daily lives.

Thus, designing social studies learning that integrates logical, creative, and innovative aspects is not only a curriculum demand, but also a strategic step to prepare a young generation that is resilient, adaptive, and able to contribute in the future. One relevant approach to addressing this challenge is the STEAM (Science, Technology, Engineering, Arts, and Math) learning model. This approach not only integrates different fields of study but also encourages students to think critically and creatively through project-based activities rooted in everyday life (Ananda et al., 2023; Cook & Bush, 2018; Mariana & Kristanto, 2023). However, many teachers in the field still face difficulties in implementing this approach, such as time constraints, lack of understanding of interdisciplinary concepts, and limited learning resources and contextual media (Baran et al., 2019; Wardani et al., 2021).

Learning with the STEAM approach is one of the 21st century educational innovations that emphasizes the development of critical, collaborative, communicative, and creative thinking skills known as *4C skills* (Yakman & Lee, 2012). This approach focuses not only on mastering scientific concepts, but also on developing *soft skills* that are needed in life and the world of work in the future (Yakman, 2017). STEAM-based learning provides an opportunity for students to understand the interconnectedness between different fields of science holistically (Yakman, 2012). The integration between disciplines creates a more contextual and meaningful learning experience because students do not only learn science separately, but in a unity that is applicable and connected to the reality of daily life. IPAS as an integrative thematic subject requires a teaching strategy that can stimulate creativity, innovation, and cross-disciplinary thinking. In this context, art (Arts) is not only a complement, but serves as a connecting element that develops students' imagination and expression, so that they are freer in exploring new solutions and approaches to a problem.

Through *project-based learning* projects, the STEAM approach provides students with the opportunity to develop skills in designing, evaluating, and realizing their ideas collaboratively (Ananda et al., 2023). Learning becomes more active and exploratory, as students are invited to experiment, discuss, and devise real solutions to contextual issues. Thus, STEAM is one of the promising approaches to improve the quality of IPAS learning in the era of the Independent Curriculum, because it is in line with the goal of strengthening *the Pancasila Student Profile* which encourages students to have complete character, competence, and literacy.

Chung et al., (2018) states that the application of the STEAM approach helps students develop critical thinking and creativity more effectively than conventional methods. Additionally, it offers students the opportunity to build problem-solving skills through challenging projects that require them to analyze, experiment, and make decisions based on data and logic. As a result, students not only understand the theory but are also able to apply it in various life contexts. Educators have more alternatives at their disposal when it comes to presenting STEM ideas to students, especially at the elementary school and early childhood levels, when those ideas are complemented by art (Kim et al., 2012).

Given the urgency of developing high-level thinking skills and the complexity of learning challenges in the era of the Independent Curriculum, researchers designed and used an innovative learning model called STEAM-PROKSI (*Students' Creativity Project and Innovation Synergy*). This model is the result of an adaptation of the STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach which is specifically tailored to the characteristics of elementary school students and the demands of the applicable curriculum. In contrast to the conventional STEAM approach which is more widely applied at the middle and upper levels, STEAM-PROKSI was developed

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by paying attention to the concrete learning needs of elementary school-age children, including the need for exploratory, contextual, and hands-on experience-based activities.

STEAM-PROXI integrates problem-based and contextual science projects with activities aimed at strengthening logical, creative, and innovative thinking skills across the board. In this model, students are encouraged to explore real issues in their surroundings, design solutions in the form of projects, and present them through an integrative approach between subjects. Art (arts) not only acts as an aesthetic enrichment, but also as a medium for the expression of ideas and creativity that strengthens the communication of ideas visually and conceptually (Mariana & Kristanto, 2023). This study is focused on examining how the implementation of the STEAM-PROXSI model is applied in the learning of IPAS Phase B in elementary schools, namely in grades IV and V which have been introduced to thematic approaches and simple projects. In addition, this study aims to analyze the effectiveness of the model in developing students' high-level thinking skills (HOTS), especially in the aspects of logical reasoning, the ability to generate original ideas, and innovation in problem solving. Not only that, this research also explored various challenges and obstacles faced by teachers during the implementation process. The aspects studied included teacher readiness, planning and implementation of cross-disciplinary learning, availability of resources, and students' perception of project-based learning activities. The findings of this study are expected to be a foundation for future learning design improvements, as well as a contribution to the development of integrative thematic learning models that are in accordance with the spirit of the Independent Curriculum and the needs of basic education in the 21st century.

METHODE

This study employs a mixed-method research design, combining a descriptive qualitative approach and a quasi-experimental quantitative design to comprehensively investigate the implementation and effectiveness of the STEAM-PROKSI learning model (Science, Technology, Engineering, Arts, and Mathematics – Problem and Project-Based Learning). The qualitative component aims to thoroughly describe the learning processes, classroom experiences, and students' perceptions during the implementation of STEAM-PROKSI. This approach was chosen for its strength in exploring the natural dynamics of classroom learning, emphasizing meaning,

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perception, and students' active participation (Miles, 2014). Qualitative research offers flexibility that allows researchers to adjust instruments and strategies to contextual realities, making it highly appropriate for studying innovative pedagogies that are still under development or not yet widely applied in elementary education settings (Creswell & Creswell, 2017).

The quantitative component utilizes a quasi-experimental design with a two-group pretest-posttest structure: an experimental group and a control group. The experimental group consists of fourth-grade students receiving instruction through the STEAM-PROKSI model, which integrates interdisciplinary scientific concepts in the form of contextual problem-solving projects. Students are encouraged to explore real-world issues, apply scientific and technological principles, and produce innovative, tangible outcomes. Conversely, the control group receives instruction using conventional teaching methods, such as lectures, Q&A sessions, and individual assignments, with minimal integration of cross-disciplinary or project-based learning. This design enables a comparative analysis of the two instructional approaches in terms of their impact on students' higher-order thinking skills.

The research is conducted in two elementary schools in the Moga Subdistrict, Pemalang Regency, namely SD Negeri 06 Sima and SD Negeri 02 Moga. These schools were purposefully selected based on their geographical diversity (semi-urban and rural), openness to pedagogical innovation, and availability of basic facilities that support project-based STEAM activities. In addition to students, fourth-grade teachers are also involved as key informants who provide pedagogical perspectives on the implementation process. Data collection integrates both qualitative and quantitative instruments. The qualitative data are obtained through: (1) observation sheets, to capture classroom interactions, student engagement, and the learning environment; (2) semi-structured interviews with school principals, teachers, and students, to gather insights into experiences, challenges, and benefits related to STEAM-PROKSI implementation; and (3) project assessment rubrics, used to evaluate student group projects based on creativity, collaboration, and problem-solving processes. Meanwhile, the quantitative data are collected using a thinking skills test administered before and after the intervention, consisting of open-ended questions designed to measure logical reasoning, creative idea generation, and innovative problem-solving.

Meanwhile, the quantitative data were gathered using a thinking skills test administered in a pre-test and post-test format to both experimental and control groups.

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This test consisted of open-ended questions that measured students' logical reasoning, creative thinking, and ability to generate innovative solutions. Data analysis was conducted using procedures appropriate to each method. The qualitative data were analyzed using the interactive model by (Miles, 2014), which includes the stages of data condensation (reduction), data display, and conclusion drawing/verification. To ensure data credibility and trustworthiness, triangulation of data sources (observations, interviews, documentation) and methods was employed. For the quantitative analysis, the pre-test and post-test scores were analyzed using descriptive statistics and inferential statistics, specifically the paired sample t-test to determine the significance of differences in thinking skill improvements between the experimental and control groups. Effect size calculations were also included to assess the magnitude of learning gains resulting from the STEAM-PROKSI intervention.

With this integrative methodological framework, the study aims not only to assess the effectiveness of the STEAM-PROKSI model in enhancing students' higher-order thinking skills, but also to offer rich contextual understanding of how the model functions in real classroom environments. The findings are expected to contribute significantly to the refinement of meaningful, interdisciplinary, and project-based learning practices in Indonesian elementary education, while enriching scholarly discourse on STEAM model applications at the primary level.

RESULT AND DISCUSSION

In the context of Natural and Social Sciences (IPAS) learning for Phase B in elementary schools, the STEAM-Proksi approach is expected to enhance student engagement through more meaningful learning experiences that are closely tied to their everyday lives, especially in areas such as the Moga District. For example, in a project themed around the water cycle in their local environment, students not only study concepts like evaporation and condensation but also conduct simple experiments, draw water cycle diagrams, create educational posters, and even perform science dramas based on their observations of local weather.

Unlike traditional STEAM methods that tend to be abstract and laboratory-oriented, the STEAM-Proksi approach utilizes local resources and community contexts as learning materials. For instance, in a topic on the life cycle of living things, students may plant local seeds such as mung beans, observe their growth, record data in graphs, and then create digital presentations or illustrative paintings explaining the plant's life

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cycle. These activities not only instill scientific concepts but also sharpen students' communication and digital literacy skills.

Research shows that approaches like STEAM-Proksi have a positive impact on increasing learning motivation, understanding of scientific concepts, and 21st-century skills such as critical thinking and problem-solving (Liao, 2019; Quigley & Herro, 2016). However, implementing this method comes with challenges, particularly in regions like Moga District, which may face limitations in infrastructure, teacher readiness, and technology access. Therefore, teacher training becomes essential to equip educators with the ability to design interdisciplinary, project-based learning suited to local realities (Margot & Kettler, 2019)).

Furthermore, the STEAM-Proksi approach also encourages collaboration among schools, communities, and businesses to create a learning ecosystem that supports creativity and innovation. Learning activities are no longer confined to the classroom but also involve the surrounding environment as a living laboratory. Thus, the STEAM-Proksi approach not only equips students with academic knowledge but also empowers them as change agents capable of understanding, processing, and providing solutions to real-world issues in their communities.

The diagram above illustrates a comparison of logical, creative, and innovative thinking skills between the experimental and control classes at two elementary schools: SDN 06 Sima and SDN 02 Moga. Each school implemented both experimental and control classes, providing a comprehensive basis for assessing the effectiveness of the STEAM-PROKSI model in fostering higher-order thinking skills among students. At SDN 06 Sima, the experimental class exhibited significant improvement across all measured skills. Following the first cycle of learning implementation (Cycle I), students achieved average scores of 74% for logical thinking, 70% for creative thinking, and 68% for innovative thinking. These figures marked a notable progression from pre-intervention levels. After Cycle II, however, scores rose substantially to 85% for logical thinking, 82% for creative thinking, and 80% for innovative thinking. This growth was accompanied by an enhancement in teaching quality, as reflected by the teacher's observation scores across the cycles. In Cycle I, the teacher's performance was rated 86.5 (P1), 88.46 (P2), and 96.1 (P3), with an average of 90.35. In Cycle II, the teacher's performance improved further, with scores of 93.75 (P1), 95.2 (P2), and 98.07 (P3), culminating in an average of 95.67. This increase in teaching quality was closely linked to the students' growing proficiency in logical, creative, and innovative thinking.

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Similarly, student engagement at SDN 06 Sima demonstrated significant progress. Observational data revealed an increase in student activity from Cycle I, where student participation rates were 75.6%, 78.2%, and 80.3%, to Cycle II, where engagement jumped to 85.7%, 88.6%, and 91.2%. This increase in participation directly reflected the students' deeper involvement in the STEAM-PROKSI model's activities, particularly in tasks that demanded logical reasoning, creative exploration, and innovative problem-solving.

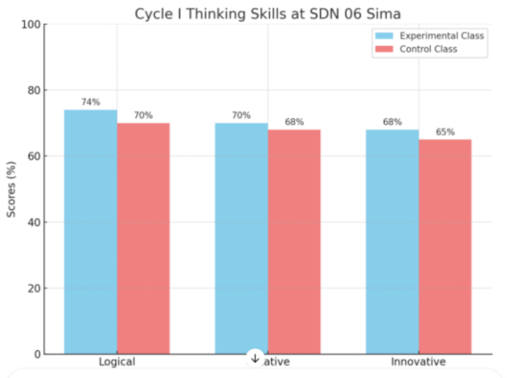

Figure 1. Cycle I Thinking Skiils at SDN 06 Sima

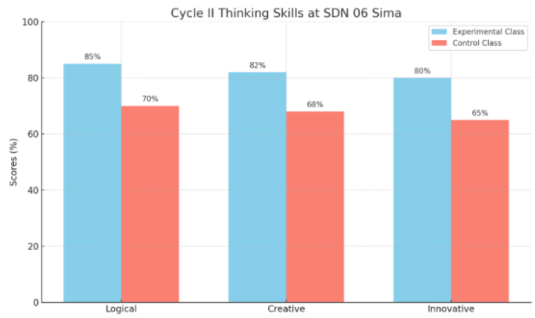

Figure 2 Cycle II Thinking Skiils at SDN 06 Sima

At SDN 02 Moga, a comparable pattern of improvement was observed. The experimental class exhibited a rise in thinking skills from 72% (logical), 69% (creative), and 66% (innovative) in Cycle I to 83%, 80%, and 78%, respectively, in Cycle II. This upward trend mirrored qualitative observations of increased student collaboration, enhanced enthusiasm for idea exploration, and a notable improvement in students' ability to present and develop innovative solutions. Teacher observations at SDN 02 Moga also highlighted effective facilitation, with a structured focus on project-based activities that significantly supported student learning and skill development across both cycles.

In contrast, the control classes in both schools, which utilized conventional teaching methods, showed minimal progress in the development of thinking skills. At SDN 06 Sima, control class students maintained static scores of around 70% (logical), 68% (creative), and 65% (innovative), with little change between the cycles. Likewise, at SDN 02 Moga, control class scores hovered at 72% (logical), 69% (creative), and 66% (innovative), indicating a lack of substantial improvement over time.

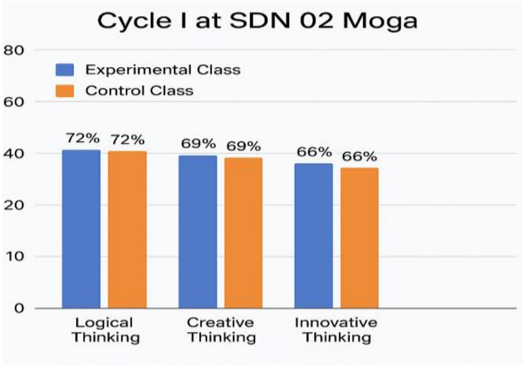

Figure 3. *Cycle I Thinking Skiils at SDN 02 Moga*

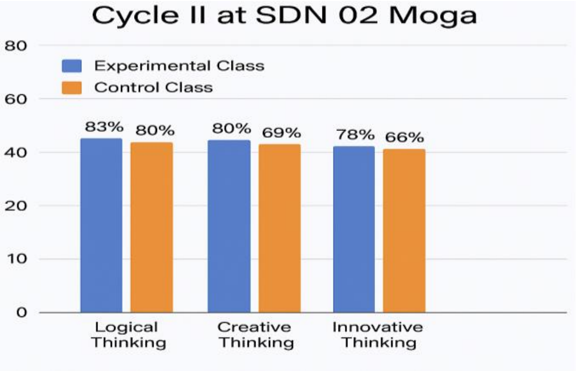

Figure 4. *Cycle I Thinking Skills at SDN 02 Moga*

The results of this study reveal that the STEAM-PROKSI learning model a contextual adaptation of the STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach combined with project and problem-based learningvhas a significant impact on developing students' higherorder thinking skills. These include logical reasoning, creative idea generation, and innovative problem-solving abilities. At both SDN 06 Sima and SDN 02 Moga, experimental classes demonstrated substantial improvement in students' cognitive abilities between Cycle I and Cycle II. This growth was consistently observed across the three skill domains logical, creative, and innovative thinking. The significant increase in student scores is indicative of how the STEAM-PROKSI model promotes deeper engagement and supports cognitive development through interdisciplinary learning tasks. According to Yakman (2012), STEAM education allows students to make meaningful connections between disciplines, which not only enhances understanding but also fosters creativity and innovation through the integration of arts and real-world application.

Moreover, this study found that improvement in students' thinking skills was positively correlated with enhanced teaching performance. Teachers' observation scores improved across cycles, suggesting that professional growth in implementing STEAM-based learning approaches contributes to better facilitation of higher-order thinking (Quigley & Herro, 2016). In line with this, Capraro & Slough (2013) argue that teacher quality is a key factor in the successful implementation of STEAM, particularly in early education settings where structured guidance and scaffolding are crucial. The notable increase in student engagementvevidenced by rising participation rates in STEAM-PROKSI activitiesvfurther affirms the model's effectiveness in creating a student-

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centered learning environment. Research has shown that active learning strategies, especially those involving real-life problem solving and collaborative tasks, enhance intrinsic motivation and cognitive engagement (Bell, R. L., Smetana, L., & Binns, 2005; Suryaningsih, 2019). This was clearly demonstrated in the experimental classes where students became more involved in exploring issues, designing solutions, and presenting their projects with confidence.

On the other hand, control classes that followed conventional, teacher-centered methods showed minimal improvement in student thinking skills across both cycles. This contrast reinforces findings from prior studies indicating that traditional rote-based instruction fails to promote critical, creative, and reflective thinking, particularly in elementary school contexts (Darling-Hammond et al., 2020). The findings emphasize the urgent need for pedagogical transformation in Indonesian elementary education, in line with the goals of the Kurikulum Merdeka, which encourages personalized, inquiry-driven, and competency-based learning (Kemdikbud, 2022).

Finally, the STEAM-PROKSI model's emphasis on using the surrounding environment as a "living laboratory" helps to contextualize learning and build students' problem-solving capacity grounded in real-world experiences. This is consistent with the constructivist theory of learning, which holds that authentic and situated learning experiences enhance knowledge retention and the development of transferable skills (Brown & Duguid, 2001). Therefore, beyond academic gains, this model empowers students as agents of change within their communities, capable of understanding, processing, and addressing issues that affect their everyday lives.

CONCLUSION

The findings from SDN 06 Sima and SDN 02 Moga clearly demonstrate that the integration of the STEAM-PROKSI model in the learning process significantly contributes to the development of students' higher-order thinking skills, particularly in logical, creative, and innovative thinking. The experimental classes in both schools showed consistent and meaningful improvements across two learning cycles. These improvements were not only evident in the students' scores but were also supported by qualitative indicators such as increased engagement, collaboration, and the ability to present innovative ideas. Moreover, the enhancement of teaching quality played a crucial role in supporting student growth, as reflected in the teacher observation scores. In contrast, the control classes, which continued to use conventional teaching methods,

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exhibited minimal or no significant changes in student performance. This disparity emphasizes the transformative potential of active, project-based, and interdisciplinary learning models like STEAM-PROKSI in fostering 21st-century competencies. Therefore, it is recommended that such innovative pedagogical approaches be adopted more widely to support holistic student development and improve the overall quality of education.

REFERENCE

Ananda, L. R., Rahmawati, Y., & Khairi, F. (2023). Critical thinking skills of Chemistry students by integrating design thinking with STEAM-PjBL. *JOTSE: Journal of Technology and Science Education*, *13*(1), 352–367.

Ananiadou, K., & Claro, M. (2009). *21st Century Skills and Competences for New Millennium Learners in OECD Countries* (OECD Education Working Papers, Vol. 41). https://doi.org/10.1787/218525261154

Baran, E., Bilici, S. C., Mesutoglu, C., & Ocak, C. (2019). The impact of an out-of-school STEM education program on students' attitudes toward STEM and STEM careers. *School Science and Mathematics*, *119*(4), 223–235. https://doi.org/10.1111/ssm.12330

Bell, R. L., Smetana, L., & Binns, I. (2005). Simplifying Inquiry Instruction. *The Science Teacher*, *72*(7), 30–33.

Brown, J. S., & Duguid, P. (2001). Creativity versus structure: a useful tension. , 42(4), 93-94. *MIT Sloan Management Review*, *42*(4), 93–94.

Chung, C.-C., Lin, C.-L., & Lou, S.-J. (2018). Analysis of the learning effectiveness of the STEAM-6E special course—A case study about the creative design of IoT assistant devices for the elderly. *Sustainability*, *10*(9), 3040.

Cook, K. L., & Bush, S. B. (2018). Design thinking in integrated STEAM learning: Surveying the landscape and exploring exemplars in elementary grades. *School Science and Mathematics*, *118*(3–4), 93–103.

Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.

Herianingtyas, N. L. R., Suryaningsih, T., Sumantri, M. S., Utomo, E., & Nurhasanah, N. (2024). How Science-Mathematics based Fairytale Book Enhance Critical

Thinking Skills and Curiosity in Elementary School Students? *Al Ibtida: Jurnal Pendidikan Guru MI*, *11*(1), 1–17.

Kemdikbud. (2022). Rencana Strategis Pusat Penguatan Karakter 2020-2024. *Kemendikbudristek*, 1–36.

Kim, S.-W., Chung, Y.-L., Woo, A.-J., & Lee, H.-J. (2012). Development of a theoretical model for STEAM education. *Journal of the Korean Association for Science Education*, *32*(2), 388–401.

Liao, C. (2019). Creating a STEAM map: A content analysis of visual art practices in STEAM education. In *STEAM education: Theory and practice* (pp. 37–55). Springer.

Margot, K. C., & Kettler, T. (2019). Teachers' perception of STEM integration and education: a systematic literature review. *International Journal of STEM Education*, *6*(1), 1–16.

Mariana, E. P., & Kristanto, Y. D. (2023). Integrating STEAM education and computational thinking: Analysis of students' critical and creative thinking skills in an innovative teaching and learning. *Southeast Asian Mathematics Education Journal*, *13*(1), 1–18.

Miles, M. B. H. A. M. & S. J. (2014). *Qualitative Data Analysis, A. Methods Sourcebook, Edition 3*. Sage Publications.

OECD. (2019). PISA 2018 Results Results Combined Executive Summaries. In *PISA 2009 at a Glance: Vol. I*. https://doi.org/10.1787/g222d18af-en

OECD. (2023). *PISA 2022 Results Factsheets Indonesia PUBE*. https://oecdch.art/a40de1dbaf/C108.

Quigley, C. F., & Herro, D. (2016). "Finding the joy in the unknown": Implementation of STEAM teaching practices in middle school science and math classrooms. *Journal of Science Education and Technology*, *25*(3), 410–426.

Suryaningsih, T. (2019). Evaluasi kemampuan dasar pemecahan masalah siswa berdasar heuristik Krulik-Rudnick materi geometri. *JRPD (Jurnal Riset Pendidikan Dasar)*, *2*(1), 9–13.

Suryaningsih, T., & Astuti, A. (2021). Pengaruh Model Pembelajaran Open Ended terhadap Kemampuan Berpikir Kreatif Matematis Siswa Kelas IV pada Materi Pecahan. In *Elementar (Elementary of Tarbiyah): Jurnal Pendidikan Dasar* (Vol. 1, Issue 1). http://uinjkt.ac.id/index.php/elementar

Suryaningsih, T., Sabila, A. I., Widiyanto, R., Herianingtyas, N. L. R., & Siron, Y. (2025). The Influence of the Problem Posing Approach on the Creative Thinking Ability of Class V Students on Geometry Material at Elementary School. *Journal of Elementary Educational Research*, *5*(1), 21–33.

Suyanto, Y. P., Susanto, H., Linuwih, S., Fisika, J., Matematika, F., Ilmu, D., & Alam, P. (2012). Unnes Physics Education Journal KEEFEKTIFAN PENGGUNAAN STRATEGI PREDICT, OBSERVE AND EXPLAIN UNTUK MENINGKATKAN KEMAMPUAN BERPIKIR KRITIS DAN KREATIF SISWA. *UPEJ*, *1*(1). http://journal.unnes.ac.id/sju/index.php/upej

Trilling, B., & Fadel, C. (2009). *21st century skills: Learning for life in our times*. John Wiley & Sons.

Wardani, D. S., Wulandari, M. A., Nurfurqon, F. F., & Kurniawati, D. (2021). STEM-INTEGRATED PROJECT-BASED LEARNING (PJBL) MODEL AND LECTURE WITH EXPERIMENTS LEARNING MODEL: WHAT IS THE SCIENTIFIC LITERACY SKILLS OF ELEMENTARY TEACHER EDUCATION STUDENTS IN THESE LEARNING MODELS? *Al-Bidayah : Jurnal Pendidikan Dasar Islam*, *13*(1), 55–72. https://doi.org/10.14421/al-bidayah.v13i1.634

Yakman, G. (2012). Recognizing the in STEM Education. *Middle Ground*, *16*(1), 15.

Yakman, G. (2017). STEAM education professional development practicum & research. *Proceedings of the PATT*, *34*.

Yakman, G., & Lee, H. (2012). Exploring the exemplary STEAM education in the US as a practical educational framework for Korea. *Journal of the Korean Association for Science Education*, *32*(6), 1072–1086.