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Students' Misunderstandings about the Energy Conservation Principle: A General View to Studies in Literature

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Abstract: This paper serves to review previously reported studies on students' misunderstandings about the energy conservation principle (the first law of thermodynamics). Generally, studies in literature highlighted student' misunderstandings about the energy conservation principle stem from preliminaries about energy concept in daily life. Since prior knowledge of students' misunderstandings of scientific content knowledge is the first step in preventing these misunderstandings, it is considered that such a study will provide an important source for studies which aims to reduce or eliminate misunderstandings on the energy conservation principle.

Key words: Energy conservation, energy degradation, first law of thermodynamics, misunderstandings

INTRODUCTION

In science, one of the most important observations is the reality that energy can neither can energy be eliminated from existence nor created from absence; that is energy is conserved (Brown et al. 2000, p.781). Its ease in stating and remembering made it one of the most known principles. When asked students could recite the statement which resembles to a jingle comfortably. Apart from this, the principle of energy conservation composes the infrastructure of scientific explanations to account for the observable and unobservable phenomenon around us. Consequently, this principle has an important place in science and technology.

Energy and energy conservation are such closely related concepts that it is almost impossible to discuss one without the other in a closed system. For students who are recognizing energy concept, energy conservation principle must be absolutely mentioned in the other step (Goldring and Osborne, 1994, p.26). Even though energy's conservation principle which has such an important place from the respect of science education appears to be understandable for educators and learners, it was found that students had misunderstandings related to this principle (Solomon, 1985; Driver and Warrington, 1985; Brook and Wells, 1988; Beynon, 1994; Goldring and Osborne, 1994; Trumper, 1997; Barker, 2000; Pintó et al. 2004; Treptow, 2005; Çengel, 2005; Millar, 2005). With this study, we attempt to present the result of the literature findings on students' misunderstandings related to the energy conservation principle. It is thought that such a study will be beneficial to science teachers and especially to researchers who try to eliminate the difficulties in science education.

General View to Literature

Energy conservation law, also known as the first law of thermodynamics takes place in both quantitative and qualitative studies which are specific to thermodynamics. Some misunderstandings stated in literature related to energy conservation are presented in below.

Reported misunderstandings;

1. Energy is used up or lost.
2. If stays in system, energy will be conserved.
3. Energy degradation means decreasing in its quantity.
4. Energy degradation is opposite to energy's conservation.
5. Energy conservation means saving.
6. Burning m substance produces energy as much as mc^2.
7. Energy is stored in food and fuel.

Kruger et al. (1992), stated that the majority of the answers received in studies they made with primary school teachers about energy concept contradicted with the principle of energy conservation. Also, in a study by Brook and Driver (1984), on 15 years age group students' opinions about energy conservation, approximately two third of the students stated that energy was used up or lost.

Students look to energy as an existence which ends, exhausts or expends. We can use the term "energy" which we also frequently encounter in our daily life in the same meaning with verbs such as "used up, expend" which are opposite to "protect". This condition may cause wrong prejudices about energy concept. And according to Ross (1993), students have the opinion that "energy is used up or lost" in their personal encounters with exhaustion of batteries and the refilling of fuel tanks in their daily lives.

Since "conservation" can have a passive meaning in the context of its usage in daily life, it brings to mind the statement of "influencing of a thing which is out of". And this will bring together the meaning that if energy is given out, to the environment, it will not be conserved. In Pinto et al.'s (2004) study high school science teachers used the statement that "if environment is a part of system, energy is conserved, if it is not, it is degraded and dispersed ".n addition, a study carried out Solomon (1985) on primary school students revealed that student tend to think that it is necessary for energy to stay within a reaction system because of energy conservation.

The principle of energy conservation can be understood as energy's qualitatively invariableness. In this situation, any decrease in quality is interpreted as energy's not being conserved. Pinto et al. (2004), in their study with high school science teachers determined that a majority of teachers saw "energy conservation" and "energy degradation" as opposite facts to each other. According to this, energy would only be degraded on the condition that it was not conserved. However, the conservation of energy in every condition is a reality. Again in the same study Pinto et al. found out that in an addition to this misunderstanding, some teachers looked at energy degradation as a decreasing quantity. Energy loss and decrease in energy phases were interpreted as not a decrease in energy's availability or usefulness but a decrease in its quantity. The exchange in energy's quality and usefulness may give students the impression that in quantity too. Energy usages occurring around us leave products that can not be used in the later time. In daily conversations, the frequent expressions like energy is decreasing, losing or finishing firstly bring to mind a decreasing in quantity.

The synonymous use of the terms "conservation" and "saving" in daily life causes students to misunderstand the energy conservation principle in a wrong way. Since energy saving reality coming to agenda with energy crisis, the students think of energy conservation as energy saving because the latter term is used when issues on depleting energy sources are discussed. One of the researches made with this view is Carr and Kirkwood's (1988) study which were carried out related to the teaching of energy concept. One part of the study composed of class observations on 13-15 years age group students. In this study, it is determined that students were confused between the principle of energy conservation which states that energy cannot be created from absence, and it cannot be exterminated from existence and the idea of "conservation of energy resources" getting exhausted gradually. In another research related to energy concept made at primary school level, Goldring and Osborne (1994) determined that approximately 30% of the students viewed energy conservation as energy saving .

One of the misunderstood points about energy conservation has to do with the $E=mc^2$ equation. The relation put forth by Einstein reveals the connection between mass and energy. While this theory helps students understand chemical events, it can cause some misunderstandings from the view of energy conservation, if it is not explained sufficiently. Students explained the visible quantity decrease of products occurred in the energy giving events for example, in the combustion of wood, coal, candle and paper. They think that a decrease in mass is accompanied by a decrease in energy as "c" (speed of light) is a constant. According to Treptow (2005), discussions of nuclear and subatomic particle reactions often led to the misconception that mass was converted into energy. In fact, if a complete calculation of reaction system and its surroundings is done, it can be shown that both mass and energy are conserved. At best, that claim that mass can be converted into energy is to provide a facility by calling attention to a more definitive reaction. It is wrong in reality. The mass lost in a reaction system is often too small to be detectable. $E=mc^2$ phrase does not mean the burning of coal with mass, m, produces an energy equivalent to mc^2 . This statement can only be valid when proton and neutron subatomic particles move in the speed of light (Beynon, 1994, p.88). This equation which is easily remembered by students can result in misjudgment when evaluating events related to these concepts in daily life.

The mentioned relation expresses when the energy of a system exchanges its mass will also exchange. However in almost all energy interactions, the exchange in mass can be so insignificant that it cannot be measured even with the most sensitive apparatus (Çengel and Boles, 1996, p.166) available. Actually, mass and energy are only alternative measures of the single quantity known as mass-energy. As for $E=mc^2$, it is an equality which enables us to calculate the energy-equivalent of any mass or the mass-equivalent of any energy (Treptow, 2005, p.1640).

Besides all these misunderstandings, students also saw energy as a substance that could be stored. Food and fuel are considered as energy resources in which energy is stored. (Holman, 1985; Ross, 1993; Millar, 2005; Sefton, 2004; Solomon, 1985; Beynon, 1990). Generally energy is defined as "the capacity or ability for doing work". According to this, can a capacity or ability be stored? (Beynon, 1990, p.314). Energy being an abstract idea cannot be stored. But energy used in daily life is generally obtained from the combustion of food and fuel. These personal experiences could have caused us to think that food and drinks like chocolate, jam, energy drinks, and fuel like petrol, coal, wood are one of energy store. The lack of knowledge that oxygen gas is also involved in the combustion process could also result in further complications in understanding.

CONCLUSION

Although energy conservation is considered as a simple concept and well-known principle in numerous studies conducted, it is found that students have misunderstandings about this idea. Since energy is an important concept that concerns our daily life, students' mistakes in usage can have detrimental influence on the scientific comprehension of the energy conservation principle. In future studies related to the teaching of energy conservation, it is hence necessary to focus on the misunderstood points discussed above. Therefore, we concluded that it would be beneficial to carry out more studies on methods to reduce or eliminate such misunderstandings that can hinder learning.

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