Learning outcomes of entropy concept in thermodynamics

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Abstract. A short semester was an optional semester for students and the duration was eight weeks including a final exam. This research was conducted to describe student learning outcomes about entropy in thermodynamics. The research was conducted in the thermodynamics class of Physics Department Universitas Negeri Semarang 2018/2019 which was taken by 16 students as the object of this research. The learning outcomes were analyzed from data taken from final exam scores. The data were analyzed by using descriptive qualitative analysis. Based on the result, the score (student learning outcome) was 8.8 on average from the maximum score was 16. It could be concluded that thermodynamics learning outcomes at a short semester program of the entropy concept were in fair category.

1. Introduction

Learning outcomes are one of the information that can be used to determine the ability of the student and the successful level of an educational program [1]. Learning outcomes are usually shown from the result of the test [2]. Sometimes, the student didn't satisfy with their learning outcomes and want to take remedial. A short semester program is an option where students can take the classes needed at an eight-weeks meeting. This program is held between the regular semester. This program is not only for remediated students but also for the student who is trying to complete a set of required courses for graduation faster with better GPA (Grade Point Average). Despite the short of time, this program has identical requirements in terms of assignments and exams with the regular semester. In consequence, the students might not be able to understand the overall class material well.

Thermodynamics is one of the classes that can be taken in the short semester of 2018/2019. Although the concept of thermodynamics is found in everyday life, because there are several abstract concepts in it with a high enough complexity, makes it seems difficult to understand [3]. Thermodynamics is one of the hard subjects for students to understand from year to year. This is proven by the majority of student's final grades for thermodynamic class at some of the universities was in grade C and below [4,5,6]. Based on preliminary research, the student's final grades before taking a short semester program were 25.00% in grade BC, 50.00% in grade C, and 6.25% in grade CD. Besides, 18.75% of students didn't have grades because they never take a thermodynamics class before.

Thermodynamics is a branch of science that studies the transformation of energy involving heat, mechanical force, and other aspects of energy-related to the properties of matter [7]. Based on preliminary research, the hardest thermodynamics concept to understand by the majority of students (46.60%) was entropy, followed by ideal gas and Carnot refrigerator. Entropy among other thermodynamic concepts is considered an abstract concept that is difficult to understand, especially for those who are new to learning thermodynamics. A research stated that after being given an introduction
to thermodynamics, the impression left from entropy material was small and some felt they did not leave any impression at all [8]. No concept in the whole field of physics is more difficult to understand than entropy material [9].

The purpose of this study was to describe student learning outcomes about entropy in thermodynamics at the short semester program.

2. Method

The research was conducted in the thermodynamics class of Physics Department, Universitas Negeri Semarang (UNNES) 2018/2019 that was taken by 16 students as an object of this research. The method of determining the respondent was using saturation sampling.

This research was conducted to describe student learning outcomes about entropy in thermodynamics at the short semester program. The learning outcomes were analyzed from data taken from final exam scores. The question about entropy was 3 with the total problem was 8 in the final exam. The score test scale was 0 – 2 for each problem and the maximum score was 16. The data were analyzed by using descriptive qualitative analysis and the result was verified by interview. The category of student learning outcomes based on the reference assessment standard by Azwar [10].

3. Results and Discussions

3.1 Data Description

According to student self-perception, the short semester gave positive experiences. Based on the result, most students (81.25%) felt satisfied with learning outcomes, while several students (12.50%) felt less satisfied and one student (6.25%) not satisfied. In terms of the improvement of the material mastery, most students (81.25%) felt that mastery of thermodynamics material was increased, while several students (18.75%) felt less improvement. Besides that, the concept of thermodynamics that the student majority think the most difficult was still entropy (68.75%), followed by ideal gas (25.00%) and work (6.25%).

| Code | Number of Problems | Total score |
|------|--------------------|-------------|
| A1   | 0 0 0 0 0 0 0 1 | 4           |
| A2   | 1 2 2 1 0 0 1 0 | 7           |
| A3   | 2 2 2 2 1 1 2 0 | 12          |
| A4   | 2 2 2 1 0 2 1 12|
| A5   | 1 0 0 0 0 0 0 1  |
| A6   | 2 2 2 2 2 2 2 0 14|
| A7   | 2 2 2 1 0 2 0 9  |
| A8   | 2 2 2 0 0 1 0 0 7 |
| A9   | 2 2 2 0 0 1 1 8  |
| A10  | 1 1 1 1 0 0 2 0 6 |
| A11  | 2 2 2 2 0 2 1 13|
| A12  | 2 2 2 1 0 0 1 0 8 |
| A13  | 2 2 2 2 1 0 2 0 11|
| A14  | 2 2 2 2 0 0 2 0 10|
| A15  | 2 2 2 2 1 0 2 0 10|
| A16  | 2 2 2 2 1 0 2 1 12|

| Average | 1.69 | 1.69 | 1.75 | 1.31 | 0.56 | 0.25 | 1.44 | 0.31 | 8.8 |

Table 1. The test result
Based on the average score of the test result (Table 1), it appears that problem 2d was the hardest problem with the smallest average score (0.31) and problem 2a is the easiest problem with the highest average score (1.75). The average score of the test result reaches 8.8. It appears that 56.25% of the total students have learning outcomes above the average and the other students were below average by 43.75%. The student learning outcomes category can be seen at Table 2.

Table 2. Student Learning Outcomes Category

| Score | Interval          | Category | F | %    |
|-------|-------------------|----------|---|------|
| A     | x > 12.8          | Very Good| 2 | 12.50%|
| B     | 9.6 < x ≤ 12.8    | Good     | 6 | 37.50%|
| C     | 6.4 < x ≤ 9.6     | Fair     | 5 | 31.25%|
| D     | 3.2 < x ≤ 6.4     | Poor     | 2 | 12.50%|
| E     | 3.2 > x           | Worse    | 1 | 6.25% |

3.2 Learning outcomes at short semester

Entropy remains the most difficult concept to understand before and after the program. It was contradictory from research that stated the compressed semester student grasped the concept faster and could use them well during the exams [11]. It is because entropy is one of the difficult physics concepts to understand and students still not familiar with it. In entropy, choose a particular formula to be used is more difficult than to understand entropy in real life. Most students have been able to write down what was known and asked of the problem, but sometimes they couldn’t understand the problems and what equation to be used. This inline with research regarding students’ difficulties in solving physics problems [12]. Although math ability was an important factor, that ability alone was not the best predictor of success on the exam, their logical thinking skills were [13]. This can be seen, for example, from the answer of question test number 2, point c and d.

A current of 1 A is maintained for 1 s in a resistor of 50 Ω while the temperature of resistor is kept constant at 27°C.

a. What is the entropy change of the resistor?

b. What is the entropy change of the universe?

The same current is maintained for the same time in the same resistor, but now thermally insulated, with the same initial temperature 27°C. If the resistor has a mass of 10 g and a specific heat of 836 J/kg. K. Show:

c. the entropy change of the resistor

d. the entropy change of the universe

In point c, most students have trouble in executing the equation, especially when looking for the final temperature of the environment. Some students also think that the final temperature was the entropy change of resistor. Meanwhile, in point d, students used the value of entropy change in the universe from point b as the entropy change in the surrounding. It made the answer became wrong. When clarified during the interview, students said they still didn’t understand entropy concept well.

This study also found some missed basic concept that happened to the student based on the interview. When the researcher asked: "Is the change of entropy in the universe always remains constant?", half of the student said yes. These lines might base on assumption from the popular notion that total entropy remains unchanged during a real process, and can lead to difficulties in understanding the role of entropy in the second law of thermodynamics [14]. When the researcher asked: "What do you remember about entropy?", the student answer that entropy is the degree of randomness or they said they didn't remember. The "degree of randomness" is one of verbal expression for entropy, but it not adequate for describing the concept entropy as a whole well than "degree of diffusion" [15].

Likely, the students did not commit the nuances of the practical learning activities to long-term memory due to the effects of time and the speed of the delivery materials, students were might difficult to recall them later during or after the exams [16]. Encountering an explanation about the
correct concept in the next semester needed to keep the stability of the representation concept in memory accurately [17]. Regardless of entropy concept mastery, the student's final score was increased. The research found that the short semester was effective for increasing GPA [18]. More than that, the student grade distribution in a shorter semester was significantly higher than the regular program [19]. In general, it was because short semester offering a more intense class, such as their duration, class size (students learn more in smaller classes [20]), another course load (none of the students took more than three courses), and the break lengths (longer break lengths between semesters may also be associated with lower grades [21]). Although students did express an interest in being able to take major courses during the short semester, they wanted to continue to be taught face-to-face during 16 weeks long in the regular semester [22].

4. Conclusion
Based on the result, the score of student learning outcomes was 8,8 on average from the maximum score was 16. It could be concluded that thermodynamics learning outcomes in the short semester program of the entropy concept were in the fair category. Students still have difficulty in analyzing conditions related to the entropy change and the equation needed. Entropy was the most difficult concept from the start until the end of the program, this was partly due to the limited time. Besides, the research also found that the student felt the improvement of material mastery in a thermodynamics course and satisfied with their learning outcomes, especially for students who aim to increase their GPA. However, the result of the study was done for only one concept in one course in a short semester. The study will hopefully generate enough interest to do further research on comparing student learning outcomes in other concepts or courses during the short semester program and the regular semester program.

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