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[Research Article]

PRE-CLASS TUTORIAL (PCT): LEARNING STRATEGIES TO IMPROVE STUDENTS' UNDERSTANDING OF THE P–V–T DIAGRAM ON THERMODYNAMICS

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ABSTRACT

This research was motivated by students' difficulties drawing and interpreting P-V-T diagrams to describe thermal processes and the ideal gas cycle. The method used in this study is a quasi-experimental method by comparing the results of the students' pre-test and post-test. This research was conducted on 21 students in one of the public schools in Pandeglang, Banten. Based on the study's results, PCT improved students' understanding of drawing and interpreting P-V-T diagrams to describe thermal processes and the ideal gas cycle. Several conceptual difficulties founded during the research. First, the most difficult in P-V, P-T, and V-T diagrams, respectively, is to draw the adiabatic process. Second, the percentage of students who answered the P-V diagram correctly was higher than those who answered the P-T and V-T diagrams. Third, students were more interested in and understood processes with unique characteristics such as isobaric, which means constant pressure; isochoric, which means constant volume and isothermal, which means constant temperature.

Keywords: Pre-Class Tutorial, Concept Understanding, Thermodynamic

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1. INTRODUCTION

Physics is the basic science of the physical universe that occurs in our daily lives. Physics explains and describes scientific events that occur both microscopically and macroscopically. Studying physics is mastering products in the form of a collection of laws, theories, principles, rules, and formulas built by concepts according to the study process. This confirms that understanding concepts in studying physics is essential (Coletta & Phillips, 2005; Johnson, 2001; Kim & Pak, 2002; McDermott & Shaffer, 1992).

Physics will not be separated from the physical quantities themselves. For example, when we study thermodynamic material, we will be introduced to the quantities of Pressure (P), Temperature (T), Volume (V), Entropy (S), Energy (U), Enthalpy (H), Helmholtz free energy (F) and Gibbs free energy (G) (Heiner et al., 2014; Hsu et al., 2004).

Thermodynamics studies the relationship between energy and the work of a system. Thermodynamics only studies large-scale (macroscopic) quantities of a system that can be observed and measured experimentally.

The results showed that students experienced difficulties when studying thermodynamics, including conceptual difficulties when studying temperature, the ideal gas law, and the first law of thermodynamics (Coletta & Phillips, 2005; Johnson, 2001; Kim & Pak, 2002) Further research conducted found that one of the students' difficulties was making and interpreting PV, PT, VT, and TS diagrams on thermodynamic processes and cycles in ideal gases. The thermodynamic processes in question are isobaric, isothermic, isochoric, and adiabatic processes (Coletta & Phillips, 2005).

Seeing this situation, there needs to be an effort to redesign learning that can help students prepare themselves well before learning and, simultaneously, help students understand the concepts they want to learn. Efforts that have previously been reported to stimulate students to prepare well before lectures are through the use of multimedia modules (Stelzer et al., 2009), giving an initial assignment to read a particular part of a book accompanied by an online quiz (Heller et al., 1992), and giving some questions selected from the book later via e-mail before lectures (Finch & Hand, 1998).

This study will use a Pre-Class Tutorial (PCT) to improve students' understanding of PV, PT, and VT diagrams for ideal gases. The application of PCT in learning is considered effective in improving students' conceptual understanding (Van Heuvelen, 1991). Technically, the PCT is given early in the hope that students can fill it out first. This allows students to learn about the material and are considered more ready to learn. Readiness to learn is essential in determining optimal learning outcomes.

2. METHOD

The method used is quasi-experimental to determine the effectiveness of using PCT to improve conceptual understanding in thermodynamic physics learning, especially in drawing and interpreting P-V-T diagrams. The subjects involved in this study were 22 students of class XI IPA 4 at SMAN Cahaya Madani Banten Boarding School for the 2019/2020 academic year.

The instrument used is a Pree Class Tutorial (PCT) module adjusted to thermodynamics indicators. Before being used as a research instrument, the module has been validated by experts in terms of content and language. PCT is assigned to students before future lessons take place. Students must complete the module individually or in groups before joining the lesson. This PCT was prepared to train students to read physics books word for word carefully before learning routinely. This causes students to know what they want to learn in class. Discussions occur more interactively in learning because students already have learning readiness. The teacher is only a facilitator who guides the discussion and provides concept reinforcement.

3. RESULTS AND DISCUSSION

The data obtained from this research are the pre-test and post-test values. The value is obtained from the student's answer sheet. Based on the data from students' answers, conclusions can be drawn regarding the students' understanding of making and interpreting PV, PT, and VT diagrams of thermal equilibrium conditions for thermodynamic processes and cycles. The thermodynamic processes in question include Isochoric, Isobaric, Isothermal, and Adiabatic. The recapitulation of pretest and posttest is in Table 1.

Table 1. Pretest and posttest recap data

No.	Subject Code	Pre-Test	Post-test
1	S-1	50.00	100.00
2	S-2	58.33	83.33
3	S-3	25.00	83.33
4	S-4	50.00	100.00
5	S-5	50.00	75.00
6	S-6	16.67	100.00
7	S-7	58.33	91.67
8	S-8	16.67	66.67
9	S-9	41.67	91.67
10	S-10	33.33	75.00
11	S-11	33.33	66.67
12	S-12	58.33	100.00
13	S-13	25.00	100.00
14	S-14	8.33	66.67
15	S-15	50.00	91.67
16	S-16	58.33	75.00
17	S-17	41.67	91.67
18	S-18	25.00	83.33
19	S-19	41.67	83.33
20	S-20	75.00	91.67
21	S-21	0.00	91.67

Based on the table above, there is a difference between the pre-test and post-test scores. All students experienced an increase in grades. Based on the data above, the average pre-test score is 38.89, while the post-test average is 86.11.

Further increase analysis was tested statistically using the SPSS program, as shown in Table 2.

Table 2. Statistical Testing

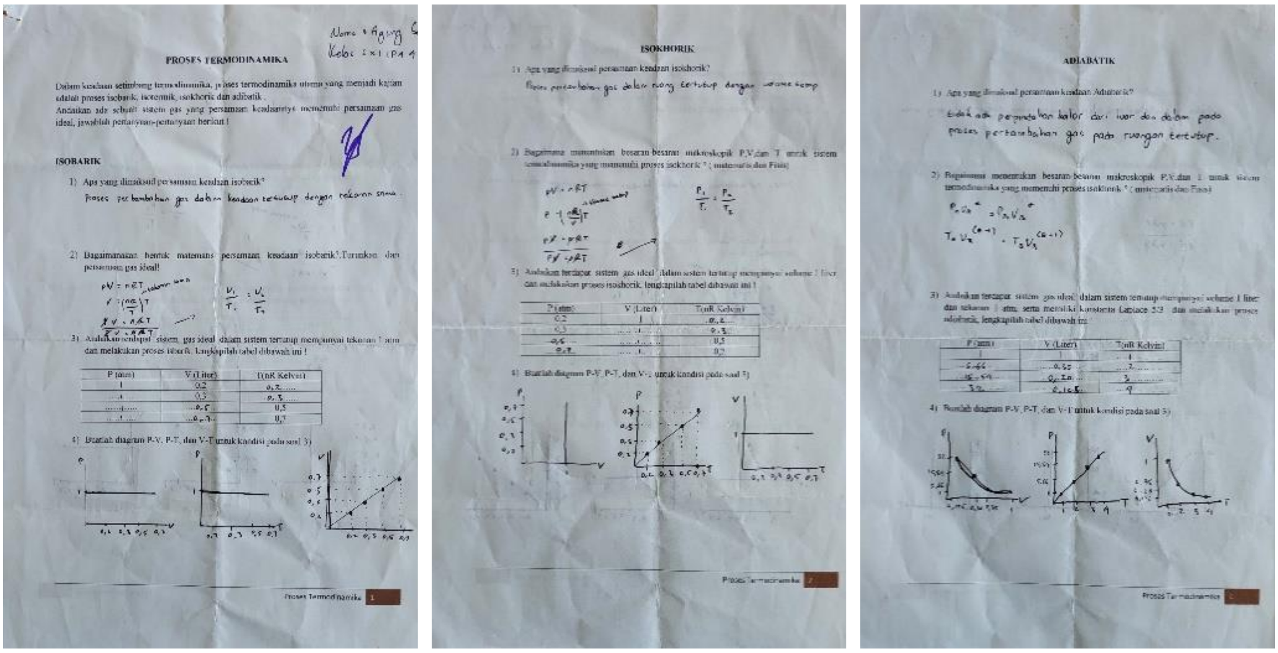
	Value
Mann-Whitney U	4.5
Wilcoxon W	235.5
Z	-5.46
Asymp. Sig. (2-tailed)	0.000
a. Grouping Variable: Groups	

Based on this data, it appears that the increase in the pre-test and post-test results occurred significantly. This can be seen from the Asym Sig value < 0.05. This increase in achievement indeed cannot be separated from the role of the PCT. This is based on changes in students' thinking (embodied in the tutorial) found during the learning process. The provision of PCT also allows learning in the classroom to be more active and prosperous, with interactive conceptual discussions between students or between students and teachers. Learning is no longer monotonous and informative but becomes a place for discussion to solve problems students find before entering class—furthermore, analysis for each process can be seen in Table 3.

Table 3. Student Score for Each Process

Isobaric		Isochoric		Isothermic		Adiabatic	
Pre-test	Postest	Pre-test	Postest	Pre-test	Postest	Pre-test	Postest
39.68	95.24	47.62	93.65	50.79	88.89	17.46	66.67

The table above shows a recap of the value data for each process. Based on the data above, the highest increase occurred in the isobaric process, which was 55.56. In contrast, the smallest increase occurred for the isochoric process. The smallest mean value was obtained for the adiabatic process. This is because students still have difficulty describing the adiabatic graph. Students better understand processes with unique characteristics such as isobaric, which mean constant pressure, isochoric, which means constant volume, and isothermic, which means constant temperature. Meanwhile, students still have difficulty pouring it into a PVP graph for the adiabatic process. This is evident from the post-test score, which is still 66.67.



(a) (b) (c)

Figure 1. (A) Example Of Child's Answer for Isobaric Process, (B) Example Of Child's Answer For Isochoric Process, (C) Example Of Child's Answer For Isothermal Process

Next, we can see the data from the pre-test and post-test results based on each graph. The data for each graph is presented in Table 4.

Table 4. The data for Each Graph

PV		PT		VT	
Pre	Post	Pre	Post	Pre	Post
42.86	89.29	35.71	88.10	38.10	80.95

Based on the table above, we can see that the highest increase was obtained for the PV, which was 89.29. Meanwhile, the smallest increase for the PT was 52.39.

After processing the research data, more detailed data were obtained regarding students' understanding of PVP graphs in thermodynamic processes. First, students are more interested in thermodynamic processes with distinctive characteristics such as isobaric, which means the pressure is constant; isochoric, which means the volume is constant and isothermic, which means the temperature is constant. We can see this from the children's answers, which are primarily correct for describing isobaric, isochoric, and isothermal graphs. Here are children's answers for isobaric, isochoric, and isothermal processes.

Meanwhile, for Adiabatic, some children still have difficulty in describing and defining adiabatic process graphs, especially for PV graphs. There are several misconceptions, including, firstly, they still think that the PV graph for isothermal and adiabatic processes is similar but only differs in steepness, the graph of isothermal processes is steeper than the graph for adiabatic processes. This does not seem right. The graph of the adiabatic process must be steeper than the graph of the isothermal process because there is a factor (Laplace's constant, > 1) in the adiabatic process while the isothermal process only fulfills PV = K. Second, there is no heat transfer, Q = 0 according to the equation Q= mcΔT, which means that there is no change in temperature.

Likewise, in the adiabatic process, they assume that there is no change in temperature. In other words, the temperature is constant. The adiabatic conception of Q = 0, based on the equation Q = mcΔT, means that no change in temperature applies only to systems that transfer energy using heat (release or absorption). However, heat is not the only means of transferring energy for gas systems. Heat (Q), work (W), or both are energy transfer mechanisms. In addition, every system that does or does work is not all said to release or absorb heat energy but can also be converted in the form of energy changes in the system (U). Figure 2 is an example of student answers for the adiabatic process.

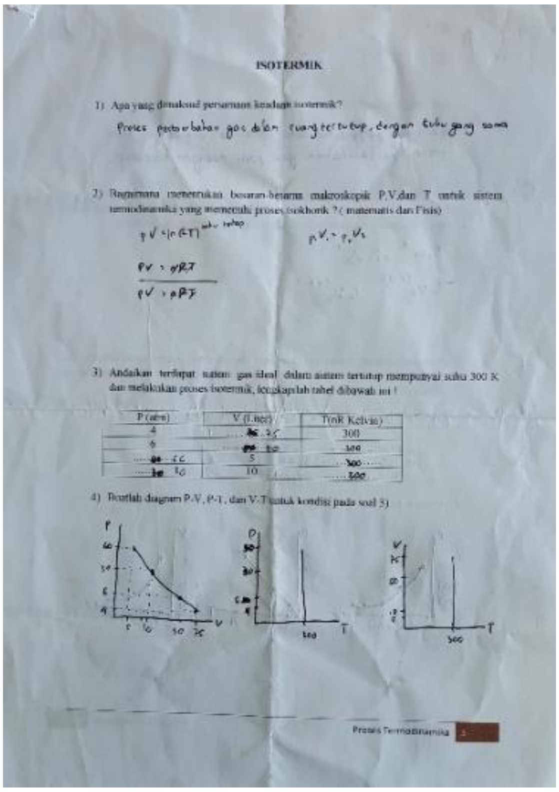


Figure 2. Example of a child's answer for the Adiabatic process

4. KESIMPULAN

Pre-Class-Tutorial (PCT) in physics learning about thermodynamics, especially in drawing and defining PVP graphs for isobaric, isochoric, isothermic, and adiabatic processes, has increased students' understanding. We can see this from the results of the pre-test and post-test. Further testing was carried out with statistics. The difference between the pre-test and post-test scores was found to be significant. Students still have difficulty describing PV, PT, and VT gravity for adiabatic processes. The percentage of students who answered the P-V diagram correctly was higher than those who answered the P-T and V-T diagrams. Students better understand thermodynamic processes with unique characteristics such as isobaric, which means constant pressure, isochoric, which means constant volume, and isothermal, which means constant temperature.

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