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Research Article

HANDS-ON ACTIVITIES TO PROMOTE STUDENT UNDERSTANDING OF CONVECTION CAUSING THE OCCURRENCE OF NATURAL DISASTERS

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ABSTRACT

Convection is the underlying concept that explains the occurrence of natural disasters such as storms, earthquakes and Tsunamis. However, in the middle school science curriculum of Thailand, convection and natural disasters are taught in isolation. In addition, hands-on activities that show the link between convection and the occurrence of natural disasters do not exist in the curriculum. Therefore, this study aims to develop a set of hands-on activities to promote conceptual understanding and the link between these concepts. The hands-on activities were used among middle school students (N=27). A pretest and post-test analysis shows that the students had a statistically significant shift from lower level of understanding to more complex understanding after doing the activities. Therefore, it is recommended middle school science teachers to use these hands-on activities with their students.

INTRODUCTION

Active learning in the form of hands-on activities shows great benefits in science education. Research shows that various forms of active learning such as hands-on activities, experiments and educational games can help promote student conceptual understanding, problem-solving skills and student learning opportunities in class(Huerta, 2007). In addition active learning has been found to increase student attention rate and interest (Handelsman *et al*. 2004). As Woodley (2009) points out, through hands-on activities students are able to build a bridge between what they can see and handle (hands-on) and scientific ideas that account for observations (minds-on). Also, Bennett *et al*. (2007) point out that real-world connections offer teachers the chance to help students see science in the world around them and put science into a context that is meaningful to the student.

Convection and natural disasters

Convection is heat transfer by mass motion of a fluid such as air and water. When the fluid is heated, it will move away from the source of heat and carry energy with it (Bejan, 2013). There is a link between convection and the occurrence of natural disasters such as storms, earthquakes and Tsunamis can be explained by the concept of convection (Tackley, 2000). For example, storms occur because of fast-moving winds flowing between two surface areas that have a great difference in temperature. The difference in temperature causes different density of the air above the surface. Above the hotter surface, the air becomes less dense. This leads to the flow of the air from the cooler surface which has higher density to replace the rising hotter air. The flow of the air from the cooler surface to the hotter surface here is the flow of the wind. And this motion of the air is convection. If the difference in the temperature is high between the two surfaces, the wind will flow more strongly. This is how storms occur (Smithsonian Science Education Center, 2006).

Convection and natural disasters in science textbooks

According to the science curriculum from Institute for the Promotion of Teaching Science and Technology (IPST), heat transfer including convection is taught in Science 1 for grade 7 students and natural disasters are taught in Science 2 for grade 7 students. However, the experiments on convection in Science 1 limit to convection in water only (to observe the rising temperature and the upward movement of the colour of $KMnO_4$ after putting the heat on), not in the air. In addition, they focus only basic understanding about convection which is not applicable to real life. Second, the class activities about natural events in Science 2 have no hands-on activities. Therefore, to

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improve the current teaching of convection and natural disasters, there has to be the development of useful hands-on activities. Hands-on activities can help students build a bridge between actions and thinking (Woodley, 2009). And real-world connections can make learning more meaningful (Bennett *et al*., 2007)

SOLO Taxonomy

The structure of observed learning outcomes (SOLO) taxonomy is a model that describes levels of increasing complexity in student's understanding of subjects (Wells, 2015). The model consists of five levels of understanding: *prestructural*(no understanding), *unistructural* (understanding of one concept), *multistructural* (understanding of many concepts in isolation), *relational* (understanding and linking many concepts together), and *extended abstract* (applying the concepts to a new context). This framework is used for data analysis in this study

SOLO not only shows the instructors how the learners are progressing, but also the learners themselves. In addition, it can be used in assessment and designing the curriculum in terms of the learning outcomes intended, which is helpful in implementing constructive alignment.

RESEARCH METHODOLOGY

Research objectives

- To develop a set of hands-on activities on convection in fluid that illustrate the connection of this scientific concept with the occurrence of storms, earthquakes and Tsunamis for middle school students
- To investigate changes in level of complexity of understanding of student participants between before and after doing the hands-on and minds-on activities using SOLO taxonomy

Research question

How do student participants change their level of complexity of understanding about the connection between convection and natural disasters after doing the hands-on activities, compared to before doing the activities?

Development of hands-on activities

There are two sets of hands-on activities in this study. The first activity represents convection in the air that causes storms. The second activity represents convection in fluid that causes earthquakes and Tsunamis. The development of this learning innovation aims to elaborate the link between theoretical perspectives on heat transfer in the form of convection to real-world contexts regarding natural phenomena.

In the first activity, materials compose of two plastic bottles, two clear straws, incense, candles and ice. Students can perform the activity by connecting two plastic bottles with two straws. One bottle contains ice and the other bottle candles in the bottom. Students can observe the direction of smoke after putting the incense in the bottles. The movement of the smoke shows the convection in the air. They can also compare the speed of the smoke between the two straws and later on discuss about the occurrence of storms.

In the second activity, materials compose of a small tank, washing-up liquid, plastic sheets and candles. Students are expected to pour some washing-up liquid in the small tank. Then they can put small pieces of plastic sheets on the surface of the washing-up liquid which represent tectonic plates. After that, they put candles to heat up one side of the tank and then observe the movement of the washing-up liquid and the plastic sheets. Then, they discuss about the occurrence of earthquakes and Tsunamis.

Data collection and analysis

The student participants were 27 students in grade 9. First, they did a pretest which took 15 minutes. Second, they divided into 6 groups and did the activities which took 1.5 hours. Third, they did a post-test which took 15 minutes. Both pretest and posttest are the same. They are written exam. Students' answers from both pretest and posttest were classified into different levels according to the SOLO taxonomy. The change in levels were statistically analysed by descriptive statistics and Wilcoxon signed-rank test which is a non-parametric test used when comparing two related samples (Johnson & Christensen, 2008).

RESULTS AND DISCUSSION

In the pre-test, about 45% of the student participants were identified in *unistructural*, 7.4% in *relational*. Over 20% were in *prestructural* or *multistructural*. Nobody was identified in *extended abstract*. However, in the post-test, nobody was identified in *prestructural.* Most of them (74.1%) were in *relational*. Over 10% were identified in *extended abstract*. In sum, this descriptive analysis shows that over 90% of the students were identified in the levels lower than *relational* in the pre-test. However, over 85% of the students were identified in the *relational* and the *extended abstract* levels.

Table 1 Percentage of student levels on SOLO

SOLO level	Pre-test		Post-test	
	n	%	n	%
prestructural	7	25.9	0	0
unistructural	12	44.4	1	3.7
multistructural	6	22.2	3	11.1
relational	2	7.4	20	74.1
extended abstract	0	0	3	11.1
Total	27	100.0	27	100.0

A Wilcoxon signed rank test shows that 25 students were identified in a higher level in the posttest compared to the pretest. Two were in the same level. However, nobody showed backward movement, changing from a higher SOLO level to a lower one. Therefore, there was a statistically significant shift to a higher level of complex understanding in the posttest compared to the pretest ($Z = -4.430$, $p = 0.000$).

To answer the research question, the student participants changed their complexity of understanding about the connection between convection and natural disasters from a lower to a high level according the SOLO taxonomy after doing the hands-on activities. This positive result confirms the effectiveness of the developed hands-on activities which aim for students to do the tasks and think about the tasks in order to develop their conceptual understanding. In addition, the developed hands-on activities can help students see the clear link between convection and natural disasters (storms,

earthquakes and Tsunamis) as most of the students were identified in the relational level after doing the activities.

In fact, the links between those concepts are evident. However, they are not pointed out specifically in any science textbooks currently used in Thailand. The developed hands-on activities are believed to be the first set of experiments that show how convection occurs as an underpinning concept for explaining the occurrence of natural disasters. Although acknowledging that causes of natural disasters are diverse, this study points students to one of the roots of such occurrences. It is strongly suggested to integrate this educational innovation which is developed from cost-effective materials in science classes in Thailand as well as other places.

However, there are some limitations in this study. First, the time for doing the activities and completing the pretest and posttest was limited. In the future, the period of time should be 3 hours. Second, the number of students is too small in this study to make a confident claim and it is difficult to generalise that other groups of students would show the same result. In addition, some of the questions used in the written tasks of the pretest and posttest should be revised because they might be a kind of leading questions that can guide students to expected answers. Also, students should have more time to do the written tasks in the pretest and posttest.

In conclusion, two sets of hands-on activities were developed to promote students' understanding about the connection between convection and the occurrence of natural disasters. After doing the activities, students can change their level of understanding from lower levels of SOLO taxonomy to higher levels. This shows that the activities are suitable for science teachers to use with their middle school students to promote their understanding. However, there are many points to develop more for future research.

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