Contextual-Based Physics Learning Through Experimental Method to Increase Learning Outcomes in Thermodynamics Material

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ABSTRACT

One of the important benefits of implementing meaningful learning for students is improving better learning outcomes. But in general, the capacity for management of meaningful learning is relatively low. Low capacity to manage meaningful learning is due to teacher’s difficulties in presenting the advance organizer, especially determining and understanding the learning model to be used and also determining the learning media to be used. The aim of this study is to describe and explain the effectiveness of contextual-based physics learning through experimental method to increase learning outcomes in thermodynamics material. The effectiveness was described using data on improved student learning outcomes. The one-group pretest-posttest pre-experimental design was used in this study. The results of this study indicated that contextual-based physics learning through experimental method was able to increase learning outcomes of science education students in thermodynamics material with N-gain of 0.69 categorized into medium increase category. The Wilcoxon test informed that the learning can effectively improve learning outcomes of undergraduate science education students in thermodynamics material.

INTRODUCTION

Physics according to Stax (2020) as a branch of science basically aimed at describing the fundamental aspects of our universe, including what things are in it, what properties of visible things, and what processes experienced by objects or their properties. In simpler term, the description of the basic mechanisms that can make our universe behave the way it does is explained in physics. Physics will have use-value if physics is embodied in technology. When physics has been embodied in the form of technology, physics will be useful and make work easier (Harefa, 2019). For example, a nuclear energy power plant. Physics explains how air is converted into hot high-pressure steam to turn turbines that generate electricity. This principle is called thermodynamics. Study of the relationships among heat, work, temperature, and energy (Drake, 2022). Hakim (2017) found that nature has shown what phenomena it has and how the existence of work can be transferred to heat. Where humans have also shown how heat can be transferred and utilized to work with the help of machines. Various engine technologies apply the important principle and method of thermodynamics, for example energy power generation engines, jets, cooling systems, transportations, and thermoelectric systems (Hakim, 2017).

Based on preliminary results showed that students’ learning outcomes in thermodynamics material was still relatively low. The students’ average pretest only reached 35.62. This low...
acquisition of learning outcomes indicates low students’ learning performances and low ability to manage meaningful learning (Ismail, 2021). Ausubel argues that there are 6 important steps in meaningful learning, namely: (1) determining learning objectives; (2) identifying students’ initial characteristics, including students’ initial abilities; (3) determining subject matter that fits the students’ characteristics and organizing it into several core concepts, (4) determining learning topics and displaying them in the form of advance organizers, (5) studying these core concepts and applying them in real life; and (6) evaluating student learning processes and outcomes (Rahmah, 2013). Advance organizer according to Djonga et al. (2022) is tool that helps teachers convey lesson topics and reconnect with previous learning. This advance organizer can be in the form of strategy, approach, method, and learning technique (Suherman in Rahmah, 2013). But in general, many teachers have difficulty in presenting the advance organizer. Alfandry et al. (2021) found that 75.56% of teachers have difficulties in planning lesson, especially they have difficulties in determining and understanding the learning model to be used and also determining the learning media to be used. Nevertheless, Ausubel said that not all discovery learning activities are meaningful and not all conventional learning activities are less meaningful. A person who has done the meaningful learning, is someone who is able to associate his new phenomena into their knowledge structure before (Rahmah, 2018).

Learning approach that is appropriate for helping students associate their new phenomena, namely, student-centered learning, that really noticed meaningful learning (Haryono, 2015). Where a learning focuses on the process of forming knowledge and understanding of subject material by students themselves, understanding the symptoms that arise in their living environments, and at any time they can use that knowledge in fixing their problems (Haryono, 2015). Through this forming knowledge by students, students don’t just accept lessons for granted (Rahmah, 2018). For this reason, a Contextual Teaching Learning (CTL) approach is needed.

There have been many studies showing the success of contextual approach in learning physics. Implementing a contextual learning model in teaching physics can improve students’ learning outcomes (Putri et al., 2019). Providing learning with a contextual approach can increase physics concept understanding than conventional learning physics (Wahab et al., 2019). Prastuti et al. (2018) found that learning using contextual-based physics module can increase students’ learning creativities and students’ critical thinking skills. Astiti (2018) conducted a study about the effect of contextual-based teaching materials and it was proven that it can improve students’ understanding of physics concepts.

In contextual-based physics learning, supporting learning methods is needed that can embed the concept well and construct students’ understandings. Contextual-based physics learning complemented by experimental-based learning methods promises successful cooperation (Wati et al., 2021). Wati et al. (2021) in her study proved that students’ motivation and learning outcomes can be increased through the application of contextual-based physics learning that is integrated with experimental method.

Suryaningisih (2017) defined experiment as a learning activity that provides opportunities for students to test and apply theory using both facilities inside and outside the laboratory. The existence of experimental activity also plays an important role for students’ understandings of learning material (Supriadi & Lismawati, 2018). This is caused experiment has two main advantages. First, students are given the freedom to test and apply theories they get through experimental activities. Second, experiment is able to develop students’ interests in developing concepts because experiments are able to provide direct experience for them to observe a topic or phenomena (Supriadi & Lismawati, 2018).

Based on these two explanations, in this study integrating contextual-based physics learning using experimental method. The combination can theoretically have the potential to associate students’ new phenomena and improve students’ learning outcomes. Likewise, Ariansyah et al. (2021) found that the learning outcomes of students in physics can be improved by contextual learning. Separately for the experimental method, Lovisia (2019) conducted a
study about using the experimental method for learning outcomes of students in physics and it was proven that it can improve students’ physics learning outcomes.

Although study on the implementation of contextual-based physics learning and experimental method has been partially carried out by several researchers in improving students’ learning outcomes. However, only a few studies combine both approaches and methods with the aim of increasing learning outcomes. In addition, based on the results of bibliometric mapping using Vosviewer, it can be known that study using contextual-based physics learning and experimental method has not been carried out in thermodynamics material. Therefore, the researcher raised the title “contextual-based physics learning through experimental method to increase learning outcomes of students in thermodynamics material”. The research question in this study is how the effectiveness of contextual-based physics learning through experimental methods to increase learning outcomes in thermodynamics material.

RESEARCH METHOD
Contextual physics learning through the experimental method to improve student learning outcomes in thermodynamics material. To look for an increase in the learning outcomes of students using contextual physics learning through the experimental method, this research employed a one-group pretest-posttest pre-experimental design Knapp (2016) with no repetition. This research was conducted on undergraduate science education students, Faculty of Mathematics and Natural Sciences, State University of Surabaya, with 29 students in a class.

To determine the impact of contextual-based physics learning and experimental method, conducting pretest and posttest were necessary. The pretest is designed to assess the students’ mastery of the basic knowledge and skill before learning process, where this basic knowledge is commonly called prerequisite knowledge (Salim, 2018). While the posttest is used to describe the level of student achievements of learning material that has been given after treatment (Salim, 2018). The normalized gain, or N-Gain, between pretest and posttest is used to examine student learning gains. Formulation of N-Gain from Hake (1998) in Apsari & Budiyanto (2021), that is:

\[ \text{<} g \text{>} = \frac{\text{< posttest score >} - \text{< pretest score >}}{100} - \text{< pretest score >} \]

Furthermore, the gain scores are converted or descriptively analyzed using Apsari & Budiyanto (2021)’s N-Gain criterion, namely: (1) “low gain” result if (<g>) < 0.30; (2) “medium gain” result if 0.70 > (<g>) ≥ 0.30; and (3) “high gain” result if (<g>) ≥ 0.70. In general, to determine the category of improvement in student learning outcomes, the use of N-Gain is applied whether they are grouped into high, medium, or low.

Not only N-Gain is used for descriptive analysis, a paired t-test is needed to determine the significance of increasing students’ learning outcomes. Paired t-test was used to analyze the data using SPSS software. There is an important requirement must be fulfilled before the paired t-test can be used, that is the data should have a normal distribution. If this requirement is not fulfilled, the significance of increasing students’ learning outcomes can be determined by using the Wilcoxon test. Testing normality and significance of increasing learning outcomes also conducted using SPSS.

RESULTS AND DISCUSSION
Results
The study’s findings were divided into two areas, namely the categorization of improvement of the learning outcomes of the students and the significance of increasing student outcomes. The categorization of improvement of students’ learning outcomes was conducted using N-Gain. Increased student learning outcomes can be grouped into three classes, namely high, medium, and low, each depends on the N-Gain value. Table 1 presents data on the increasing of student learning outcomes.
Table 1. Pretest posttest results and N-Gain

<table>
<thead>
<tr>
<th>Category</th>
<th>Average Pretest</th>
<th>Average Posttest</th>
<th>Average N-Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium</td>
<td>35.62</td>
<td>80.72</td>
<td>0.69</td>
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</tbody>
</table>

Table 1 shows that the average increase in student learning outcomes is 69% (N-Gain score 0.69). Based on Apsari & Budiyanto (2021)’s criteria, N-Gain of 0.69 is grouped in a medium increase. Thus, the result showed contextual-based physics learning through experimental method was effective to improve students’ learning outcomes in thermodynamics material. Using the data in Table 1, to make it easier to compare increases in student learning outcomes, the students were grouped based on the pretest, posttest scores, and N-Gain achieved as shown in Figure 1.

Figure 1 shows that generally learning outcomes of students in science education have increased with a medium increase category. The figure also shows that the pretest posttest results and N-Gain score have improved which is proportional to the understanding level. Student learning outcomes were improved by more than 69% categorized into medium category. This indicates that the contextual physics learning through the experimental method effectively improve student outcomes in thermodynamics material.

Beside on the pretest and posttest results, it is also important to determine the significance of increasing student outcomes. The significance of increasing student outcomes can be determined using paired t-test to test the mean difference between pretest and posttest result. SPSS software was used to perform the paired t-test for mean differences. The formulation of the research hypothesis in the paired t-test is the null hypothesis (H₀) which indicates there is no difference between the results of the pretest and posttest which is proportional to the absence of improvement in the learning outcomes of the students, while the alternative hypothesis (H₁) which states that there is a difference between the results of pretest and posttest which is proportional to the increased learning achieved by the students with a significance level of 0.05. Based on the following hypothesis, the decision rule in the paired t-test is if the significance (2-tailed) is less than 0.05, reject H₀.

Before the paired t-test can be used, the data should be normally distributed, means that the sampled data is taken from a population with a normal distribution. The hypothesis tested are H₀ (data are normally distributed) and H₁ (data are not normally distributed). The statistical analysis used for the normality test of the data is the Kolmogorov-Smirnov test also uses SPSS. The decision rule for the normality test is that if the significance (2-tailed) is more than 0.05, H₀ can be accepted. However, if this requirement is not fulfilled (data was not normally
distributed), the significance of increasing students’ learning outcomes can be determined by using the Wilcoxon test. Table 2 shows the results of the normality test using SPSS.

| Table 2. Normality test of pretest and posttest results using the Kolmogorov-Smirnov test |
|---------------------------------|-------------------------------------------------|----------------|---------------------|
| Pretest                         | Posttest                                        |
| Statistic                       | df                                              | Significance   | Description         |
| 0.125                           | 29                                              | 0.200          | Normal              |
| 0.241                           | 29                                              | 0.000          | Abnormal            |

Based on the Table 2, shows that the normality test results are significant (2-tailed) for pretest and posttest results as much as 0.200 and 0.000 respectively. This result of normality test describes that the significant value of pretest value is greater than 0.05, accepting H0. This means the data is normally distributed. However, it can also be seen that the significant posttest value is below 0.05, rejecting H0. This means that the data is not normally distribute. As this condition is not met, the paired t-test can’t be used to the test and the Wilcoxon test must be used.

As same as the paired t-test, the Wilcoxon test is also used to determine if there is a significant increase between pretest and posttest results. By the significance of the increase between pretest and posttest scores, we can find the positive impact significantly from the implementation of contextual-based physics learning through experimental method. The hypothesis tested in the Wilcoxon test as Ha which states that there is a difference between pretest and posttest results which is proportional to the increase in the learning outcomes of the students. The criteria of Ha rejection is that the Asymp. Significance (2-tailed) is more than 0.05.

Table 3 informs that the Asymp. Significance (2-tailed) for pretest and posttest pairs is 0.000 (<0.05). Thus, Ha is accepted for the difference between the results of the pretest and posttest. Students’ learning outcomes can be significantly improved by implementing contextual-based physics learning through experimental method also shown in Table 3.

<table>
<thead>
<tr>
<th>Table 3. Results of Wilcoxon test between pretest and posttest results</th>
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<tbody>
<tr>
<td><strong>Posttest - Pretest</strong></td>
</tr>
<tr>
<td>4.704</td>
</tr>
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</table>

**Discussion**

Table 1 indicates that students’ average pretest achieved only 35.62, but in the posttest the students’ average achieved 80.72. The result of N-Gain generally describes that students’ learning outcomes have increased by 0.69 categorized into medium increase category. Also, Table 3 informs that the students’ learning outcomes have increased significantly. In other word, students’ learning outcomes can be improved by implementing contextual-based learning through experimental method in physics learning.

The appropriate learning approach to achieve better learning outcomes for students is Contextual Teaching and Learning (CTL) (Baker *et al.*, 2009). Baker *et al.* (2009) also defined that people learn includes the concept of motivation, social cognitive, learning style, and problem-based learning. These learning person concepts could be found in CTL. These theories pushed the CTL as a facilitator for increasing interest, motivation, usefulness, connection, and also accommodating various learning styles (Baker *et al.*, 2009). Surdin (2018) defined CTL as a learning system that connects students’ knowledge and understanding with everyday student life situations. Linking students’ knowledge and understanding is important to apply so that the knowledge can be placed in long-term memory, applied in everyday life, and it is not easily forgotten (Surdin, 2018). This corresponds to Haryono (2015) with the statement that in this
technological age, the learning focuses on the process of forming knowledge, understanding by students themselves, understanding the symptoms that arise in their living environments, and they can use that knowledge in fixing their problems any time.

Murtini et al. (2022) stated that students’ characteristics, motivations, and outcomes could be significantly affected by applying the contextual learning model. She said that her study results were due to the contextual approach, which provided meaningful learning. Where the contextual approach creates a more comfortable, fun, independent, active, and courageous learning environment. According to Suryawati & Osman (2018), contextual approach provides students with high-level thinking skills through the process of identifying and analyzing problems that make a more effective learning.

One of the advantages possessed by CTL is that the learning is focused on the flow of constructivism. Where the flow of constructivism assumes students can find and build their own knowledge, so that learning will be more productive and able to cultivate the strengthening of the concept for students (Surdin, 2018). Focusing on the flow of constructivism, teachers must have the attitude of a facilitator (Sudibyo et al., 2016). The physics learning applying the CTL approach emphasizes the learning process according to the new paradigm, where the learning process must be student-centered learning (Haryono, 2015). Therefore, to acquire knowledge and understanding, teacher has to provide the widest possible opportunity for students to find their own information. Thus, the knowledge can be stored in long-term memory.

One way to present physics learning material according to (Murtini et al., 2015) is to implement the experimental method, where students can experience directly through experiments to prove a physics theory based on certain hypotheses or questions. If the teacher wants a learning in which students conduct experiment and prove physical theory through a question, then the teacher can implement experimental method in learning (Sari et al., 2023). Furthermore, Sari et al. (2023) explains that the experiments can be carried out in the form of observation, measurement, or interpretation. Students also given the widest possible range of opportunities for experiencing or working, observing, processing, and clarifying a truth in the experimental method. According to Syiarah et al. (2022), between experiment can help students

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**Figure 2.** Students are expected to be able to understand the symptoms that may be experienced and use them in fixing their problems in everyday life through the implementation of CTL.

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Kamu sedang berjemur di bawah sinar matahari yang panas sinar mataharinya bersuhu 34°C. Hasil penelitian (Urra et al., 2017) menunjukkan nilai emisivitas warna ungu (purple comet) sebesar 0.91, emisivitas warna hijau (going green) sebesar 0.84, emisivitas warna biru (true blue) sebesar 0.77, emisivitas warna merah (talk of the town) sebesar 0.66, emisivitas warna hijau muda (apple martini) sebesar 0.61, emisivitas warna biru muda (sky blue) sebesar 0.54, emisivitas warna jingga (orange torch) sebesar 0.50, emisivitas warna coklat muda (pastry puff) sebesar 0.46, emisivitas warna kuning (absolute yellow) sebesar 0.37, dan emisivitas warna merah muda (crystal pink) sebesar 0.24. Ambil luas permukaan badan 1,5 m dengan asumsi suhu kulit 26.5°C. Tentukan warna baju yang cocok kamu gunakan dan yang tidak cocok kamu gunakan berjemur di bawah sinar matahari dengan memperkirakan laju kehilangan panas tubuh melalui radiasi.

gain their knowledges independently, experiment can also add experience to participate in the learning process.

Research that has been conducted by Hart *et al.* (2000) on investigation of the purpose of the experiment found that 21 of 22 students were enjoyed experiment class with 10 students, assume that the purpose of the experiment is to give them an opportunity to observe some materials. Others, think that the purposes are to develop useful skills that are needed for work, give them experience in doing experimental work, use equipment, write an experimental report, give them insight into aspects of the practice of science, and how scientific knowledge is established. Hart *et al.* (2000) concluded that experiment was successfully helped students to think about an aspect of science (for example: developing, communicating, and verifying procedures and results from experimental work) and an aspect of the way science is conducted (for example: communication, publication, and verification of results).

The most important thing is that teacher must confront their students with a problem, so it can stimulate students thinking skills and actions in accordance with existing problem-solving methods. This corresponds to Pérez & Furman (2016) with the statement that in the experimental activity, however, students must be faced with questions or problems that must require solutions and the answers or solutions must be unknown for students before. If it refers to meaningful learning, experiment activity is very suitable to facilitate students learning through direct experience, that really notices meaningful learning. This is because experiment provides an opportunity for students to get a real situation about what is obtained in theory (Siagian, 2021).

Research that has been conducted by Li & Wong (2018) on investigation of the effectiveness of carrying out experiments before covering relevant concepts in classroom found that experiments have a positive impact on student achievement. This is because experiments provide students with valuable learning experiences and knowledges. Experiments help students understand the key components of a theory, and then those key components will become knowledge (Li & Wong, 2018).

Based on pretest result, learning outcomes for undergraduate science education students were still low with an average of 35.62 (see Table 1). Achievement of this average value is still classified in the category of low mastery (see Figure 1). This result corresponds to Hanna *et al.* (2016), which also showed that physics learning outcomes were low. Based on data from PUSPENDIK in 2011/2012 it is known that the national exam score for physics subject in Indonesia is still relatively low, with an average score of 7.2, even this score being the lowest score between chemistry and mathematics. Not only that, research that has been conducted by Triwiyono & Lumbu (2017) on investigation of prospective teachers’ difficulties in understanding thermodynamics processes concluded that they have difficulties in: (1) understanding the concept well; (2) analyzing and solving the problems; (3) distinguishing between the work of the system or the work of the environment; and (4) understanding a diagram or changing a diagram in a various diagram. According to Musyarrofah (2018), there are still many physics education students who have misconceptions about thermodynamics material.

**CONCLUSION**

The implementation of this research was limited to undergraduate science education students, Faculty of Mathematics and Natural Sciences, State University of Surabaya with direct instruction model. Based on the results and discussions that have been explained above, it can be concluded that: (1) Contextual-based physics learning through experimental method was effectively increased learning outcomes in thermodynamics material with N-gain of 0.69 categorized into medium increase category. (2) The learning outcomes have increased significantly after they got the contextual-based physics learning through experimental method. The hope for future research is to have more development of contextual-based physics learning that is integrated with experimental method, so that learning can be more effective and efficient.
not only in increasing students’ learning outcomes, but also other skills. In addition, further research can be conducted to explore in other models and/or lecture materials to ensure how contextual-based physics learning and experimental method in enhancing students’ learning outcomes.

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