

The phenomenon of buying and selling as a bridging analogy of learning work and energy

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Abstract. Effective physics learning can be designed by recognizing students' difficulties in understanding the concepts of physics. One of the students' difficulties is the difference in work and energy definitions in physics and in everyday life. Learning using analogies is offered in the design of learning to improve understanding of students' work and energy concepts. An incorrect analogy can cause misunderstandings, so bridge analogy is needed as a conceptual link. The analogy bridge is designed using a phenomenon of buying and selling that is relevant to everyday life. The analogy bridge is used to relate the concept that students have understood (reference concept) with the concept of physics (target concept). This research stage includes identification of the reference concept, preparing a mapping of source concept with target concept, as well as the identification of relevant and irrelevant concept between the reference concept and the target concept. Teachers can take advantage of this alternative method as one way to trace students' analogy abilities and improve students' thinking skills. This bridging analogy can be used as an alternative to train analogy skills and improve students' thinking ability. This analogy introduces a new paradigm in physics learning to improve the understanding of work and energy concepts with different perspectives.

1. Introduction

Physics studies the characteristics and phenomenon of objects in nature as a whole. Physical concepts are concrete but some are abstract. The abstract concept of physics can make it difficult for students to understand the concept so that it takes a certain way to teach the concept. Analogy became one of the alternative strategies in physics learning to explain a concept. An analogy helps students build an understanding of previously known concepts [1]. The analogy is required primarily on teaching concepts beyond the reach of the five senses. Teaching the concept requires visual observation tools. Teaching concepts that require learning aids include concepts on the atomic scale (microscopic) such as electron dynamics and macroscopic phenomena such as solar system concept.

Physics studies on work and energy concepts in high school have a wide scope and widely used in everyday life. The concept of work and energy is complex and abstract because it contains interrelated concepts, so that there may be misconceptions [2]. Previous research has revealed that students still have difficulty understanding the concept of work and energy.

Suana's research [3] in uncovering misconceptions on the concept of mechanics found that matter of work and energy experienced the highest misconception. Students' difficulties among students are difficult to distinguish between the concept of force, mass, and weight [4] and the difficulty of understanding work as multiplication of dot product force with displacement [5]. Barniol and Zavala

[6] also found that confused students determine the work performed by certain force components. Students also experience difficulties in using energy conservation laws [7] and difficulties in understanding the energy of systems in which they comprise several objects [8].

The difficulties are caused by the students used to memorize the formula in understanding the concept of work and energy [9]. Work and energy concepts need to be understood by the students by analyzing the events presented verbally, describing the similarities with the real situation, interpreting in the form of free-body diagrams and creating vector diagrams. The making of vector diagrams is used to find mathematical equations so that students have a deeper understanding [10]. This can make it difficult for students to understand the concept of work and energy so that certain strategies are needed so that students have a good understanding of the concept.

Teaching strategy with analogies is believed to facilitate the learning process of students, but the application of this technique should consider the preconceptions and absorption of students in order to avoid misconceptions [11]. The misconception is caused by the analogy chosen too far with the analogous concept. Analogy bridges are needed to bridge the concept of source problems and target problems. This connective analogy is more easily understood by students because it makes the analogy distance closer to the analogy (target) closer [12].

The chosen analogy bridges provide for the similarity of the flow of thinking. The flow of thinking is adjusted between the teaching concepts that are already understood before by the new learning concept being studied [13]. The similarities of thinking flow include the chronology of reasoning and mathematical devices used to describe the physical phenomena being studied [14].

The thinking flow is designed through mapping source problems and target issues. The source problem as a reference concept is necessary for the analogy to work effectively. One of the concepts of reference that can be presented in the form of a phenomenon of buying and selling in everyday life. The concept of buying and selling is quite simple and much encountered even done in everyday life.

The phenomenon of buying and selling is indirectly already understood even done by students. The reference concept was then developed to explain the target problem. Target problem in the form of physics concept of work and energy. Mapping of the two concepts is adapted to relevant concepts and irrelevant concepts in order not to confuse the students and cause misconceptions.

Teachers can take advantage of mapping the concept of reference and the concept of the target as one way to trill student analogy ability as well as improve students' thinking skill. The analogy through this buying and selling phenomenon introduces a new paradigm of physics learning to gain a broader and deeper understanding of matter with different points of view.

2. Methods

The draft bridge design of analogies on work and energy concepts is prepared through literature studies. This research phase involves identification of the phenomenon of buying and selling as a reference concept, preparing the mapping of the concepts of reference with the target concept, and identification of relevant and irrelevant concepts between the concept of reference and the concept of the target. The analogy bridges that have been compiled are then validated by expert content.

The design of analogy bridges is used to reduce students' difficulties in understanding work and energy conspiracy. Based on some previous studies, the difficulties students experience mainly on the following concepts:

- Students have difficulty distinguishing concepts of force, mass, and weight [4].
- Students consider the gravitational acceleration experienced by objects while still in a stationary position equal to zero [4].
- Student confusion determines the work performed by certain force components [6].
- Students have difficulty using energy conservation laws [7].
- Students assume when the object is drawn to the left then the work will always be negative, regardless of the direction of movement of the object [2]
- Students are still hesitant in distinguishing between positive, negative and zero work [2]

- Students assume kinetic energy is always influenced by the force of gravity of the earth. The greater the gravitational force of the earth, the greater the kinetic energy of matter [2]
- Students have difficulties understanding work as multiplication of dot product force with displacement [5].

The analogy bridge is designed by making a comparison map between the reference concept of the phenomenon of buying and selling and the concept of targets on work and energy. The design of this analogy bridge is used as a basis for training students' analogy skills in solving problems. If there are many similarities between the two concepts compared, then a thought analogy can be constructed.

The phenomenon of buying and selling as a reference concept is assumed to have been known and reapplied first before the teaching concepts are used as the target analogies. Under certain conditions, the concept of a target can precede the concept of reference so that the concept of reference should still be submitted first to the student before discussing the concept of the target.

3. Results and Discussion

Work and energy learning is directed in line with the achievement of the indicators that must be taken by the students. Indicators of achievement of student learning outcomes on work and energy are described in the syllabus of Curriculum 2013. The analogy bridge offered using the phenomenon of buying and selling approach. As students have understood that the interaction between humans and the buying and selling environment can be approached as a transaction activity of goods and services.

This analogy is chosen because it is a thing that is often encountered by everyday students. The analogy of buying and selling activities is quite simple so that students are expected to find the red thread of physics concepts studied. Students are then directed to discover other analogies after understanding the concepts. Discovery of analogy by students will add the ability to think critically and think creatively.

3.1. The Phenomenon of Buying and Selling as Reference Concept

Buying and selling activities are found and performed in everyday life. Buying and selling activities are often found such as transactions of buying and selling and storage in the bank. Buying and selling activities is a routine activity that occurs on a daily basis. The buying and selling activities will be executed if there is an agreement between the two parties to exchange goods or services with money (Weetman, 2013). The definition of the concept of sale and purchase is shown in Table 1.

Table 1. The definition of the concept of buying-selling in everyday life.

Concept of buying-selling	Definition
1. Money	1. The means of exchange owned by a person or group of people as a means of accumulating wealth
2. Rupiah	2. The official currency unit of Indonesia
3. Force of attraction	3. Quality of goods as a requirement so as to attract consumers to make a purchase
4. Purchase	4. Conducting transactions to transfer ownership of goods and or services
5. Transaction	5. Activities that occur between two or more parties which may cause changes to the financial position and ownership between the two parties.
6. Location of the transaction	6. Place of doing a transaction
7. Cash	7. Money (in the form of coins or banknotes) circulating in the community
8. Items	8. Everything human needs to survive and to gain prosperity and comfort
9. Transaction rate	9. The speed of transactions made by a person in meeting the
10. Purchasing power	needs

Concept of buying-selling	Definition
11. Period	10. A person's ability to make transactions
12. Savings	11. The time period required for the transaction
	12. Deposits withdrawal may only be made under certain agreed conditions
13. Deposit system	13. How a person in the storage in the bank with a certain amount
14. Deposits	14. Client's money deposited or invested in the bank.
15. Profit	15. A number of rewards from banks to customers on deposits with a certain percentage and term of deposit
16. Saldo	16. Total ownership within a specified period of time

The definition of the concept of sale-sale described in Table 1 is used to describe the concept of a reference to be used during work and energy learning. The definition needs to be explained so that students have an initial picture before doing an analogy with the concept of physics. Furthermore, students are directed to look for analogies that fit the work and energy concepts. Students need to be accompanied when making analogies and direct evaluation to avoid misconceptions.

The concept of buying and selling that is used as a reference concept has a similar nature with the concept of physics being targeted, but it should be understood that some of the concepts are also part of irrelevant nature. This suggests that the mapping of the concept of reference and the concept of targets needs to take account of the similarity and inappropriateness of the two concepts.

3.2. *The Concept of Work and Energy*

In physics, work is defined as a force acting on an object that causes it to move. Thus, if a force acts on an object but it does not move, it is said that the force is not doing work. Some concepts students need to understand business and energy will be explained later

3.2.1. *Work as energy transfer*

Some concepts that students need to understand about work as energy transfer include:

- Energy is owned by the system (objects) so that objects can do work
- Energy can be transferred from one object to another while doing work

Energy is analogized as money owned by a person. Money is used to transact in order to satisfy the interest of an item so that it can make a purchase (transfer of ownership). Money can also be transferred from the owner of the money to the recipient (eg from A to B) who needs money so that it can transact. The money transfer causes the owner's (A) money to be reduced and the recipient's money (B) becomes increased.

3.2.2. *Work as the dot product of the $F - s$*

Work occurs when a force (F) is applied to the object so that the object is displaced as far as (s), where

$$W = F\Delta x \quad (1)$$

The work is zero when there is no displacement and when the force (F) and displacement (Δx) are perpendicular to the equation $W = F\Delta x \cos\theta$

The working concept on the dot multiplication of the $F - s$ is analogous to the projection of the location of the transaction with several alternative road options. The choice of the appropriate path will likely find the location and make the transaction. Incorrect road choices will minimize the chances of a transaction. The wrong road option will make it difficult to find the location and have a chance to cancel the transaction.

3.2.3. *Work by some forces*

The total work done on an object is the amount of force applied to the object. The amount of work can be expressed by the equation

$$W_{total} = W_1 + W_2 + W_3 \quad (2)$$

Enterprises by various forces are analogous to a family consisting of father, mother and two children buying goods (eg electronic goods). Transactions for the totals that occur are the sum of all transactions they make.

Some analogous concepts have similar characteristics that guide students to understand the concept of targets. The concept of reference and the concept of a target on the sub-concept of work and energy is analogous to the concept of buying and selling as in Table 2.

Table 2. The concept of work and energy.

Comparison of concept characters	Concept Referred	Concept Target
Something the system has	Money	Energy
Unit	Rupiah	Joule
Work done system	Transaction	Work
The cause of the work	Goods pulling style	Object style
	Purchase	Moving
	The location of the transaction	Corner

Mapping the concept of work and energy using buying and selling activities has some irrelevant concept properties. Some irrelevant concepts include:

- Energy transfer occurs if no energy is lost (eg due to friction), whereas when transferring money there will be an administrative fee during the transaction process.
- Road projections as work analogy as dot multiplication can confuse the students because the choice of a road with a certain direction does not indicate a large angle when moving goods.
- Enterprises on the $F - s$ graph are analogous to transactions while surrounding the region. An irrelevant concept occurs when the same area, the transaction can be larger or smaller depending on the needs of each.

3.3. Work concepts and kinetic energy

The amount of work the object does is equal to the energy change of the object. If the object is done work the energy of the body increases, for example, stationary (zero motion energy) and then given the work the energy of motion increases. The addition of energy that causes moving objects is an energy transfer. Things that have moved will have motion energy called kinetic energy.

The energy-work theorem states that the work done by the resultant force acting on an object is equal to the kinetic energy changes experienced by that object ($W = \Delta EK = EK_2 - EK_1$). The energy-work theorem is written through equations

$$W = \frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2 \quad (3)$$

Energy is something that objects need to get things done. Each object has different capabilities in doing work at certain intervals. The ability of an object to conduct a work per unit of time is called power (P). Some power concepts include:

- The work performed per unit time, expressed by $P = \frac{W}{t}$
- The force F to perform the displacement (s) within a certain time interval (t), is expressed by $P = \frac{Fs}{t}$
- The force F performed on an object of a certain velocity, expressed by $P = Fv$

The concept of kinetic energy and power is analogous to the availability of cash to meet the needs. The availability of cash is influenced by the number of needs and the rate of transactions. The more needs and more frequent transactions in a certain period of time the more cash that must be provided.

Power of objects to do work at a certain time interval is analogous to the buying force. Everyone has different purchasing power in making transactions for a certain period. Purchasing power can be influenced by several things, namely the number of transactions in a certain period of time, the tensile force of goods so as to buy the goods within a certain time, and the tensile force of goods resulting in the rate of transactions. The relation of the concept of a kinetic energy of matter through bridge analogies as in Table 3.

Table 3. Work concepts and kinetic energy.

Comparison of concept characters	Concept Referred	Concept Target
Something the system has Influential quantities	Cash	Kinetic Energy
	Items	Mass
	The rate of transactions	Speed
	Goods pulling style	Force
	Transaction	Work
	Purchase	Moving
Other quantities	Purchasing power	Power
	Period	Time

The mapping of the concept of kinetic energy and power using the buying and selling activities has some irrelevant conceptual properties. Mass is analogous to necessity. The mass is a fixed quantity whereas the needs may vary. Kinetic energy is owned by the system as mass objects move at a certain speed while cash needs to be provided to meet the needs and rate of transactions.

3.4. *Work concept and potential energy*

Work done by a force depends solely on the initial position and the end position of the object is a conservative force. The work done by conservative forces depends only on the starting and ending positions making it easy to define potential energy. Potential energy is energy possessed by an object because of the influence of the position or position of the object. The potential energy of an object because its position satisfies the equation

$$E_p = mgh \quad (4)$$

Potential energy is analogous to savings or saved money. Saving is a public saving as a reserve in order to keep the need to transact in the short term. Savings are influenced by future needs (as a mass analogy), gravitational attraction type (gravity), and holding period (position or altitude).

The work done on an object is proportional to the potential energy change of the object. This is analogous to the transactions that occur affect the withdrawal of money in savings. The amount of transactions that occur is proportional to the change in the money saved.

The second form of potential energy is the elastic potential energy. Elastic potential energy can be stored in rubber bands arc, spring, spring, trampoline, and others. The spring has potential energy when stretched or pressed. Large springs force declared with $F = -kx$

The negative sign indicates that the direction of the force is always opposite to the direction of the spring length change. If the spring is pulled to the right beyond the equilibrium position then the spring force is directed to the left. Conversely, if the spring is pressed to the left beyond the equilibrium position the spring force is directed to the right. Mathematically big work by the spring force expressed with

$$W_{pegas} = -\frac{1}{2}k(x_2^2 - x_1^2) \quad (5)$$

Potential energy in the spring is analogous to the amount of savings (savings) that are affected by the deposit system (force of deposit), initial and final deposit, and interest. Relation of potential energy concepts as described in Table 4.

Table 4. Work concept and potential energy.

Comparison of concept characters	Concept Referred	Concept Target
Something the system has Influential quantities	Savings	Potential Energy
	System deposit	Spring force
	Deposits	Spring splits
	Profits	The spring constant
Other quantities	Transaction	Work
	Bank without profits	Conservative
	Bank with profit	Nonconservative
	Period	Time
	Goods pulling style	Force

Mapping the concept of potential energy using buying and selling activities has some irrelevant conceptual properties. Facts on the ground, saving is the sum of deposits and interest given. This is irrelevant to the concept of a target which only explains that there are several things that affect the magnitude of the potential energy of the spring.

3.5. The concept of mechanical energy

If the object only works conservative force, then the mechanical energy of the object is always fixed. This relationship is an expression of the law of conservation of mechanical energy. The amount of mechanical energy in the body can be illustrated by $E_{M1} = E_{M2}$

The mechanical energy of the object at each position is always fixed, which changes only potential energy with its kinetic energy. The law of conservation of mechanical energy applies also to the case of motion of an object influenced by the spring force. Students understand that energy can be altered entirely from one form to another. Mechanical energy as a result of the sum of kinetic energy and potential energy is analogous to the saldo of ownership. Saldo is an accumulation of deposits in the form of cash (kinetic energy) and savings (potential energy).

If the entire saldo in the form of savings then the amount of savings to the maximum while the amount of cash equal to zero. If the entire saldo is in the form of cash then the maximum amount of cash while the amount of savings equal to zero. The ownership saldo is deemed fixed as long as no additions or deductions are made. The relation of kinetic energy, potential energy, and mechanical energy is analogous to Table 5.

Table 5. The concept of mechanical energy.

Comparison of concept characters	Concept Referred	Concept Target
Something the system has	Saldo	Mechanical energy
	Savings	Potential energy
	Cash	Kinetic energy

Mapping the concept of potential energy using buying and selling activities has some irrelevant conceptual properties. The mechanical energy in each position is always fixed, but the saldo in the buying and selling activities is not fixed as it may vary according to the transaction.

Mapping the concept of a reference to the phenomenon of buying and selling activities need to be tested field to determine the effectiveness of the bridge analogies used. The concept of buying and selling that is difficult to understand students can make students have difficulty understanding the

concept of the target. The application of the bridge of the analogy needs to pay attention to the learning model being implemented. Appropriate learning models can help to increase student activity in searching for conformity between the concept of reference and the concept of the target being studied. On other occasions, students can be directed to look for analogies of other phenomena already understood by students by mapping out relevant and irrelevant concepts.

4. Conclusion

Learning through analogy is one of the alternatives offered in improving students' understanding of the concept of work and energy. In the analogy of learning need bridging analogy to make the concept easier to understand. The analogy bridge used in work and energy learning uses the concept of buying and selling approach.

The concept of buying and selling is quite simple and much encountered even done in everyday life. Analogy uses the concept of buying and selling as a reference concept into an alternative idea that gives an idea that the concept physics can be viewed from different angles. Mapping the concept of buying and selling and the concept of physics need to pay attention to the concept of relevant and irrelevant so as not to result in misconception.

The idea of this alternative analogy is worth trying to be trained to students so that physics learning is not monotonous. The application of analogies to the phenomenon of buying and selling in the classroom can be combined with the appropriate learning model. The aided instructional analogy can bridge the conception of students so that physics learning is more effective.

Acknowledgments

This research is supported by DIPA Unnes. We thank for our colleagues from the graduate of Semarang State University who provide insights and expertise that really helps this research.

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