Computer Virtual Media-Aided Active Learning Student Sheets (ALSS) to Improve Students’ Understanding on PV, PT, VT, and TS Diagrams of Ideal Gas

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Abstract. The study was motivated by the finding that prospective physicist students’ understanding in the manufacture of PV, PT, VT, and TS diagrams for ideal gas that still low. The findings further indicate the conceptual difficulties experienced by students in the manufacture of PV, PT, VT, and TS diagrams to describe the process and the thermodynamic cycle in the ideal gas system. The method used is quasi-experimental with its initial analysis of the descriptive to the development of Active Learning Student Sheets (ALSS). The treatment provided in the form of learning with the help of virtual media followed ALSS as reinforcement to the students’ understanding. A number of 31 prospective physicist students involved collecting research data. Improved students’ understanding in the charting of the achievements of the average value of students in related test instrument manufacture PV, PT, VT, and TS diagrams processes and thermodynamic cycles. The findings show the use of computer virtual media - aided Active Learning Student Sheets (ALSS) effectively improve the prospective physicist students’ understanding in the manufacture of PV, PT, VT, and TS diagrams.

1. Introduction

Physics is the science that is closely associated with the influence of variables or between physical quantities. Those can be represented through the verbal, computational, mathematical, graphs, or diagrams [1]. Conceptual understanding (represented through the verbal, computational, mathematical, graphs, or diagrams) is one of the most important aspects in the study of Physics [2]. For the example in learning thermodynamics, the magnitudes which learned in the thermodynamics includes coordinate macroscopic scale or Pressure (P), Temperature (T), Volume (V), Entropy (S), Energy (U), Enthalpy (H), the Helmholtz free energy (F) and Gibbs free energy (G).

From the experiments that have been carried out and involving the 8 system state variables, generated a lot of relationships, linkages, and formulas that describe the functional relationships between the various magnitudes. Especially for a closed system, i.e. to the gas system unchanged number of particles, obtained three important conclusions as follows. First, all the experiments showed that when the system is in equilibrium then each coordinate expressed as the function of two other coordinates. Second, only two of the eight coordinate system which is the independent variable. Third, in a state of equilibrium thermodynamics (equilibrium of mechanical, chemical, thermal, and phase) be in effect the relationship: \( f (x, y, z) = 0 \), with \( x, y, \) and \( z \) coordinates of macroscopic
thermodynamics states. For the example, review the gas system in a closed vessel (closed system) whose the composition has not changed, the meaning that not happening chemical reactions that may change the number of particles in the system, and no diffusion occurs, the system of the gas in a given volume (V), may be temperature (T) whatever or at a certain temperature, whatever it can be given volume (V); This is possible because there are a coordinate thermodynamics 3rd adapt, for example, the pressure (P), so that the gas system can be described by a pair of coordinate-free (P), which mathematically can be written by $f(P, V, T) = 0$.

We are often faced with the fact that, although fast (i.e. non-quasistatic) processes cannot be represented diagramsically, in the literature these processes appear sometimes associated with curves in diagrams [3]. In addition, expressed in the form of a mathematical model, the relationship between variables in thermodynamics is often in the form of diagrams/charts. The ability to create and interpret data in multi-representative is required by a prospective Physicist. For example, the interpretation in diagramsical form. Interpretation and construction in the form of a diagrams in a relationship report are very important because it is part of an experiment, and is the heart of science [4].

The data of preliminary study was obtained from the analysis of the students’ answers on the written test subjects thermodynamics shows one of the difficulties students is to create and interpret diagrams of PV, PT, VT, and TS on the process and the thermodynamic cycle of a condition of thermal equilibrium for the process and the thermodynamic cycle for a closed gas system that meets the ideal gas equation of state. The thermodynamic process in question is the isobaric process, isotherm, isochoric and adiabatic, while the thermodynamic cycle includes the Cycle of Carnot, Diesel, and Otto. In general, difficulties finding students as follows. First, the biggest difficulty is in describing PV, PT, VT, and TS is the adiabatic process. Second, the rate of students’ correct answers at the higher than the diagrams of PV for PT, VT, and TS. The third, students whose better understand the characteristics of the typical thermodynamic process, such as isobaric process with constant pressure, isotherm with constant temperature, and isochoric with constant volume. The poor understanding of students on the depiction and interpretation in the PV, PT, VT, and TS diagrams to process turns their impact on the lack of understanding in describing the thermodynamic cycle in the PV, PT, VT, and TS diagrams. In fact, this understanding is important to describe the process or the thermodynamic cycle, due mainly to the PV and TS diagrams for processes and cycles have physical meaning as the work done by/on the system. As an example, the pressure-volume (P-V) and temperature-entropy (T-S) diagrams are often used as teaching aids to describe refrigeration processes [5].

The Conceptual difficulties that faced by the students from various parts of the world has been widely documented in the research report Physics and used as a basis for the development of learning in order to improve [6] [7].

This study would be focused on the implementation of Active Learning Students Sheets (ALSS) and virtual media in improving students understanding of the PV, PT, VT, and TS diagrams in the ideal gas. The application of ALSS in learning is considered effective in improving students’ conceptual understanding [8]. The implementation is in line with research ALSS Van Heuvelen (1991a; 1991b) in the form of learning Physics Overview Case Study (OCS) which is supported by the First Concept by Gautreau [9]. This learning emphasis on active learning, cooperative and utilize diverse representations to solve problems. Heller et. al. also devises a strategy problem solving through collaborative learning [10]. Eric Mazur designing a learning Peer Instruction (PI) to teach Physics at Harvard University [11]. All of the instructional design is seen can be accomplished with the implementation ALSS. As the use of virtual learning is intended as a means of strengthening and visualize the physical condition of the system. The use of information and communication technology (ex. virtual) will make the learning process more interesting and challenging, facilitating the teachers and students in teaching-learning processes [12]. Learning by utilizing information technology media turned out to have a positive impact such as can improve student learning achievement and give a positive effect on conceptual understanding [13] [14]. Computer simulations in learning are closely related to one form of constructivism learning, i.e. scientific discovery learning,
simulations giving students the opportunity to display their learning outcomes in semi-real-world situations and 'force' students to display the capabilities of applications, analysis and synthesis [15]. In addition, computer simulations can also provide opportunities for students not only to develop an understanding and strengthening of Physics concepts, but also to develop skills in scientific investigation, inquiry, as well as critical thinking skills [16].

2. Methods
The method that utilized is quasi-experimental with its initial analysis of the descriptive to the development of Active Learning Student Sheet (ALSS). The subjects who involved in this study are 38 students of Physics Department of the academic year 2014/2015. The instrument test used was a written test instruments in the form of a description. Analysis of the prospective student's understanding and interpretation of Physicists in making PV, PT, VT, and TS diagrams from the thermal equilibrium conditions for the process and the thermodynamic cycle is obtained from the student answers on the written test.

3. Results and discussion
Based on the data from the students answers on the answer written tests, it can be determined the percentage of students’ understanding level in making and interpreting the PV, PT, VT, and TS diagrams from the thermal equilibrium conditions for the process and the thermodynamic cycle. In general, the data presented in Table 1.

Table 1. the recapitulation of the prospective physicist students’ correct answers on the test about PV, PT, VT, and TS diagrams.

| Diagrams | Students’ Academic Year | Percentage of Students with right answer |
|----------|-------------------------|------------------------------------------|
|          |                         | Isobaric | Isotherm | Isochoric | Adiabatic | Carnot | Diesel | Otto |
| PV       | 2014/2015 (N=38)        | 65,79    | 47,37    | 60,53     | 50,00     | 68,42  | 47,37  | 36,84 |
|          | 2015/2016 (N=34)        | 94,12    | 79,41    | 97,06     | 76,47     | 91,12  | 79,41  | 73,53 |
| PT       | 2014/2015 (N=38)        | 63,16    | 55,26    | 52,63     | 44,74     | 55,26  | 47,37  | 44,74 |
|          | 2015/2016 (N=34)        | 97,06    | 94,12    | 85,29     | 73,53     | 82,35  | 76,47  | 73,53 |
| VT       | 2014/2015 (N=38)        | 50,00    | 65,79    | 55,26     | 47,37     | 57,89  | 44,74  | 39,47 |
|          | 2015/2016 (N=34)        | 82,35    | 94,12    | 94,12     | 76,47     | 79,41  | 76,47  | 76,47 |
| TS       | 2014/2015 (N=38)        | 50,00    | 57,89    | 44,74     | 39,47     | 55,26  | 39,47  | 36,84 |
|          | 2015/2016 (N=34)        | 70,59    | 94,12    | 76,47     | 88,24     | 94,12  | 79,41  | 73,53 |

Table 1 indicates the achievement of learning outcomes in the academic year 2014/2015 has not been optimal. In general, the students’ difficulty in this academic year includes the following. First, for each diagram of PV, PT, VT, and TS is the greatest difficulty in describing the adiabatic process. This is apparently due to the characteristics of the adiabatic process typically "no interaction of heat, or Q = 0", no amount of which can be represented directly in the PV diagram, PT and VT. Second, the rate of students’ correct answers at the higher PV diagrams and the lowest is the TS diagrams. The students accustomed to in the PV diagram for the presentation of equilibrium thermodynamics to the various regular process they discovered in the PV diagram. Third, the students with better understand the characteristics of the typical thermodynamic process, such as isobaric process with constant pressure, isotherm with constant temperature, and isochoric with constant volume. That is to diagram the magnitudes involved, the students can make for staying draw a straight line that indicates that the value is constant. Fourth, the students with lack of understanding in the diagrams of PV, PT, VT, and
TS to illustrate the impact on the low thermodynamic process of understanding their depictions PV, PT, VT, and TS diagrams for the thermodynamic cycle.

The test instrument being tested to the students, as presented in Figure 1.

In thermodynamics, we discuss many thermal processes, i.e. the change of macroscopic coordinates of a system due to interacting with the environment, include a isochoric, isobaric, adiabatic and isotherm. Explain those processes qualitatively for ideal gases. Represent each process by using $P-V$, $P-T$, and $V-T$ diagram, and provide an interpretation (mathematically or physically) based on the diagrams you make.

**Figure 1.** A written problem posed on the examinations

As the example of student’s answer is shown in Figure 2.

**Figure 2.** The Sample of Student’s Answer

From the student’s answers, it appears that for the diagrams of PT, VT isotherm and the adiabatic process is made in the same curve as if they are the same characteristics. The analysis continuation of the interview the student obtained several findings as follows.

1. The adiabatic process similar to the process isotherm. For $P-V$ diagram only different steepness. Isotherm process steeper than the adiabatic.
2. In the adiabatic process no heat interaction, $Q = 0$, based on the equation, means there are also changes in temperature so that the adiabatic process "no change in temperature" means the temperature constant.

Both of these conceptions are clearly less precise. First, adiabatic similar to the isotherm, but $P-V$ diagram on adiabatic should be steeper than isotherm. This is due to adiabatic process factor (constant Laplace,) or while isotherm. Second, both of the conceptions associated adiabatic $Q = 0$, and based on the equation, means there is no temperature change also applies only to systems that only interact heat only (release or absorption). But for the gas in thermodynamic system reviews the interaction not only the heat, but there is the interaction of heat ($Q$), business ($W$) or both. In addition, in thermodynamics
is not generally accepted that each receive/make effort then will be converted into heat which is release/absorption, but can also to be converted in the form of changes in the energy (U).

The examples of these findings become the basis for the development of Active Learning Students Sheets (ALSS). ALSS is one of the learning strategies to facilitate the learning process to improve understanding students in PV, PT, VT, and TS diagrams. A learning process is one of the important aspects for the improvement of students' conceptual achievement [17]. In addition, ALSS accommodate students' abilities including student difficulties. The students' learning capability will determine the role of a teacher conducting the learning in a class [18]. The implementation of ALSS deemed able to improve students' understanding [8]. Because of the related representation, virtual presence is very important to strengthen or clarify their understanding related PV diagram, PT, VT, and TS for the process and the thermodynamic cycle. As an example, for the isobaric process, ALSS and the virtual designed as shown in Figure 3.

The limited trial of ALSS followed by the virtual application in the depiction of the PV, PT, VT, and TS diagrams for the process and the thermodynamic cycle implemented on 34 prospective physicists on the academic year 2015/2016. The learning process by using virtual followed ALSS more interactive because the students are guided to resolve the issues in ALSS. The ALSS implementation effectiveness is measured by the test instrument. Test results indicate the test instrument pretty good achievement. This is apparent from the percentage of the number of students who answered correctly for the academic year 2015/2016 as presented in Table 1.

4. Conclusion
The development of Active Learning Students Sheets (ALSS) has been done on a thermodynamic study sub-material of PV, PT, VT, and TS diagrams for the thermodynamics process and the cycles. The development is based on the students’ conceptual difficulties. The ALSS implementation followed by a virtual use as the reinforcement material. The results of students’ learning achievement in the PV, PT, VT, and TS diagrams is higher than before the implementation ALSS. These finding alternative solutions give the improvement of students' understanding of the PV, PT, VT, and TS diagrams for the process and the thermodynamic cycles.
Acknowledgments
We greatly thank to all those who have helped and contributed in this study, especially the second-year students in Department of Physic Education at Indonesian University of Education who signed the thermodynamic course.

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