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A Systematic Literature Review: Project-Based Learning to Empower Students' Science Process Skills

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ABSTRACT

Science process skills are an essential aspect that supports critical, creative, collaborative, and communicative thinking skills. The reality reveals that science learning in schools is still dominated by traditional methods focusing on memorising concepts. Project-Based Learning (PjBL) offers a promising approach to improving KPS. PjBL is a student-centred learning model, where students work collaboratively to design, implement, and evaluate projects that are relevant to real life. This study determines the effect of the project-based learning model on empowering students' science process skills by using a systematic literature review (SLR). Systematic Literature Review involves searching and analysing relevant literature from various sources published from 2016 to 2024. A systematic method could identify relevant literature studies to the pre-determined criteria. The applied content analysis ensured the model, method, focus, and results achieved from the study. The results indicate that (a) project-based learning improves students' science process skills, (b) project-based learning is feasible to use for teaching and learning activities, and (c) project-based learning is effective in science learning, especially for improving science process skills. Educators are advised to consider using the project-based learning model in learning strategies to support students' science skills development comprehensively.

Keywords*: *project-based learning, science process skills, systematic literature review, science

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INTRODUCTION

Science process skills (KPS) are an important aspect of science education that supports the development of critical, creative, collaborative and communicative thinking abilities. The reality in the field shows that science learning in schools is still dominated by traditional methods that focus on memorizing concepts. As a result, students' KPS is less developed, which impacts their ability to solve problems, make decisions, and participate actively in the scientific community. Project-Based Learning (PjBL) offers a promising approach to improving KPS. PjBL is a student-centered learning model, where students work collaboratively to design, implement, and evaluate projects that are relevant to real life. This research determined the effect of Project-Based Learning (PjBL) on improving students' science process skills and examined the feasibility and effectiveness of project-based learning in the learning process. This research expects the learning process will become more meaningful for students.

Learning is a conscious and planned effort to create a learning atmosphere and educational process in which students actively develop their abilities. Although Indonesia has successfully integrated learning, it still needs further development (Maison et al., 2019). Hamadi (2018) asserts that scientific processes establish and develop knowledge or natural sciences. Conventional science learning generally relies on thinking

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(*minds-on*), limiting science to merely a collection of knowledge (*a body of knowledge*). This condition provides students with strong mastery of scientific concepts but only partially or minimally fosters the acquisition of process skills (Wola et al., 2023).

Science process skills are part of the thinking skills utilized by scientists, teachers, and students when studying science (Turiman et al., 2012). Scientists use science process skills for investigation and exploration. Through science process skills, students are expected to perform steps of the scientific method to acquire new knowledge or develop existing knowledge. A constructivist learning theory also explains that learners actively construct knowledge based on their experiences (Wola et al., 2023).

Science process skills refer to the physical and mental abilities scientists use to acquire and develop knowledge. In addition, science process skills also involve intellectual, manual, and social skills utilized by students during the learning process (Rustaman, 2005). Direct experiences can cultivate these skills, allowing students to deeply internalize the learning activities they engage in (Fitriana et al, 2019).

Therefore, PjBL model focuses on making students active participants in the learning process, thereby enhancing their knowledge, understanding, and skills through project creation. Teachers play the role of guides or facilitators in the learning process.

The PjBL model is highly relevant for improving science process skills. Its relevance lies in the project stages that students and teachers must undergo, which align with the steps and principles of science (Musfiqon & Nurdyansyah. 2015). Students are required to create projects that involve: 1) real-world problem and issue solutions; 2) active learning process engagement and identification of key aspects during the project; and 3) tangible evidence for the students to master important concepts and skills (Addin et al., 2014).

LITERATURE REVIEW

One critical element in improving education quality is the curriculum. Minister of Education Culture research and tecnologi Regulation No. 12 of 2024 discusses the characteristics of independent Curriculum, the student-centered. This curriculum encourages students to be more active in developing their competencies, including attitudes, knowledge, and skills to apply in school and society. Science process skills are among the skills that students need to develop.

Science learning focuses on thinking skills that produce facts, concepts, principles, laws, theories, and procedural knowledge. Procedural knowledge refers to learning how to acquire information through scientific activities based on science process skills. Learning science is not only about memorizing content but also about mastering and applying science process skills in scientific investigations (Tadsanai Jeenthong, Pintip Ruenwongsa, 2013). Science Process Skills (SPS) represent science as a process.

Nworgu & Otum (2013) divide science process skills into two categories: basic skills and integrated skills. Basic Science Process Skills (BSPS) include observing, concluding, measuring, communicating, classifying, and predicting. Integrated Science Process Skills (ISPS) involve controlling variables, defining operationally, formulating hypotheses, interpreting data, conducting experiments, and modelling. Ongowo & Chisakwa Indoshi (2013) explain basic science process skills include: 1) observing by using the five senses to gather relevant data; 2) classifying by grouping objects based on properties and characteristics; 3) predicting by making forecasts about future events based on patterns, concepts, and principles; 4) measuring by comparing an object against a standard unit; 5) concluding by determining the state of an object based on known facts, concepts, principles, or theories; and 6) communicating by conveying facts, concepts, principles, and theories in various forms, including audio, visual, or audiovisual. On the other hand, the Integrated Science Process Skills include: 1) controlling variables: by identifying and managing independent, dependent, and controlled variables; 2) defining operationally by determining how to measure identified variables; 3) formulating hypotheses by answering questions based on observations or prior knowledge; 4) interpreting data by organizing and drawing conclusions from data; 5) conducting experiments by testing hypotheses according

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to procedures to verify their validity; and 6) modelling by creating representations of a process (Ongowo & Chisakwa Indoshi, 2013).

Project-Based Learning (PjBL) is a suitable model for teaching science (Brooke et al., 2019). PjBL involves contextual learning through authentic questions and real-world problems, enabling students to collaborate toward a final product. This model equips students with analytical, synthetic, practical, and reflective abilities (Sivia, A., & Sheryl, 2019; Aini et al., 2022). PjBL is widely used, from elementary schools to universities (Hung et al., 2012).

The PjBL model aims to improve the quality of the learning process and identify academic achievements as authentic learning outcomes (Bell, 2010; Kokotsaki et al., 2006). PjBL is considered more effective in enhancing students' achievements compared to conventional learning methods (Kinchin, 2019). Student learning achievements can be measured through indicators such as written tests, performance assessments, or learning outcomes. Authentic learning artifacts are strongly correlated with the level of thinking skills achieved during the learning process (Bell, 2010; Blumenfeld et al., 1991; Helle et al., 2006; Kokotsaki et al., 2016). Learning outcomes from authentic products are directly tied to the learning process (Af'idayani et al., 2018; Quansa, 2018).

Learning essentially involves communication between teachers and students, or among students themselves, through questions, statements, and activities related to the subject matter (Forster et al., 2019). Classroom interactions involve both closed and open-ended questions (Albergaria-Almeida, 2010; Forster et al., 2019; Hannel, 2009). Open-ended questions are especially effective in encouraging higher-level thinking among students (Forster et al., 2019). Teacher questions play a crucial role in engaging students' thinking abilities and enhancing the quality of the learning process (Forster et al., 2019; McDonald et al., 2017; Zheng & Wang, 2019).

METHOD

In this literature review, PRISMA (The Preferred Reporting Items for Systematic Reviews and Meta-Analysis). This Systematic Literature Review (SLR) method involves the identification, assessment, evaluation, and interpretation of research data that meets specific criteria. SLR is a comprehensive review of existing studies of a similar nature using a rigorous and structured approach, to provide answers to the research questions posed. The SLR research procedure includes literature search, literature selection, literature quality assessment, data extraction, data synthesis, and writing a literature review report. Research is carried out in libraries (physical and digital), based on online data, and other relevant literature sources. The journal period studied was journals published in 2016-2023. The research was conducted from January 5 to January 11 2025, with the SLR process carried out at our residence in Lemah Duwur, RT 01/II, Joho, Purwantoro, Wonogiri.. The stages of the systematic literature review used in this study are based on the following framework:

1. Formulation of Research Questions

This stage involves the formulation of clear and focused research questions to guide the process of searching and reviewing the literature.

2. Literature Search

At this stage, the researchers searched electronic databases, journal articles, conferences, and other sources for relevant literature. The researchers used appropriate keywords and predetermined inclusion/exclusion criteria for the search. The inclusion criteria were established to limit the articles referenced in this study. These criteria include articles relevant to the research theme on Project-Based Learning (PjBL) and science process skills.

3. Article Selection

The researchers evaluated the identified articles from the previous stage using the predetermined inclusion/exclusion criteria. We select articles relevant to the research topic for further review. The researchers obtained the literature for the study by conducting searches on databases like sinta.kemendikbud.go.id, Google

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Scholar, Scopus, and the Garuda portal. This search yielded 45 articles meeting the keywords related to project-based learning and science process skills. We then filtered these articles based on the inclusion criteria, which yielded 19 articles that met the requirements.

4. Quality Evaluation of Studies

The researchers evaluated the methodological quality and reliability of the selected studies at this stage and critically examined the research and its potential limitations.

5. Data analysis and synthesis

The researchers systematically extracted and analyzed data from the selected articles. The researchers identified, grouped, and synthesized relevant findings to provide a comprehensive understanding of the research topic. At this stage, we assess the studies' quality using predetermined criteria, as follows:

a. QA1: Have national or international journal articles published the referenced article?
b. QA2: Is the research discussed in the referenced article relevant to the current research?
c. QA3: Does the referenced article employ research methods relevant to project-based learning and science process skills?
d. Each referenced article is assessed based on the above questions with a response of "yes" (√) or "no" (-).

6. Interpretation and report writing

The final stage involved the interpretation and explanation of the data analysis findings. The researchers prepared the research report, which clearly and logically summarized the results of the literature review. This systematic approach ensures a thorough evaluation of the literature and provides a solid foundation for understanding the influence of project-based learning on science process skills.

RESULTS AND DISCUSSION

Literature Review

Analysis of selected literature was carried out to gather information related to implementation KPS assessment in chemistry learning in Indonesia includes objectives, types of instruments used, KPS indicators measured, and integration of KPS in chemistry learning. Literature those analyzed are listed in Table

Table 1. The Research Quality Assessments

No	Years	Authors	Research Variables	QA1	QA2	QA3	Conclusions
1	2016	Chasanah, A. R. U., Khoiri, N., & Nuroso, H	The Effectiveness of the Project-Based Learning Model on Science Process Skills and Students' Creative Thinking Abilities in the Topic of Heat in Class X at SMAN 1 Wonosegoro for the 2014/2015 Academic Year	√	√	√	√
2	2016	Kusumaningrum, S., & Djukri, D.	Development of Learning Tools Using the Project-Based Learning (PjBL) Model to Enhance Science Process Skills and Creativity	√	√	√	√

Jurnal PAJAR (Pendidikan dan Pengajaran)
Volume 9 Nomor 3 May 2025 | ISSN Cetak : 2580 - 8435 | ISSN Online : 2614 - 1337
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3	2016	Maghfiroh, N., Susilo, H., & Gofur, A	The Effect of Project-Based Learning on Science Process Skills of Class X Students at SMA Negeri Sidoarjo	√	√	√	√
4	2017	Maryani, L., Sunyono, S., & Abdurrahman, A.	The Effectiveness of LKPD (Student Worksheet) Based on Project-Based Learning to Improve Students' Science Process Skills	√	√	√	√
5	2018	Fitriyani, L. O., Koderi, K., & Anggraini, W.	Project-Based Learning: Its Impact on Science Process Skills of Learners in Tanggamus (4D)	√	√	√	√
6	2018	Hasanah, I., Sarwanto, S., & Masykuri, M.	Development of a Heat and Temperature Module Based on Project-Based Learning to Improve Science Process Skills and Critical Thinking Skills of High School Students (ADDIE)	√	√	√	√
7	2019	Anggriani, F., Wijayati, N., Susatyo, E. B., & Kharomah, K	The Effect of Project-Based Learning in Chemistry Product Development on Conceptual Understanding and Science Process Skills of High School Students	√	√	√	√
8	2019	Astutik, F. I., Nur, M., & Prastowo, T	Physics Learning Tools Using the Project-Based Learning (PjBL) Model to Improve High School Students' Science Process Skills (4D)	√	√	√	√
9	2020	Jatmika, S., Lestari, S., Rahmatullah, R., Pujianto, P., & Dwandaru, W. S. B.	Integration of Project-Based Learning into Science, Technology, Engineering, and Mathematics (STEM) to Enhance Science Process Skills in Physics Learning	√	√	√	√
10	2021	Kurniawati, E. E., Sumarti, S. S., Wijayati, N., & Nuswowati, M	The Effect of Project-Based Learning Oriented to Chemoentrepreneurship with E-Worksheet Assistance on Science Process Skills and Entrepreneurial Attitudes	√	√	√	√

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11	2021	Tindige, S. A., Rende, J. C., & Komansilan, A.	The Implementation of the Project-Based Learning Model to Improve Physics Learning Outcomes and Science Process Skills of Class X Students at SMA N 2 Tondano	√	√	√	√
12	2022	Amsikan, A.	The Implementation of the Project-Based Learning Model to Improve Physics Learning Outcomes and Science Process Skills of Learners	√	√	√	√
13	2022	Yuniasih, E., Hadiyanti, A. H. D., & Zaini, E	The Implementation of Project-Based Learning to Improve Science Process Skills and Learning Outcomes in Elementary School Students	√	√	√	√
14	2022	Rahayu, R., & Ismawati, R.	The Effectiveness of Online Project-Based Learning Based on Ethnoscience in Science Education on Students' Science Process Skills During the Pandemic	√	√	√	√
15	2022	Rahman, A	Project-Based Learning as an Effort to Improve Learning Outcomes and Science Process Skills of Learners	√	√	√	√
16	2022	Saryono, T.	The Effect of the Project Work Learning Model on Science Process Skills and Cognitive Learning Outcomes (Educatoria)	√	√	√	√
17	2022	Bariyah, I. L. N., & Sugandi, M. K.	Project-Based Learning to Improve Students' Science Process Skills in the Concept of Ecosystems	√	√	√	√
18	2023	Hamidah, N., Alamsyah, M. R. N., & Kusumaningrum, S. B. C	The Effect of the Project-Based Learning Model on Science Process Skills and Learning Motivation of Students at SMA Negeri 1 Candimulyo on Environmental Change Material	√	√	√	√
19	2023	Syamsuddin, S., & Salmawati, S	The Implementation of the Project-Based	√	√	√	√

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Discussions

The reviewed journal articles revealed that the Project-Based Learning (PjBL) model can enhance students' intrinsic motivation. The first syntax of the project-based learning model in these studies requires students to engage in observation and question formulation activities. These two activities can stimulate curiosity, thereby increasing students' interest in learning.

Based on the reviewed journal articles, the population and sample in these studies generally involved elementary school, junior high school, senior high school students, and university students. The research method commonly employed was a quasi-experiment with a pre-test and post-test design, using a control class as a comparison. The research instruments included tests on science process skills, covering aspects such as observation, interviews, questionnaires, classification, prediction, data interpretation, and communication.

The reviewed journal articles reported an increase in the average score of science process skills after the implementation of the project-based learning model. Project-Based Learning was effective for various types of students, including those with varying levels of understanding. These journal articles demonstrated that students with lower initial abilities experienced greater improvements compared to those with higher initial abilities. The journal articles also stated that project-based learning is suitable in terms of material presentation, language, visuals, and the process skills approach.

The journal articles generally used statistical tests, such as t-tests or ANOVA, to analyze the differences before and after the use of project-based learning. The statistical test results indicated a significant difference between science process skill scores before and after the implementation of Project-Based Learning. These results suggest that project-based learning can be an effective tool in science education, particularly for improving science process skills.

This review identifies several important factors that influence the effectiveness of PjBL in improving KPS. Good project design should be relevant to students' real lives, challenging, and provide opportunities for students to develop a variety of PPPs. Projects that are too simple or irrelevant may not provide enough stimulus to develop a student's KPS. Conversely, projects that are too complex or unstructured can frustrate students and reduce their motivation (Thomas, 2000).Teachers play an important role in facilitating PjBL learning. Teachers need to provide appropriate scaffolding, provide constructive feedback, and monitor student progress. Teachers also need to create a collaborative and supportive learning environment, where students feel comfortable asking questions, sharing ideas, and learning from mistakes (Hmelo-Silver, 2004). The effectiveness of PjBL can vary depending on student characteristics, such as ability level, interests, and learning styles. PjBL may be more effective for students who have high intrinsic motivation and good independent learning abilities. However, with the right support, PjBL can also benefit students with lower ability levels or different learning styles. Availability of resources, support from schools and parents, and a school culture that supports innovation and collaboration can also influence the effectiveness of PjBL. Schools that have complete laboratories, fast internet access and adequate libraries will be better able to support the effective implementation of PjBL.

PjBL is a promising learning approach to improve students' science process skills. However, the effectiveness of PjBL depends on various factors, such as project design, teacher role, student characteristics, and learning context. Future research needs to address the gaps in the existing literature and investigate the long-term effects of PjBL on student KPS. With proper implementation, PjBL can help students develop the KPS needed to succeed in science and life.

Jurnal PAJAR (Pendidikan dan Pengajaran)
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CONCLUSIONS AND RECOMMENDATION

Based on the findings and discussions presented earlier, the project-based learning model consistently shows a positive effect in enhancing students' science process skills. The Project-Based Learning model not only helps students better understand scientific concepts but also improves their science process skills, making it suitable for use as a learning model across various educational levels, including elementary school, junior high school, senior high school, and university students. Educators are advised to consider using the project-based learning model in learning strategies to support the development of students' science skills more comprehensively.

Project based learning (PjBL) can be used to assess Science Process Skills (KPS) used in science learning in Indonesia in accordance with the objectives, principles and indicators of what KPS should be. Assessment PjBL in science learning is integrated with active learning involving students so that students gain real experience and can build a complete understanding in the learning process IPA. By implementing project based learning that is in accordance with the objectives, principles and indicators. The right PPP will produce quality learning and be able to measure it KPS students well.

REFERENCES

Abidin, Z. (2023). Science Learning Based on Problem Based Learning Reviewed from Students' Science Process Skills. Panthera: *Jurnal Ilmiah Pendidikan Sains dan Terapan*, *3*(4), 199-205.

Amanda, N. G., Biru, L. T., & Suryani, D. I. (2023). The Effect of Project Based Learning Model on Science Process Skills in Food Around You Class VIII. PENDIPA Journal of Science Education, 7(2), 168-177.

Amsikan, A. (2022). Application of Project Based Learning Model to Improve Physics Learning Outcomes and Science Process Skills of Students. *Jurnal Penelitian Pendidikan*, *25*(1).

Anggriani, F., Wijayati, N., Susatyo, E. B., & Kharomah, K. (2019). The Effect of Project-based learning of chemical products on high school students' understanding of concepts and science process skills. *Jurnal Inovasi Pendidikan Kimia, 13*(2), 2404-2413

Astutik, F. I., Nur, M., & Prastowo, T. (2019). Physics Learning Tools Project Based Learning Model (PJBL) to Improve High School Science Process Skills. *Jurnal Pendidikan Dan Manajemen Islam*, *8*(02), 1338-1347

Aziz, S. A., & Nurachadijat, K. (2023). Project Based Learning in Improving Students' Learning Skills. *Jurnal Inovasi, Evaluasi Dan Pengembangan Pembelajaran (JIEPP)*, *3*(2), 67-74

Bariyah, I. L. N., & Sugandi, M. K. (2022, October). Project Based Learning to Improve Students' Science Process Skills on Ecosystem Concepts. In Proceedings of the National Seminar on Education (Vol. 4, pp. 135-144). *Prosiding Seminar Nasional Pendidikan* (Vol. 4, pp. 135-144).

Bell, S. (2010). Project-Based Learning for the 21st Century: Skills for the Future. The Clearing House: A Journal of Educational Strategies, Issues and Ideas, 83(2), 39–43. https://doi.org/10.1080/00098650903505415

Brooke, T.C., Kyle, C.L., & Troy, M. T. (2019). Project-Based Learning (Pjbl) in Three Southeastern Public School: Academic, Behavioral, and Social Emotional Outcomes. Interdiciplinary Journal of Problrm-Based Learning., Vol.13(Issue.2).

Chasanah, A. R. U., Khoiri, N., & Nuroso, H. (2016). The effectiveness of the project based learning model on students' science process skills and creative thinking abilities on the topic of heat in class X SMAN 1 Wonosegoro in the 2014/2015 academic year. *Jurnal Penelitian Pembelajaran Fisika*, *7*(1), 19-24.

Ernawati, T., & Sujatmika, S. (2018). Development of LKS based on project based learning to improve junior high school students' science process skills. JIPVA (Jurnal Pendidikan IPA Veteran), 2(2), 149-161.

Fitriana, F., Kurniawati, Y., & Utami, L. (2019). Analysis of Students' Science Process Skills on Reaction Rate Material Through the Bounded Inquiry Laboratory Learning Model. JTK Jurnal Tadris Kimiya, 4(2), 226-236. https://doi.org/10.15575/jtk.v4i2.5669

Fitriyani, L. O., Koderi, K., & Anggraini, W. (2018). Project based Learning: Its influence on students' science process skills in Tanggamus. Indonesian Journal of Science And Mathematics Education, 1(3), 243-253.

Hamadi, A. A. L. (2018). Pemahaman Guru Terhadap Keterampilan Proses Sains (Kps) Dan Penerapannya Dalam Pembelajaran Ipa Smp Di Salatiga. Edu Sains: Jurnal Pendidikan Sains & Matematika, 6(2), 42. https://doi.org/10.23971/eds.v6i2.935

Hamidah, N., Alamsyah, M. R. N., & Kusumaningrum, S. B. C. (2023). The Effect of Project-Based Learning Model on Science Process Skills and Learning Motivation of Students of SMA Negeri 1 Candimulyo on Environmental Change Material. *Jurnal Inovasi Pendidikan*, *1*(2), 129-142.

Hanim, N., Maison, M., & Kurniawan, D. A. (2022). The Effect of Project Based Learning (Pjbl) Learning Model Based on STEM on Science Process Skills of Physics Students. Proceedings of Amal Insani Foundation, 1, 152-157.

Hasanah, I., Sarwanto, S., & Masykuri, M. (2018). Development of temperature and heat modules based on project based learning to improve science process skills and critical thinking abilities of high school students. JP (Jurnal Pendidikan): Teori dan Praktek, 3(1), 38-44.

Hernawati, D., & Amin, M. (2016). The Student Perceptions On Learning Models Of Inquiry Integrated Project Based Learning Towards Science Process Skill Of Student And Scientific Literacy. Research Report, (2).

Hung, C.-M., Hwang, G.-J., & Huang, I. W. (2012). A project-based digital storytelling approach for improving students' learning motivation, problem-solving competence and learning achievement. Journal of Educational Technology & Society, 15(4), 15(4), 368–379.

Jatmika, S., Lestari, S., Rahmatullah, R., Pujianto, P., & Dwandaru, W. S. B. (2020). Integration of project based learning in science technology engineering and mathematics to improve science process skills in physics learning. Jurnal Pendidikan Fisika Dan Keilmuan (JPFK), 6(2), 107-119.

Jatmiko, M. A., Hatibe, A., & Darsikin, D. Effect of Science Process Skills with Project Based Learning Model on Physics Learning Outcomes of Grade XI IPA. Media Eksakta, 17(1), 24-27.

Juwita, R. (2022). Best Practice Building Science Process Skills Through the Steam Approach Project Based Learning Model for Acid Base Material for Class XI Ipa Sman 1 Bontang. *Learning: Jurnal Inovasi Penelitian Pendidikan Dan Pembelajaran*, *2*(3), 268-277

Kause, M., Sutarto, J., & Kustiono, K. (2022). Implementation of web-assisted project based learning model learning to improve critical thinking skills and science process skills. Jurnal Pendidikan MIPA, 23(4), 1598-1609.

Kinchin, I. M. (2019). Accessing expert understanding: The value of visualising knowledge structures in professional education. In K. Trimmer, T. Newman & F. Padró (Eds.). Springer International Publishing, Kinchin, I, (pp. 71–89).

Kokotsaki, D., Menzies, V., & Wiggins, A. (2006). Project-based learning: A review of the literature. *Improving Schools, 19(3)*, 267–277. https://doi.org/10.1177/1365480216659733

Kurniasih, R. D., & Ruwanto, B. (2017). The Application Of Project Based Learning Model To Increase Students Result Of Study Of Physics And Students Science Progress Competence Class X Sma N 1 Banguntapan. *Jurnal Pendidikan Fisika*, *6*(5), 358-368.

Kurniawati, E. E., Sumarti, S. S., Wijayati, N., & Nuswowati, M. (2021). The effect of project based learning oriented to chemoentrepreneurship assisted by E-LKPD on science process skills and entrepreneurial attitudes. Chemistry in Education, 10(1), 61-67.

Jurnal PAJAR (Pendidikan dan Pengajaran)
Volume 9 Nomor 3 May 2025 | ISSN Cetak : 2580 - 8435 | ISSN Online : 2614 - 1337
DOI : http://dx.doi.org/10.33578/pjr.v9i3.112

Kusumaningrum, S., & Djukri, D. (2016). Development of project based learning (PjBL) model learning tools to improve student skills. *Jurnal Inovasi Pendidikan IPA*, *2*(2), 241-251.

Lette, M., & Kuntjoro, S. (2019). Development of Student Worksheets Based on Project Based Learning to Practice Science Process Skills on Environmental Change Material for Grade X High School Students. *Berkala Ilmiah Pendidikan Biologi (BioEdu)*, *8*(2).

Lukiyati, L. (2022). The Influence of Project-Based Learning of Chemical Products on Concept Understanding and Science Process Skills of Class X Mechanical Engineering Students at SMK Negeri 2 Samarinda. Educationist: *Educationist: Journal of Educational and Cultural Studies*, *1*(2), 252-278.

Maghfiroh, N., Susilo, H., & Gofur, A. (2016). The effect of project based learning on science process skills of class X students of Sidoarjo State Senior High School (Doctoral dissertation, State University of Malang).

Maison, Darmaji, Kurniawan, D. A., Astalini, Dewi, U. P., & Kartina, L. (2019). *Analysis Of Science Process Skills In Physic Education Students. Jurnal Penelitian Dan Evaluasi Pendidikan* (Vol. 23, Issue 2, pp. 1–23).

Maryani, L., Sunyono, S., & Abdurrahman, A. (2017). The effectiveness of project based learning-based LKPD to improve students' science process skills. *Jurnal Pembelajaran Fisika*, *5*(3), 1-12.

Nasir, M., Fakhrunnisa, R., & Nastiti, L. R. (2019). The implementation of project-based learning and guided inquiry to improve science process skills and student cognitive learning outcomes. International Journal of Environmental & Science Education, 14(5), 229-238.

Nawahdani, A. M., Kurniawan, D. A., & Melisa, D. (2021). Analysis of Project Based Learning Model on Students' Science Process Skills in Physics Subjects. In *Prosiding Seminar Nasional Matematika Dan Sains* (pp. 348-354).

Noviani, N., Wahidin, W., & Nur, S. H. (2023). Project Based Learning with STEM Application to Improve Science Process Skills in the Scope of Chili Plant Cross Biology in Class XII MIPA 3 SMA Negeri 1 Banjar. *Cendikia: Jurnal Pendidikan dan Pengajaran*, *1*(1), 229-237

Ongowo, R. O., & Chisakwa Indoshi, F. (2013). Science process skills in the Kenya certificate of secondary education biology practical examinations. 4(11), 713–717. https://doi.org/10.4236/ce.2013.411101

Rahayu, W. R. R. (2016). The Science Process Skill Diverfication Of Subject Specific Pedagogy Based On Project Based Learning. Didaktika Tauhidi: *Jurnal Pendidikan Guru Sekolah Dasar*, *3*(1).

Rahman, A. (2022). Project Based Learning as an Effort to Improve Learning Outcomes and Science Process Skills of Students. NEM Publisher.

Roziqin, M. K., Lesmono, A. D., & Bachtiar, R. W. (2018). The effect of project-based learning models on students' learning interests and science process skills in Physics learning at SMAN Balung. *Jurnal Pembelajaran Fisika*, *7*(1), 108-115.

Saryono, T. (2022). The Effect of Project Work Learning Model on Science Process Skills and Cognitive Learning Outcomes. Educatoria: *Jurnal Ilmiah Ilmu Pendidikan*, *2*(2), 105-122.

Suryaningsih, S., & Nisa, F. A. (2021). Contribution of STEAM project based learning in measuring students' science process skills and creative thinking. *Jurnal Pendidikan Indonesia*, *2*(06), 1097-1111.

Syamsuddin, S., & Salmawati, S. (2023). Application of PjBL Learning Model to Improve Physics Learning Outcomes and KPS of Grade XI MIPA Students. *Jurnal Pemikiran Dan Pengembangan Pembelajaran*, *5*(2), 1412-1418.

Tindige, S. A., Rende, J. C., & Komansilan, A. (2021). Application of Project Based Learning Model to Improve Physics Learning Outcomes and Science Process Skills of Grade X Students of SMA N 2 Tondano. Charm Sains: *Charm Sains: Jurnal Pendidikan Fisika*, *2*(2), 106-113.

Umi, U. (2015). Application of scientific approach through project based learning model to improve process skills and learning outcomes of grade IV students of SD Negeri Seworan, Wonosegoro. *Scholaria: Jurnal Pendidikan Dan Kebudayaan*, *5*(1), 24-38

Usman, I. D. L., Rahmah, R. A., Handayani, P., Yuliasari, A., Lukmansyah, U., Aliyah, H. S., ... & Widiya, Y. (2022). The Process of Biology Learning in the Implementation of Independent Curriculum at SMAN7 Tangerang. Jurnal Inovasi Pendidikan dan Sains, 3(2): 56-60.

Wijanarko, A. G., Supardi, K. I., & Marwoto, P. (2017). The effectiveness of guided project-based learning models to improve science process skills and science learning outcomes. Journal of Primary Education, 6(2), 120-125.

Yuniasih, E., Hadiyanti, A. H. D., & Zaini, E. (2022). Implementation of Project Based Learning Model to Improve Science Process Skills and Learning Outcomes of Elementary School Students. *Edukatif: Jurnal Ilmu Pendidikan*, *4*(5), 6670-6677