

# The investigation of high school student's energy concept by using analogies

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**Abstract.** Alternative energy tends to be more widespread in Thailand because the advanced technology, enhance the potential of equipment which becomes more economically rather than setting in laboratory likes in the past. For this reason students should understand profoundly about the characteristic of energy before they learned about alternative energy. To help students get more comprehension about the characteristic of energy, we need to investigate the idea about energy. There are three main reasons for the investigation (1) to know how students use analogy to describe characteristic of energy (2) to find out the most frequent characteristic that student used (3) to classify analogies for energy by using category of misconceptions which helped us to group students if there were any vague content in students' explanation. Students were given a task to write their analogies after doing the STEM activity (Bungee Jump) in class. The answers were categorized into four terms of scientific contexts: energy can be accounted, can change forms, can be lost and can be transferred.

## 1. Introduction

Energy education has become extremely convincing people in society because the demand of energy has been rising but the energy resources has been decreasing [4]. To teach the energy, analogies are valuable tools to explain energy in a tangible way [3]. In the present many science text books use analogies to illustrate the idea of science [5]. On the other hand analogies can show how students conceptualized the idea of energy [7]. There were the investigations about energy concept by using students' analogy. Those paper focused on students who study in different science topic or same topic with different aspects [7]. But in this paper we did both investigation and classify the students' analogies with. There were three objective (1) to know how students use analogy to describe energy characteristic analogies (2) to know the most frequent characteristic that students used (3) to classify analogies for energy by using category of misconceptions. We used analogies as tools to see what students conceptualized energy in the way that student.

## 2. Theoretical Framework

### 2.1. Analogy

An analogy is very useful in science education. The role of analogy is to explain the scientific model in more concrete terms, and explicitly states a functional or structural relationship between the target concept and the analogy [8]. By asking students to describe something in science class with analogy.

They can create the mental model by individuals even working in a group or alone and analogy is often used to represent a mental model [2]. Mental models are iconic, that is, their structure as far as possible corresponds to the structure of what they represent [6]. To investigate student's concept teacher can use analogy to reflect what idea that student has.

### 2.2. *Criteria for Analogy*

An analogy is often used in science, however students may not perceive the gist of analogy furthermore sometimes an analogy can be misinterpreted or discounted, educationalists often concern about the use of an analogy in teaching [1]. To consider the use of analogies, several analogies are very convincing so the reader may pay attention to the similarities that relevant to the problem however the justification of the conclusion bases on logic in nature thus the overall degree of similarity has no meaning in the process [9]. Under this framework, the analogies were categorized by using scientific misconception because we really want to explore that how many students use their past science knowledge to explain new concept. If the students mention things that is not relevant with science or base on science logic, will be categorize as follows [8]

- Preconceived notions are conceptions that base on daily life experience.
- Non-scientific beliefs are conceptions that cannot be proved by science.
- Conceptual misunderstandings occur when scientific information do not lead students to the law, theory or model in science.
  - Vernacular misconceptions happen when students use a familiar word but it has the different meaning in science context.
  - Factual misconceptions are false conceptions happen when students memorize the situation and assume that is a fact. Mostly those conceptions happen in early childhood when something happened and students believed it without asking for a reason.

## 3. Literature Review

### 3.1. *Definition of Energy*

Giving, the definition of energy, is difficult. There is no absolute or universal concept to define an abstract concept like energy [9]. In science education energy is usually defined as: (1) energy defined through the concept of work; (2) energy as something that 'makes things go'; or (3) energy as a measure of change in a system [5]. However in science the energy definition remain controversial but the calculation and application of energy is more necessary.

### 3.2. *Characteristic of Energy*

Duit [2] has proposed five aspects of energy in science class. Those aspects were concept of energy; energy degradation; energy conservation; energy conservation and energy transfer. However Lancor [7] has presented the five characteristics of energy which consists of energy conservation; energy degradation; energy transformation; energy transfer and energy source. So I decided to choose four items from their lists which intersect as characteristics of energy in this paper.

- Energy conservation – Energy cannot be destroyed or created.
- Energy degradation – The usable form of energy is decreased because it changes into unusable form such as when you put a hundred joules into a pistol the pistol changes 80 joules into mechanic energy but the rest of energy transformed into sound and heat energy.
- Energy transformation – Energy has various form and it can be converted back and forth.
- Energy transfer – Energy moves from higher intensity to lower intensity in a system. For example, if you throw a ball into a stack of cans. Energy in a ball is higher when it collides, energy from a ball will transfer to a stack of cans.

## 4. Method

### 4.1. Participants

Participants were twenty-nine high school students from intensive mathematic-science program which have been lectured in mathematics and science by professor at Ubon Rachatani University. The class was conducted by the professor and his assistances, there were two section- the first was lecture which took about 2 hours the topic covered gravitation and elasticity energy. The second part was STEM activity, students spent 3 hours to finish the activity.

### 4.2. Data Collecting and analysis

The task were given to students at the end of the class, students were asked to write the analogy which represented the energy and to give the description to support their analogy. The data were analyzed concisely by three physics teachers and judged by the coding criteria. If there was a split decision, judges had to discuss together to find out the consensus.

### 4.3. Coding for the characteristics of energy

There are the criteria for classifying the characteristic of energy as follow:

- Energy conservation – if the students mentioned that energy cannot be lost or created.
- Energy degradation – if students mentioned that energy transforms into other forms that cannot be used or can be lost from a system to environment.
- Energy transformation – if students mentioned that energy has ability to change forms.
- Energy transfer – if students mentioned that energy moves from one place to another or being transported by carrier.

The example for split decision in the characteristics of energy was “Energy is like lightning strike because lightning strike can turn into heat, sound and light as energy can change its forms...” two judges agreed that was the characteristic of energy transformation but the other one did not agree, he gave the reason that when lightning strike happens it produces tremendously heat and small amount of light and sound compared to percentage of total energy, so it should be energy transformation and energy degradation because the most energy from lightning strike is heat and only few loses into light and sound. Then one of the two argued energy degradation was considered when students defined usable energy in the system. Finally they all agreed that energy degradation was nonsense in this case.

### 4.4. Coding for the types of misconception

There are the criteria for categorizing the types of misconception as follow:

- Preconceived notions – if students gave an example in daily life that conflicts with science.
- Nonscientific beliefs – if students supported ideas by things that science has no explanation
- Conceptual misunderstandings – if students used a reason to support their analogies but it is contradiction with reality.
- Vernacular misconceptions – if students used words or slangs to support their analogies but those words mislead to the right explanation.
- Factual misconceptions – if students claimed something which believe that is the fact but it is false in reality.

The example for split decision in the categorizing of analogy was “Energy is like money. We can exchange money to other things. Energy is also, it can change into other forms.” One of the judge claimed that money should be considered as non-scientific belief because money does not have real value (unit) in science, so we cannot measure it by scientific method. But the other judge offended that

money should be unidentifiable (none of five items in misconception) in this case because it has its value in economic which is quite tangible for human being so as it is real for human life but it does not real in science, unidentifiable is a better choice for me. The last judge also agreed that money can use for substitute in this case and student had not mentioned things that were wrong in scientific context, he just had related science by using the logic from economic. Lastly all judges decided to classify money as indefinable.

## 5. Result

**Table 1.** The Examples of student's analogies

Characteristic of Energy	Students' analogies	
	Percentage	Example of analogies
Energy conservation and Energy transform	66.7	Energy is like water because water can change states and energy also can change forms. Neither energy nor water can be destroyed or rebuilt. Such as someone wants to destroy water by boiling them in fact the water isn't being destroyed, it is changing the state from liquid to vapour
Energy conservation and Energy transfer	7.4	Energy is like opening the door. While the door is standstill, no one pushes it. The door isn't moving. The moving of the door is caused by a person who is disturbing the balance of the force then the door is going to move. Like the energy can transfer from a person to the door and the energy doesn't vanish it just changes into other forms.
Energy conservation, Energy transfer and Energy transform	3.7	Energy is like a Pinball game. Because energy causes work and work can cause motion. When we push the button to hit the ball the ball will hit other objects which causes energy transfer but the energy doesn't lost, it just changed forms into heat.
Energy transfer and Energy Degradation	3.7	Energy is like the moving swing. The moving of the swing is like periodic motion. When we push the swing, the force will be applied from a person who sits on the swing to itself. However we have to push or shove more than one times to constrain the movement because the force is needed to be applied to compensate the friction force between the swing and the bar.
Energy Transform	14.8	Energy is like money. We can exchange money to other things. Energy is also, it can change into other forms.

### 5.1. The frequent of energy

Water was the most frequent analogy (29.6%), most of students used water to represent energy as a substance that can be transferred and changed. The rest of the frequent of analogies were feeling (14.8%), process or activity (11.1%), etc (40.7%) and unusable content (3.7%) respectively.

### 5.2. The categorizing of analogy

About 63% of students supported their analogies by using scientific content. The others were categorized as non-scientific beliefs (25.9%) and Conceptual misunderstandings (7.4%) and indefinable (3.7%).

## 6. Discussion

The findings indicated that even most of students gave the same representative of energy (water) but their explanations showed that were divergence. An example for the difference between students' answer was water in body respiration (biology context) and was water in chemical reaction (chemistry context) but both of them had expressed the idea of energy conservation and transformation in the appropriate way. On the other hands students compared feeling with energy that was not absolutely wrong because their model could represent the characteristics of energy but the models was limited due to the feeling is an abstract as energy. According to the investigation of misconception, the first step to wipe it out is to find what is kind of perceived notion that students have [9]. Lancor[8] found that students compared energy to the soul and then students changed to another analogy due to the limitation of the soul. Finally most students gave the reasonable explanation to support their analogies.

## 7. Conclusion

The study found that students used crystallized idea, daily experience and belief to help them explaining energy and most of them selecting water as a representative of energy. They used the same thing to express the characteristics of energy in different explanation but those aspects converged to the same key concept. By using the misconception category, the result shown few students' analogies were classified in the category because their analogies cannot be supported by scientific content. Some students substituted energy with non-scientific belief which we do not want them to respond in that way (we preferred to see students using activities, events, tangible objects to represent the energy). Vice versa the majority used analogies which we can found in daily life and followed up by scientific content. According to the mistake we suggested that the answer sheet should have detail for preventing unwanted answers. However students honestly answered the questions with their thought. In the future, we can reinvestigate students' concepts through their analogies again and give them the energy conceptual understanding survey to find out how students really understand the characteristic of energy that they explained.

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