Development of the Concept of Energy Conservation using Simple Experiments for Grade 10 Students

S Rachniyom¹,²,³, K Toedtanya¹ and S Wuttiprom¹,³,*
¹ Department of Physics, Faculty of Science, Ubon Ratchathani University, Thailand
² Mahannaparam School, Bangkok, Thailand
³ Thailand Center of Excellence in Physics, Thailand

* E-mail: sura.w@ubu.ac.th

Abstract. The purpose of this research was to develop students’ concept of and retention rate in relation to energy conservation. Activities included simple and easy experiments that considered energy transformation from potential to kinetic energy. The participants were 30 purposively selected grade 10 students in the second semester of the 2016 academic year. The research tools consisted of learning lesson plans and a learning achievement test. Results showed that the experiments worked well and were appropriate as learning activities. The students’ achievement scores significantly increased at the statistical level of .05, the students’ retention rates were at a high level, and learning behaviour was at a good level. These simple experiments allowed students to learn to demonstrate to their peers and encouraged them to use familiar models to explain phenomena in daily life.

1. Introduction

Energy and the law of energy conservation in daily usage have several meanings. For example, energy may mean the ability to transport food from one place to another and may also mean the potential for running and/or jumping [1,2]. The law of conservation may refer to the saving of energy and conservation of the environment [3]. Identification of concepts about energy may take the forms of misconceptions, alternative concepts, or prior knowledge, and quick assessment by teachers is required. If not quickly assessed, students may have misunderstandings of the phenomena of physics and this may affect future teaching and learning in the area [4].

Physics education researchers agree that instruction using lectures only or traditional teaching does not correct misconceptions in the majority of students. The instructional pattern considered to encourage students and correct misconceptions in physics is Interactive Lecture Demonstrations (ILD) [5].

ILD engages students in activities that confront their prior understanding of a core concept. The activities may be a classroom experiment, a survey, a simulation, or an analysis of secondary data. ILD instruction provides interaction between students and teacher and students and students, and may be used for large or small classes.

ILD instruction has three steps: 1) Predict the outcome of the demonstration. Individually, and then with a partner, students explain to each other which of a set of possible outcomes is most likely to
occur; 2) Experience the demonstration. Working in small groups, students conduct an experiment, take a survey, or work with data to determine whether their initial beliefs were or were not confirmed; 3) Reflect on the outcome. Students think about the reasons for their initial beliefs and in what ways the demonstration confirmed or contradicted these beliefs. After comparing these thoughts with other students, they individually prepare a written report on what was learned. Much research showed that ILD instruction in physics can minimize misconceptions in students [6,7,8]. Thus in this paper, the researchers designed ILD instruction by the use of a falling egg situation to develop work and energy concepts.

2. Methodology

2.1. Participants
The participants in this research were 30 purposively selected grade 10 students in second semester of the 2016 academic year registered in a fundamental physics course and living in Bangkok. The range of the students’ ability was at the high and intermediate levels.

2.2. Questionnaire assessing students’ concept of the law of conservation of energy
The researchers created the law of conservation of energy test (LCET) which contained three items for a two-tier test. The first tier was a series of multiple choice questions and the second tier was descriptive reasoning to support answers in the first tier.

2.3. ILD Scenarios
The researcher created activities for ILD by focusing on the law of energy conservation. Materials and equipment consisted of eggs, A4 paper, pencil, and measuring tape. The experimental was divided into 2 sub-activities.

Activity 1: Let the students predict the results of two situations.
Situation 1: The teacher dropped three different sized eggs from a height of one meter. It was assumed that from that height, there was no air resistance. The students predicted what would happen after the eggs hit the floor and made drawings to answer the question.
Situation 2: The teacher dropped three same sized eggs from different heights of 1, 2, and 3 meters. Again, it was assumed that there was no air resistance. The students predicted what would happen after the eggs hit the floor and made drawings to answer the question.

Activity 2: The teacher allowed the students to do the experiment to test their predictions. The students noted the results of the experiment on a result sheet and made comparisons with their predictions. These notes were made up of two parts, the first showed the students’ drawings of the dropped eggs, and the second recorded the measurements of the displacement of the eggshells. There were five position of egg shells, the first position was the closest one and the last position was the furthest one. Finally, the students calculated the average of displacement of egg shell from the impact point to explain the relationship between the heights from which the eggs were dropped and the distances of shell from the places at which the eggs landed.
3. Results

The students’ learning gain average was 1.03 or 34.33% for the pre-test and 2.80 or 93.33% for the post-test. This result indicated that the students’ average score increased significantly at .05, t = 10.77 (t0.05, 29 = 1.69). By using the normalized gain [9], the result showed that students had a high gain (<g> = 0.89). The students’ answers are shown in figure 1:

![Figure 1](image)

Figure 1 The graph shows the percentage of students who answered correctly.

Figure 1 shows that students who answered question no.1 correctly for the first tier only escalated from 33.33 (q1) to 86.67 (Q1). For question no.2, the percentage of students who answered correctly increased from 13.33 (q2) to 96.67 (Q2) in the first tier only. In addition, the first and second tiers increased from 0 (q2) to 90 (Q2). The number of students who responded correctly increased from 56.67 (q3) to 96.67 (Q3) in only the first tier and 10 (q3) to 83.33 (Q3) in the first and second tiers.

ILD Prediction Sheet Analysis

There were three types of the answers in situation 1.

1) The responses were that the small egg would not break; the medium egg would break and the yolk would spread out; and the large egg would break and the eggshell would be scattered to the furthest point from the center of impact. These responses accounted for 43.33% of the students’ responses.

2) The responses were that the small egg would slightly crack and yolk would not spread out; the medium egg would break and shell would be scattered from the point of impact but the yolk would not break; and the large egg would break, shell would be scattered, and the yolk would break. These responses accounted for 16.67% of the students’ responses.

3) The responses were that the small egg would break so that the shell would be in large pieces and the yolk would spread out partially; the medium egg would break and the shell would be in small pieces and the yolk and the white would be mixed together; and the large egg would break, shell would be scattered around the yolk, and the yolk and the white would be mixed together. These responses accounted for 40% of the students’ responses.
There were three types of answers in situation 2:
1) The responses were that from the height of 1 meter, the yolk and the white would be mixed together and the shell would be spread out a little; from 2 meters, the yolk would be slightly broken and the shell spread out; and from 3 meters, the yolk and the shell would be broken and spread out together. These responses accounted for 43.33% of the students’ responses.

2) The responses were that from the height of 1 meter, the shell would be in large pieces and the yolk would not break; from 2 meters, the yolk would be slightly broken and the shell would be scattered in large and small pieces; and from 3 meters, the yolk would be considerably broken, the shell would be scattered in tiny pieces, and some pieces would be dispersed far from the point of impact. These responses accounted for 16.67% of the students’ responses.

3) The responses were that from the height of 1 meter, the yolk would be slightly broken and the shell scattered reasonably close to the point of impact; from 2 meters, the shell would be scattered in small and large pieces; and from 3 meters, the shell would be scattered far away from the point of impact and large pieces of shell would be stuck to the yolk. These responses accounted for 40.00% of the students’ responses.

After situation 1, students took photos of the shells (Figure 4) and found that the dropped small, medium, and large eggs had the same result as pattern 1 (Figure 2). The students concluded that the factors that affected the breaking of the eggs were size and height.

After situation 2, the students took photos of the broken eggs (Figure 5). The results were similar to pattern 3 (Figure 3).
80 cm, 100 cm, and 150 cm respectively. The relationship can be expressed as distance \((S_n)\); \((s \text{ - distance})\) and \((n \text{ - height})\). By considering the shape and surrounding area of the point of impact, the relationship can be expressed as area \((A_n)\); \((A \text{ - area})\) and \((n \text{ - height})\).

4. Discussion
This research used simple experimental activities with ILD instruction to develop the concept of work and energy. The participants are from the same misconception and cannot reason about the change of potential energy, kinetic energy and the law of conservation of energy. The use of ILD in this research promoted the students’ understanding of the concept and their reasoning skills improved. As a result of the experiments, the students were able to describe the relationship of gravitational potential energy to kinetic energy. The use of different heights indicated gravitational potential energy \((PE)\) and the measured distances from point of impact to pieces of shell were evidence of the kinetic energy \((KE)\). These results showed the change of energy in the eggs from one form to another. Due to the students performing their own experiments, they were able to visualize the changes in the forms of energy, making learning meaningful and knowledge easy to retain.

Acknowledgments
This work was supported in part by Thailand center of Excellence in Physics (ThEP). The authors thank Bob Tremayne of the Office of International Relations at Ubon Ratchathani University for assistance with English and Woottichai Worachin (The director of Mahannaparam School) and the students.

References
[1] Duit R 2014 Teaching and learning the physics energy concept Teaching and Learning of Energy in K-12 Education pp67-85.
[2] Bülbül M.Ş 2015 The three eggs experiment Phys. Educ. 51 1-7
[3] Tatar E and Oktay M 2007 Students' Misunderstandings about the Energy Conservation Principle: A General View to Studies in Literature International Journal of Environmental and Science Education. 279-81
[4] DALAKLIOĞLU S and ŞEKERCİOĞLU A. P. D. A. 2015 Eleventh grade students’ difficulties and misconceptions about energy and momentum concepts. International Journal of New Trends in Education and Their Implications. 6 13-21
[5] Sokoloff D. R. and Thornton R. K. 1997 Using interactive lecture demonstrations to create an active learning environment The Physics Teacher. 35 340
[6] Wattanakasimwich P, Khamcharean C, Taleab P, and Sharma M 2012 Interactive lecture demonstration in thermodynamics Lat. Am. J. Phys. Educ. 6 508-514.
[7] Šlekiëně V and Raguliënë L 2010 The Learning Physics Impact of Interactive lecture Demonstrations Problems of Education in the 21st Century. 24 120-129.
[8] Zimrot R and Ashkenazi G 2007 Interactive lecture demonstrations: a tool for exploring and enhancing conceptual change Chemistry Education Research and Practice. 8 197-211
[9] HaAe R. R. 1998 Interactive-engagement versus traditional method: A six thousand student survey of mechanics test data for introductory physics courses American Journal of Physics.66 64-74