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Meta-analysis of Project Based Learning Models on 21st-Century Student Skills

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ABSTRACT

This research aims to analyze the impact of the project-based learning model on student's 21st-Century skills about environmental pollution. This article was written using a meta-analytic research design. This was done using effect size testing by analyzing 7 relevant research publications. Research data can be obtained through online database based on google scholar and semantic scholar. The result of the study of critical thinking skills in the influence test were 3.85 and 4.52 showing that the influence criterion is very high. The result of communication skills research in the influence test were 3.44 and 0.83 showing that the influence criteria were very high and large. The result of research on creative skills in the effect size test are 3.55; 2.94; 1.42 and 5.4 represent very high and large influence criteria. The research result on collaboration skills in the influence test is 0.89 demonstrating large influence criteria. Based on impact test, implementing a project based learning model on student's 21st-century skills about environmental pollution has a great impact. Through materials on environmental pollution has a great impact. Through materials on environmental pollution using a project based learning model, student's critical thinking, communication, collaboration and creativity skills can be improved

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1. INTRODUCTION

During science learning many different skills are acquired through the scientific process. Scientific learning studies the phenomena of everyday life. This can strengthen students' scientific knowledge, concepts and attitudes. Principles of scientific learning can develop knowledge and skills of the scientific process by conducting direct learning activities. Research on science learning can be conducted by collecting learning materials. Learning the science of materials related to environmental pollution requires project based learning because it is abstract. Experiential learning methods can make learning science more interesting for students. Indeed, students can accumulate experience based on the observations they have made (Lestari & Ilhami, 2022).

Environmental pollution is an easily seen problem in daily life. Environmental pollution occurs due to irresponsible human activities that can pollute the environment. Cause of environmental pollution such as household waste, industrial waste, and agriculture waste. An example of environmental pollution is global warming. Global warming is cause by a number factors due to human activities such as use air conditioning, motor vehicles, and presence of smokestacks that produce carbon emissions. The growth of the internet likely to increase energy consumption and carbon emissions. This requires energy consumption and carbon emission reduction policies in the role of the internet (Lin & Zou, 2021; Wang & Xu, 2021).

Digital activity has an impact on increased electricity consumption. Some still use steam power plants named PLTU. The main source used by PLTU is fossil fuels. Excessive fossil burning will lead to increased carbon dioxide (CO_2) emissions into the air. Digital technology emits 4 % of global greenhouse gases and energy consumption increase by 9% each year. Digital usage, especially online video, generates 60 % of global data flows and generates more than 306 million tons of carbon dioxide each year. This number account for 20 % of total greenhouses gas emissions. Video usage such as streaming, video conferencing (Skype, Zoom, Camgirls, telemedicine, etc.) accounts for 20 % of the data stream and non-video usage such as websites, images, e-mails, and other enterprises networks.

Account for 20 % of data flows. This use includes all activities opened up by digital technology (Hess & Geist, 2019). Online learning multimedia videos can be relevant to students' learning activities. The existence of online video learning materials can help improve students' critical thinking (Hendriyani, et al., 2022; Johan et al., 2020). Educational video clips can improve students' 21st-century skills, specifically teamwork creativity, communication, critical thinking digital competencies, leadership and planning (Omiles, et al., 2019; Johan et al., 2022). Both of these claims are problematic because there are many studies showing that online videos contribute to carbon emissions. Carbon emissions can damage the ozone layer in the atmosphere and cause global warming. Global warming is an example of the effects of environmental pollution.

Environmental pollution can be avoided through project based learning. Project based learning is presented as waste management in educational issues. Then there is the problem of rivers overflowing with sewage and garbage because of flooding. Applying a project based learning models is valuable to inspire students and teacher to consider more environmental education resource in the future. The goal of this learning is to raise awareness about environmental pollution but also to provide students with the skills and knowledge needed to create positive change in the world, especially related to the environment (Rachman & Toru, 2023). This article aims to analyze the project based learning model on students' 21st-century skills of environmental pollution material. The results of 7 literature studies are analyzed by the author in the article. This study compares the results of applying the project

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based learning model with students' 21st-century skills of environmental pollution material. The question that will be analyzed and discussed in this article is "How does analyzing the project based learning model affect students' 21st-century skills on the environmental pollution material?"

2. METHODOLOGY

This type of research uses meta-analysis guided by PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) as the assessment and research decision. The object of this research uses primary data, specifically scientific theses and articles. This research sample uses scientific theses and articles with predetermined criteria. Determine the criteria for the research sample using keywords such as project based learning model, document, middle school environmental pollution, critical thinking, communication, collaboration, and creative. Research data were obtained from database searches on Google Scholar and Semantic Scholar. This is the PRISMA diagram for this study in the figure 1.

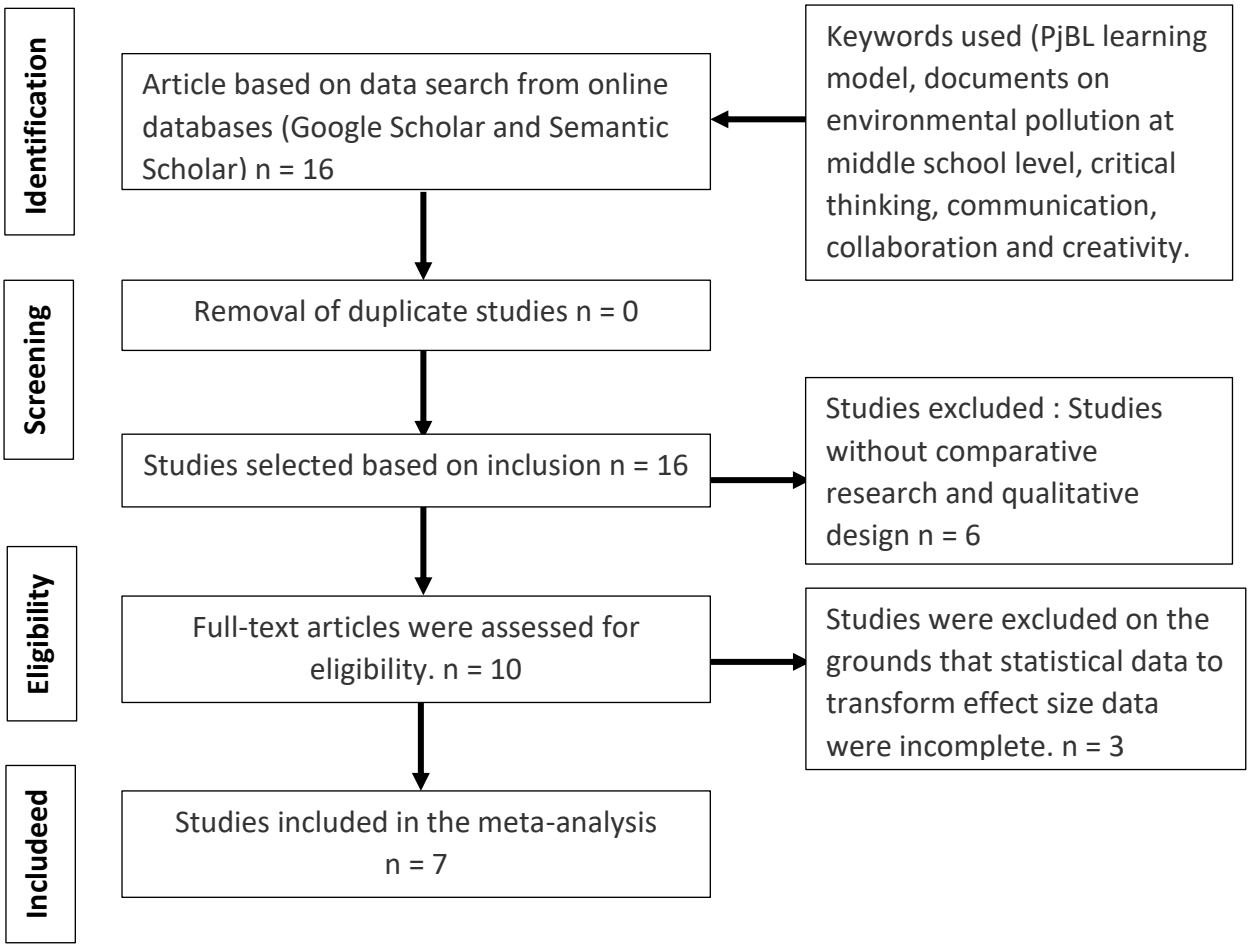

Figure 1. PRISMA Diagram for Study Meta-Analysis

Data processing steps include 1) identifying research objects, 2) determining the mean value and standard deviation of experimental data and control data for each research object, and 3) calculating a degree of influence when using the Glass formula. The measurement of the effect size using the Glass formula was performed as follows (Glass et al., 1981).

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$$Effect\ size = \frac{Mean\ eksperimen\ grup - Mean\ kontrol\ grup}{Standard\ deviasi\ kontrol\ grup}$$

With effect size criteria in the table 1 (Becker, 1999) below:

Table 1. Cohen's D Effect Size Value Criteria

Size	Criteria
D ≥ 2,1	Very High
0,8 ≤ d ≤ 2,0	Large
0,5 ≤d ≤0,79	Medium
0,2 ≤d ≤0,49	Small
0,0 ≤d ≤0,19	Very Small

3. RESULT AND DISCUSSION

Independent curriculum is an expression of educational program development that includes in-class and out-of-class learning system. In an independent education system, teachers have the space to design learning tools that suit their students' characteristics and interest. The independent program includes student activities including curricular and extracurricular activities and projects aimed at strengthening Pancasilas' student profile. The independent study program provides ideas for independent study polices. The independent learning policy should consider education as a transformation that can produce superior human resources, reflect the student profile of Pancasila and be competitive in the professional world.

The Pancasilas' student profile enhancement project is carried out to rain students to explore skills and knowledge about problems occurring in the environmental. Teachers as guides and facilitators encourage students to collaborate with each other may be redundant problems to generate ideas for solutions. Teachers can design learning by implementing a project based learning model. Pancasilas' student profile enhancement project is a learning activity in the form of study, research, discussion, physical and mental strengthening methods or project based learning to acquire characteristics of Pancasilas' student profile (Prabawati, 2022).

The project bases learning model is learning model that integrates projects into the learning process of students by having them explore synthesis and information in groups, evaluate their interpretation, and then present it to the class. In the project based learning model, students must follow the following steps: 1) determine the project activities, 2) design the project activities, 3) organize the project activities to be implemented, 4) complete the project under the teacher's guidance, 5) presentations on the result of the project, 6) evaluate the implemented project activities (Pratiwi & Setyaningsih, 2020). The project based learning model can allow students to participate and discover new experiences, allowing them to critically reflect on their opinions (Dywan & Airlanda, 2020). The learning process understanding by practicing the learning material directly. Students can analyze problems tailored to the material being studied. Students can also respond to problems critically, communicatively, collaboratively and creatively. Teacher can help students find solutions to problems by creating a project in the learning process. The effect of using the project based learning model was statistically tested using a meta-analysis design. The meta-analysis test

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was conducted by comparing 7 relevant research publications. The following are the research topics on students' skills included in 7 research publications in the Table 2.

Table 2. Distribution of Research Topics Based on 7 Reviews of Relevant Literature on the Project Based Learning Model on Environmental Pollution Material

Author	Reference Type	Research Topics Skill			
		Critical Thinking	Creatif	Communication	Collaboration
Andri Tri Nugroho, Tri jalmo & Arwin Surbakti. (2019)	scientific articles		√	√	
Era Ariyani, Tri Jalmo & Berti Yolida. (2019)	scientific articles		√	√	
Sepnindya Ayu Permata Sari. (2019)	scientific articles		√		
Agnes Rofika Dewi. (2020)	thesis		√		
Lum'atul Khoirot Rizki. (2021)	thesis	√			
Salsabila Faradisa Nuris. (2022)	thesis	√			
Irma Erviani, Muhiddin Palennari & Rahmaningsih.(2023)	scientific articles				√

Based on Table 2 above, a test of effect size of was performed. This was done to analyze the influence of the project based learning model on 21st-century students' skills regarding environmental pollution. The influence of the project based learning model on students' 21st-century skills can be shown in tables 3, 4, 5 and 6.

Table 3. The Extent on the Influence of Project Based Learning Model On Students' Critical Thinking Skills

Research Topic	*Effect Size*	Criteria
Critical Thinking	4,85	Very High
	4,52	Very High

In Table 3 above, the project based learning model has a very high impact on improving students' critical thinking skills regarding environmentally polluted material. This is reflected in the test effect sizes of 4.85 and 4.52. The test result show very high effectiveness criteria.

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Applying the project based learning model can improve students' critical thinking skills (Jeniver et al., 2023). This learning model provides students with challenges and meaningful connections to processing problems, fostering the ability to think critically and develop solutions to processing problems (Oyewo et al., 2023). Critical thinking allows students to analyze information, evaluate evidence, and make decisions which are essential to scientific inquiry and research (Zulyusri et al., 2023). Project based learning contributes to the development of critical thinking and problem-solving skills in students by allowing students relate their knowledge to relevant, real-life situation (Kurniasari & Yamtinah, 2023). Enhance students' critical thinking skills and foster a caring attitude toward the environment by integrating environmental education into the curriculum, implementing a student-centered learning approach, providing direct learning experiences, and encouraging problem-solving activities (Hillary et al., 2023).

Teachers can provide students with hand-on learning experiences that encourage critical thinking and application of knowledge in real-life contexts (Yanti et al., 2023). Critical thinking skills have the advantage of analyzing a problem and finding solutions based on case studies. Students' critical thinking skills can be trained through discussions, making it easier for students to ask question and provide answers (Aziz & Nurachdijat, 2023). Project based learning has a positive influence on students' skills, especially by improving their critical thinking (Puspitasari et al., 2023).

Table 4. The extent on the Influence of Project Based Learning Model on Students' Communication Skills

Research Topic	Effect Size	Criteria
Communication	3,44	Very High
	0,83	Large

Table 4 above shows the results of the meta-analysis test by calculating the effect size on students' communication skills using the project based learning model on environmentally polluted materials. The result of the effect sizes calculation were 3.44 and 0.83. The meta-analysis test conducted showed very high and large criteria. This shows that the application of the project based learning model has a very high impact on students' communication skills on the topic of environmental pollution. Applying the project based learning model while paying attention to syntax can support and promote verbal communication skills when presenting project result. In addition, communication skills can be promoted by writing projects (Ariyani, et al., 2019).

To improve students' communication skills, incorporating citizen science projects that provide positive feedback and build trust among contributors can improve motivation and engagement. Additionally, providing opportunities for social interaction and professional development through projects can further develop communication skills (Maund, et al., 2020). Effective communication skills are essential for successful interaction and collaboration in diverse environments. By actively listening, maintaining clarity and brevity, paying attention to body language, practicing empathy, giving and receiving feedback, adapting communication style, demonstrating confidence, and with regular practice, individually can significantly improve their communication skills (ardoin et al., 2020).. Improving students' communication skills is intended to ensure that the messages conveyed

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by students are accepted and that there are no misunderstandings in the learning process (Aziz & Nurachadijat, 2023).

Table 5. The Extent on the Influence of Project Based Learning Model on Students' Creative Skills

Research Topic	Effect Size	Criteria
Creatif	3,55	Very High
	2,94	Very High
	1,42	Large
	5,4	Very High

Table 5 above, students can improve their creative very high through the project based learning model on environmental pollution materials. This was demonstrated by the meta-analysis test by calculating an effect sizes of 3.55; 2.95; 1.42 and 5.4. Applying the project based learning model can enhance students' creative skills at the project design stage. Indeed, at this stage students can develop project ideas, combine ideas during group discussion, and promote creativity in the project to be implemented (Nugroho, et al., 2019). Students need to have creative skills to be brave and express their thoughts. Teachers can use their creative skills to provide students with the means to develop their creativity (Azis & Nurachadijat, 2023). This creative skill can be used to solve problems in case studies. Students are trained to think creatively to find solutions for a learning project.

Projects based learning to help studies develop creative thinking skills through product design activities that solve real-world-problems. Project based learning leading to good result on creative thinking skills assessment. Create project based learning can be structured to incorporate opportunities for students to explore environmental issues. Project based learning encourage them to develop deeper understanding of sustainability and environmental management (Yamin, et al., 2020). This learning model involves designing projects through scientific processes including idea generation, problem formulation, hypothesis development, and creation of innovate products. This practical experiences helps students apply to real life situations thereby promoting creativity (Rahayu & Indriyanti, 2021). Project based learning model encourage students to think more diversely and meaningfully about content. Project based learning helping them problem-solving skills and creative solutions (Sumarni & kadarwati, 2020). Research shows that involving students in project can improve their ability to address environmental problems. Students can develop their creativity and innovation with environmental issues (Kamil et al.2020).

Table 6. The Extent on the Influence of Project Based Learning Model on Students' Collaboration Skills

Research Topic	Effect Size	Criteria
Collaboration	0,89	Large

Table 6 above, shows the impact of the project based learning model on students' collaboration skills on environmental pollution materials. The effect size yielded a result of

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0.89. this shows that the project based learning model has a great impact on students' collaboration skills on environmental pollution materials. Applying the project based learning model can a positive impact on improving students' ability to collaborate on environmental pollution material. This is because there are benefits to the project based learning model. The result of the project that involves collaboration between students in a group. This activity can improve student collaboration (Erviani et al., 2023).

Collaborative skills can provide ideas for solving problems in case studies. Students' ability to collaborate can actively participate in learning, respond according to their role, be more empathic, and respect others' differences of opinion during discussions (Aziz & Nurachadijat, 2023). Project based learning, especially through carefully designed group project can significantly improve student learning by promoting mutual learning, enriching discussions, and deeper understanding of the topic (Park, 2022). Students responded positively to project based learning model in term of collaborative work, independent learning and environmental awareness. They value the active role they play as group members, the opportunity to explore information outside the textbook, and the opportunity to express their ideas and challenge each other. Additionally, students feel that they can learn with minimal dependence on the teacher with increasing autonomy in their learning process (Nugraha & Ridwan, 2019). Encourage a culture in which project based learning is integrated into the curriculum and teachers' collaborative project efforts are supported to enhance environmental knowledge and skills sustainability among educators (Bramwell-Lalor et al., 2020).

Project based learning model has been proven to be very effective in improving 21st-century skills students including critical thinking, problem-solving, creativity, collaboration, and communication skills. Because of it provides students with meaningful learning experiences that involve exploring problems, real-world topics, and projects. This learning model encourages students to actively engage in problem-solving activities, promoting creativity by allowing them to generate diverse ideas and solutions.

Additionally, the collaborative nature of project based learning model promotes teamwork and communication skills as students work together to solve complex challenges (Triana, 2020). Project based learning model in the middle school science subjects can increase motivation, collaboration, critical thinking, and problem-solving skills (Mckinney, 2023). This learning model helps students develop a deeper understanding of concepts and increases motivation and interest in learning. Project based learning model encourage students to work collaboratively, thereby improving communication and teamwork skills. This approach also allows students to explore their interest and talents preparing them for the 21st-century (Pratiwi et al., 2021).

4. CONCLUSION

Based on research conducted by meta-analysis testing on 7 literature studies to determine the effectiveness of implementing project based learning model on pollution subject skills environment of 21st-century students. The result of research on critical thinking skills in the impact test are 4.85 and 4.52, showing that impact criteria are very high. The result of communication skills research skills research in the influence level test are 3.44 and 0.83, showing that the criterion has a very high and large influence level. The result of research on creative skills in the effect size test are 3.55; 2.94; 1.42 and 5.4 representing very high and large influence criteria. The result on collaboration skills in the influence test is 0.89, demonstrating large influence criteria. This shows that implementing the project based learning model into students' 21st-century environmental pollution skill has a great impact.

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Therefore, the researcher offers suggestion including 1) when learning material about environmental pollution in science learning phase D, the project based learning model should be used to improve the skills of 21st-century students. 2) the project based learning model implemented in instructional modules will help students achieve learning outcomes based on the unidentified KKTP determined. 3) further research is needed to analyze the influence of project based learning model on students' environmental pollution skills in the middle school phase D.

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