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PRE-SERVICE PHYSICS TEACHERS' KNOWLEDGE, DECISION MAKING, AND SELF-SYSTEM TOWARD ENERGY CONSERVATION

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ABSTRACT

Along with the increase of world's energy need in one hand and of the impact of its uses in the other hand, conservation is indispensable. This paper describes pre-service physics teachers' knowledge about energy conservation, how they use their knowledge to make energy-related decisions, and how their self-system toward energy conservation. The data presented here are from selected items of a field test of instrument intended to measure energy literacy that involved 123 pre-service physics teachers from three state universities in Indonesia. They are one state university in South Sumatera and two state universities in West Java. Data from this survey study were analyzed qualitatively. Results showed that pre-service physics teachers were still lack of knowledge and knowledge utilization to make energy-related decision. However, they showed a tendency to engage in energy conservation efforts.

ABSTRAK

Seiring meningkatnya kebutuhan energi dunia di satu sisi dan dampak penggunaannya di sisi lain, konservasi menjadi sangat penting. Artikel ini menggambarkan pengetahuan mahasiswa calon guru fisika tentang konservasi energi, bagaimana mereka menggunakan pengetahuan tersebut untuk mengambil keputusan, dan bagaimana self-system mereka terkait konservasi energi. Data diperoleh dari uji lapangan terhadap instrumen yang ditujukan untuk mengukur literasi energi yang melibatkan 123 mahasiswa calon guru fisika dari tiga perguruan tinggi negeri di Indonesia. Ketiga universitas negeri tersebut adalah satu berada di Sumatera Selatan, dan dua berada di Jawa Barat. Data dari penelitan survey ini dianalisis secara kualitatif. Hasil analisis menunjukkan mahasiswa calon guru fisika kurang dalam pengetahuan dan penggunaan pengetahuan untuk membuat keputusan terkait energi. Namun demikian, mereka menunjukkan kecenderungan untuk terlibat dalam upaya konservasi energi.

Keywords: Energy Conservation; Decision Making; Pre-Service Physics Teacher; Self-System

INTRODUCTION

Along with the increase of energy needs on the one hand and the effects of its uses in other hand, conservation is deemed to be the solution. The term energy conservation can indeed have two interpretations. Firstly, energy conservation, in physics, means that energy is conserve or is known as principle of conservation of energy. Energy is neither created nor destroyed. This meaning appears to be opposed to the second meaning, that energy conservation is interpreted in everyday language as energy saving. Regarding to energy saving, it can be done in two ways, technology development (efficiency) and behavioral change.

Development of technology to improve efficiency is necessary, but it is not sufficient to reduce the energy consumption (Costanzo, Archer, Aronson, & Pettigrew, 1986). The development of technology will has more impacts if it is supported by the changes of human behavior in using energy. Behavioral changes will occur if a person has sufficient knowledge (Finger, 1994; Frick, Kaiser, & Wilson, 2004; Jen-

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sen, 2002; Kaiser & Fuhrer, 2003; Zografakis, Menegaki, & Tsagarakis, 2008) and the attitude or affect (Davis, 1985; Dewaters & Powers, 2011; Gomez-Granell & Cervera-March, 1993; Lee, Lee, Altschuld, & Pan, 2015; Vlahov & Treagust, 1988). A such characteristic of individual is called as an energy literate person (Barrow & Morrisey, 1989; DeWaters & Powers, 2013).

Without a basic knowledge of physics the ideas around energy conservation are likely meaningless (Newborough, Getvoldsen, Probert, & Page, 1991). System knowledge, action-related knowledge, and effectiveness knowledge are regarded as conservation-relevant knowledge (Frick et al., 2004). System knowledge relates to knowledge about energy problems. This is a basic scientific knowledge. Action-related knowledge relates to how to conserve energy. To select among alternatives which is more effective way to conserve energy, then someone needs effectiveness knowledge.

When someone select between two or more alternatives that initially appear equal, the process of decision making is used (Baron & Brown, 1991; Marzano & Kendall, 2007). Informed decisions regarding energy issues faced in everyday life constitute process of someone utilize his/her knowledge. However, in making decision, someone may use normative (rational) or naturalistic approach (Jonassen, 2012). With rational perspective, decisions are made by considering the one that provides maximum utility, while with naturalistic perspective, decisions are made by considering the one that is most consonant with personal beliefs (Jonassen, 2012).

Interconnected attitudes, emotions, and personal beliefs shape individual self-system (Marzano & Kendall, 2007). Further, Marzano & Kendall (2007) proposed four type of self-system. They are examining importance, examining efficacy, examining emotional response, and examining motivation.

This paper aims to describe the measurement results of pre-service physics teachers related to energy conservation. Questions that will be answered in this paper are: (1) what is the pre-service physics teachers' knowledge regarding energy conservation; (2) how do pre-service physics teachers make decisions related to energy conservation; and (3) what is *the self-system* of pre-service physics teachers toward energy conservation.

METHOD

The data reported on here resulted from selected items according to the topics of energy conservation of the instrument that purported to measure pre-service physics teachers' energy literacy. The instrument was developed based on previous work (Yusup, Setiawan, Rustaman, & Kaniawati, 2017). For our purpose in this paper, we relabeled the code of items from its original version. There were 123 pre-service physics teachers from three state universities in Indonesia who involved as participants. They are one state university in South Sumatera, and two state universities from West Java. The participants were from the first to third year of study in the universities. Their participation in the current study were voluntary. Descriptive method was used to analyze the data.

RESULTS AND DISCUSSION

Pre-service physics teachers comprehension toward energy conservation

Figure 1 depicts two items to assess pre-service physics teachers' comprehension of energy conservation. Question 1 conflicted pre-service physics teachers' understanding about the principle of energy conservation (energy is neither created nor destroyed) and the current consideration of conservation of energy (resources) where the world is seen as running out of energy, There were 39% of participants agreed that energy will not be exhausted and 41% of participants added the statement that although energy in the world will not be exhausted but remains vital to save energy. Only 7% of participants who could answer precisely this question.

The result indicates that the majority of pre-service physics teachers did not understand the principle of energy conservation well. They could not distinguish the concept of energy conservation and energy degradation. This can be confirmed from their answer to the Question 2 (Figure 1).

In Question 2, participants were asked to evaluate issue on depleting non-renewable energy sources. Majority of participants (92%) expressed disagreement if non-renewable energy sources were used regardless of the availability of energy sources for future generation.

The results revealed that pre-service physics teachers have not understood the concept of energy conservation well. They equated principle of energy conservation with energy conservation in the sense of energy saving. These findings are consistent with previous studies (Kesidou & Duit, 1993; Papadouris, Hadjigeorgiou, & Constantinou, 2014). This weakness is due to the use of the term energy in everyday life are not in accordance with the conception of physics (Duit, 1981; Kesidou & Duit, 1993). Another cause is the lack of recognition of the concept of energy degradation in learning (Daane, Vokos, & Scherr, 2014; Goldring & Osborne, 1994; Pinto, Couso, & Gutierrez, 2004).

Question 1
Based on his understanding of the law of conservation of energy, a student argues that energy in this world will not be exhausted. Therefore, according to him, we do not need to save energy. What will be the consequences if the student's opinion is followed? Explain your reason.

Question 2
Although our petroleum and natural gas reserves are getting lesser, it does not matter that we use as much petroleum and natural gas as we need now because future generation will have new energy that we do not have today.
Do You agree with this statement? Explain your resason.

Figure 1. Items to assess pre-service physics teachers comprehension toward energy conservation.

Pre-service physics teachers' energy-related decision making regarding effectiveness knowledge

Two questions in Figure 2 were intended to assess how pre-service physics teachers use their knowledge to make energy-related decision. Question 3 provides a condition in which the available alternatives of *incandescent light bulb* (ILB), *compact fluorescent light* (CFL), and *light emitting diodes* (LED) bulbs for purchase. Sensible option is to buy products that are more economical and less impact on the environment and the choice should be LED bulb.

The decision-making tendency to consider only one aspect was confirmed by pre-service physics teachers' responses to Question 4 (Figure 2). A total of 56% of participants chose the product only on the basis of the electric power consumption or of the price aspect. Only 4% of participants chose product with comprehensive consideration, which was more beneficially from economical and environmental aspects.

Question 3
The power consumption, lifetime, and price of the ILB, CFL, and LED bulb with the 800 lumens light output in the table below.

Type	Power (watt)	Life-time (hours)	Price (IDR)
ILB	60	1 000	8.000
CFL	14	8 000	38.000
LED	10	25 000	88.000

If you have Rp 90,000 to buy bulb(s), which bulb(s) will you buy? Explain the reasons for your choice?

Question 4
One day your father asked your help to accompany him to buy in cash an air conditioner (AC) to be installed in one room in your house with installed power is 2 200 watts. He tells you that his budget is a maximum of Rp 3,000,000,00. Apparently, in the store there are available products with different power prices and power consumption. All products are warranted one year for indoor unit and three year warranty for outdoor unit (compressor).Product specifications as shown in the table below. Your father only receive the price up to Rp 3,000,000,00. Apparently, in the store there are available products with different prices and power consumption. All products are warranted one year for indoor unit and three years warranty for outdoor unit (compressor). Product specifications are as in the table below.

Brand	Power (watt)	Price (IDR)	Compressor material	Dimension of indoor unit (cm)
A	795	2.900.000	Fiber	100x30x25
B	840	2.700.000	Fiber	88x30x23
C	900	2.600.000	Zinc	87x29x22
D	925	2.500.000	Zinc	77x24x18

Which brand of AC product do you recommend to buy?

Figure 2. Items to assess pre-service physics teachers' energy-related decision making regarding effectiveness knowledge.

Pre-service physics teachers' energy-related decision making regarding action-related knowledge

When challenged with a situation that requires taking action, pre-service physics teachers did not use action-related knowledge well. Question 5 (Figure 3) illustrates the situation of someone leaving home (to go to campus) using a motorcycle then realizing that he left light bulbs still on. The choice to be taken is to go back immediately and turn the lights off or continue to go to campus. A total of 74% of participants are not able to answer the question and only 9% were able to answer comprehensively. The majority of the answers were with no an appropriate argument and so were identified as guessed answers, such as, "I will go back," or "I will continue to go to campus."

The lack of knowledge utilization to make energy-related decision of pre-service physics teachers was confirmed from responses of Question 6. The situation was when finished watching television, what they do to the television. The action could be considered as habitual. The response from participants showed that only 21% who stated that they turn the television off and disconnect the plug from the electric terminal. The rest of participants prefer to turn the television off but let it in standby mode (the power cable remain plug in electric terminal). Even a few of participants stated they let the television on.

Question 5
One day when you ride your motorcycle to go to campus, you suddenly remember that you had not turned the bulbs off that totaly use 100 W of power consumption. With only consider of CO_2 emitted, would you go back to turn bulbs off or continue to go to campus?
Use the following assumption:

- If you do not come back now there is an additional time the lights will be on for 8 hours until you get home from campus.
- The bulbs have an emission intensity of 0.6 kg CO_2/kWh.
- If you back home, you will travel a total distance of 5 km (back and forth) and your motorcycle gasoline consumption is 50 km/liter, with an emission factor of 3.2 kg CO_2/liter of gasoline.

Ignore the CO_2 emitted by the bulbs during the time you need to get home if you decide to go back.

Figure 3. Item to assess pre-service physics teachers' energy-related decision making regarding action-related knowledge.

In making decision toward energy, pre-service physics teachers tend to consider only one aspect, especially the economic aspect. They tended to use rational perspective (Jonassen, 2012). Indeed, cost factors, or the ratio of personal costs and ecological benefits (Kaiser & Fuhrer, 2003), can be considered in making decision. Pre-service physics teachers did not showed an integrated or comprehensive approach (Liu, Gupta, Springer, & Wagener, 2008 in making decision. The effectiveness and action-related knowledge (Kaiser & Fuhrer, 2003) should be required to make decisions related to energy conservation.

Pre-service physics teachers' self system toward energy conservation

Items related to *self-system* include *self-efficacy,* emotional response, and motivation. To examine the *efficacy* of pre-service physics teacher in conserving energy, the question asked whether they believe that they can use energy efficiently. A total of 54% participants believed they could use energy efficiently, while the rest stated they were not sure. Generally, the reason of those who were not sure because they did not know how to reduce their consumption of energy.

The proportion of efficacy responses was the same as the answers of the question of whether they have a motivation to teach students to save energy. There were 54% of participants expressed their wish and were confident to do so, while the rest expressed their wish but were not sure they could.

Emotional response of pre-service physics teacher related to energy use were tested by asking a question that illustrate a situation when at noon someone found in one of the empty lecture room the light bulbs are left on. The majority of participants (75%) expressed emotions that reflect the attitude of energy saving. Among the feelings that they were annoyed or deplore see a situation where the energy is used unwisely (wasteful). A little percentage of participants (25%) felt that it was prevalent situation so that was nothing wrong.

The answers of question to examine motivation were similar proportion to the emotional responses question. Pre-service physics teachers were asked whether it is important or not to teach energy conservation to students at school. A total of 78% of participants stated that energy conservation attitude was an important competency to be taught at school.

Self-system determines whether a person will be involved in a program or not (Marzano & Kendall, 2007). The results showed that the majority of pre-service physics teachers had motivation to engage in energy conservation, but only half of those who had confidence to do so. Although in different topic, Rokhmah, Sunarno, & Masykuri's (2017) finding about the lack of disposition in some textbooks they used in high school, can be suspected as the cause of the low of pre-service physics teachers' efficacy. Nevertheless, pre-service physics teachers expressed emotional responses that showed a tendency to conserve energy.

CONCLUSION

Energy conservation principle is often confused with the everyday life that associate with the energy saving. Unfortunately, the majority of pre-service physics teachers have not had a proper understanding of the concepts. At the level of knowledge utilization to make energy-related decisions, pre-service physics teachers also showed low performance. Although the majority of pre-service physics teachers stated that energy conservation is important competency and they showed their motivation to involve in such efforts, but they were still lack of efficacy.

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