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Meta-Analysis: The Effect of Project Based Learning on Science Process Skills

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Abstract

Using meta-analysis techniques, this study attempts to investigate how the Project-based Learning paradigm affects biological science process abilities. This study employed a meta-analysis methodology. The research population consists of scholarly publications concerning the use of the project-based learning model that have been published in national and international journals throughout the past ten years. The project-based learning scientific paper on science process skills in biology education serves as the example. The aforementioned meta-analytical computations indicate that all papers measuring the impact of the project-based learning model on science process skills show a connection, where the p value of < 0.002 means that the analysis is significant with sig. 0.05 and I^2 of 94.508% show that learning using the project-based learning model has a very large influence on science process skills

Keywords: *Project Based Learning, Process Science Skills, Meta Analysis*

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INTRODUCTION

Everyone should have a wide range of skills necessary to live a modern life. The 21st century also provides a variety of information that can be accessed anytime and anywhere around the world (Asrizal et al., 2022; Mufit et al., 2020). With the rapid development of science and technology, there is no longer any limit to communication. The development of science and technology has an impact on the problems and competition faced by every country around the world. For Indonesia to compete with the global community, quality human resources must be built. Thus, 21st century education should be able to improve students' knowledge, skills, attitudes, and values (Asrizal et al., 2018; Asrizal et al., 2022).

In accordance with Permendikbud No. 21 of 2016, 21st century National Education aims to realize the ideals of the nation through the formation of a society consisting of quality human resources, namely individuals who are independent, willing, and able to realize the ideals of their nation. The Indonesian nation wants to be a prosperous and happy country, with an honorable position and equal to other nations in the global world. Education must have the ability to create a golden generation that is able to compete in a global society. Due to the demands of an increasingly competitive era, society must be more productive. In addition, advances in information communication technology have changed people's lifestyles, including the way they work, study, and socialize at work. The government changed the curriculum to encourage educational progress. This is done until the independent curriculum is implemented (Seftiani et al., 2021).

21st century capabilities are a new requirement for 21st century needs (Griffin Patrick & Care Esther, 2015). 21st century ability, according to Silva (Sugiarti, 2017), is an ability that includes innovation, tenacity, and problem solving, as well as effective group interaction. According to BSNP (Rahmayati, 2017) in the 21st century, students are required and required to have the ability to think creatively, think critically and problem solving, communicate, and collaborate. But the fact is that from several research results, 21st century skills are still calculated to be low in students in Indonesia. In the learning process, learners are only required to understand ideas and solve problems mathematically. In this case learners are not educated in the process of learning and applying information, as a result they only remember concepts, theories, and principles without understanding them (Karomatunnisa et al., 2022; Rahmayati, 2017).

According to Permendiknas no. 21 of 2016, students must have the following abilities in biology lessons: using scientific work procedures and occupational safety in biology laboratories; understand different biological problems; communicate the results of observations and experiments orally and in writing; and present data based on observations and experiments by applying scientific procedures (Suryaningsih, 2017). The goal of project-based learning is to address complicated issues that call for students to apply what they have learned in real-world situations (Listiani & Purwanto, 2018; Munawaroh et al., 2012) The inquiry process is initiated by posing a leading question using the Project Based Learning Model, and students are then guided in a cooperative project that incorporates many disciplines (materials) in the curriculum. Students may immediately see the key components and different concepts of a field they are studying when their queries are addressed. The Project Based Learning approach is a comprehensive exploration of a practical subject that will benefit students' focus and effort.

By designing and developing projects that may be utilized to address issues, students can showcase their creativity through project-based learning, commonly referred to as the project-based learning approach. Furthermore, according to Prameswari & Wahyudi (2019) this learning model is methodical and capable of generating fresh knowledge that takes into account the surroundings in which students are situated and acquire knowledge. In the context of project-based learning, teachers

and students collaborate closely. Science process skills include observation, tool and material use, interpretation, project planning, application of concepts, questioning, and effective communication throughout projects.

As stated by Artayasa et al., (2017), improvement in students' science learning outcomes can not only be achieved through teaching science concepts or theories, but also through teaching science process skills. This is because science is basically the process and product of science, namely facts, concepts, laws, and theories (Khairunnisa et al., 2020). There is a significant positive correlation between students' ability in the science process and the level of mastery of science process skills. Therefore, expanding the concepts and skills of the science process while improving students' science learning outcomes.

The Project Based Learning model has several advantages, namely: 1) it can increase students' desire to learn; 2) be able to improve their skills in managing various resources; 3) can make students more active in learning; 4) can result in more natural collaboration between students; 5) can indirectly improve students' communication skills; 6) can teach students how to organize projects; and 7) allowing students to learn (Fahrezi et al., 2020).

Based on the background description that has been explained, the researcher wants to recite through experimental research with the title meta-analysis of the influence of the Project Based Learning learning model on the science process skills of Biology students. The formulation of this research problem is how the meta-analysis of the influence of the Project Based Learning learning model on the science process skills of biology students. The purpose of this study is to determine the meta-analysis of the influence of the Project Based Learning learning model on the science process skills of biology students.

METHOD

This research is a type of quantitative research that uses a data analysis technique known as meta-analysis. According to Littel (Anadiroh, 2019), meta-analysis techniques are statistical techniques used to combine quantitative research results to produce a complete summary of empirical knowledge on a particular topic. To identify errors and biases in the study, the results of previous studies are evaluated to identify central trends and variations in findings**.**

The population in this study is the journal of Biology Education about the application *of project-based* learning (PJBL) to students' science process skills in Biology learning with a range of 2013-2023 or the last 10 years. The samples taken were 12 studies. The way to find the effect size used in this study uses Cohen's theory (Seftiani et al., 2021) The formula and description of effect size used in Cohen's theory are as follows.

$$\text{Effect Size} = \frac{\text{posttest averagescore} - \text{pre tes average score}}{standar\ deviation}$$

With the interpretation of the effect size as follows.
0 - 0.20 = weak effect (less)

0.21 - 0.50 = modest effect
0.51 - 1.00 = moderated effect
> 1.00 = strong

RESULT AND DISCUSSION

The study was conducted to analyze the effect of using the project-based learning model on science process skills. The study analyzed 12 accredited national journals and international journals,. Data obtained from journals that are relevant to this study and support the calculation of the effect size of each journal. Researchers collected data from various sources such as GoogleScholar, Crossref, and others. From several journals collected, effect size estimates were analyzed using the OpenMEE application. The following are the results of the effect size estimation in Table 1.

Table 1. Effect category size 12 research

ID	d	Var (d)	category
(Pratiwi et al., 2020)	-1.091	0.067	Tall
(Hamidah et al., 2023)	2.521	0.110	Tall
(Safaruddin et al., 2020)	-0.093	0.068	Less
(Özer & Özkan, 2013)	0.128	0.108	Less
(Siwa et al., 2013)	0.000	0.059	Less
(Winarti dan Sri Nurhayati et al., 2014)	1.129	0.077	Tall
(Winarti dan Sri Nurhayati et al., 2014)	0.623	0.070	Keep
(Chasanah et al., 2016)	1.903	0.097	Tall
(Wulandari & Sari, 2023)	6.025	0.527	Tall
(Okoye & Osuafor, 2021)	2.189	0.072	Tall
(Parmiti et al., 2021)	0.868	0.072	Keep
(Can et al., 2017)	0.658	0.178	Keep

Based on the data in Table 1, the average ES value is obtained by looking at the analysis results in Table 2 below. Results obtained from the calculation of effect size using the OpenMEE application from 12 journals. The following details of the research results can be described as follows:

Table 2. Average effect size

Metric: Standardized Mean Difference				
Model Results				
Estimate	**Lower bound**	**Upper bound**	**Std. error**	**p-Value**
1.147	0.423	1.870	0.369	0.002
Heterogeneity				
tau^2	**Q(df=11)**	**Het. p-Value**	**I^2**	
1.517	200.282	< 0.001	94.508	

From table 2 above, it can be seen that the average effect size of the 12 journal articles measured by the influence of the project-based learning model on science process skills is 1.147, the lower limit of the effect size is 0.423 and the upper limit is 1.870. This indicates that the use of the project-based learning model is influential in improving science process skills. Then in the calculation of heterogeneity of the 12 articles analyzed, it was found that the value of tau^2 was 1.517, the value of Q(df=11) was 200.282, Het. p-Value < 0.001 and I^2 94.508. because the value of Het. p-Value < 0.001, The 12 journal papers that were examined are varied, and it can be inferred that the project-based learning approach significantly affects science process abilities..

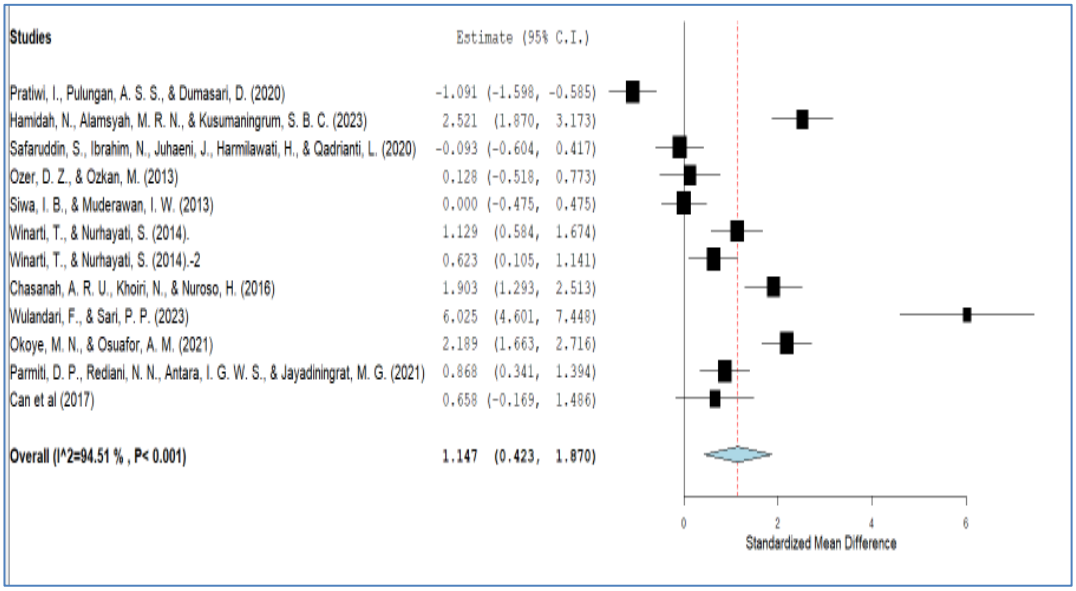

Figure 1. Standard mean difference

Based on figure 1, it can be explained related to the diversity of size effects in the 12 articles previously analyzed. From the picture, it can be seen that there is the largest size effect in Wulandari and Sari's articles in 2023, this indicates that the influence of using the project-based learning model on their research has a major effect on science process skills. In addition to the largest size effect, figure 1 also shows a negative size effect and a positive size effect. Where the negative size effect occurred in Pratiwi et al., (2020) research articles in 2020, this indicates that the value in the control group is greater than the value in the experimental group using the project-based learning model. While other research articles have a positive size effect where the experimental group that uses the project-based learning model is larger than the dick group that does not use the project-based learning model in improving science process skills.

DISCUSSION

Based on the results of the research above, it can be seen that the project-based learning model has a high positive effect on science pose skills, where it can be seen in table 2 and figure 1 which shows that the average effect size of the 12 articles analyzed using the OpenMEE application gets an average effect size of 1.147 with a lower limit

of effect size of 0.423 and an upper limit of effect size of 1.870. One learning model that might encourage students to participate actively in the learning process is the project-based learning model, claims Silberman (Silberman, 2016). With the use of lengthy, organized inquiry processes, real, challenging questions, and thoughtfully crafted product assignments, project-based learning is a methodical approach to education that helps students acquire information and skills (Kokotsaki et al., 2016). There is a great deal of promise in using project-based learning to give students more relevant and interesting learning experiences. It has been demonstrated that the paradigm benefits students in ways that include raising their success, grasp of topics, attitudes toward science, engagement after learning, self-efficacy, science process skills, and capacity for learning. (Çakici & Türkmen, 2016; Irfana et al., 2022; Kurniawati, 2021; Pitipornpin & Kuhapensang, 2015; Priatna et al., 2022; Setiyadi, 2023; Setiyadi et al., 2023; Simbolon & Koeswanti, 2020). In addition, project-based learning is also able to produce professional teachers (Yamin et al., 2017).

In essence, the project-based learning approach helps students build their problem-solving abilities while working on a project that might yield adequate results and give them lots of opportunity to make decisions about what to investigate, how to proceed with a project, and so on. Furthermore, the project-based learning paradigm developed by Setiyadi (2023) has the potential to enhance student learning outcomes and self-efficacy. According to Zativalen et al. (2022), learning through project-based learning involves acquiring abilities through the application of the concept of learning by doing, or what is known as "learning by doing." Developing students' science process skills is also essential to improving the caliber of education (Dirks & Cunningham, 2006). Furthermore, science process skills help pupils understand information more quickly (Af'idayani et al., 2019). Furthermore, scientific process skills help students acquire information more quickly (Rahman et al., 2023; Santosa et al., 2021). Thus, it is imperative that kids acquire science process skills at a young age (Darmaji et al., 2020). The science process abilities of students are more successfully encouraged by teachers when they use the project-based learning paradigm. Furthermore, one way to enhance students' cognitive quality throughout the learning process in schools is through the implementation of the project-based learning paradigm (Monhardt & Monhardt, 2006).

CONCLUSION

Based on the meta-analytical calculations above, it can be concluded that there is a relationship from all articles that measure the effect of the project-based learning model on science process skills, where the p value < 0.002 means that the analysis is significant with sig. 0.05 and I^2 of 94.508% indicate that learning using the project-based learning model has a very large influence on science process skills.

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