Vol 10(2) (2021): 169-176
DOI: http://dx.doi.org/10.24235/sc.educatia.v10i2.9093

SCIENTIAE EDUCATIA: JURNAL PENDIDIKAN SAINS

http://www.syekhnurjati.ac.id/jurnal/index.php/sceducatia

The Effects of Generative Learning Model for Learning Temperature and Heat on Science Learning Outcomes

Boby Syefrinando, Rahmi Putri Wirman, Fibrika Rahmat Basuki*, Nova Andriani

Department of Physics Education, Faculty of Tarbiyah and Teacher Training, UIN Sulthan Thaha Saifuddin Jambi, Indonesia

*Corresponding author: Jl. Jambi–Muara Bulian KM. 16, Kab. Muara Jambi, Provinsi Jambi, Indonesia. E-mail addresses: fibrikabika@yahoo.com

article info

Article history:
Received: 06 October 2021
Received in revised form: 20 October 2021
Accepted: 08 December 2021
Available online: 31 December 2021

Keywords:
Generative model
Outcome learning
Science learning
Temperature and heat

abstract

This study aimed to determine the effects of the generative learning model for learning temperature and heat on science learning outcomes. This study was quasi-experimental research and used a non-equivalent control group design involving control and treatment groups. This research investigated class seven Islamic Junior High School students in Jambi Province, Indonesia. Random cluster sampling was used to select the control and treatment classes. The data were collected by the science learning outcomes test with the pretest and posttest. The data were analyzed using a t-test. The results of the t-test showed t_{count}= 2.74 > t_{table} with a significance level of 5%. Therefore, the H_0 is rejected. The generative learning model significantly affected students' science learning outcomes when discussing temperature and heat. The science learning outcomes of the treatment class were higher than those of the control class.

1. Introduction

The problem of science learning in Indonesia is students' low-scientific literacy at a junior high school level. The Programme for International Student Assessment (PISA) in 2018 revealed that Indonesia was ranked 74th of 79 countries with a score of 396 (OECD, 2019). Scientific literacy refers to the ability to use scientific knowledge to analyze and solve problems of science and daily life (Snow & Dibner, 2016). Moreover, it is closely related to understanding the concepts of science. Students who understand these concepts will apply them to solve scientific problems. Scientific literacy positively correlates with science learning outcomes (Bayram & Comek, 2009; Jufrida et al., 2019). Therefore, low scientific literacy indicates low science learning outcomes.

The problem of low science learning outcomes also occurred in one of the Islamic junior high schools in Jambi Province, Indonesia. The average score of 95 class seven students of science learning outcomes in the even semester 2019/2020 was 59.4. This score is still below the specified minimum completeness standard 70. Meanwhile, only 39% of the students reached the minimum completeness. Data of science learning outcomes are shown in Table 1.

Table 1. The average score of class VII students at Islamic junior high school in Jambi

Class	Average scores	Students passing the standard	Students failed the standard
VII A	55.5	8	23
VII B	64.7	17	15
VII C	58.1	12	20
Total		37	58

Source: Science teacher at Islamic junior high school

The result of observing an Islamic junior high school in Jambi denotes that the science learning process still applies the teacher-centered method. The teacher did not use various learning models while the students participated in learning activities by paying attention to the teacher's material and examples conventionally presented. Moreover, the teacher did not give the exercises at the end of the lesson. They were less actively involved in discovering scientific concepts and were not accustomed to constructing their knowledge through investigations or experiments individually or in groups. Moreover, the teacher did not optimally utilize ICT-based teaching materials and learning media because he only used science textbooks and blackboard to teach. Therefore, it is necessary to improve the quality of science learning and create a learning model following the characteristics of the science subject matter.

Science is the study of natural phenomena through scientific processes and attitudes to find concepts, principles, laws, and theories. The national curriculum (K13) formulates that science learning aims to develop scientific attitudes, knowledge, and scientific process skills by observing a phenomenon, questioning a problem, gathering information, associating or analyzing a phenomenon, and communicating the investigation results. Temperature and heat are topics studied in grade seven. The students must master the basic competencies of analyzing the concepts of temperature, expansion, heat, heat transfer, and its application in daily life. The concepts of temperature and heat have previously been studied and introduced at the elementary level. In other words, students at a junior high school level have learned the concept of temperature and heat materials. Therefore, learning the topics of temperature and heat must be designed with learning models that accommodate and bridge the students' conception.

There are several learning models suitably applied in science learning: inquiry, discovery, problem based-learning, generative learning, learning cycle (5E and 7E), prediction observation evaluation (POE), and cooperative learning (Rusilowati et al., 2019). The generative learning model is suitably applied when learning temperature and heat. The generative learning model can construct the relationship between learning materials and students' knowledge or experience (Ariani, 2017). The generative model syntax is the orientation, concentration, challenge, and application (Ritchie & Volkl, 2000; Ulusoy & Onen, 2014). The generative learning model has four stages: orientation, idea disclosure and focusing, challenge, and application (Ariani, 2017).

In the orientation phase, teachers explore students' initial knowledge by asking several questions. They are trained to express their ideas of a topic studied bravely. Moreover, they can build an impression and get an overview of the topic discussed by linking the material with their daily activities (Firmansyah & Wulandari, 2016). in the focus phase, teachers give a question, or problem about the topics studied. Then, the students are asked to propose a temporary hypothesis or answer. Students are guided to conduct an investigation or experiment at the challenge stage. They discuss the results of the investigation and conclude the results of the investigation in the group (Rosdianto, 2019). Then, group representatives present the investigation results in front of the class. Students can test alternative ideas built to solve various problems (Irwandani, 2015).

Several previous studies revealed that the generative learning model affects creative thinking to discuss the buffer solution and hydrolysis materials (Wijaya et al., 2014), science process skills in light material (Rosdianto, 2019) that reduces students' misconceptions on circular motion (Firmansyah & Wulandari, 2016), students' learning outcomes on work and simple aircraft materials (Effendi & Pantriani, 2020), and comprehension of the scientific concepts (Irwandani, 2015). A study by (Maryani et al., 2020) discovered that the generative learning model using the PQ4R method through scaffolding affected physics problems. The generative learning model is based on hands-on activities and affects students' critical thinking skills in dynamic fluid material (Uki et al., 2017).

The fundamental difference in this research is applying a generative learning model supported by media using Adobe Flash Professional CS6, graphic design software to design presentation media, moving animation, and simulation. This learning media of this research served to present temperature and heat materials. The ICT-based learning media is expected to make the learning process more interesting. The generative learning model was applied to temperature and heat materials for grade seven students of Islamic Junior High School. This research aimed to determine the effect of a generative learning model for learning temperature and heat materials on science learning.

2. Method

The quasi-experimental research aimed to determine the effects of a generative learning model for learning temperature and heat materials on science learning outcomes. This research used a non-equivalent control group design and involved the control and treatment groups (Maciejewski, 2020; Miller et al., 2020). This research investigated grade seven Islamic Junior High School students in Jambi Province, Indonesia. Random cluster sampling was used to select the control and treatment classes (Williamson & Johanson, 2017). Class VIIb (N = 32) served as the treatment group, and class VIIc (N = 32) served as the control group.

In the treatment class, temperature and heat were taught using the generative learning model supported by Adobe Flash Professional CS6 media. Meanwhile, the learning activities consisted of four phases: orientation, focus, challenge, and application (Ulusoy & Onen, 2014). The teacher asked several questions to explore the students' initial conception of temperature and heat materials in the orientation phase. In the focus phase, the teacher gave questions or discussed the topic of heat; then, the students formulated the hypothesis. In the challenge phase, the students conducted investigations or experiments, discussed the results of the investigations in groups, and presented the results classically. In the application phase, the teacher gave questions about applying heat concepts to test the students' comprehension. In the control class, the heat materials were taught conventionally by using the question-and-answer method in PowerPoint.

The data of science learning outcomes were collected through pretest and posttest. The instrument used was the science learning outcomes test. The test consisted of multiple choices with four alternative answers. The questions comprised 20 items for the pretest and 20 items for the posttest. Before the test, the questions had been tested to gain validity, difference power, level of difficulty, and reliability. The reliability of the pretest and posttest questions was 085. The next step was to analyze the data of science learning outcomes using descriptive statistics to determine the mean, standard deviation, maximum, and minimum values. The improving science learning outcomes were analyzed using the N-gain test (Bao, 2006; Hake, 1998). The differences of the N-gain on science learning outcomes in the treatment and control groups were carried out by the t-test with a significance level of 5% (Kim, 2015; Mood et al., 2019).

3. Result and Discussion

The data were obtained from the pretest and posttest in the treatment and control classes. The students in the treatment class applied generative learning while the students in the control class applied traditional learning. The pretest, posttest, and N-gain results in the control and treatment classes are shown in Tables 2 and 3.

Table 2. Data of science learning outcomes in the treatment class

	N	Average	Standard deviation	Max	Min	Difference	N-gain
Pretest	32	43.7	10.4	70	30	33.5	0.61
Posttest	32	77.3	8.2	95	65		

Table 3. Data of science learning outcomes in the control class

	N	Average	Standard deviation	Max	Min	Difference	N-gain
Pretest	32	40.3	14.4	70	15	30	0.48
Posttest	32	70.3	5.9	80	60		

Table 2 shows that the learning outcomes in the treatment class increased by 33.5, with an N-gain of 0.61. Meanwhile, the learning outcomes in the control class increased by 30 with an N-gain of 0.48. To find out a significant difference in the average increase (N-gain) of science learning outcomes in the treatment and control classes, a hypothesis test was carried out by the t-test. The data must be tested using the normality and homogeneity test.

The N-gain normality test of science learning outcomes was carried out by the Kolmogorov-Smirnov test with a significance level of 0.05. The results of the N-gain normality test of science learning outcomes are shown in Table 4.

Table 4. The results of the N-gain normality test of science learning outcomes

Variable	Class	Kolmogorov-Smirnov		
		Statistics	df	Sig.
Science learning outcomes	Treatment	0.112	31	0.167*
	Control	0.135	31	0.158

Table 4 shows that the significance value of N-gain data from science learning outcomes in the treatment and control classes is > 0.05. Therefore, the H_0 is accepted. It shows that the N-gain data from science learning outcomes in the treatment and control classes were normally distributed.

The variance homogeneity test was carried out on the N-gain of science learning outcomes. Moreover, the homogeneity test was carried out by the Levene test with a significance level of 5%. The Levene test was carried out with the help of the SPSS 25 for Windows program. The results of the N-gain homogeneity test are shown in Table 5.

Table 5. The results of N-gain homogeneity test of science learning outcomes

Variable	Levene statistics	df_1	df_2	Sig.
Science learning outcomes	0.130	1	62	0.521

Table 5 shows that the N-gain significance value of science learning outcomes is 0.521 > 0.05. Therefore, the H_0 is accepted. It shows that the N-gain data of science learning outcomes had relatively similar/homogeneous variance.

The t-test conducted the hypothesis test to compare the average N-gain of science learning outcomes in the treatment and control classes. The t-test was carried out with the help of SPSS 25 for Windows program with a significance level of 5%. The decision criteria were employed to reject the H_0 if the significance value was < 0.05. The results of the t-test are presented in Table 6.

Table 6. The results of the N-gain t-test of science learning outcomes

Variable	t	df	Sig.
Science learning outcomes	2.74	62	0.000

Table 6 shows that the significance value of the N-gain on science learning outcomes is 0.000 < 0.05. Therefore, the H_0 is rejected. It shows that the average N-gain on science learning outcomes of students who applied the generative learning model was significantly different from those who applied the traditional learning method using PowerPoint. The application of the generative learning model significantly affected the students' science learning outcomes when discussing temperature and heat materials.

This research showed significant differences between science learning outcomes using the generative learning model and those using the traditional learning assisted by PowerPoint. The generative learning model syntax could connect the students' initial knowledge with the material studied and train students to construct knowledge through the investigation or experiment. The generative learning model requires students' active involvement to discover a concept; thus, the learning activities are no longer teacher-centered (Brod, 2021; Wardono et al., 2020).

The results of this research are in line with that of (Nafikah 2011), who discovered that the application of the generative learning model could improve students' science learning outcomes when learning the concept of heat transfer. The generative learning model effectively improves students' creative thinking skills and science process skills in buffer solution and hydrolysis materials (Wijaya et al., 2014). Moreover, the generative learning model can reduce students' misconceptions in circular motions (Firmansyah & Wulandari, 2016). The conceptual understanding of students who use the generative learning model is higher than that of students who use the conventional learning model (Irwandani, 2015). The generative learning model significantly affects science process skills in light material (Rosdianto, 2019).

Meanwhile, (Maryani et al., 2020) explain that the generative learning model affects the PQ4R method by scaffolding physics-solving capabilities. Implementing the generative learning model affects the students' learning outcomes when learning business and simple aircraft materials (Effendi & Pantriani, 2020). The hands-on-activity-based generative learning model to discuss dynamic fluid material affects students' critical thinking skills (Uki et al., 2017).

In this research, the learning activity explored students' conceptions of heat topics. At the orientation stage, the teacher displayed a slide that contained temperature and heat topics. This slide also displayed pictures or animations; thus, the students were more interested in learning. Then, the teacher explored the students' initial knowledge by asking some questions (Fiorella & Mayer, 2016; Rahayu et al., 2019). At the concentration stage, the teacher asked questions or gave temperature and heat materials problems. He also displayed the problem on the slide to clarify the problem. Then, the students were divided into groups. They discussed the materials in groups to formulate a hypothesis.

Moreover, they were challenged to conduct an investigation or experiment to solve the problems (Prawita et al., 2019; Roelle & Nückles, 2019). Furthermore, the students were given worksheets as a guide to conduct investigations. The worksheet consists of questions/problems, hypotheses, tools and materials, and procedures. Then, the students in groups conducted investigations/experiments to prove the hypotheses.

Furthermore, the students actively discussed some issues to analyze the results of the investigations or experiments and draw a conclusion (Hindriyanto & Kurniasih, 2018). The students were trained to communicate the investigation results in classical presentations. The teacher confirmed the concepts of temperature and heat learned. Moreover, he displayed a simulation of temperature and heat experiments. At the end of the lesson, the students were asked to work on exercises in applying the concepts of temperature and heat.

Meanwhile, in traditional learning, the students only paid attention to the teacher's PowerPoint presentation on temperature and heat materials. He gave some examples and explained the application of temperature and heat concepts in daily life. At the end of the lesson, the students were asked to work on exercises. Learning activities in this class tended only to transfer knowledge; thus, the students showed low involvement in finding concepts.

4. Conclusion

The application of the generative learning model significantly affected the science learning outcomes of grade seven students of Islamic Junior High School when learning temperature and heat materials. Students in the treatment class showed higher science learning outcomes than the students in the control class. The generative learning model could connect the students' initial knowledge of temperature and heat with the concepts studied. The model also involved students in solving problems through investigation and experiments. The learning activities began by exploring students' conceptions on heat topics. Then the teacher asked questions or problems concerning the effects of heat on temperature, the shape of the objects, and heat transfer. Therefore, the learning topics were focused. The students were given challenges to do investigation and experiments to solve problems and present the results of their investigation. At the end of the lesson, the students were asked to apply the concept to solve problems.

References

Ariani, Y. (2017). Developing college students' soft skills through generative learning model. *Proceedings of the 9th International Conference for Science Educators and Teachers (ICSET 2017)*, *118*, 830–834. https://doi.org/10.2991/icset-17.2017.42

Bao, L. (2006). Theoretical comparisons of average normalized gain calculations. *American Journal of Physics*, *74*(10). https://doi.org/10.1119/1.2213632

Bayram, H., & Comek, A. (2009). Examining the relations between science attitudes, logical thinking ability, information literacy, and academic achievement through internet-assisted chemistry education. *Procedia - Social and Behavioral Sciences*, *1*(1), 1526–1532. https://doi.org/10.1016/j.sbspro.2009.01.269

Brod, G. (2021). Generative learning: Which strategies for what age? *Educational Psychology Review*, *33*(4), 1295–1318. https://doi.org/10.1007/s10648-020-09571-9

Effendi, E., & Pantriani, D. (2020). Penerapan model pembelajaran generatif pada materi usaha dan pesawat sederhana kelas VIII MTs Nurussalam Sidogede OKU Timur. *Physics Education Research Journal*, *2*(1), 59. https://doi.org/10.21580/perj.2020.2.1.4906

Fiorella, L., & Mayer, R. E. (2016). Eight ways to promote generative learning. *Educational Psychology Review*, *28*(4), 717–741. https://doi.org/10.1007/s10648-015-9348-9

Firmansyah, J., & Wulandari, S. (2016). Penerapan model pembelajaran generatif untuk mengurangi miskonsepsi pada materi gerak melingkar. *Serambi Akademica*, *IV*(1), 18–27.

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, *66*(1). https://doi.org/10.1119/1.18809

Hindriyanto, Y., & Kurniasih, M. D. (2018). The influence of the generative learning model assisted with wingeom software on students' mathematical learning outcomes. *Formatif: Jurnal Ilmiah Pendidikan MIPA*, *8*(3). https://doi.org/10.30998/formatif.v8i3.2614

Irwandani, I. (2015). Pengaruh model pembelajaran generatif terhadap pemahaman konsep fisika pokok bahasan bunyi peserta didik MTs Al-Hikmah Bandar Lampung. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, *4*(2), 165. https://doi.org/10.24042/jpifalbiruni.v4i2.90

Jufrida, J., Basuki, F. R., Kurniawan, W., Pangestu, M. D., & Fitaloka, O. (2019). Scientific literacy and science learning achievement at junior high school. *International Journal of Evaluation and Research in Education (IJERE)*, *8*(4), 630–636. https://doi.org/10.11591/ijere.v8i4.20312

Kim, T. K. (2015). T test as a parametric statistic. *Korean Journal of Anesthesiology*, *68*(6). https://doi.org/10.4097/kjae.2015.68.6.540

Maciejewski, M. L. (2020). Quasi-experimental design. *Biostatistics and Epidemiology*, *4*(1). https://doi.org/10.1080/24709360.2018.1477468

Maryani, S., Sahidu, H., & Sutrio, S. (2020). Pengaruh model pembelajaran generatif dengan metode pq4r melalui scaffolding terhadap kemampuan pemecahan masalah fisika Peserta Didik. *Jurnal Pendidikan Fisika Dan Teknologi*, *6*(1), 82. https://doi.org/10.29303/jpft.v6i1.1562

Miller, C. J., Smith, S. N., & Pugatch, M. (2020). Experimental and quasi-experimental designs in implementation research. *Psychiatry Research*, *283*. https://doi.org/10.1016/j.psychres.2019.06.027

Mood, D. P., Morrow, J. R., McQueen, M. B., & Mood, D. P. (2019). Two-Sample t-test. In *Introduction to Statistics in Human Performance*. https://doi.org/10.4324/9781351211062-8

Nafikah, L. (2011). *Pengaruh model pembelajaran generatif terhadap hasil belajar fisika pada konsep perpindahan kalor*. UIN Syarif Hidayatullah Jakarta.

OECD. (2019). PISA 2018 Results. In *OECD Publishing*.

Prawita, W., Prayitno, B. A., & Sugiyarto, S. (2019). Effectiveness of a generative learning-based biology module to improve the analytical thinking skills of the students with high and low reading motivation. *International Journal of Instruction*, *12*(1), 1459–1476. https://doi.org/10.29333/iji.2019.12193a

Rahayu, R., Masrukhan, M., & Sugianto, S. (2019). Mathematics teaching using generative learning model with character-building content aided by interactive learning media. *Unnes Journal of Mathematics Education Research*, *8*(1).

Ritchie, D., & Volkl, C. (2000). Effectiveness of two generative learning strategies in the science classroom. *School Science and Mathematics*. https://doi.org/10.1111/j.1949-8594.2000.tb17240.x

Roelle, J., & Nückles, M. (2019). Generative learning versus retrieval practice in learning from text: The cohesion and elaboration of the text matters. *Journal of Educational Psychology*, *111*(8), 1341–1361. https://doi.org/10.1037/edu0000345

Rosdianto, H. (2019). Students' science process skills through generative learning model in the topic of light. *JIPF (Jurnal Ilmu Pendidikan Fisika)*, *4*(1), 8. https://doi.org/10.26737/jipf.v4i1.792

Rusilowati, A., Astuti, B., & Rahman, N. A. (2019). How to improve student's scientific literacy. *Journal of Physics: Conference Series*, *1170*(1), 012028. https://doi.org/10.1088/1742-6596/1170/1/012028

Snow, C. E., & Dibner, K. A. (2016). Science literacy. In C. E. Snow & K. A. Dibner (Eds.), *Science Literacy: Concepts, Contexts, and Consequences*. National Academies Press. https://doi.org/10.17226/23595

Uki, R. S., Saehana, S., & Pasaribu, M. (2017). Pengaruh model pembelajaran generatif berbasis hands-on activity pada materi fluida dinamis terhadap kemampuan berpikir kritis siswa. *Pengaruh Model Pembelajaran Generatif Berbasis Hands-On Activity Pada Materi Fluida Dinamis*

Terhadap Kemampuan Berpikir Kritis Siswa, *1*(2), 6–11. https://doi.org/10.15294/physcomm.v1i2.10431

Ulusoy, F. M., & Onen, A. S. (2014). A Research on the generative learning model supported by context-based learning. *EURASIA Journal of Mathematics, Science and Technology Education*, *10*(6), 537–546. https://doi.org/10.12973/eurasia.2014.1215a

Wardono, W., Rochmad, R., Uswatun, K., & Mariani, S. (2020). Comparison between Generative Learning and Discovery Learning in Improving Written Mathematical Communication Ability. *International Journal of Instruction*, *13*(3), 729–744. https://doi.org/10.29333/iji.2020.13349a

Wijaya, I., Suastra, M., & Muderawan, M. (2014). Pengaruh model pembelajaran generatif terhadap keterampilan berpikir kreatif dan keterampilan proses sains. *Jurnal Pendidikan Dan Pembelajaran IPA Indonesia*, *4*(1).

Williamson, K., & Johanson, G. (Eds.). (2017). Research methods: Information, systems, and contexts. Chandos Publishing.,