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Project-Based Learning Based On Stem (Science, Technology, Engineering, And Mathematics) Enhancing Students Science Knowledge Competence

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ABSTRAK

Literasi sains siswa masih dikategorikan rendah. Salah satu penyebabnya adalah siswa dihadapkan dengan menghafal materi – materi Ilmu Pengetahuan Alam (IPA) yang berdampak pada rendahnya pemahaman konsep IPA. Penelitian ini bertujuan untuk mengkaji efektivitas model *Project Based Learning* Berorientasi STEM terhadap kompetensi pengetahuan IPA SD. Jenis penelitian adalah *Quasi eksperimen* dengan menggunakan *Nonequivalent Control Group Design*. Populasi penelitian adalah siswa kelas V SD, berjumlah 209 siswa. Penelitian ini menggunakan dua kelompok sampel yaitu kelompok eksperimen dan kelompok kontrol. Sampel penelitian didapatkan melalui teknik *random sampling* dan telah melewati uji kesetaraan. Kelompok eksperimen dalam penelitian ini berjumlah 33 siswa, dan kelompok kontrol berjumlah 30 siswa. Data dikumpulkan menggunakan tes objektif pilihan ganda biasa kemudian dianalisis dengan uji-t *polled varians*. Hasil analisis data menunjukkan t_{hitung} = 2.237 > t_{tabel} = 2.000, dengan taraf signifikansi 5% dan dk = 61 sehingga H_0 ditolak. Artinya terdapat pengaruh kompetensi pengetahuan IPA antara kelompok eksperimen dan kelompok kontrol. Penerapan model *project based learning* berorientasi STEM dapat membuat siswa lebih termotivasi dalam pembelajaran sehingga mempermudah dalam memahami materi-materi IPA

ABSTRACT

Student scientific literacy is still low categorized. One of the reasons is that students are memorizing natural science (IPA) materials, which result in poor understanding of science concepts. This study examines the effectiveness of the STEM Oriented Project Based Learning model for elementary science knowledge competencies. This type of research is a Quasi-experiment using Nonequivalent Control Group Design. The study population was fifth-grade elementary school students, 209 students. This study uses two sample groups, the experimental group, and the control group. The research sample was obtained through random sampling techniques and had passed the equality test. The experimental group in this study amounted to 33 students, and the control group was 30 students. Data were collected using an ordinary multiple-choice objective test and then analyzed by polled variance t-test. The data analysis results showed that t = 2,237> t table = 2,000, with a significance level of 5% and dk = 61 so that H0 was rejected. It means that there is an influence of science knowledge competence between the experimental and control groups. Applying the STEM-oriented project-based learning model can make students more motivated to learn to make it easier to understand science materials.

1. Introduction

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Education is the most effective means of welcoming a bright future. In facing the sophistication of technology and communication that continues to develop, human resources' improvement also needs to be continuously strived to form human beings who are intelligent, skilled, independent, and have noble character. Education's role is so central as a blowing wind of change that can bring a nation in a better direction. The government always tries to improve the quality of education, especially in formal education. One such effort is, for example, discussing the educational curriculum that leads to perfection. The current curriculum in Indonesia is the 2013 curriculum, aiming to increase student curiosity and spurring students to be more active. The 2013 curriculum was designed to contribute to students' widest possible learning experience in developing their knowledge. The learning process in educational units is interactive, inspiring, fun, challenging, motivating students to participate actively. It provides sufficient space according to the talents, interests, and physical and psychological development of students. Each education unit carries out lesson planning, implementing the learning process, and assessing the learning process to increase graduate competencies' efficiency and effectiveness. Therefore, teachers need to understand the models, approaches, methods, and strategies used in developing the classroom's learning process.

The learning models prioritized in implementing the 2013 Curriculum are the Inquiry-Based Learning model, the Discovery Learning model, the project-based learning model (Project Based Learning), and the Problem Based Learning model. Establishing a learning model that follows the characteristics of the 2013 curriculum hopes that the teacher will vary the learning model's application in classroom learning activities according to the material provided. However, the facts found in the teacher's field are still a source of information, which results in students becoming passive in learning. The lack of teachers' variation in learning models in schools affects student enthusiasm and activeness in learning, impacting students' knowledge competencies. The Indonesia National Assessment Program (INAP) results by the Education Assessment Center of the Ministry of Education and Culture (Kemendikbud) show that most students in Indonesia are less proficient in scientific literacy. Only 1.01% of students are in a good category, while 25, 38% are in the moderate category. Meanwhile, students who are less proficient in scientific literacy account for 73.61% (Balitbang Kemendikbud, 2019). In this case, scientific literacy is still categorized as low. One of the reasons is that students are faced with memorizing Natural Science (IPA) materials, which impacts the low understanding of science because students only keep their memory in the short term so that the learning is meaningless. The main problem in science learning has not been completely resolved because of students' assumption that this lesson is difficult to understand and understand (Permanasari, 2016). Science is very important to elementary school students. Through science, students are taught to get to know their surroundings. Science is also natural science, where nature has a meaning related to nature. Science also has the meaning of science (Rani, 2019)

Science is the knowledge learned from natural phenomena in the form of facts, concepts, or principles from experiments or observations to conclude (Diawati, 2019). Science learning emphasizes providing direct experience to develop competencies to explore and understand the natural surroundings scientifically. It directed to find out and do something to help students understand the natural surroundings (Evitasari & Nurjanah, 2019). On the other hand, science subjects can foster curiosity, a positive attitude, and awareness to play an active role in maintaining, protecting, and preserving the natural environment. An educator's challenge is to provide a model and approach in learning that creates opportunities for students to connect knowledge and skills to optimize thinking skills, analytical power, activeness, and students' knowledge. Thus, teachers need to innovate with the models, approaches, methods, and strategies. One of the innovative learning models suitable for use in the learning process with science subject content in class is the Project-Based Learning model.

Project-Based learning is a model that emphasizes students to be able to learn independently by solving problems faced, and students can produce a real project or work (Dewi, et al., 2013). This model makes student-centred learning and activities carried out by collaborating with groups to complete projects according to the design (Jagantara, 2014). Project-Based learning is defined as teaching that links technology with everyday life problems familiar to students or school projects (Rati, 2017). The Project-Based Learning Model provides great opportunities to produce interesting and meaningful learning experiences for students. Project-based learning encourages students to be creative and independent in producing products due to Learning (Baidowi, 2015). So that in the implementation of learning, students will show their creativity, and the results of students' understanding of the material presented will produce maximum learning outcomes (Nugraha, 2018). In line with this, (Afriana, 2016) also explained that innovative Learning, either Project Based Learning or Problem Based Learning, improved students' scientific literacy. The advantage of this project-based learning model is to develop the total involvement of each individual in the process of learning activities. This learning model is a student activity-oriented

learning model suitable for ensuring individual accountability in group discussions/performance (Khanifah, 2019). A learning model is said to be effective if it succeeds in achieving the learning objectives formulated. The learning model is said to be efficient if learning attracts students' attention to continue studying the material on an ongoing basis. This project-based learning model is very good if applied in a Science, Technology, Engineering, and Mathematics (STEM) orientation.

An important problem in the 21st century is Information and Communication Technology in learning activities to be more active, creative, innovative, and fun, causing multi-interaction between teachers, students, media, and learning resources. STEM-based learning can train students' abilities and talents to face the problems of the 21st century. STEM is alternative learning that can build 21st-century skills that build mastery of content and provide skills (Skills) based on attitudes, characters, and habits (Permanasari, 2016). Torlakson (2014) states that the four aspects of STEM are a harmonious pair between problems in the real world and learning that focuses on solving problems experienced in everyday life. STEM learning is one of the lessons, and strategies are seen as an approach that can significantly change the 21st century. Learning with a STEM approach is more than just integrating science, technology, engineering, and mathematics. But is an interdisciplinary and applied science that combines the real world and problem-solving. In line with this, Tsupros (in Winarni, 2016) states that integrated STEM education is an interdisciplinary approach to learning, in which students use science, technology, engineering, and mathematics.

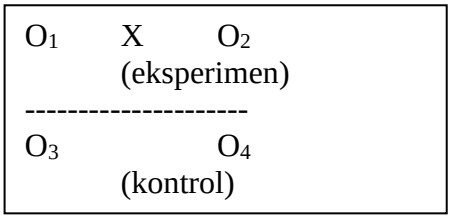
STEM-oriented learning will form students' character who can recognize a concept or knowledge (science) and apply it with the skills (technology). They master to create or design a method (engineering) with analysis and mathematical data calculations (mathematics) to solve a problem. The integration of STEM aspects can positively impact learning, especially in improving student learning outcomes in science and technology (Becker & Park, 2011). Through STEM learning, students have scientific and technological literacy that can be seen from reading, writing, observing, and doing science. They can use as provisions for living in society and solving everyday life problems related to the science's field ofayasari, 2014).

The process of learning project-based learning with an effective STEM approach has five stages, reflection, research, discovery, application, and communication Laboy-Rush (in Jauhariyyah, 2017). Reflection aims to connect the knowledge they have and what they will learned, leading students into the context of the problem, and providing inspiration to start investigating/investigating. Research helps students gather relevant information in developing conceptual understanding. Discovery has the goal of developing students 'abilities in building students' thinking from the design and design process. The application aims to express ideas in a product or find solutions in solving problems. Communication aims to present a product or solution within the scope of the class.

The STEM approach benefits make students solve problems better, innovative, independent, logical thinking, and technological literacy (Morrison in Stohlmann, 2012). The research results conducted by Adiwiguna (2019) show that STEM can improve students' scientific literacy and critical thinking skills. Implementing the STEM project-based learning model for students' scientific literacy is very good because it can encourage students to learn about nature and the environment through exploration, investigation, and problem solving (Asghar, 2012).

2. Method

This research is in the type of quasi-experimental design (Quasi-Experimental Design). It is because not all variables that appear in the experiment can be strictly regulated and controlled. According to Sugiyono (2018: 114), "quasi-experimental design has a control group, but it cannot fully function to control external variables that affect the implementation of the experiment." The form of quasi-experimental design used in this study is the Nonequivalent Control Group Design. The design of this study as follows.



Gambar 1. Nonequivalent Control Group Design (Sugiyono, 2018)

This research's implementation consists of three stages: the experimental preparation stage, the experiment implementation stage, and the experiment's final stage. The research that will carry out cannot separate from the subject studied with the terms population and sample. The population is a generalization area consisting of objects or subjects with certain qualities and characteristics set by the researcher. Then conclusions are drawn (Sugiyono, 2018). This study's population were all fifth grade SD Gugus Ki Hajar Dewantara, East Denpasar District for the 2019/2020 academic year, which consisted of 7 classes in five elementary schools. Many population members make it impossible to study everything in the population, so a sample is used. The sample is part of the number and characteristics of the population (Sugiyono, 2018).

The sampling technique in this study is the random sampling technique. The random sampling technique provides equal opportunities for each class to become the research sample. The group that left the lottery used as the research sample. This study's sample consisted of 2 classes, the fifth grade SD N 22 Dangin Puri and the VA class SD N 29 Dangin Puri. Then the sample was given a pre-test to equalize the two groups.

The results of the score of pre-test score obtained were analyzed using the t-test. Before carrying out the t-test to find equality, the prerequisite analysis test must first carry out the normality test of data distribution and the homogeneity of variance test. The data normality test was calculated using the Kolmogorov-Smirnov test, while the F test's variance homogeneity test was used. If the two groups' pre-test results are normally distributed and homogeneous, then proceed with the equivalence test using the t-test with the polled variance formula.

Based on the results of the t-test, two sample groups were equivalent. The analysis showed that the score of t = 0.092, for α = 5% with dk = 61, then t table = 2,000. So tcount <ttable so that H0 is accepted and equivalent. After the two sample groups were equal, they continued to draw to select the experimental and control groups. The raffle stated that the experimental group was class five SD Negeri 22 Dangin Puri, and the control group was class V A SD Negeri 29 Dangin Puri.

A variable is something that used as an object of observation in a study. The variables used in this study consisted of two variables, the dependent variable and the independent variable. The dependent variable is a variable influenced by the independent variable (Sugiyono, 2018). The dependent variable can be observed through the results arising from treating a situation or object in a study. Science knowledge competence is the dependent variable in this study, while the STEM-oriented Project Based Learning model is the independent variable in the study. Independent variables influence or cause the change or the dependent variable's emergence (Sugiyono, 2018). The independent variable can also be a variable that causes changes or influences the dependent variable.

The data collected in this study are science knowledge competency data. In the process of collecting data, the method used is the test method. The test is a specific and systematic procedure for measuring a person's behavior, or an objective measurement of a person's behavior so that behavior can be described with the help of numbers, scales, or a category system (Yusuf, 2015). The method by giving tests used to obtain data about the results of science knowledge. The type of test used to assess students' knowledge of the cognitive aspects is an objective test with multiple-choice forms. The data collection instrument must pass the testing stage. Testing of the test instrument was tried out on a class group that was higher than the sample class. After being tested, the instrument's test results were analyzed for the validity of the test items with several instrument tests, including the content validity test, the item validity test, the difference power test, the difficulty level test, and the reliability test.

Based on the validity test results using the biserial point correlation coefficient formula (ypbi) with a significance level of 5%, it can be said whether an instrument is valid or not by comparing the rcount score with the rtable. Based on the calculations performed, a valid test obtained as many as 40 questions. After the validity continued with a different power test, if the discrimination index is closer to 1.00, the questions' distinguishing power will be better. However, if an item's discrimination index is close to the score of 0.00, the question has no distinguishing power. The different power tests calculation obtained 19

questions in sufficient categories, 19 questions in good categories, and two questions in very good categories. The difficulty level test results show that the test difficulty index is 0.68, which is included in the moderate criteria, with 4 difficult questions, 25 medium questions, and 11 easy questions. Giving interpretation of the reliability coefficient of the r11 test is generally used the following standards: (1) If r11 = or> than 0.70 means that the knowledge competency test tested for reliability is declared reliable, (2) If r11 is smaller than 0.70 it means the competency test knowledge that is being tested for reliability is declared unreliable. The results of the calculation of the 40 questions that were declared valid obtained r11 were 0.94> 0.70, which means that the multiple-choice test items in this study classified as reliable.

The data obtained are numerical and quantitative so that it uses statistical analysis. Inferential statistics are techniques and methods used in analyzing sample data to make conclusions that apply to the population (Sugiyono, 2018). In conducting parametric statistical tests, the prerequisite test carried out first, the data normality test and the variance homogeneity test. The normality test aims to determine whether the group data is normally distributed or not. The formula used to test the normality of data distribution in this study is Kolmogorov-Smirnov.

Furthermore, the variance homogeneity test was carried out. The homogeneity test of variance in this study uses the F test formula as follows.

$$F = \frac{Varian\ terbesar}{varian\ terkecil}$$

(Sumber: Sugiyono, 2018)

Data that has been tested for normality and homogeneity then tested the hypothesis. The hypothesis (H0) that was tested was that there was no difference between the competency of the science knowledge of the group of students who were taught using the STEM (Science, Technology, Engineering, and Mathematics) oriented project-based learning model and the group of students who were taught conventionally in fifth-grade students of SD Gugus Ki Hajar. Dewantara. The statistical analysis used to test the hypothesis is the t polled variance test because the number of samples in this study is n1 ≠ n1, and the variance is homogeneous. With the criteria or provisions, if tcount ≤ t table then there is acceptance of H0 and rejection of Ha, whereas if tcount> t table then there is a rejection of H0 and acceptance of Ha. The test is carried out based on the 5% significance level.

3. Result and Discussion

The data obtained in this study grouped into two data, the fifth-grade science knowledge competency that taught using the STEM-oriented Project Based Learning model as an experimental group, and the science knowledge competency taught by conventional learning as the control group. The fifth-grade students of SD Negeri 22 Dangin Puri are an experimental group in this study, amounting to 33 people. After being given treatment six times by applying the STEM Oriented Project Based Learning model, students were given a post-test to obtain data on science knowledge competency. The descriptive calculations of the data for each group can be seen in table 1.

Table 1. Descriptive Statistics of Mathematical Knowledge Competencies

Statistik Deskriptif	Experiment Group	Control Group
Mean	77.24242	72.2
Median	78	73
Mode	80	70
Standard Deviation	9.463	8.310
Variance	89.564	69.062
Highest Score	95	90
Lowest Score	60	58

Based on the post-test score calculation for the science knowledge competency, the mean (average) score of the experimental group was 77.24242 higher than the mean (average) of the control group, 72.2. Before analyzing with the t-test, the data must first meet the prerequisite test. The prerequisite tests that

must be met are the normality test of the data distribution and the homogeneity test of variance. The normality test carried out on the post-test data on the competence of scientific knowledge of fifth-grade students of both sample groups. It is necessary to do a normality test to know whether or not the distribution of the data distribution is normal. The recapitulation of the normality test results of the distribution of science knowledge competency data in the experimental group and the control group presented in table 2 below.

Table 2. Results of Normality Test of Research Sample Data

Sample	N	Maximum Score | Ft - Fs |	Kolmogorov-Smirnov Score	Conclusion
Experiment Group	33	0.112653	0.231	Normal
Control Group	30	0.106861	0.242	Normal

Based on the experimental group normality test results, obtained | Ft-Fs | maximum = 0.112653, then the score is compared with the Kolmogorov-Smirnov table score = 0.231. It shows that | Ft-Fs | maximum ≤ the Kolmogorov-Smirnov table score means that the experimental group's science knowledge competency data is normally distributed.

The results of the normality test for the control group obtained | Ft-Fs | maximum = 0.106861. Then this score is compared with the Kolmogorov-Smirnov table score = 0.242. It shows that | Ft-Fs | maximum ≤ the Kolmogorov-Smirnov table score means that the experimental group's science knowledge competency data is normally distributed.

The next prerequisite test on the experimental and control classes' science knowledge competency data is the F test formula's variance homogeneity test. The homogeneity test's calculation results in the research sample group presented in table 3 below.

Table 3. Results of the Variance Homogeneity Test for the Study Sample Group

Sample	dk (n-1)	Variance	F_{hitung}	F_{tabel}	Conclusion
Experiment Group	32	89.564	1.297	1.674	Homogen
Control Group	29	69.062			

The homogeneity test analysis results, obtained Fcount = 1.297 and Ftable = 1.674 at the 5% significance level with dk (32.29). It means that Fcount <Ftable, so that the two groups' data has a homogeneous variance. Based on the prerequisite test results, which consist of the normality test and the homogeneity test of variance, it can conclude that the two-sample group data are normally distributed and have homogeneous variances. Thus, hypothesis testing using the t-test can be done, and the recapitulation of the t-test results in the two sample groups presented in table 4 below.

Table 4. Results of the t-test for the sample group

No	Sample	N	dk	$\bar{X}$	Varians	t_{hitung}	t_{tabel}
1.	Experiment Group	33	61	77.24242	89.564	2.237	2.000
2.	Control Group	30		72.2	69.062		

Based on the table, it shows that the results of tcount = 2.237 and ttable = 2,000 with dk = n1 + n2 - 2 = 61 and a significant level of 5%. Based on the calculation result criteria, tcount> ttable, H0 rejected, and Ha is accepted. It shows differences in the competence of scientific knowledge of fifth-grade students of SD Negeri Gugus Ki Hajar Dewantara for the 2019/2020 academic year.

After knowing that the STEM-oriented project-based learning model affects students' science knowledge's competence, it continued by calculating the model's effectiveness. The magnitude of the STEM-oriented project-based learning model's effectiveness on students' competency in scientific knowledge can be done by calculating Cohen's coefficient d. According to Cohen (in Gravetter and Wallnau, 2014), effectiveness can standardize by measuring the average difference in standard deviation units. The following formula can calculate the coefficient of Cohen's d.

$$d = \frac{perbedaan\ rata{-}rata}{standa\ r\ deviasi\ sampel} = \frac{M\ treatmen - M\ notreatmen}{sspp}$$

Keterangan :

d	=	nilai efektivitas
M *treatment*	=	nilai rata-rata *post-test* kelompok eksperimen
M *no-treatment*	=	nilai rata-rata *post-test* kelompok kontrol
sspp	=	standar deviasi gabungan

4. Conclusion

Based on the data analysis and discussion it can be concluded that the STEM (Science, Technology, Engineering, and Mathematics) oriented project-based learning model affects the scientific competence of fifth-grade students of SD Negeri Gugus Ki Hajar Dewantara in the 2019/2020 academic year even though it has a small effect. This is evident from the results of data analysis showing tcount = 2.237> ttable = 2,000 at the 5% significance level with dk = 61. Then proceed with calculating the effect to determine the model's effectiveness, and the score of d = 0.058383 obtained. Following the criteria regarding the size of the effect size, it stated 0 <0.058383 <0.2, which means that applying the STEM-oriented project-based learning model has a small effect on science learning in elementary schools.

As for some suggestions submitted to several parties related to the results of the research, suggestions for teachers to be more creative to increase student enthusiasm and motivation in learning by using a project-based learning model-oriented STEM (Science, Technology, Engineering, and Mathematics) so that learning is meaningful to students, it was suggested to the principal to make this research a supporting source of teacher learning in improving the quality of learning by creating fun learning in schools so that schools could produce students who had quality output. It is suggested to other researchers that this study's results used as a reference for relevant research studies.

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