Effectiveness Of The Steam-GBL Approach with The Help of Educated Games to Improve Students' Science Learning Achievement

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Abstract. This study focuses on improving science education, specifically in the area of temperature and heat, where only 45% of students achieve the Minimum Passing Grade (MPG). Using the STEAM-GBL model with Educandy Games, the aim is to provide a more comprehensive understanding of the material and connect it to the real world, making it easier for students to grasp. The primary objective is to assess the effectiveness of the STEAM-GBL model in enhancing science learning achievements, particularly regarding temperature and heat. The study involved 52 seventh-grade students exposed to the experimental model. Statistical analyses, including t-tests, N-Gain, and effect size calculations, were employed. The results indicate that the learning model significantly influences student achievement (sig. = 0.026 ¡ 0.05). The N-Gain analysis reveals that the experimental class achieved a higher score (0.66) compared to the control class (0.43), both falling in the medium category. However, the experimental class's N-Gain score is notably higher, almost reaching the high category. Among subtopics, temperature had the highest N-Gain score in both classes, followed by expansion, with heat scoring the lowest. Additionally, challenges related to the concept of heat had the highest N-Gain score, while problems associated with the effects of heat on changes in the state of matter had the lowest N-Gain score in both classes. The effect size analysis indicates a moderate impact (d = 0.6) of the STEAM-GBL model on improving student achievement. In conclusion, the STEAM-GBL model, combined with Educandy Games, effectively addresses challenges in teaching temperature and heat, as evidenced by significant improvements in student achievement. Therefore, educators are encouraged to consider integrating the STEAM-GBL model into their teaching methodologies to enhance science learning experiences

Keywords: STEAM-GBL model, educandy games, physics education

1 Introduction

PISA or Program for International Student Assessment is a global test conducted by the Organization for Economic Co-operation and Development (OECD) to test students' proficiency in literacy, science and mathematics in various countries. Indonesia

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is ranked 74th out of 77 countries taking part in the 2018 PISA science test, with an average score of 396, which is below the OECD average of 489 [1]-[2] state that science is designed to help students develop their skills and abilities in mastering science concepts. Science is not only related to understanding facts or information about the universe, but also related to how to solve problems and develop critical thinking skills. Science material for class VII Junior High students consists of 7 materials in one year. This material includes matter and its changes, magnitude and size, motion and force, temperature and heat, ecology and biodiversity, classification of living things, as well as the earth and the solar system [3] In the study of Natural Education (IPA), one of the materials that often encounter problems is temperature and heat [4]. Ineffective teaching methods such as the use of lecture methods or learning that are only theoretical in nature can make it difficult for students to understand temperature and heat materials so that student achievement becomes low [5]. One of the materials that often encounter problems is temperature and heat [4].

Students will study material about temperature and heat throughout their education level, from elementary school to university. These concepts are applied to everyday life in junior high school student learning. Even so, students often experience difficulties in understanding the concept. One of the difficulties students face is to think of temperature and heat as the same thing, even though temperature is a measure of the degree of warmth or coldness of an object, while heat is the transfer of energy from a hotter object to a colder object [6]. From a research study conducted by [7] said that if the level of difficulty in understanding the concept of temperature and heat is 68.57%, the level of difficulty in calculating temperature and heat is 40.0%. From these results it can be seen that the level of difficulty of students when studying temperature and heat materials is still high [7]. [8] in his research also explained that in terms of temperature and heat, student achievement was lower than other natural science materials, as evidenced by 55% of students who were unable to reach the MPG (Minimum Passing Grade).

Applying PDEODE and PBL as learning models on temperature and heat material. Based on the results of this study, the use of the PDEODE and PBL learning models is the right level of learning to build learning situations in such a way that they can provide encouragement and focus students' thinking activities with their own learning models and abilities and participate in groups[9]. But the PBL learning model itself has drawbacks because it is difficult to organize teaching situations, which creates opportunities for noise, and teacher skills are required for good teaching leadership and management. In addition, students also experienced difficulties in the data collection process and also made some children passive in groups [10].

The development of other learning media was also carried out in the form of a game of snakes and ladders on the topic of temperature and heat. According to the assessment of experts, the use of the snakes and ladders game as a medium for learning physics to discuss the concept of temperature and heat in Junior High Students has a level of accuracy that is included in the category of "very good" according to the concept expert, "good" according to the media expert, and "very good". " according to the teacher. However, the game also has not presented daily problems so that it seems less challenging for students. Meanwhile, everyday problems can be solved by students in groups who can actively produce alternative miniature technology solutions as solutions to these problems [11]. Such activities are fulfilled by the STEAM model. Therefore learning science through STEAM-based games can be used as a selection of appropriate learning presentations to find problems and draw conclusions by applying them through engineering, science, mathematics, and technology.

STEAM is basically a model and also a business that combines its elements, namely STEAM [12]. The application of STEAM-based science learning helps increase student learning interest. In the STEAM model, students can naturally solve problems in a systematic way. Previous studies have shown that many students are uneducated then motivated for STEM learning, and for many students their motivation to engage in STEM-based lessons has decreased and can cause students to avoid STEM-based learning. Learning these disciplines is considered to have various difficulties and challenges because the subject is complex, abstract, and multidimensional. Meanwhile, educational games are considered to have great potential to meet these challenges and have a positive impact on student acquisition and achievement [13].

Educational games require innovative learning models that can adapt learning activities to be more enjoyable for children. Appropriate innovative learning is game-based learning (game-based learning = GBL). Game-based learning refers to an educational system in which teachers can adapt games to suit students' cognitive interests and learning motivation [13]. Furthermore, researchers have noted that educational games can achieve various STEM learning goals and can increase students' motivation to learn, increase their intelligence regarding knowledge concepts and develop their own problem-solving skills [14]. As a universal product, the use of games for STEAM does not only rely on achieving better learning outcomes, but also needs to stimulate young people's interest in STEAM as a future career from an early age [13]. Many application functions can be used as learning media along with current technological developments, such as the Kahoot application [15]. Kahoot is a web-based learning application that allows users to create and take interactive quizzes online. Even though Kahoot offers quite complete features for creating interactive quizzes, there are still some limited features [15]. Another learning application that can be used is Educandy Games. Educandy Games is a web-based learning application that provides various types of games that can be used to create quizzes, flashcards and other interactive games [16]. (However, the extent to which Educandy Games is the most suitable choice for STEAM-GBL may vary depending on specific educational goals and context. It's worth noting that the use of Educandy Games in the context of STEAM-GBL may still be relatively uncommon, and its adoption may benefit from further exploration and implementation in educational settings.

It appears that Educandy Games within the STEAM-GBL framework have the potential to enhance students' understanding of temperature and heat concepts. However, their utilization in heat-related learning materials remains limited. Educandy Games is an educational game application that serves as a valuable learning resource, yet it remains relatively unfamiliar to many individuals. According to [17], Educandy Games is a web-based application with the motto "Makes Learning Sweeter," offering an engaging and enjoyable learning experience. These games are designed to be educational but not dull. They can be utilized both offline in the classroom and online, making them adaptable to various learning environments. Students often find games appealing when seeking relief from boredom and stress. Given the aforementioned background, the research aims to investigate the effectiveness of the STEAM-GBL model with the assistance of Educandy Games in enhancing student learning outcomes in the context of temperature and heat.

2 Method

This study used a quasi-experimental method with a pre-posttest design. The research population was class VII students in one of the Junior High School in Indonesia who were currently taking science lessons about temperature and heat. The sample was selected using the cluster random sampling technique, where each class has the same opportunity to be sampled. There were two sample groups, namely the experimental class (26 students from class VII G) and the control class (26 students from class VII A). Pre-test and post-test are used to measure student achievement before and after treatment. The research design can be seen in table 1.

Table 1. Research Design

Group	Pre-test	Treatment	Post-test
Experiment	O1	X1	O2
Control	O1	X2	O2

Information :

O1: Tests on the experimental and control groups before being given treatment
X1 : Students learn how to apply STEAM-GBL with the help of Educandy Games
O2 : Tests on the experimental and control groups after being given treatment
X2 : Students get conventional learning

In this study the experimental class used 3 STEAM-GBL cycles in 6 meetings and each cycle had 2 meetings, which means that each cycle was carried out for 2 meetings and total learning using the STEAM-GBL model was carried out for 6 meetings. The convention model used in the control class also uses the same pattern with 3 cycles for 6 meetings, with each cycle being carried out for 2 meetings. The main difference between the two classes lies in the learning instruments used. In the experimental class, the learning instruments used came from researchers, while in the control class the learning instruments came from schools. The instruments used in the experimental class were designed to be able to measure student achievement taught through the STEAM-GBL model. Thus, the use of learning instruments from researchers in the experimental class is expected to provide a more accurate picture of the effectiveness of the STEAM-GBL model in improving student achievement. Whereas in the control class, learning instruments from schools were still used to compare the effectiveness of the STEAM-GBL model with conventional models that had existed before.

In this study, the analysis technique used included prerequisite tests, namely the normality test and homogeneity test. In addition, the t-test is used to evaluate the level of effectiveness, while the N-Gain test is used to measure the increase in students' understanding or achievement before and after an intervention. Based on the results of the N-Gain test calculations, the level of learning effectiveness is then categorized according to table 2.

Table 2. N-Gain Category (Meltzer, 2002)

N-Gain Value	Interpretation
$g > 0.7$	High
$0.7 > g \geq 0.3$	Moderate
$0.3 > g$	Low

Then in order to measure the effectiveness of the STEAM-GBL learning model, an effect size test was carried out. The effect size test is a statistical technique used to evaluate the effectiveness of a learning model in a study. By using this technique, it can be determined how large the scale of the effectiveness of the learning model that has been carried out [18].

3 Result and Discussion

Pretest and posttest data were obtained from the experimental class and the control class, each of which consisted of 26 students. Student achievement (pretest and posttest) was taken from the cognitive domain of students in the form of a written test in the form of multiple choice of ten questions according to indicators of the cognitive domain. The range of values given is 0-100. Study results data can be seen in table 3.

Table 3. Students' Pretest-Posttest Scores

	Experiment Class		Control Class	
	Pre-test	Post-Test	Pre-test	Post-Test
The highest score	60	100	50	80
Lowest Value	20	60	10	50
Average	40,77	80,00	30,40	60,38
Standard Deviation	10,71	10,74	10,91	11,43

In Table 3, it can be seen that the results of the pretest of the experimental class and the control class were different, which means that the results of the similarity test of the initial state of the pretest of the experimental class and the control class showed that the initial conditions before learning in the experimental class and the control class were different. In other words, there are differences in student achievement that will be taught using STEAM-GBL and those that will be taught without using STEAM-GBL.

Because the pretest results of the experimental class and the control class are different, it is necessary to find the average increase of each class according to table 4.

Table 4. Student Pretest-Posttest Improvement Results

	Experiment Class	Control Class
Average Increase	39,23	29,61
Standard Deviation	13,884	15,80

In table 4, it can be seen that the results of the pretest-posttest increase in the experimental class were higher than the control class. The relationship between the effectiveness of the STEAM-GBL approach to learning and student achievement can be seen using the t-test. Before testing, the pre-test and post-test data must be tested for normality and homogeneity. The normality test aims to determine whether the average student achievement scores are normally distributed. The normality test was carried out using the SPSS (Statistical Package for Social Science) application using the ShapiroWilk criteria. The normality test results were obtained as shown in Table 5.

Table 5. Normality test results

Tests of Normality				
Class		Shapiro-Wilk		
		Statistic	df	Sig
Learning achievement	Experiment	0,913	26	0,051
	Control	0,954	26	0,290

Berdasarkan hasil perhitungan uji normalitas yang telah dilakukan diperoleh hasil nilai signifikasi kelas eksperimen dan kelas kontrol ¿ 0.05 artinya seluruh data terdistribusi normal.

Table 6. Homogeneity test results

Test of Homogeneity of Variance				
	Levene Statistic	df 1	df2	Sig.
Learning achievement Based on Mean	0,000	1	50	0,385

Based on table 6, it is known that the significance value is 0.385 ¿ 0.05, so as the basis for decision making in the homogeneity test, it can be concluded that the variance of the pretest and posttest learning outcomes data is the same or homogeneous. After the normality and homogeneity tests were carried out, then the analysis was carried out with the t-test. The results of the t-test (independent sample t test) are presented in Table 7.

Table 7. t-Test

	Conclusion Significance	Conclusion Significance
Experiment-Control	0,026	H0 is rejected

In the t-test calculation results obtained a significance value of 0.026 ¡0.05, which means that the alternative hypothesis formulated in this study is accepted. From this study it can be concluded that there are differences in student achievement between the STEAM-GBL learning model and the conventional learning model. This is in accordance with the operationalization of researchwhere conventional learning tends to use one-way teaching methods (from teacher to student), while STEAM-GBL uses more student-centered teaching methods and allows students to learn through collaboration, exploration, and projects which will later affect their learning achievement [19].

To find out the level of effectiveness of the STEAM-GBL model on temperature and heat material on student achievement, the N-Gain test was carried out. The aim is to determine the increase in student achievement before and after treatment. The N-Gain test results are shown in Table 8.

Table 8. Test n-gain

Class	**N-Gains**
Experiment	0.66 (Currently)
Control	0.43 (Currently)

Based on table 8, it shows that the N-Gain of the experimental class is 0.66 higher than the N-Gain of the control class is 0.43 and both are in the medium category, but the N-gain experimental class is higher and even almost reaches the high category. This is because in the STEAM-GBL learning process, students are faced with situations that demand solving real problems and building useful products or works. To achieve this goal, students need to use critical and creative thinking skills, as well as the ability to analyze and evaluate the information obtained.These results indicate that STEAM-GBL learning is better than learning that does not use STEAM-GBL in improving student achievement.Learning with modelsSTEAM-GBLcan help in solving problems for students by thinking about relevant theories and concepts. Games and simulations have the potential to advance various STEAM learning goals, including motivation to learn science, conceptual understanding, and scientific discourse. Games are considered to have great potential to meet this challenge and have a positive impact on student achievement. Games based learning in STEAM learning has become a new way of learning in education and is a suitable learning model for teaching STEAM disciplines.

The results of a similar study were conducted where the result was an increase in student learning achievement in science learning with the STEAM model on rigid body equilibrium material. This is because with the STEAM model students are active in finding and finding the core of the material being taught.Applying technology with a pedagogic approach to learning can make it easier for students to understand concepts well when they are working on project assignments, which will have an impact on high learning outcomes [20]. According to [21] students like the learning process that involves experiments. STEAM Learning In a project, students can get direct experience in solving real problems, which can make them more actively involved in learning activities [22]. This can add to students' scientific attitudes and skills and provide a memorable learning experience, which in turn can achieve good learning achievements and support student careers in the future.

Table 9. N-Gain Subtopics

Subtopic	N-Gain Experiment Class	N-Gain Control Class
Temperature	0.88 (high)	0.65 (moderate)
Heat	0.52 (moderate)	0.28 (low)
Expansion	0.87 (high)	0.55 (moderate)

From that datashown in table 9, it is understandable if the experimental class achieved higher N-gain values on the three subtopics tested compared to the control class. However, the heat subtopic showed the lowest N-gain value in both classes. These results are in accordance with research previously carried out by [6] Taqwa (2020) which found that there was a fairly large level of misconceptions about the heat subtopic, namely 46 (56.10%) students. As is known, heat is a topic that often causes misconceptions in students. Students often experience misconceptions when solving questions about mixing two types of objects that change form to achieve thermal equilibrium. [6].

This research includes 10 questions in multiple choice form. The N-Gain score for each question is presented in table 10.

Table 10. N-Gain Question

No.	N-Gain Experiment Class	N-Gain Control Class
1	1.00 (high)	1.00 (high)
2	1.00 (high)	1.00 (high)
3	0.83 (high)	0.52 (moderate)
4	0.73 (high)	0.44 (moderate)
5	0.36 (moderate)	0.23 (low)
6	0.44 (moderate)	0.13 (low)
7	0.53 (moderate)	0.28 (low)
8	0.90 (high)	0.37 (moderate)
9	0.75 (high)	0.45 (moderate)
10	1.00 (high)	0.71 (high)

N-gain results respectivelythe questions in table 10 explain if the experimental class achieves a higher score level than the control class, with a difference of up to 80%. In question numbers 1 and 2, the experimental and control classes had perfect scores, where in questions 1 and 2 discussed the concept of temperature without counting. This is in accordance with the statements of students when interviewed which stated that they understood more and found it easier to work on questions without calculations than questions that used calculations. Question numbers 5 and 6 have low N-gain scores in both classes, where the two numbers discuss the relationship between heat and temperature. These findings are in line with the results of which found that students experienced a 48.32% misconception about the concept of the relationship between temperature and heat. The results of research conducted by [23] revealed that students had a wrong perception about the bond between the specific heat of a substance and the length of the temperature change. They thought that the longer the temperature change occurred, the lower the specific heat of the substance. In fact, according to the equation $Q = mc\Delta T$, the magnitudes between c and ΔT are inversely proportional. This shows that students' understanding of the relationship between temperature and heat is still lacking.

Analysis of the effect size of student achievement was carried out in the experimental class and the control class. The result of the effect size test is d = 0.6 in the "medium" category. These results indicate that the operationalization of STEAM-GBL has an impact on the moderate category to improve student achievement. It is recommended that the STEAM-GBL proposal be widely applied in an effort to increase student achievement. Based on the research findings, the recommendation that can be put forward is to widely adopt the STEAM-GBL model to enhance student learning achievement. These findings indicate that the implementation of this model has a significant impact in the "medium" category on improving student achievement. Therefore, it is suggested that the STEAM-GBL proposal be widely applied in an effort to increase student learning achievement.

4 Conclusion

In accordance with the results of the analysis and discussion that has been carried out, a conclusion can be drawn if there is a significant difference in student achievement between the STEAM-GBL learning model and the conventional learning model, as seen from the t-test conducted. From the results of the N-gain analysis, it can be concluded that the experimental class with a score of 0.66 has a higher score than the control class which has a score of 0.43and both are in the moderate category, but the N-gain experimental class is higher and even almost reaches the high category. The difference lies in the magnitude of the increase, especially at the cognitive level of questions C4. The temperature subtopic had the highest N-Gain score in both classes, followed by expansion subtopic and finally heat. The problem with the concept of heat has the highest N-Gain score in both classes, while the problem with the effect of heat on changes in the state of matter has the lowest N-Gain score in both classes. Effect size analysis with the result d = 0.6 shows that the operationalization of the STEAM-GBL model has a "moderate" effect on improving student achievement. The outcomes of this study underscore the model's effectiveness, as evidenced by the significant improvement in student achievement. As a result, it is recommended that educators consider integrating the STEAM-GBL model into their teaching methodologies to foster enhanced science learning experiences.

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