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ANALYSIS OF TRIGGER EVENT, EXPLORATION, INTEGRATION, AND RESOLUTION SKILLS OF PHYSICS EDUCATION STUDENTS IN SOLVING THERMODYNAMICS PROBLEMS

Fenno Farcis[1], Gunarjo S. Budi[2]

[1,2]Physics Education Study Program, Faculty of Teacher Training and Education, Universitas Palangka Raya, Palangka Raya 73111, Indonesia.

Abstract

Critical thinking skills are skills that must be had by science teachers in the current 4.0 industrial revolution era. Indicators of critical thinking skills that must be possessed include trigger events, namely identifying problems, exploring thinking about personal and social ideas in order to make a decision preparation, integration that is constructing the intent/meaning of an idea, and integrating relevant information that has been set at the exploration stage, and Resolution is implementing and testing a solution. This research was conducted to determine the critical thinking skills of physics education students in solving problems in lectures on thermodynamics. The research sample were 30 physics education students at the Faculty of Teacher Training and Education, Universitas Palangka Raya who programmed the Thermodynamics Course and taken randomly. Evaluation of critical thinking skills consists of 8 questions that ask students to complete in a structured manner. The results showed that by applying the critical thinking skills evaluation instrument students had: 55% trigger event skills with low criteria, 45% exploration skills with very low criteria, 35% integration skills with very low criteria and 30% resolution skills with very low criteria. The results of this study are the basis for recommending the need for a learning model or approach that can be implemented in thermodynamic lectures to improve the critical thinking skills of trigger events, exploration, integration, and resolution of physics education students.

Keywords: *trigger event, exploration, integration, resolution, thermodynamics*

[1]Correspondence address:
Physics Education Study Program, Faculty of Teacher Training and Education, Universitas Palangka RayaJl. YosSudarso, Palangka, Kec. Jekan Raya, Kota Palangka Raya, Central Kalimantan Province 73111
Email: fenno.farcis@fkip.upr.ac.id

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INTRODUCTION

Physics is one of the basic sciences which is the foundation of individual thinking patterns to be developed into a major supporter of problem-solving, especially with the application of practical science (Sunaryo, 2011). Physics studies natural phenomena involving matter, energy, and their interactions through observation, experimentation, and analysis. The nature of physics is physics as a product, attitude, and process. Physics as a product is a body of knowledge that can be in the form of facts, concepts and principles. One part of science that is closely related to the practical application of physics and technology to various aspects of daily life is thermodynamics.

Thermodynamics is closely related to the universe and has an important role in human life. Hassan & Mat (2005) suggested that thermodynamics is basic knowledge related to energy and has long been an important part of the engineering curriculum. Thermodynamics is a subject related to energy and is one of the materials needed to understand natural phenomena. Thermodynamics is an important topic that must be studied in physics because of its many applications in the fields of science and technology (Kulkarni &Tambade, 2013).

The curriculum of Physics Education Study Program, Universitas Palangka Raya places the Thermodynamics Course as one of the expertise courses. This course aims to strengthen students' understanding of basic physics materials and equip students to follow advanced recovery. Thermodynamics is one subject that has a content of physics concepts that must be mastered by physics education students. The concept of thermodynamics is very closely related to events in everyday life. Understanding the concept of thermodynamics is needed by students to explain physical phenomena in everyday life. The results of Tatar &Oktay's research (2011) suggest that students who do not understand the concepts of physics can certainly not explain everyday phenomena by using physical concepts. Students have not been able to connect one concept with other concepts because each of these concepts has not been constructed intact in their thinking.

Students' thinking ability to master physical concepts requires basic thinking skills (Novak &Gowin, 1984), and also complex (high-level) thinking skills, including critical thinking skills (Costa, 1985). Critical thinking is one of the higher-order thinking skills (HOTS) besides creative thinking, creative thinking, problem-solving, and reflective thinking. There are several definitions of critical thinking put forward by experts, including Paul & Elder (2002) stating that critical thinking is a popular term in the fields of education, psychology, philosophy, and has been defined and theorized as a "set of intellectual standards" that can be used by an individual in thinking. The definition of critical thinking according to Halpern (2003) is thinking that aims, reasons and aims at the goal-type of thinking needed to solve problems, formulate inferences, calculate tendencies, and make decisions. Moore (2005) defines critical thinking as the ability to critically analyze complex situations. A rapidly changing world, increasing complexity, and increasing interdependence resulting in critical thinking is a condition for social and economic sustainability. The learning process that lacks training in students' critical thinking skills tends to form students who are passive and less able to optimize their thinking skills by only accepting what is conveyed by their lecturers.

Efforts to improve critical thinking skills need to be done by paying attention to the phases of critical thinking skills. Garrison, Anderson, & Archer (2001) divide the four phases of critical thinking, namely: (1) *trigger event* (rapid response to events), i.e. identifying or recognizing an issue, problem, dilemma from the experience of someone spoken by the instructor, or other students; (2) *exploration*, thinking of personal and social ideas in order to make decision preparations; (3) *integration*, which is to construct the intention or meaning of ideas and integrate relevant information that has been determined in the previous stage; and (4) *resolution* (repeating resolution), which proposes a hypothetical solution, or applies a solution directly to an issue, dilemma, or problem and tests ideas and hypotheses.

The results of a preliminary study in the Physics Education Study Program, Universitas Palangka Raya showed that the thermodynamics learning outcomes in the last five years were still relatively low at an average of 62 out of 100. The low learning outcomes is one of them caused by students' difficulty in understanding abstract and macroscopic thermodynamics concepts that are difficult to describe in real terms. And lecturers in their learning tend to use a mathematical approach in teaching thermodynamics concepts and rarely do lab work. Students are less involved in the process of constructing thermodynamics concepts. Therefore, to understand difficult and abstract concepts can be done where students are involved in the process of constructing a concept in their minds and science skills through the science process (Risamasu, 2016).

Thinking of various experts, facts in the field, and also various relevant research results described above are the rationale for the need to conduct a study that aims to find out the students' critical thinking skills of Physics Education Study Program, Universitas Palangka Raya on the Thermodynamics Course.

METHOD

This research used descriptive-qualitative and quantitative methods which are directed to explore data from actual field conditions. The data in question is the critical thinking skills of students in the process of solving thermodynamics problems. Descriptive research explains or illustrates what is happening (Arikunto, 2013) without manipulating or changing independent variables so that they describe the actual conditions. The research was conducted in the Physics Education Study Program, Universitas Palangka Raya. The research sample were 30 students who programmed the Thermodynamics Course and determined by cluster random sampling. The instrument used was the evaluation of critical thinking skills (EKBK) in the form of essays.Assessments developed for critical thinking skills should be in the open-ended test format rather than multiple-choice tests because the open-ended tests are stated to be more comprehensive (Ennis, 2011). Data analysis was performed with quantitative percentage analysis with qualitative discussion.

RESULTS AND DISCUSSION

The EKBK is given to the students as an evaluation of all skills. The EKBK is given to evaluate students' critical thinking skills which consist of 4 (four) indicators of critical thinking, namely: (1) trigger event; (2) exploration; (3) integration; and (4) resolution. The evaluation of critical thinking skills assessment refers to a test that has been developed previously, namely the California Critical Thinking Skills Test (CCTST). Indicators of critical thinking skills used in this research same with the indicators of critical thinking skills from Garrison, Anderson, and Archer. Each item is adjusted to the question indicator that refers to critical thinking skills that have been set on the indicator. Each question is a separate part of the next problem so that it is not a prerequisite for solving further problems.

Evaluation of critical thinking skills developed in the form of essay/objective description which has answers with definite formulations, so that scoring can be done objectively. There were 8 questions done by students in 120 minutes. Critical thinking skills scores are converted into 5 (five) criteria, namely: (1) $89\% < x \leq 100\%$ (Very High); (2) $78\% < x \leq 89\%$ (High); (3) $64\% < x \leq 78\%$ (Medium); (4) $55\% < x \leq 64\%$ (Low); and (5) $0\% < x \leq 55\%$ (Very Low). EKBK results are presented in Table 1.

Table 1. Students' Critical Thinking Skills

Indicator	Percentage (%)
Trigger Event	55,00
Exploration	45,00
Integration	35,00
Resolution	30,00
Average	**42,50**

Table 1 shows the results of the EKBK contained in the Trigger Event indicator of 55.00%, the Exploration indicator 54.00%, the Integration indicator 35.00%, and the Resolution indicator 30.00%. The average achievement of students' critical thinking skills of the Physics Education Study Program, Universitas Palangka Raya is 42.50%, this shows that the critical thinking skills of Trigger Event, Exploration, Integration, and Resolution of students were at very low criteria.

The low critical thinking skills of students were possible due to several things, first, the lack of trained student skills in identifying and classifying the substantive concepts in the thermodynamics. Learning on thermodynamics concepts is learning about the change of energy into mechanical motions and work. A complete understanding of the macroscopic and microscopic quantities of thermodynamics is needed in understanding the essence of thermodynamics (Loverude, Kautz, & Heron, 2002). An understanding of the two quantities will make it easier for the students to understand the concepts of gas, temperature, heat, effort, internal energy, and entropy concepts. Furthermore, students also have difficulty solving problems related to the First and Second Law of Thermodynamics. Students' understanding and training on critical thinking questions are still lacking. Next, the students are not used to implementing the steps of critical thinking skills in Trigger Event, Exploration, Integration, and Resolution as the implications of the low frequency of solving critical thinking problems.

In solving thermodynamics problems, students have not been consistent in using the concept of gas state equations (Loverude et al., 2002). Students have difficulty using the concept of the gas state equation. In the Trigger Event process students have difficulty in identifying the physical state of each thermodynamics process, constructing the meaning/meaning of the idea of each problem related to the equations of the gas state and the First and Second Law of Thermodynamics in the Exploration process. Furthermore, in the Integration stage students cannot and integrate relevant information that has been determined in the Exploration stage, and in the resolution, stage students cannot implement and test solutions.

The difficulty faced by students is that they have not been able to connect microscopic and macroscopic quantities. In addition, students do not understand the isobaric phenomenon and the relationship between temperature, pressure, and volume that occurs in the syringe which is initially dipped in cold water and then into hot water. The syringe has a piston with zero friction. Furthermore, another difficulty related to the First Law of Thermodynamics that students interpret heat as a specific quantity of energy present in an object and temperature is a measure of quantity. The actual concept is heat is a representation of energy transfer between the system and the environment because there is a difference in temperature while the temperature is a representation of the average kinetic energy of the system (in the kinetic theory of gases) (Meltzer, 2004). In solving problems related to the Second Law of Thermodynamics, when students were asked to explain the Carnot machine, the students only explained that the heat was converted into business and the rest was converted into heat. Students should explain it in terms of efficiency, entropy, and Carnot's theorem

CONCLUSION

The results of this research provide an overview for lecturers, educators, and researchers regarding the condition of critical thinking skills of the Physics Education Study Program, Universitas Palangka Raya students on the Thermodynamics Courses. The average achievement of students' critical thinking skills is less than 55% which is 42.50%, this shows that the critical thinking skills of Trigger Events, Exploration, Integration, and Resolution of students are at very low criteria. Results This research can be used as a reference for designing and developing learning processes that can improve students' critical thinking skills.

Suggestions for further research related to improving the quality of critical thinking skills of students are very much needed a model, tools, and learning media that support the learning process that should be fully developed so that it can help students achieve the learning outcomes of the Thermodynamics Course.

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