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Thai Students' Conceptual Understanding on Force and Motion

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Abstract. The aims of this study are to investigate the conceptual understanding and to define misconceptions of Thai students on force and motion focusing on six topics: 1) Acceleration, 2) Action and Reaction, 3) Friction, 4) Moment, 5) Buoyant Force, and 6) Motion of Objects. The participants were 93 ninth grade students in Uthaithani province, Thailand. The conceptual understanding test adapted from the Force and Motion Conceptual Evaluation was served as an instrument for collecting data. The test was administered to the students participating in the study before and after traditional instruction. The results indicated that Thai students have low conceptual understanding on force and motion which is only 30 percent of the students gave correct answer. Furthermore, they have misconceptions in many concepts, which a well plan improvement is necessary to be conducted.

Keywords: conceptual understanding, misconception, force and motion

1. Introduction

Teaching science for conceptual understanding is one of the main goals of science teaching in Thailand[1]. Students' conceptual understanding is important to successful science learning and teaching. Conceptual understanding requires students to organize facts and ideas into a meaningful concept. Furthermore, conceptual understanding enables students to align intuitive ideas with scientific ones. Therefore, students can apply their understanding of concepts to multiple contexts[2].

Force and Motion concept is one of the most important concepts in science teaching, because it is a fundamental concept needed for understanding more advanced science. Promoting students' understanding the nature of force and variety types of motion in daily life are the aims of the 4th Strand of the Thai Science Curriculum[1]. Furthermore, force and motion is the basic concept for learning Mechanics in the higher level, especially Newton's laws of Motion. Therefore, this is one of basic concepts that students should understand.

The purposes of this study are to investigate the conceptual understanding by comparing the students' conceptual understanding mean scores before and after traditional instruction as well as comparing the conceptual understanding mean scores between genders and to describe misconceptions of ninth grade Thai students on force and motion

2. Methods

2.1. Participants

The participants of this study were 93 ninth grade students (41 boys and 52 girls) who were studying in the first semester of 2011 academic year of a school in Uthaithani province, Thailand.

2.2. Research Instrument

The conceptual understanding test on force and motion concepts was served as an instrument for collecting data. The content domains of the test were developed based on the 4th Strand, Force and Motion, in

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the national science curriculum standards of Thailand[1]. This test was adapted from the Force and Motion Conceptual Evaluation[3] for appropriateness with ninth grade students. The test comprised of 30 multiple choice items, each of which had only one correct answer and three alternative answers that were based upon students' misconceptions about the topics. The content domains covered in the test were: Acceleration, Action and Reaction, Friction, Moment, Buoyant force, and Motion of Objects, each of which consisted of 5 items (see more detail in Table 1). Most of the questions were emphasized on main concept in force and motion rather than calculation and all are connected to daily life. The reliability of the test calculated with KR-20 formulations was 0.78. The Index of Item-Objective Congruence (IOC), item difficulty (p), and item discrimination (r) of the test ranged between 0.67-1.00, 0.23-0.75, and 0.21-0.63, respectively as can be seen in Table 2.

Table 1: Summary of Measured Concepts of the Test

Content	No.	Concepts
Acceleration	1-5	Relationship between net force and acceleration of an object.
Action and Reaction	6-10	Identifying of action and reaction and understanding of their equality of magnitude.
Friction	11-15	Identifying an understanding of three types of friction
Moment	16-20	Finding moment of a force from the picture and relationship between rotational equilibrium and moment
Buoyant force	21-25	Relationship between floating and sinking and density difference of an object and of liquid.
Motion of objects	26-30	Relationship between force as well as acceleration and curved motions.

Table 2: The Results' Evaluation of the Conceptual Understanding Test

NO.	IOC	p	r	No.	IOC	p	r	No.	IOC	p	r
1	1.00	0.47	0.48	11	0.67	0.67	0.38	21	1.00	0.75	0.23
2	1.00	0.75	0.41	12	0.67	0.74	0.44	22	1.00	0.62	0.40
3	1.00	0.63	0.33	13	1.00	0.31	0.27	23	1.00	0.24	0.27
4	1.00	0.35	0.34	14	1.00	0.41	0.21	24	1.00	0.27	0.53
5	1.00	0.32	0.36	15	1.00	0.51	0.48	25	0.67	0.39	0.26
6	1.00	0.23	0.35	16	1.00	0.54	0.54	26	1.00	0.25	0.35
7	1.00	0.59	0.31	17	1.00	0.67	0.46	27	0.67	0.23	0.31
8	1.00	0.28	0.31	18	1.00	0.67	0.63	28	1.00	0.25	0.42
9	1.00	0.23	0.29	19	1.00	0.68	0.53	29	1.00	0.25	0.25
10	1.00	0.37	0.28	20	1.00	0.30	0.27	30	1.00	0.41	0.28

2.3. Research Procedure

At first, the conceptual understanding test was applied to all students for collecting pre-test mean scores before instruction. After that, the students participating in the study were taught with traditional instruction in all content areas for 6 weeks. Finally, the conceptual understanding test was administered to the students again for measuring the understanding of force and motion concept after instruction. After that collected data were analyzed as follows:

- The t-test for dependent samples was used to test the significant difference of students' pre-test and post-test mean scores.
- The t-test for independent samples was used to test the significant difference of students' post-test mean scores between genders.

In this part, example questions of the conceptual understanding test used to define the misconceptions were analysed as follows:

Question 1: What is the acceleration of a stone falling down under the earth's gravitational force?

- The acceleration is zero.
- The acceleration is in the same direction of motion and constant.
- The acceleration is in the same direction of motion and increasing.
- The acceleration is in the opposite direction of motion and decreasing.

Table 3: The classification of the answers given by students to the 1st question

A		B*		C		D	
f	%	f	%	f	%	f	%
11	11.80	32	34.40	42	45.20	8	8.60

* Right answer choice

In this question, it is expected for students to express that an object falling down under gravitational force is increasing velocity, therefore, the acceleration of a stone is constant in the same direction of motion. As it is seen in Table 3, the ratio of students who gave the right answer is 34.40%. The rest of the students gave wrong answers. When the wrong answers are examined, it can be concluded that 45.20% of students have misconceptions about the acceleration of an object moving down under the earth's gravitational field.

2.4. Result

The results of data analysis presented that students' conceptual understanding between post-test mean scores and pre-test mean scores were significantly different at the 0.05 level (see Table 5). Therefore, the students' conceptual understanding after learning through traditional instruction is significantly higher.

Table 5: The Results of Comparing Students' Conceptual Understanding

Test	Mean	S.D.	T	p
Pre-test	7.98	2.21	4.687*	.000
Post-test	9.70	3.64		

* $p < 0.05$

After considering in gender, the t-test for independent samples was used to test the significant difference of students' post-test mean scores between boys and girls. The result indicated that the students' conceptual understanding post-test mean scores between boys and girls were not significantly different at the 0.05 level. Therefore, there is no difference between boys' and girls' conceptual understanding (see Table 6).

Table 6: The Results of Comparing Boys' and Girls' Conceptual Understanding

Gender	Mean	S.D.	T	p
Boys (N=41)	10.20	4.23	1.167	.246
Girls (N=52)	9.31	3.10		

Table 7: The Mean Scores of the Conceptual Understanding Test

Topic	**NO.**	**Mean**	**Topic**	**NO.**	**Mean**	**Topic**	**NO.**	**Mean**
Acceleration	1	0.34	Friction	11	0.54	Buoyant Force	21	0.60
	2	0.28		12	0.46		22	0.33
	3	0.29		13	0.18		23	0.40
	4	0.15		14	0.31		24	0.25
	5	0.23		15	0.77		25	0.15
	total	1.29		total	2.26		total	1.73
Action	6	0.18	Moment	16	0.33	Motion	26	0.23

and Reaction Force	7	0.43		17	0.48	of Object	27	0.28
	8	0.43		18	0.32		28	0.28
	9	0.27		19	0.42		29	0.30
	10	0.40		20	0.20		30	0.32
	total	1.71		total	1.75		total	1.41

From Table 7, the results have shown that the students' conceptual understanding is very low in every topic. The mean scores of each topic are less than half, the total scores of each topic is 5.

From the data analysis, the misconceptions about force and motion based on alternative answers which were chosen more than 30 percent of the students are as follows:

2.4.1. Acceleration

- The acceleration of an object moving down under the earth's gravitational force is in the same direction of motion and increasing.
- The acceleration of an object moving with constant velocity along a straight line is in the same direction of motion and constant or increasing.
- Net force acting on an object moving with constant velocity along a straight line is in the same direction of motion and constant.
- Net force acting on an object moving with constantly decreasing velocity along a straight line is in the opposite direction of motion and decreasing.

2.4.2. Action and reaction

- Reaction of an object's weight is force exerted on the plane by the object.
- Reaction force of plane acting on an object is not equal to the force from object exerting on plane, but in opposite direction.

2.4.3. Friction

- If there is external force acting on a rest object on plane and an object still rest, this means no friction acting on it.
- If there is a force of 10 N. acting on a rest object on a plane and the object moving with acceleration, this means a friction of more than 10 N. is acting on it.

2.4.4. Moment

- Students could not tell how to make equilibrium of a lever by increasing or decreasing weight of an object.

2.4.5. Buoyant Force

- Two containers contain the same volume of liquid A and B inside and liquid A has more density than that of liquid B. When an object c is put in the liquid, it sinks at the bottom of both containers. Comparing level of the liquid A and B, it will be found that level of the liquid in both containers is not change.
- Two containers have the same volume and liquid. When an object A having more volume than an object B are put in the liquid, it was found that they float and the replaced volume of liquid in both case are the same. Buoyant force acting on object A is more than object B.

2.4.6. Motion of Objects

- The more mass of an object, the more acceleration it gains, when it is falling from the same level.
- The net force acting on an object A which is in a circular motion is along the loop of the motion.
- The acceleration of an object moving in a circular motion is parallel to direction of velocity.
- The acceleration of an object moving in a projectile motion is perpendicular to direction of velocity.

2.5. Conclusion

The results of this study were indicated that the students' conceptual understanding pre-test and post-test mean scores were significantly different at the 0.05 level, however the students still have very low conceptual understanding mean scores which is only 30 percent of the total scores. These mean most

students still lack of an understanding in basic concepts of force and motion. This implied that students who were educated science according to traditional method have many misconceptions[4].

In addition, the results presented that the conceptual understanding between boys and girls were not significantly different at the 0.05 level. These mean boys' and girls' conceptual understanding on force and motion are in the same level.

All the above results have shown that the conceptual understanding of Thai students is rather poor. There were many misconceptions found which might be a barrier for students in understanding related concepts at higher levels. Therefore, it should be pay more attention on science conceptual understanding development that prevent students' misconceptions and enhance students fully understanding the basic concept in science.

2.6. Appendix

An example of the conceptual understanding test using in this study are as follows:

1. What is the acceleration of a stone falling down under gravitational force?
   - The acceleration is zero.
   - The acceleration is in the same direction of motion ad constant.
   - The acceleration is in the same direction of motion and increasing.
   - The acceleration is in the opposite direction of motion and decreasing.
2. What is the acceleration of a car moving along a straight line with constant velocity?
   - The acceleration is zero.
   - The acceleration is in the same direction of motion and constant.
   - The acceleration is in the same direction of motion and decreasing.
   - The acceleration is in the same direction of motion and increasing.
3. The zero net force acting on an object A moving with constant velocity of 10 m/s, what the velocity of the object A is?
   - The velocity is increasing.
   - The velocity is decreasing.
   - The velocity is zero.
   - The velocity is not change.
4. What is the net force acting on a car moving with constant velocity of 50 m/s?
   - The net force acting on a car is zero.
   - The net force acting on a car is in the same direction of motion and increasing.
   - The net force acting on a car is in the same direction of motion and constant.
   - The net force acting on a car is in the opposite direction of motion and constant.

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4. References

[1] The Ministry of Education. *The Basic Education Core Curriculum B.E. 2551 (A.D. 2008)*. Bangkok: Kurusapa Ladprao Publishing, 2008

[2] N. Kang and C. Howren. Teaching for Conceptual Understanding. *Science and Children.* September 2004, 29-32.

[3] R. K. Thornton and D. R. Sokoloff. Assessing student learning of Newton's laws: The Force and Motion Conceptual Evaluation and the Evaluation of Active Learning Laboratory and Lecture Curriculum. *American Association of Physics Teachers.* 1998**, 66** (4): 338-352

[4] A. H. Hancer and N. Durkan. Turkish Pupils Understanding of Physical Concept: Force and Movement. *World Applied Sciences Journal*. 2007, **3**(1): 45-50