The Effect of PBL-based STEAM Approach on The Cognitive and Affective Learning Outcomesof Primary School

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Abstract. The purpose of this study was to discover the existence of cognitive and affective learning outcomes of students using Project Based Learning (PBL) - based STEAM (Science, Technology, Engineering, Art, and Mathematics) with scientific learning with inquiry learning models. The type of research was a quasi experimental design. Data were collected by means of test analysis, observation, interviews, and documentation from all fifth grade students of primary school. Data analysis used t-test technique. To discover the effect of PBL-based STEAM approach on cognitive learning outcomes obtained from the pretest-posttest results, while affective learning outcomes were obtained through observation using the measurement data scale in the rubric.The results showed that there were significant differences between the experimental class and the control class on cognitive learning outcomes, however, there were differences in affective learning outcomes. It is expected to strengthen the results of the discussion in the long term to strengthen cognitive and affective learning outcomes.

Keywords: *PBL-based STEAM approach, cognitive learning outcomes, affective learning outcomes, fifth-grade, primary school*

Introduction

Education in Indonesia to improve quality human resources must have an understanding of the liberal arts and skills to develop continuously by following the global changes so that the intelligence obtained can be useful for facing competition (BSNP, 2018). Education must begin with curiosity to increase competence balanced with physical and mental skills that are in accordance with cultural backgrounds (Haryanto, 2019). Students in the 21st century must have acting skills which are one of the educational challenges, namely the ability or skills to communicate effectively with various parties. (Ridwan, Rahmawati, & Hadinugrahaningsih, 2017; Setyosari, Degeng, Praherdhiono, Sulton, & Ikhsan, 2019)

The Increase of knowledge, skills, and attitudes are developed through teaching methods that are in accordance with current developments and these methods can increase talent, interest, and motivation to create innovation by expressing conceptual and practical creative ideas (Trilling & Fadel, 2009; Greenstein, 2012). In the attitudes, it is very effective in growing and developing students' moral values and also good behavior of human humans (manner) (Anam, Degeng, Murtadho, & Kuswandi, 2019).

In fact, students often gain abstract learning material, even though the material is an activity that is often carried out by students, one of which is temperature and heat (Başer, 2006). In addition, the lack of development through examples of events in everyday life, as well as weakness in solving problems (Chen, Huang, & Chou, 2019; Juškevičienė, Stupurienė, & Jevsikova, 2021), it leads to the students have difficulty understanding on the material and they are less active. In connection with the concept of heat energy, the complete mastery is needed (Young & Freedman, 2004). Therefore, it is important to improve students' soft skills and hard skills on temperature and heat materials related to the concept of heat energy to improve cognitive and affective learning outcomes.

Learning outcomes are an indicator of the success rate of learning outcomes and are the results of reactions that are triggered in experience with the aim of gaining intelligence through effort and practice that is measured and observed until the end of learning (Huang, Kuo, & Chen, 2020; Liao, Chen, & Shih, 2019; Priawasana, Degeng, Utaya, & Kuswandi, 2020). In general, cognitive learning outcomes become a student's goal orientation even though besides this there are many accompanying impacts that follow each learning process (Liao, Chen, & Shih, 2019). The abilities obtained by students are measured through three aspects of mastery of science, namely cognitive, affective, and psychomotor. However, in this study researchers only measured knowledge (cognitive) and social attitudes (affective), namely cooperation, tolerance, and student activity.(Akyol & Garrison, 2011)

Students' understanding of the concepts or principles that have been studied, with regarding to the components of thinking and the components of acquisition that will be remembered, understood, applied, analyzed, evaluated and developed by creating new products, this is the level of cognitive development in accordance with the revision of Anderson and Krathwohl-Bloom's Taxonomy (Wilson, 2016). Whereas in the affective domain or attitude competency is related to feelings, values, and emotions that teaches sensitivity in receiving, reactions to stimulation, the willingness to organize the values that are chosen, and internalization (Darmawan & Sujoko, 2013; Degeng, 2013).

The high and low of student learning outcomes are influenced by internal factors, namely students themselves and external factors which can be family, school environment, learning methods, fellow students, and so on From these factors, to determine the achievement of cognitive learning outcomes is done through written tests before and after learning (pretest-posttest), while affective learning outcomes are undertaken through observation during learning (Bati, Yetişir, Çalişkan, Güneş, & Saçan, 2018; Ozkan & Umdu Topsakal, 2020). Therefore, teachers must improve the quality of learning in the classroom. Instead of using the lecture method, teachers should use appropriate learning methods and models to optimize and improve the quality of teacher teaching and to improve student learning outcomes (Yuanita, Degeng, & Sudarmiatin, 2018).

One of the learning strategies that might be applied to improve students' learning outcomes both in cognitive aspects, especially in the field of science and affective aspects, namely STEAM. STEAM is apart from the science (science), but it also links to technology, engineering, art, and mathematics through research to be guided in discussion, collaboration and critical thinking (Yakman & Lee, 2012). STEAM also provides students the elements of design, creative, and innovative Students and groups develop concepts with supervision and student stimulus to build an understanding of the relationship between content (Kim et al., 2019; Nurhikmayati, 2019)

STEAM which integrates several fields is in line with those applied in elementary schools, namely thematic learning (Saddhono, Sueca, Sentana, Santosa, & Rachman, 2020). Learning with the process of applying ideas, ideas and concepts. Teaching children's skills such as communication, work, persistence, creativity, and cooperation. STEAM is divided into three levels, namely determining the time limit according to the research that will be carried out by students both individually and in groups. Research conducted by students supports knowledge and skills that can be used in real life and encourages students to respect each other's skills and interests well. Research activities carried out by students can show (1) give positive results in scientific knowledge, (2) teach problem solving, (3) create ideas in the latest technology, (4) explore abstract concepts in mathematics, (5) increase artistic creativity, and (6) hone visual intelligence (Quigley, Herro, & Jamil, 2017; Rachim, 2019; Sari, Duygu, Şen, & Kirindi, 2020) STEAM is not much different from PBL, however it has different on the disciplinary content so that it can be integrated. The learning steps of STEAM integrated with the PBL model are implemented, including (1) project planning that is given by the teacher to be completed, (2) developing project plans, (3) working together by preparing schedules and teachers to monitor the students and project progress, (4) testing and assessment of results, and (5) the evaluation of experiences in the project completion process. The learning process that provides the students' freedom to submit statements and answer, be creative in expressing creative ideas can hone students' visual-spatial intelligence.(Oner, Nite, Capraro, & Capraro, 2016; Siew & Mapeala, 2016)

Regarding to this research, it was conducted with the aim of knowing whether there were differences in cognitive and affective learning outcomes skills of fifth grade students through the use of STEAM with the learning commonly used by teachers, namely scientific learning with inquiry learning models. This research is expected to broaden the understanding of STEAM. Students are expected to more easily understand concepts through practice of real phenomena, so that they can improve learning outcomes, be creative, active, and be able to be kind with others, namely cooperating and being tolerant through learning activities that are undertaken. Through the increase of student learning outcomes, it will improve the quality of the school.

Methodology

Research Design

The research method used was experimental research with quasi-experimental design with nonequivalent control group design. In one of the basic competencies of class V student learning in odd semesters. This research requires two research groups, so the sample in this study was taken from the entire population of class V SDN 2 Turen Indonesia, consisting of two classes with a total of 46 students or 23 students each, class V-A as an experimental class, taught using STEAM, while class V-B as the control class is taught by inquiry learning.

Tabel 1. Quasi-experimental

Class	Pretest	Treatment	Posttest
Experimental	O_1	X	O_2
Control	O_3	X	O_4

(Source: Sugiyono, 2014)

At the beginning and at the end of the lesson, tests were conducted to discover the cognitive results. Teaching learning was carried out during 5 meetings and conducted a subjective affective assessment using a measurement data scale on a validated rubric. Validation was carried out by material experts with 2 validators in the field of science and 1 validator in the field of basic education. The questions for the test which consisted of 10 questions divided into 25 essay questions had sufficient to high validity results, so that they could be used for research. This study used descriptive and inferential analysis methods. Hypothesis testing was undertaken by t-test with the help of SPSS 26.0 for windows. Before conducting data analysis and hypothesis testing, the data obtained must be tested with assumptions first by testing the normality and homogeneity of variance, if the results were normally distributed and had a homogeneous variety, then it was proceed with the t-test.

Procedures

The procedure in this study used instruments in the form of tests and non-tests. In cognitive variables using test instruments that have been validated by educational experts, especially in the field of science and instruments used by students using a rubric calculation of observation sheets that have been developed by researchers and have been tested for validity and reliability in different groups. Not in the control class or the experimental class. Analysis of the data in this study was parametric statistics, using the t-test to refer to the criteria for differences between the experiments and the control class before and after treatment.

Results

Validated test questions were given to students before and after treatment, these questions were the same questions to discover the students' cognitive results. The pretest result data is the test result given to students to know their ability before STEAM. Posttest data are the results of tests given to students after learning in different ways. Affective data were obtained through subjective observations assisted by the teacher for 5 lessons. The following is the statistical description of the pretest-posttest learning outcomes and the affective control class and the experimental class.

Table 2. Statistical Description of Cognitive and Affective Learning Outcomes

Descriptive Statistics	**The Result of Cognitive Learning**				**The Result of Affective Learning**	
	Control Class		**Experimental Class**		**Control Class**	**Experimental Class**
	Pretest	**Posttest**	**Pretest**	**Posttest**		
Minimum Value	32	56	31	66	41,67	25,00
Maximum Value	76	91	77	97	100,00	100,00
The Average (*Mean*)	58,83	73,13	59,48	85,09	77,68	71,38
Standard Deviation	10,86	9,04	11,39	7,89	19,23	21,44

The results of statistical descriptions show that there is an increase in learning outcomes before and after treatment. In addition, in the control class and the experimental class, there is a higher difference in results and it can be seen from the same number of students with a higher average. On affective learning outcomes, the control class has better results than the experimental class. In the prerequisite test, the results obtained are normally distributed and the range of values is homogeneous, so that a hypothesis can be tested. The following table summarizes the normality test, homogeneous test, and hypothesis testing of learning outcomes using the independent sample t-test.

Table 3. The Result of Normality Test of Cognitive and Affective Learning Outcomes

Learning Result	Class	*Kolmogorov-Smirnov*	Sig.	Description
Cognitive	Control	0,475	0,978	Normally Distributed
	Experiment	0,772	0,590	Normally Distributed
Affective	Control	0,834	0,490	Normally Distributed
	Experiment	0.939	0,342	Normally Distributed

Based on the above, cognitive learning outcomes after treatment and affective during learning are normally distributed with a significance value of more than 0.05, which tests the normality assumption using the Kolmogorov-Smirnov method.

Table 4. The Result of Homogeneity Test of Cognitive and Affective Learning Outcomes

Learning Result	Class	Levene Statistics	Sig.	Description
Cognitive	Experiment Control	0,651	0,424	Homogeneous variety
Affective	Experiment Control	0,452	0,505	Homogeneous variety

Based on Table 3 above, it is found that the significance value (p-value) of the Levene test on the comparison of cognitive (posttest) and affective learning outcomes between the control class and the experimental class is greater than 0.05, thus it can be concluded that the research information has a homogeneous range of values.

Table 5. The Result of Independent Sample t Test on Cognitive and Affective Learning Outcomes

Learning Result	Class	N	Mean	F_{count}	db	Sig.	Description
Cognitive	Experiment	23	85,09	4,780	44	0,000	Significantly Different
	Control	23	73,13				
Affective	Experiment	23	71,38	0,789	44	0,434	Insignificantly Different
	Control	23	76,45				

Description: $F_{table\ (5\%;\ 44)} = 2{,}015$

The results of the Independent Sample F-Test on cognitive learning outcomes indicate that there is a significant difference because Fcount> Ftable or the significance value is smaller than the 5% of real level, while affective learning outcomes do not have a significant difference between the control class and the experimental class due to the tcount <Ftable or the significance value is greater than the 5% of real level. Regarding to these results, that STEAM can improve student cognitive to be better than inquiry learning, but it is not for students' affective.

Discussion

1. Differences in Cognitive Learning Outcomes using STEAM and Inquiry Learning

The implementation of STEAM learning in this study was carried out in class of V Theme 6 Heat and Its Transfer. Learning encourages students' knowledge and activeness in making STEAM-based science work with curiosity so that students are more (Afriana, 2016; Prameswari, et al, 2020). In the five lessons, students made a simple thermometer, simple refrigerator, and simple air conditioner which had been preceded by questions posed by the teacher. Every learning that has been carried out proves that STEAM can develop students' skills and abilities in communication (Komarudin, 2018).

Through the practice of creating concrete media (products), it indicates that the meaning and active participation of students in learning. Learning that arouses students' enthusiasm in addition to developing curiosity and it also develops the creativity, cooperation, both intellectual and psychomotor (Falentina, Lidinillah, & Mulyana, 2018). Learning that is carried out in groups, it can increase the innovation because through the same basic material but with different forms so that the students know the effect of the engineering being made. Students tend to be provided a variety of knowledge requiring memorization, while the world of work, in general, requires an individual's skills to work collaboratively or in a group and the ability to create innovative ideas. Students should be trained to have the ability to solve problems with knowledge. Learning is no longer a "Transfer of Knowledge" (Kadek Suartama et al., 2020).

Corresponding to the 5M in the 2013 curriculum, learning is carried out in 6 STEAM stages, namely focus, detail, discovery, application, presentation, and link (Rachim, 2019). At the beginning of learning, students are given inspiration through the use of technology, namely videos of everyday life that link new knowledge with existing ones (Al-Tabany, 2017). Then a question and answer session is conducted, to determine the product to be made as a solution to the heat effect (ECLKC, 2020). Students are given the freedom to use various tools and materials and interact with the environment, namely in the classroom, outside the classroom, and at home (Christie, 2016; Christina & Kristin, 2016). Through the products that have been made, students train their creativity through an illustration as decoration. In addition, in the learning process, besides the guidance of teacher, students are also guided by student worksheets that can support learning outcomes (Haifaturrahmah, Hidayatullah, Maryani, & Nurmiwati, 2020). After completing the students' results were presented and tested to discover the impact of the results of different models and product sizes (mathematics).

In contrast to the implementation of inquiry learning, even though the learning material delivered is the same in almost the same way, namely students find themselves the material that is taught by doing questions and answers, conveying ideas, and conducting experiments. However, the learning of student is not supported by video media (technology) which makes it easier for students to go through problems in real life. In the implementation of the experiment, students are limited to the guidelines that have been given by the teacher, so that students are not free to be creative. In addition, students are merely limited to those in the class.

Dealing with the result, it found that there were differences in cognitive learning outcomes between groups of students who used STEAM and groups of students who used inquiry learning. This was proven by the t-count value of 4.780 with a significance value of 0.000. Because the value of t-count> t-table, from db = 44 or the significance value was smaller than the real level of 5%.

2. Differences in Affective Learning Outcomes using STEAM with Inquiry Learning

Learning implements affective values in the form of activeness, cooperation, and tolerance. The learning delivered by the teacher begins with a problem by giving students the freedom to express their ideas actively and freely but still focus on the learning material besides that the teacher must also take into account the allocation of time appropriately. It does not merely accept the simple or general examples, but students get new things that have not been known from examples of life around them. The development of students' curiosity, it encourages the competence of students' knowledge by critically conveying their ideas both from discussions and presentations. Learning encourages students' skills in making STEAM-based science works with curiosity so that students are more likely to be interactive (Afriana, 2016; Prameswari, et al, 2020).

STEAM gives students the opportunity to understand science through everyday life by creating projects that support activity, collaboration and tolerance. Students do not merely pay attention and listen to teachers, friends, and videos, but students can ask questions, convey ideas classically or in groups, complete projects freely, thus, students are more active and more involved in learning which can increase deep understanding, increase collaboration, and students feel happy and confident because socialization among students and help each other in project to achieve a better learning outcome (Fitriah et al., 2018; Pratiwi et al., 2018; Kanza et al., 2020). This is in accordance with the research of Meidayanti et al., (2019) that students' self-confidence can increase in doing something or self-efficacy. In this case each student has different characteristics which requires the learner's full attention and shade (Armadani, Ardhana, Degeng, & Effendi, 2017). However, the affective of students using STEAM was lower than using inquiry learning.

In inquiry learning in the control class, it emphasizes students to find and understand the material independently. Students are led to have a high curiosity to actively find out through experiments provided by the teacher and attempt to find through events systematically, critically, logically, and analytically (Junaidi, Duling, & Wiyogo, 2020).

Conclusion

There was no difference in affective learning outcomes between groups of students who used STEAM and groups of students who use inquiry learning. This was evidenced by the acquisition of a t-count value of 0.789 with a significance value was 0.434. It is expected that learning will often be carried out by allocating appropriate time so that learning objectives can be achieved properly. The development of technology media and projects that are being carried out, it can be developed. In addition, it gives the freedoom for students to be creative without depending on teachers' guidelines. In addition, it can prove that STEAM does not only improve the cognitive but also affective.

Suggestions

It is expected that learning will often be carried out by allocating appropriate time so that learning objectives can be achieved properly. The development of technology media and projects that are being carried out, it can be developed. In addition, it gives the freedoom for students to be creative without depending on teachers' guidelines. In addition, it can prove that STEAM does not only improve the cognitive but also affective.

Limitations

The limitations of The Effect of STEAM Strategy on The Cognitive and Affective Learning Outcomes of Primary School are:

1. The learning tools developed are only focused on the theme of heat and its transfer, the sub-themes of temperature and heat are integrated into six subjects, including (a) Science, (b) Indonesian, (c) PPKn, (d) Social Studies, (e) SBdP, (f) Mathematics
2. In every lesson, six subjects are not always carried out, but only two to three subjects can be integrated according to the theme.

3. There are only two lessons that make STEAM products, namely in lesson 2 making a simple thermometer and learning 5 making simple air conditioners, while in other lessons only doing a practicum.
4. The validity test of learning tools is carried out by three material expert validators consisting of two lecturers in the science field and one elementary school lecturer.

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