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The Effect of the 5E Learning Cycle Model Assisted by Problem-Solving-Based Student Worksheets on Student Learning Outcomes in the Material of Thermodynamics

Komalasari, Dwi Sulistyaningsih*, dan Eko Sujarwanto
Program Studi Pendidikan Fisika, Fakultas Keguruan dan Ilmu Pendidikan
Universitas Siliwangi, Tasikmalaya, Indonesia
*dwi.sulistyaningsih@unsil.ac.id

Abstract

This study examines the effect of the 5E learning cycle model assisted by problem-solving-based worksheets on student learning outcomes in thermodynamics material. The focus of the results studied includes aspects of knowledge, skills, and attitudes, especially cooperation, responsiveness, and self-confidence. This study used an experimental method with a post-test-only design. This research involved students in class XI MIPA at a high school in Singaparna. The results of hypothesis testing with the t-test and the Mann-Whitney test on student learning outcomes show that it is rejected, with a large effect size criterion. These results indicate that the 5E learning cycle model supported by problem-solving-based worksheets affects student learning outcomes in thermodynamics material. Thus, it can be concluded that the 5E learning cycle model assisted by problem-solving-based worksheets affects student learning outcomes on thermodynamics material.

Keywords: Learning cycle 5E; Learning outcomes; Problem-solving based worksheet

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INTRODUCTION

Education reflects the needs of dynamic human development and culture. In education, training, and mentorship, change or development in education is an interaction between teachers and students and learning materials. Implementing great education requires education development by the four pillars of education, which include learning to know, do, become something, and live together (UNESCO, 2015). Teachers must improve the learning process by using or developing new and relevant models, media, and other resources for the information they will learn. Students frequently regard physics material as challenging due to the numerous abstract concepts (Mahardika et al., 2022). According to Khoirunnisa (2020), physics is a scientific discipline concerned with the environment and its

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natural surroundings. Since abstract physics topics are typically difficult to grasp, students struggle to apply theories connected with everyday life. Generally, learning success with abstract material is lower than with concrete material (Jamuri et al., 2020). One type of material that contains abstract concepts and is difficult to understand is thermodynamics material. Thermodynamics is a fundamental subject in physics that investigates transferring energy through heat and work. Most students regard thermodynamics content as difficult if it only relies on the teacher's explanation, implying that the success rate of acquiring thermodynamics material remains low (Barokah et al., 2021). Physics learning objectives in the 2013 curriculum include concept mastery, knowledge and technological capability growth, and self-confidence. When learning physics, students must acquire skills and attitudes in addition to concepts and principles. As a result, students must be able to master concepts and actively participate in the learning process.

Observations at one Singaparna high school revealed that low learning outcomes were caused by low student participation in learning. They had difficulties articulating abstract and concrete physics concepts and applying them to an experiment. Therefore, they were less confident when communicating the experimental results with other friends. Then, there is a shortage of teaching materials or other supporting materials, such as LKPD (*Lembar Kerja Peserta Didik* or students' worksheets), to help students learn in class or during experiments. Schools continue to use student worksheets -focused instructional materials and books from publishers. As a result, some students cannot be independent throughout both learning and practicum. To overcome this, models and teaching materials are required. Learning cycle 5E is a model that can be used. The learning cycle 5E model is a paradigm that can focus students' attention on difficulties to pay attention to in the classroom when exploring, explaining, expanding, and evaluating learning. According to Reski (2020), the stages of the 5E learning cycle model include engagement, exploration, explanation, elaboration, and evaluation. Susanti et al. (2019) stated that utilizing the learning cycle 5E model could improve student learning. The learning cycle 5E approach creates an environment that encourages exploration and is student-centered (Djadir et al., 2021). The student worksheets is required in the learning process to facilitate and accommodate it. The student worksheets can help teachers with the learning process (Astuti, 2021). The student worksheets has had several developments, including using a model in preparation. The syntax of a problem-solving model is used to improve concepts, study guides, and practical instructions in student worksheets based on problem-solving. The student worksheets based on problem-solving is chosen because, according to the study of Sofiana et al. (2021), it can directly include students, for example, in problem-solving through various strategies such as reading, communicating, and good problem-solving teamwork.

According to the previous explanation, thermodynamics is a difficult material for students to understand if only the teacher's explanation is provided. It is intended that by using the learning cycle 5E model, which student worksheets based on problem-solving aids, students will be able to better understand thermodynamic content. The measured factors are learning results on knowledge with C1-C4 cognitive levels, attitude elements such as cooperation, responsiveness, self-confidence, and abilities that match the basic competencies of thermodynamics content. The use of PS-based student worksheets -assisted models

distinguishes this study from others. The student worksheets is utilized in the exploratory stage of learning. This study intends to examine the effect of the learning cycle 5E model on student learning outcomes in thermodynamics subjects utilizing problem-solving-based worksheets.

METHOD

The method used was experimental. Experimental research is a method used to find the effect of certain treatments on others under controlled conditions (Sugiyono, 2012). This study used a true experiment with a post-test only group design, in which the researchers post-tested both the control and experimental groups, but only the experimental group received treatment. Since there was no significant difference in the average score of learning outcomes between the experimental and control classes, the two groups could be considered similar. The experimental class was treated with the 5E learning cycle model and problem-solving worksheets, while the control class was treated with a traditional model and the same worksheets as the experimental class. The sample in this study consisted of students from two XI MIPA classes at a high school in Singaparna; the class was homogeneous based on the average score in the previous material. Data collection techniques were using tests and non-tests. The test instrument consisted of multiple-choice questions, whereas the non-test instrument consisted of a questionnaire and observation sheets. Tests were used to assess students' knowledge learning outcomes, while questionnaires and observations were used to assess students' attitudes and skills. The observation sheet, as was the performance sheet, was used to assess skills. The performance sheet was a compilation of data to assess students' abilities by observing their actions (Hamriani, 2018). The instrument used was a self-evaluation questionnaire and a friend assessment that included questions or statements in columns with Yes and No answers. Before being tested, test data was reviewed for validity and reliability, and experts validated questionnaires and observation sheets. The Biserial point test was used for validity, while the Kuder-Richardson (K-R 20) test was used for reliability. The number of valid and reliable questions was 24 out of 40 multiple-choice questions, and the reliability test results were 0.734. Sugiyono (2012) stated that the reliability value of 0.70-0.90 is a highly reliable category, so it could be concluded that the item instrument is reliable and feasible for use in research with a high-reliability category.

Furthermore, before evaluating the hypothesis, the test and non-test result data were subjected to a preliminary test, namely the normality and homogeneity tests. The Shapiro-Wilk test was used to test normality, whereas the F test was used to test homogeneity. A hypothesis test was performed after the data had been checked for normality and homogeneity. Since the data was regularly distributed and homogeneous, the t-test was used to test the hypothesis of knowledge and attitude data. However, the Mann-Whitney test was used to test the hypothesis of skills assessment data, which was not normally distributed.

RESULT AND DISCUSSION

The research collected data on students' knowledge, attitudes, and skills in the experimental and control groups.

Rating Result

Knowledge Aspect Learning Outcomes

Knowledge aspects derived from the post-test findings. Each test item represented one of the four cognitive levels: C1, C2, C3, and C4. Table 1 shows the proportion of the average score of students' physics learning outcomes for each cognitive domain of the experimental and control classes.

Table 1 Statistics average score

Statistics	Class E	Class K
C1 (Remembering)	95	88
C2 (Understanding)	83	74
C3 (Applying)	82	78
C4 (Analyzing)	78	73

Based on **Error! Reference source not found.**, the average post-test score of physics learning outcomes in thermodynamics material for the experimental class for each cognitive domain was always greater than the percentage of the average score for learning outcomes for the control class. **Error! Reference source not found.** contained statistics on student learning results on thermodynamic material for the experimental class and the control class as a whole.

Table 2 Knowledge aspect statistics

Statistics	Class E	Class K
Subject	37	36
Ideal Score	100	100
Highest Score	100	92
Lowest Score	67	63
Average	83.81	77.75
Variance	54.38	43.05
Deviation Standard	7.37	6.56

Attitude Aspect Learning Outcomes

Student attitudes were assessed by teacher observation of activities during learning activities and through questionnaires filled out by students. The questionnaires utilized were a self-assessment questionnaire that students filled out directly to examine self-attitude during learning and a peer-to-peer questionnaire that students filled out to assess their peers. Table 3 displays the combined findings of the attitude evaluation.

Table 3 Attitude assessment data

Indicator	Class E	Class K
Cooperative	84	81
Responsive	81	74
Self-confidence	75	64
Average	**80**	**73**

Based on Table 3, attitude aspect learning outcome data stated that the average attitude of the experimental class students was higher than that of the control class. This was because many students in the control class were still working independently and playing a lot in class.

Skills Aspect Learning Outcomes

Aspects of skills developed due to observations of students' activities while studying. When working on the student worksheets, students solved problems and performed small practicum exercises before presenting them. Table 4 displayed data from skill assessments.

Table 4 Skills assessment data

Indicator	Class E	Class K
Preparation	93	87
Process	84	76
Result	73	63
Average	**83**	**75**

Based on the findings, students' talents during learning could play an active role and collaborate with their respective groups, ensuring that group discussions ran well in the experimental class. Students were more courageous to ask questions regarding content they had not understood when studying.

Normality Test

The normality test results using the Shapiro-Wilk test are shown in Table 5.

Table 5 Normality test results

Statistic	Knowledge		Attitude		Skill	
	Class E	Class K	Class E	Class K	Class E	Class K
N	37	36	37	36	37	36
Average	83.81	77.75	80.03	73.17	83.14	75.25
T_3	0.967	0.940	0.960	0.952	0.894	0.930

Statistic	Knowledge		Attitude		Skill	
	Class E	Class K	Class E	Class K	Class E	Class K
Shapiro Wilk Table	0.936	0.935	0.936	0.935	0.936	0.935
Note	Normal	Normal	Normal	Normal	Abnormal	Abnormal

Table 4 showed that aspects of knowledge and attitudes were normally distributed, based on decision-making $T_3 \geq$ Shapiro-Wilk Table. In the skill aspect, learning outcomes data obtained $T_3 <$ Shapiro-Wilk Table, so the data was not normally distributed.

Homogeneity Test

The data tested was commonly distributed data, namely on knowledge and attitudes aspects. Table 6 displayed the homogeneity test results with the F test.

Table 6 Homogeneity test results

Statistic	Knowledge		Attitude	
	Class E	Class K	Class E	Class K
N	37	36	37	36
Average	83.81	77.75	80.03	73.17
Variance	54.38	43.05	78.42	88.37
F_{count}	1.263		1.127	
F_{table}	3.97			
Note	Homogeneous		Homogeneous	

The significance table used was 0.05 or 95%, with the decision being $F_{count} < F_{table}$, indicating that the data was homogeneous or had the same variance. The knowledge and attitude data indicated that the data was homogeneous.

Hypothesis Test

The hypothesis test for knowledge and attitudes was the t-test, while the Mann-Whitney test was used for skills. The test criteria were obtained from the t-distribution with a significance level of 95%. If $t_{count} \geq t_{table}$, H_0 was rejected, and H_a was accepted (Hartono, 2008). Table 7 shows the results of the knowledge and attitude hypothesis test.

Table 7 Knowledge and attitude hypothesis test

Statistic	Knowledge		Attitude	
	Class E	Class K	Class E	Class K
N	37	36	37	36
Average	83.81	77.75	80.03	73.17
Variance	54.38	43.05	78.42	88.37
t_{count}	3.71		3.21	
t_{table}	1.667			
Note	H_0 was rejected		H_0 was rejected	

The Mann-Whitney test was a non-parametric test that was used to analyze skill data. Table 8 displays the results of the skills hypothesis test. An effect size analysis was carried out using the post-test data. Table 9 shows the findings of this study's effect size analysis.

Table 8 Skills hypothesis test

Statistic	Class E	Class K
N	37	36
Number of Rankings	1.096	1.605
U Value	939	393
Ucount	393	
Z_{count}	-3.01	
Z_{table}	-1.96	
Note	H_0 was rejected	

Table 9 Effect size test results

Learning Outcomes	Effect Size	Interpretation
Knowledge	0.9	Large
Attitude	0.8	Large
Skills	0.7	Medium

Based on the findings of the above effect size study, it was clear that the 5E model of learning, assisted by problem-solving-based worksheets, impacted student learning outcomes.

In this study, both the experimental and control groups used problem-solving worksheets. The difference was in the model used, with the experimental class employing the learning cycle 5E model and the control class employing the cooperative model. Following that, the two courses were given a post-test to see if there were any changes in learning results in terms of knowledge. Observations were also done during the learning process to assess attitudes and skills.

This study's thermodynamic topic was covered in three meetings and one post-test at the end of the course. Learners formed groups, discussed, interacted, and assisted one another in accomplishing learning objectives.

Students in the experimental and control groups were given a post-test at the end of the meeting. The post-test results in the experimental class using the 5E learning cycle model assisted by problem-solving-based worksheets had the lowest score of 67 and the highest score of 100 with an average result of 83.81, while the average post-test result in the control class was 77.75 with the lowest score of 63 and the highest score of 92. According to the post-test average score, the students in the experimental class outperformed the control class in terms of learning outcomes.

The t_{hitung}score was 3.71, which was more than the t_{tabel} 95% confidence level of 1.667, based on the calculation of the t-test post-test findings. Based on the decision made, if $t_{hitung} > t_{tabel}$, then H_0 was rejected and H_1 accepted, indicating that the experimental and control classes had a significant effect on student learning results. The experimental class students outperformed the control class in terms of learning outcomes because they were more flexible in discussing with their groups during the exploration and explanation stages; when students were allowed to exchange information about the material they were studying, students were more interactive, and they were even able to connect learning material with real life during the elaboration stage. Participants in the elaboration approach used prior knowledge to elaborate on new ideas, retaining more information than was initially offered to students. This was in line with the study findings of Harneli et al. (2019), that 5E learning could boost students' activity and knowledge of topics and that during the exploration stage, students addressed problems by observing, analyzing, and doing experiments on the student worksheets. Furthermore, knowledge of concepts in this research had three indicators: (a) Ability to restate concepts taught, (b) Ability to give examples of concepts studied, and (c) Ability to relate various concepts learned. The learning steps of the 5E learning cycle model, assisted by problem-solving-based worksheets, could make students more favorable to the learning process, resulting in more focused thought processes of students to absorb knowledge. The prior research of Nuraini

(2021) confirmed this, stating that the 5E learning model affected students' cognitive and affective outcomes. This was because students had gone through the learning process. According to her research, students were delighted with learning cycle 5E because they might sense a new learning atmosphere, which could be nice since they were directly involved in conducting a practicum in learning.

During the learning process, observations of student actions were made using observation sheets and questionnaires. Students were given a questionnaire to measure their and their peers' opinions during the physics learning process. According to the observation and questionnaire assessment results, the average attitude value in the experimental class was 80%, which was defined as very good. In comparison, the average in the control class was 73%, which was classified as good. The experimental class students demonstrated cooperative attitude, responsiveness, and self-confidence. The research of Wiyandari et al. (2017) stated that learning the learning cycle 5E model could help one create positive attitudes. In the control class, several aspects were still not maximized in learning, namely responsiveness, and self-confidence, because there were still many students who were less sensitive to learning and the classroom environment and did not take advantage of opportunities to comment or ask questions during learning. This indicated students in the control class did not successfully apply the responsiveness and self-confidence characteristics. The findings of the assessment of responsiveness and self-confidence in the control class were lower than in the experimental class. Students in the experimental class could follow the learning process using learning cycle 5E with PS-based worksheets, particularly in exploration and explanation syntax. According to Ariska (2017), using the learning cycle 5E model affected cognitive and affective learning outcomes because students were actively involved in learning. The enthusiasm of students influenced the quality of their learning.

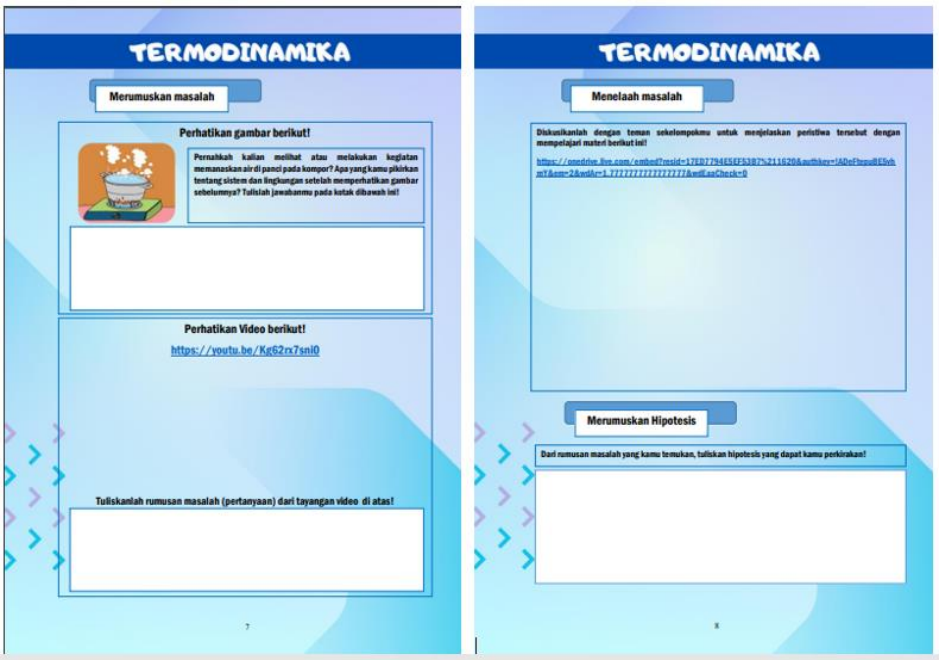

Figure 1 Problem-solving-based the student worksheets

There were differences in students' skills in the experimental and control classes, as evidenced by an average score of 83.14 for the experimental and 75.25 for the control classes. PS-based student worksheets assisted in using the learning cycle 5E model to include students in idea discovery throughout the exploration phase, namely by carrying out the problem-solving and basic experiment stages offered in the student worksheets, as illustrated in Figure 1.

These findings were supported by Halim et al. (2022), who demonstrated that problem-solving-based worksheets could increase students' skills since they were actively involved. Dani & Mz (2021) confirmed the findings of earlier studies on the skills aspect by claiming that combining learning models with problem-solving-based worksheets could make students active and excited about participating in learning. Students and their groups from the student worksheets collaborated to solve problems. According to Risa et al. (2021), research could increase problem-solving skills, idea mastery, and student attitudes. Students were encouraged to develop their creativity by the presence of a modest practicum. After completing the problem-solving process, students and their groups explained the results to other groups to compare or match the outcomes to the conclusion stage, ensuring that students understood the concepts ingrained in their cognitive structure. Furthermore, Sari et al. (2018) indicated that PS-based student worksheets could assist students in improving their skills. Another study by Budiyono et al. (2020) illustrated how the learning cycle 5E model could help students enhance their conceptual comprehension and apply physics topics in their daily lives.

Based on the explanation above, the learning cycle 5E model affected student learning outcomes in terms of knowledge, attitudes, and skills compared to cooperative model classes. Since the experimental class engaged in enjoyable learning activities, students became more active and enthusiastic about collecting reference material independently and devising their experimental techniques. Students in the control class did not take an active role and continued to use the lecture method, making it harder for them to explore their potential. The degree of the effect exerted on student learning outcomes in the area of knowledge was 0.9 in the large category, in the area of attitude was 0.8 in the large category, and in the area of skills was 0.7 in the medium category.

CONCLUSION

Based on the data analysis from this study, it was possible to conclude that the problem-solving-based 5E learning cycle model impacted student learning outcomes in knowledge, attitudes, and abilities in thermodynamics subject. The t-test yielded a value of $t_{count} > t_{table}$ and the Mann-Whitney test obtained a value$z < -z_{\text{Œ}\pm/2}$ which stated that $H_0$was rejected, indicating a significant effect. The effect size value, equivalent to 0.9 and 0.8 with a large category on the knowledge and attitude side and 0.8 with a medium category on the skills component, indicated the magnitude of the influence. As a result, it was possible to conclude that the 5E learning cycle model, aided by problem-solving-based worksheets, impacted student learning outcomes.

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