JPPIPA 9(1) (2023)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Literature Study: Utilization of the PjBL Model in Science Education to Improve Creativity and Critical Thinking Skills

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Received: November 30, 2022
Revised: January 11, 2023
Accepted: January 25, 2023
Published: January 31, 2023

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DOI: 10.29303/jppipa.v9i1.2555

Abstract: The objective of this writing audit is to look at different pieces of writing about how project-based learning can help students think more creatively and critically. The survey on writing found that project-based learning can help students think more critically and creatively. For research, a narrative review design is used in a literature review. Over the course of five years, 19 scientific articles from national and international journals were used in this study. Reliable sources, the quality of the research process, the quality of delivering information, and the completeness of the information are some of the validation criteria for scientific articles. Simplifying, displaying, drawing conclusions, and verifying data are all part of the qualitative analysis model of Miles and Huberman's method for presenting tabular data. The writing survey uncovers that project-based learning strategies can upgrade understudies' basic and imaginative reasoning abilities in science acquiring. The syntax of the project-based learning method be able to assist students in optimizing their creative and critical mindsets by starting learning with essential questions, working together to plan, developing project completion schedules, timelines, and deadlines.

Keywords: Literature studies; Project-Based Learning; Thinking critically and creatively.

Introduction

Teaching plays a fundamental role in improving the quality of society. For example, the Public School System Law (Sisdiknas) demonstrates the main task of coaching in structuring HR values that meet the standards of trust, devotion, a dignified, developed, and sharply developed, imaginative, talented, controlled, proficient, reliable, useful and intellectually solid person. Where effective efforts to shape human character in this way can be done by improving the quality of education (Tatang, 2007).

Countries in the 2018 PISA review. Indonesian students' reading ability is ranked 74th with a score of 371, mathematics proficiency is ranked 73rd with a score of 379, and science proficiency is ranked 71st with a score of 396. PISA is a study that tests students' creative and critical thinking skills. The Scientific Proficiency Index (IPA) and the average results of OECD countries are summarized in PISA. (OECD, 2018).

The low PISA score is due to the conflicting nature of public training, which results in low imaginative reasoning ability (Suharyat et al., 2022). Students must be able to think creatively to develop themselves, discover new ideas, and develop their skills and knowledge. Several attempts were made to overcome this problem, among them making the educational process simpler by teaching students to think creatively (Fradila et al., 2021). This ability to think is the process of deciphering ideas from students, which leads to new ideas or information that can answer questions. (Mursidik et al., 2015 in Lestari & Ilhami, 2022).

Students should also have skills in critical thinking as these skills help them make decisions and understand scientific concepts and procedures (Razak, 2021).

How to Cite:
Zulyusri, Z., Elfira, I., Lufri, L., & Santosa, T.A. (2023). Literature Study: Utilization of the PjBL Model in Science Education to Improve Creativity and Critical Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, *9*(1), 133–143. https://doi.org/10.29303/jppipa.v9i1.2555

Students cannot inquire about pre-existing scientific claims if they lack critical thinking skills (Oktarina et al., 2021). If students only collect information without questioning it, their knowledge does not grow (Hasanuddin, 2018). Students can benefit from developing critical thinking skills by acquiring knowledge and then using that knowledge to solve problems (Yustina, 2020).

In Fajrina et al., (2018), Anwar et al. (2012) quote from Gough that educated individuals need to be able to think clearly in order to be able to face a rapidly changing world. Learners need to be taught innovative thinking. According to Sousa (2012) in Umamah & Andi, (2019), the capacity to discover something new is creativity, useful, sustainable, or satisfying for others. While critical thinking is also important for students to develop. This ability must be taught in schools because it is one of the main objectives of science education (Ennis, 2011 in Sumardiana et al., 2019). In addition to involving processes, critical thinking skills also require the use of thinking skills such as estimating, analyzing, synthesizing, evaluating, and reasoning (Tiruneh et al., 2018).

"Natural science", also known as "science", is the most general definition of science, referring to nature, relating to nature. While science refers to science. Olivia (2008) in Nurjanah et al., (2021), asserts that the term "science" or "science" refers to a very wide range of knowledge, including knowledge of life, living beings, the universe, and the relationship between people in nature and about themselves. The study of natural phenomena or natural sciences is the literal definition of science. Science education focuses on providing students with hands-on experience to help them understand the natural world better. Students are expected to be able to think creatively, critically, innovatively, and logically when studying science (Fajrina et al., 2018).

Science is more than just knowing a set of facts, ideas, or principles, but it's also a process of discovering new things. Learning how to systematically learn about nature is related to the knowledge of science. Therefore, students are given the opportunity to discover the truth about the facts or concepts they learn through experiments as part of the science learning process. This gives students the ability to observe, analyze, prove, and draw conclusions from an object and write down situations or procedures (Sari, 2017 in Sari & Angreni, 2018).

In the 21st century, learning is awakening the ability to ask, create, understand creativity, solve problems, learn standards, and develop intellectual, moral, and other skills (Syamina et al., 2021). In today's increasingly complex society, academic and multi-skill skills are needed, including digital literacy, creative thinking, efficient communication and productivity (Turiman in Rizki et al., 2020), and critical thinking skills including the abilities needed (Yulianty, 2019).

Different techniques and approaches are used to reorient training so that students can adjust to life in the 21st century. PjBL teaching methods that are oriented towards students are expected to encourage them to come up with original concepts, solve problems related to social life, and hone their critical thinking skills. (MG Nair in Rizki et al., 2020). PjBL is also expected to be able to answer the challenges of the 21st century

The learning model, known as project-based learning, utilizes projects and activities as a medium. Students are given the task of investigating, assessing, describing, and synthesizing reports to present various learning outcomes by teachers (Hosnan, 2014). This model provides many opportunities for students to choose topics, conduct investigations, and complete projects on their own when put into practice, acquiring knowledge through projects as a learning tool, as if there is a real world that can produce products realistically, where students work in real time (Sari & Angreni, 2018). This learning emphasizes an active approach to encourage maximum student involvement in the learning process (de la Torre-Neches et al., 2020) that can stimulate the development of thinking ability by placing emphasis not only on memorization but also on problem solving (Hamdani et al., 2012).

Project-Based Learning (PjBL) has a number of advantages for learning, including (1) Increased motivation of students to learn in order to improve their skills to complete important tasks; (2) increase student activity in order to improve their ability to solve complex problems; (3) apply ergonomic, hygienic, precise, fast, ecosystem, and metacognitive principles in handling media and materials for art and technology creations; and (4) produce works that are ready to use and can be used in life (Purwanti et al., 2022).

Abidin et al., (2020) found that the project-based teaching and learning process involves in-depth research with respect to the real world. Students are challenged to engage with real problems and significant problems that arise in everyday life, specifically in the teaching and learning process. The project is well designed, so the results obtained based on observations of actual issues in the environment will give deep meaning to students. A project is a complex task that requires students to design, solve a problem, make a decision, or do research. They usually come from challenging problems or questions. Allows students to work alone for long periods of time; and produce realistic presentations or products (Jones, Rasmussen, & Moffitt, 1997; Michaelson, Thomas, and Mergendoller, 1999 in Thomas et al., 2015).

The educational method known as project-based learning offers flexibility for students to design learning activities, collaborate on projects, and the result is demonstrable creations (Nurohman, 2015). According to (Amini, 2015), project-based learning allows students to expand knowledge and skills, make learning more meaningful, and make learning activities more engaging. The PjBL model also awakens students' critical thinking skills (Sumardiana et al., 2019; Noble & Mustadi, 2019; (Yustina et al., 2020) and influence students' creative thinking, so it needs to be used in other learning processes (Fajrina et al., 2018). Learning that aims to make the learning process a source of experience must include critical thinking skills in order to compete in the future (Rachmawati & Rohaeti, 2017).

Researchers conducted this literature study research to examine various scientific articles to see more clearly the impact of project-based learning methods on students' critical and creative thinking skills. From some of the scientific literature that researchers have searched, in science education, many project-based learning methods (PjBL) have been used.

Based on the previous presentation, the researcher formulated a problem, namely: Is there a project-based teaching method that can maximize students' science learning skills in terms of creativity and critical thinking?.

The goal of the literature review is to test how the PjBL method affects students' creative and critical thinking capacity.

Method

This study includes a form of literature study. In literature reviews, researchers only use library sources to obtain information. The first step in developing a research strategy is to conduct a literature search, including using library sources to collect data (Zed, 2014 in Melfianora, 2019).

The literature study uses a narrative review research design. A type of research known as narrative review will combine existing theories, and research methods. (Chris, 2018) says that a literature study is a review of various literature on the subject to be observed and combining them into a coherent whole produces interpretations that raise important issues, tendencies, complexities, and debates. In this study, descriptive qualitative analysis was used as a data analysis technique to describe, analyze, and discuss data and draw conclusions.

Article searches are carried out by entering the keywords creative thinking, critical thinking, project-based learning, and science into the Google Scholar, Researchgate, and SINTA pages. Research results based on the publication of international journals, accredited national journals and national seminars between 2018 and 2022 are used to select articles for secondary data collection.

Open Access Journal (OJS), the quality of research methodologies used in articles, the presentation and discussion of data, and the suitability of data for analysis, whether current and relevant references or not are part of the validation process carried out. The table is used to display the validation and evaluation of the scientific article in question. The number, code, identity of the author, year published, theme of the article, journal identity and research results of the article are listed in the validation results table. The examination of information using Miles and Huberman's subjective investigation model includes grouping information, presenting information, and making conclusions.

Result and Discussion

The conclusions of the literature study obtained 19 scientific articles that have been validated and will be used as data according to the criteria of need. The results of data analysis and verification are shown by Table 1.

Table 1. Article Recapitulation

Type Article	Search Result	Verification Result
International Journals	2	2
Accredited National Journal	20	16
Unaccredited National Journal	3	0
National Seminar	1	1

The results of the review of articles on project-based teaching and creative and critical mindset skills are presented in Table 2 which is a table of results.

Table 2. Article Review Result

Code	Author's Identity	Year Published	Article Themes	Journal Identity	Research Results
A1	Purwanti, Widha Sunarno, Sukarmin, Novita Ratnasari	2022	Literature Study of Project Based Learning Learning on Creative Thinking	https://www.researchgate.net/publication/360783950_	Based on a literature review, the PjBL model can help students who study science in junior high school develop their creative thinking skills.

Code	Author's Identity	Year Published	Article Themes	Journal Identity	Research Results
			Skills in Junior High School Science		
A2	Fajrina, Rani Nur Arifah Agus, Supriyono Koes Handayanto, Arif Hidayat.	2018	The Role of Project Based Learning Models in Creative Thinking Ability class XI science through Static Fluid Materials	http://journal.um.ac.id/index.php/	The ability to think creatively is influenced by the PjBL method by 63%, the average test class score (82.18) is greater than the average control class score (67.50). It is recommended to apply the PjBL model to other physics materials because the PjBL model shows its influence on creativity.
A3	Lestari, Ina & Aldeva Ilhami	2022	Application of Project Based Learning Model to Improve Creative Thinking Skills of Junior High School Students: Systematic Review	Jurnal Pendidikan IPA Volume 12, Number 2, pages 135-144, 2022	The consequences of the review show that the PjBL method can optimize critical thinking, communication, collaboration, creativity, and innovation (4C) in science learning that focuses on the subfields of biology and chemistry, improving concept understanding, self-efficacy, scientific communication, and learning outcomes.
A4	Umamah Chairatul & Herman Jufri Andi	2019	The influence of the Project Based Learning model on creative thinking skills in applied physics learning.	Jurnal Pendidikan Fisika dan Keilmuan (JPFK). Vol. 5, No. 1, Maret 2019	The findings suggest that the creative mindset capacity of the test class is markedly higher than that of the control class.
A5	Ariyani, Era, Tri Jalmo, Berti Yolida	2019	The Effect of the PjBL Model on Students' Science Communication and Creative Thinking Skills.	Jurnal Bioterdidik, Vol. 7 No 3, Mei 2019	The creative mindset skills of the test class are significantly higher than the control class. The PjBL method has an influence on student learning outcomes, namely the ability to communicate scientifically and think creatively.
A6	Kusadi Ni Made Risa, I Putu Sriartha, I Wayan Kertih	2020	Project Based Learning Learning Model Towards Social Skills And Creative Thinking.	TSCJ, Vol 3 No 1, Year 2020	Research findings show that project-based learning methods simultaneously affect students' social skills and creative mindset skills.
A7	Amri & Hariani Muhajir.	2022	Students' Creative Thinking Skills Through Online Project Based Learning (PjBL) Model	Didaktika Biologi: Jurnal Penelitian Pendidikan Biologi (2022), 6 (1), 21-29	The creative mindset skills of learners according to the findings of the average study were in the category of less creative before using PjBL online. a percentage of 40.42 percent and belongs to the category of highly creative on average with a percentage of 90.28 percent. Creative thinking skills of class XI mipa students. significantly increased (sig.0.000 0.05) through utilization of the online PjBL learning model.
A8	Sugandi Muhamad Kurnia & Abdur Rasyid.	2019	Developing of Adobe Flash Multimedia Learning Biology Through Project Based Learning to Increase Student Creativity in Ecosystem Concepts	Biodik: Jurnal Ilmiah Pendidikan Biologi. Vol.5 No.3	Students' responses to the use of multimedia in the teaching and learning process show positive value, and the use of multimedia learning increases student creativity.

Code	Author's Identity	Year Published	Article Themes	Journal Identity	Research Results
A9	Asep Saefullah , Andri Suherman, Riska Tri Utami, Ganesha Antarnusa, Diana Ayu Rostikawati, Robby Zidny	2021	Implementation of PjBL-STEM to Improve Students' Creative	JIPF (Jurnal Ilmu Pendidikan Fisika). Vol. 6 No. 2, May 2021, Page 149-157	According to statistical analysis, the experimental and control classes showed significant differences. Based on the findings, PJBL-STEM treatment can help students become more creative in their thinking.
A10	Mamahit Jimmy Andrew, Duran Corebima Aloysius, Hadi Suwono	2020	Effectiveness of STEM Integrated Project-Based Learning Model (PjBL-STEM) on Creative Thinking Skills of Class X Students.	Jurnal Pendidikan : Teori Penelitian, dan Pengembangan Volume : 5 Number :9. September. Year 2020	Based on the analysis of research data, it is known that the creative thinking skills of the experimental class are better with the use of the PjBL-STEM model than the control class.
A11	Woro Sumarni, Nanik Wijayat & Sri Supanti	2019	Students' Cognitive Abilities and Creative Thinking Through STEM-Adjacent Project-Based Learning	Jurnal Pembelajaran Kimia. OJS Vol. 4, No. 1, Juni 2019, hal. 18-30. Universitas Negeri Malang	The mindset of students' creativity meets good benchmarks, with the highest achievement in the ability to view reports from various sides.
A13	Trimawati Karina, Tjandrakirana, Raharjo.	2020	Development of Integrated Science Assessment Instruments in Project Based Learning (PjBL) Model Learning to Improve Critical and Creative Thinking Skills of Junior High School Students	QUANTUM: Jurnal Inovasi Pendidikan Sains, Vol. 11, No. 1, 2020, 36-52	The ability of critical and creative mindsets can be improved by the use of project-based learning methods and the creation of integrated science learning tools and assessment instruments.
A13	Trimawati Karina, Tjandrakirana, Raharjo.	2020	Development of Integrated Science Assessment Instruments in Project Based Learning (PjBL) Model Learning to Improve Critical and Creative Thinking Skills of Junior High School Students	QUANTUM: Jurnal Inovasi Pendidikan Sains, Vol. 11, No. 1, 2020, 36-52	The ability of critical and creative mindsets can be improved by the use of project-based learning methods and the creation of integrated science learning tools and assessment instruments.
A14	Insani Nurul, Noor Fadiawati, Ratu Betta Rudibyani, M. Mahfudz Fauzi Syamsuri.	2018	Using Project-Based Learning in Improving Students' Critical Thinking Skills to Separate of Mixtures	IJCER. International Journal of Chemistry Education Research – Vol. 2 lss. 2 2018.	In LKS Project Based Learning (PjBL) a Non-Equivalent Control Group Design (Start-Final test) is used to improve students' critical thinking mindset (CTS) skills regarding mixed separation. The test class has a higher n-gain value than the non-test class, which is statistically significant.
A15	Sumardiana, Arif Hidayat, Parno.	2019	Critical Thinking Ability in Project Based Learning Model accompanied by STEM High School Students at	Jurnal Pendidikan : Teori Penelitian, dan Pengembangan Volume : 4 Number : 7. Juli,	The findings compare the critical thinking mindset skills of students before and after being given the implementation of the PjBL method in the subject matter of heat and temperature. Students' critical

Code	Author's Identity	Year Published	Article Themes	Journal Identity	Research Results
			Temperature and Heat	Year 2019. Pages : 874-879	thinking skills show improvement on all indicators.
A16	Istiqomah Nur, Noor Hujjatusnaini, Nurul Septiana, Astuti Muh. Amin.	2022	Implementation of Integrated Project Based Learning Learning Model Practicum Study of Antagonism Escherichia coli and Candida albicans Against Students' Critical Thinking Skills	Jurnal Pendidikan Sains Indonesia. (Indonesian Journal of Science Education).	Students' critical thinking skills are influenced by the application of an integrated practicum model of project-based learning. The main focus of this research is on a learning model that combines practicum activities with a learning model for improving critical thinking.
A17	Zahroh Fathimatuz.	2020	The Effect of Project Based Learning Learning Models on Students' Critical Thinking Ability on Electrochemical Materials	Jurnal Phenomenon. Phenomenon, 2020, Vol. 10 (No. 2), Pp. 191-203.	PjBL has a significant influence on students' critical thinking skills in electrochemistry discussions, as evidenced by the product moment correlation value of 0.67 and the significance test result of 7.10. The fact that PjBL has a coefficient of determination of 44.89% indicates that PjBL affects students' critical thinking capacity. The results of the study support the idea that PjBL makes it easier for students to think critically about electrochemistry subjects.
A18	Frestika Mulia & Ali Mustadi.	2019	Improving the Ability of Critical Thinking Skills of PGSD Students in Science Education Courses Using a Project-Based Learning Model	Lentera Pendidikan, Vol. 22 No. 1 Juni 2019: 52-63.	The average value of students' critical thinking ability from each cycle shows an orderly improvement due to the application of project-based learning methods. Until it is concluded that students' critical thinking skills have improved with the use of project-based learning methods.
A19	Muhibbuddin, Yustina, N., & Safrida.	2020	Implementation Of Project-Based Learning (Pjbl) Model In Growth And Development Learning To Increase The Students' Science Literacy And Critical Thinking Skills	International E-Journal of Advances in Education, 6(16):66-72.	The application of the PjBL model is effective in improving students' critical-minded science literacy skills.

This study is a literature review that examines how students' creative and critical thinking skills can be improved by using project-based learning methods for science learning. Two international journal articles, sixteen accredited national journal articles, and one article from a national education seminar were used as study materials.

Articles coded A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, and A13 feature articles that discuss the use of project-based learning methods (PjBL), which have the effect of maximizing creative thinking skills. In contrast, the codes A12, A13, A14, A15, A16, A17, A18, and A19 refer to project-based teaching and learning processes that maximize critical thinking skills.

The use of the PjBL learning model can also be integrated with the STEM curriculum, as seen in articles with codes A10 and A15. Students' critical thinking capacity increases when PjBL and STEM are combined. The A5-coded article shows that the PjBL model also has an impact on science communication skills.

Creative thinking skills are part of creativity, namely the creation of ideas and products to solve a

problem (Ülger, 2016; in Purwanti et al., 2022). To create new ideas, one must go through a series of processes, such as understanding how to find a problem and making hypotheses and conjectures about it, answering, providing evidence, and then reporting the results (Suriyah Puput, et al., 2021). Students need to be able to think creatively, as these abilities can help them do their best in the cognitive, affective, and metacognitive domains. Students of creative thinkers will be able to develop new and original concepts of knowledge.

(Hendriana, Heris, 2017) states that a number of indicators can be used to directly measure creative thinking, including: 1). Fluency, or the student's ability to voice his or her opinion while studying 2). Flexibility, then. the ability to think outside the box, 3). Originality, in particular the capacity to generate original new concepts and details, 4). Details, in particular the fact that students are familiar with the specifics, make it difficult for them to be satisfied with the existing knowledge.

By fully incorporating students in the evolving experience, PjBL syntax that refers to steps in a highly structured syntax will foster critical and creative thinking skills. According to (Nurohman, 2015), the syntax of PjBL begins with essential questions, collaborative planning, project completion schedules, schedules, and deadlines, as well as new ways of guiding students and asking them to provide explanations regarding method selection. In line with the opinion expressed by Weisberg (2006) in (Nurjanah et al., 2021) defines creative thinking, referring to the process of creating creative products resulting from activities directed by the goal.

Project-based learning methods (PjBL) have the potential to improve students' creative mindset skills, according to the findings of literature reviews obtained by researchers (Purwanti et al., 2022; Fajrina et al., 2018; (Lestari & Ilhami, 2022); Umamah & Andi, 2019; Ariyani et al., 2019; Nurjanah et al., 2021; (Muhajir, 2022); Sugandi & Rasyid, 2019; Saefullah et al., 2021; Mamahit et al., 2020; Sumarni et al., 2019; Andini & Rusmini, 2022; Trimawati et al., 2020). PjBL as a student-oriented learning method can encourage the development of thinking skills by focusing not only on memorization but also on problem solving (M Hamdani, et al., 2012).

While the treatment of the PjBL learning method also further develops the assertive reasoning skills of students who are accounted for from the results of exploration, this is what we know as critical thinking (Andini & Rusmini, 2022; Trimawati et al., 2020; Insani et al., 2018; Sumardiana et al., 2019; Istiqomah et al., 2022; Fathimatuz, 2020; Yustina, 2020).

The following indicators are used in assessing the skills of the creative mindset of students, according to the findings of the researcher's literature review: fluency, adaptability when thinking about a problem, originality when coming up with other ideas, and detail (or elaboration) when presenting ideas (Fajrina et al., 2018; Umamah & Andi, 2019; Saefullah et al., 2021; Mamahit et al., 2020).

Fajrina et al., (2018) / A2 code using the PjBL model tests creative thinking skills on static fluid discussions. To see how the PjBL model affects this, five questions were asked to test creative thinking skills. Two of those questions are about fluency (thinking fluently), one about flexibility, and one about the ability of originality and sincere thinking, as well as one question about capacity. In particular, the experimental class has a higher proportion of creative thinkers than the control class, according to the test results for the four creative thinking items. The way students respond to questions demonstrates their ability to think creatively. The PjBL model is recommended to be applied to other physics materials because this study found that the PjBL model has an influence on creativity.

In line with Fajrina et al., (2018)/ Code A2, Amri and Muhajir, (2022) / Code A7 conducted research to see students' creative thinking skills through the PjBL model online, the assessment of creative thinking skills was carried out by providing five question items (discussion material; cells) which were combined with doing a project to create cell props from stereoforms. After that, they create and display videos explaining about the cell, the chemical elements that make up the cell, its structure and function, as well as the bioprocesses that occur inside the cell. Amri and Hariani Muhajir use scales from very creative to moderate, less creative, and not creative to assess students' creative thinking skills. The findings suggest that students are more creative as a result of using the PjBL model.

Ariyani et al., (2019)/ Code A5 tests students' creative thinking skills through writing containing ideas for learning materials (written solutions to environmental pollution problems). Evaluation of creative thinking ability is based on; writing techniques, language, and content. Writing is a creative process that involves many different ways of thinking (expansion) rather than convergence (focus), so it can be used as an indicator of judgment (Dalman, 2014 in Ariyani et al., 2019).

Sumarni et al., (2019)/ Code A11 uses open-ended questions with multiple answers to solve questions validated by material experts and has a reliability of 0.72 to assess students' creative thinking skills in their research. It gives students meaningful learning memories in problem solving and solution development. After that, to support the test results, an interview is conducted. At the end of the session, students were given project assignments to solve

problems related to plastic waste written in LKPD. Students are taught to be more active in finding solutions to each problem, be more creative in coming up with better ideas, and come up with more effective solutions to all problems during the learning process.

Sumarni Woro et al., integrate PjBL and STEM learning models, in which students are encouraged to learn in a meaningful way to understand concepts and conduct research as part of project activities to ensure that they are actively involved in the process. According to Capraro & Slough (2013) in Sumarni et al., 2019), thus encouraging learners to have a critical, creative, and analytical mindset as well as increasing their higher reasoning skills. Higher thinking paths that generate new ideas or thoughts about a problem are critical thinking skills (Sharifah et al., 2018). Learning new information and applying that knowledge to problem solving becomes easier by understanding how critical thinking works, an alternative that is thought to improve critical thinking is project-based learning (Effendi, 2018).

Istiqomah et al., (2022)/ Code A16, conducted an objective test to assess students' critical thinking. The objective test consists of twenty multiple-choice questions from a critical perspective. The defining area of concentrated reasoning consists of 5 places, in particular, providing direct explanations, honing fundamental abilities, making conclusions, giving in-depth explanations, and developing strategies and tactics. The findings of Istiqomah Nur et al., confirm that project learning synergized with practicum tasks affects students' critical thinking

(Yustina, 2020) / Code A19, conducts critical thinking assessments in her research with subjective essay tests with six indicators: concentration, reasoning, inference, situations, clarity, and an overview used to assess critical thinking skills. In her research, Yustina compared critical thinking skills and literacy, and she found that literacy affects critical thinking. Data analysis revealed a positive and significant relationship between the two. The application of the PjBL learning model has the potential to improve students' science literacy and critical thinking because there is a positive correlation between the two. Students with good reading skills also have better reasoning skills. The PjBL learning model can be used to measure, train, and develop critical thinking skills in each student. Sumardiana et al., (2019)/ Code A15, analyzed quantitative data (pretest and posttest results) according to STEM-based project-based learning methods to investigate the critical thinking skills of high school students. Student responses are analyzed using five indicators of the critical thinking rubric in terms of: reasoning, hypothesis testing, evaluation of argumentation, assessment of probability and uncertainty, problem solving, and decision making. The majority of students are able to answer questions up to the indicator stage, solve problems, and draw conclusions. The results of Sumardiana's analysis of student reports related to projects are the high involvement of students in finding their own sources during the learning process, as well as the ability to think more clearly and add new information, being one of the achievements of project-based learning methods, this finding confirms that students' critical thinking skills on the subject matter of heat and temperature increase in each indicator.

The positive relationship between the application of the learning process using project-based methods and critical thinking skills is shown by the findings that researchers use as references. These findings reveal that project-based learning optimizes critical and creative thinking skills. This is possible because the PjBL syntax spurs students to actively participate during the learning process, allowing them to gather as much information as possible about the material and foster creativity and critical thinking. This is in line with the opinion of George Lucas Educational Foundation (2007) in (Setyowati & Mawardi, 2018) which states that project-based learning is important to use in education because it has many benefits, especially to prepare students with 21st century skills (teamwork, problem solving, conducting research, managing time, creating information, and utilizing technological tools), in addition to basic skills (reading, writing, and mathematics). 21st century skills are meant in more detail, including: 1) Accountability on a personal and collective level; 2) planning, critical thinking, and creativity; 3) outstanding interpersonal communication and presentation skills 4) Navigation and understanding of different societies; and (5) select and utilize specific tools to complete the task.

Conclusion

Based on reviews of the researcher's literature, students who use project-based learning methods have higher levels of creative and critical thinking skills. This is possible because the PjBL syntax stimulates students to actively participate in learning to maximize understanding and critical and creative thinking capacity. Project-based learning exercises can be planned based on existing realities and the imagination of students and educators, without neglecting the syntactic structure of PjBL. For teaching and learning experiences in science, this project-based learning model is highly recommended to use.

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