The students’ basic conceptions of buoyant force

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Abstract. The conception of buoyant force is an advanced concept. If students need to solve the problem on the buoyant force, they have to understand basic concepts which are mass, volume, force, pressure, and density. For solving the problems about buoyant force, students need to make a decision and use many concepts to solve the problems. The difficulty of solving a problem about buoyant force is students cannot construct and link their own related knowledge to solve the problem. In this study, the purpose was to study students’ basic concept in buoyant force of grade 10 and grade 11 students. The target group consisted of 18 students in Phangwittayayhon school. Two-tier multiple choice was used as a conceptual test in this research consisting of eight items. All of students were taught about the buoyant force concepts before doing the conceptual test. The data were analyzed by descriptive statistic. The results showed that more than 80 percent of students have many alternative basic concepts which are related to buoyant force including mass, volume, depth, pressure, and density even they have already studied buoyant force since they were in grade 9.

1. Introduction

Many countries in the world try to educate students to solve the problems even in Thailand. The Thai National Education Commission focused on improving critical thinking skills of students, practice and self-knowledge learning, moral, ethical, and coexists with others effectively. However, in literature, the problem-solving ability of Thai students is still low. [1] Because, in solving problems students have to make decisions in variety views, the important key to success in solving the problem is knowledge of science concepts, which are related to the problem. Before solving problems, students must understand all basic concept of that advance concept clearly. In some basic concepts, students have common senses of concepts via their real life. In the other hand, students’ experiences can be obstructed to learning science. Some alternative conception can build up from self-learning of students as well. Therefore, it will be very useful if the teacher knows the prior knowledge of students before teaching. [2] The conception of buoyant force is one of the physics concepts that students need to understand many concepts including mass, volume, force, pressure, depth, and density before they learn buoyant force. But the results of O-NET test in last several years showed that students still have many alternative concepts of buoyant force even they have already learned since they were in grade 9. [3] Moreover, from previous research showed that students’ conceptual understanding of buoyant force of Thai students is very low and the mean scores of each question are less than half. Yet, students though that
"If 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 is the same. Buoyant force acting on object A is more than object B" [4] which means students still have alternative conception on buoyant force.

This paper needed to study students’ conceptions on the buoyant force of high school students of Thailand, in order to help the teacher to create the situated activities for students in the future.

2. Methodology

The target group of this study consisted of 18 students totally, 12 persons of grade 11 student and 6 persons of grade 10 student in Phangwittayayhon School, during the second semester of the 2018 academic year. These 18 students were selected because they had been taught and passed buoyant force concept already since they were in grade 9. The two-tier multiple choice, adapted from Joysrikate [5], was used as a conceptual test in this research consisted of eight items that are related to the concept of buoyant force. Each of the items, both tier 1 and tier 2 had only one correct answer and two alternative answers that were based upon students’ alternative conceptions on buoyant force. There are 5 related concepts to construct understanding of the buoyant force including mass (m), volume (V), submerged depth (h), pressure (P) and object density (ρ) as follows in table 1.

Table 1. Presents context of each question and concepts to be assessed with that question.

| Items | Context | Assessed concepts |
|-------|---------|-------------------|
| Q1    | The frogman dives to explore the corals with changing positions and depth. At different depth how will the buoyant force impact on frogman in each position be? Why? | h and P |
| Q2    | The twin has the same size, also the same volume, in most respects. But the density of twin A is more than twin B (ρ_A > ρ_B). How will the buoyant force that impact on the twin should be when they dive into the water altogether? Why? | ρ and V |
| Q3    | Object A has the same mass as object B but different size. The volume of object A is more than object B. Both of them were put in the same solution. How does the buoyant force that impacts on each of them? Why? In this question, mass of the object, the volume and the buoyant force are concepts which were investigated. | m and V |
| Q4    | A cargo ship moves pass different depths of the sea. how will the buoyant force impact on cargo ship when it passes each position? Why? | h |
| Q5    | Releasing the crystal ball into the container that contains two types of liquid, water and oil. How will the buoyant force that impacts on the crystal ball while the crystal ball moving through the liquids? (If the density of water is more than oil) Why? | ρ |
| Q6    | Two sizes of modeling clay, m1 and m2, are different in size that m1 is bigger than m2 but their density is equal. If drop m1 in the glass of water, the result is as shown in the picture (table 2). The question is: if drop m2 into the same glass what do you think of the results? Why? | ρ, size, and V |
| Q7    | There are two same masses hanging on the left and right side of balanced beams, their volume is different. If the beam is dipped in a tank of water what will the result be? Why? | m and V |
| Q8    | An object m is placed at the bottom of the water tank with full water. If you put salt in water, how will the buoyant force that impacts on object m be? Why? | ρ |
The example of questions in each item is the following in table 2.

**Table 2.** The example of questions in each item.

| Item | Question |
|------|----------|
| Q6   | **Tier 1:** Two sizes of modeling clay, \(m_1\) and \(m_2\), are different in size that \(m_1\) is bigger than \(m_2\) but their density is equal. If you drop \(m_1\) in the glass of water, the result is as shown in the picture. The question is: if you drop \(m_2\) into the same glass what do you think of the results? |
|      | **Tier 2:** The reason you chose your answer is because:  
A. The object with big size will sink while the small size will float.  
B. \(m_1\) is \(\frac{1}{2}\) times of \(m_2\) size which makes buoyant force impact on \(m_1\) increase double.  
C. They sink in the same pattern because the density is equally.  
D. They sink in the same pattern because their surface and shape are the same.  
E. One sink and one float because of the different size. |

The conceptual test was provided to students. After students finished the conceptual test, they were interviewed by using Semi-structured if they chose alternative choice to investigate their alternative more deeply. The students’ responses were categorized following criteria used by Coştu et al. [6] as follows in table 3.

**Table 3.** Criteria for evaluation following Costu et al. (2012).

| Understanding level | Tier 1: Answer (multiple choice) | Tier 2: Reason (multiple choice) |
|---------------------|----------------------------------|----------------------------------|
| Scientific understanding (SU) | True | True |
| Partial understanding (PU) | True | No response |
| False | True |
| Specific misconception (SM) | True | False |
| No understanding (NU) | False | False |
| False | False |
| No response | False |

The results from conceptual test and interview were analyzed by using descriptive statistic to describe students’ basic conceptions of buoyant force.

3. **Research findings**

The students’ responses which were categorized as shown in figure 1 below. The trend of bars in each question as shown in figure 1 showed that most of students’ responses were categorized into NU and SM level which means that there are more than 80 percent of students have many alternative basic concepts which are related to buoyant force.
The results from conceptual test and interview of students who were categorized into NU and SM level showed that there are 5 students’ alternative basic concepts which are related to buoyant force including mass, volume, depth, pressure, and density. The details of these alternative concepts of basics conception can tell by analyzing students’ incorrect response, reasoning and interview.

4. Conclusions
After analyzing students’ incorrect response, reasoning and interview, we found that there are 5 students’ alternative basic concepts which are related to buoyant force as follows:

(1) Conception of mass: students thought that the buoyant forces impact on them are equally even the volumes of objects are different though they have the same mass.

(2) Conception of volume: most of students thought that if the volume of object increase, buoyant force impact on that object will decrease. Some of them thought that the volume of submerged object does not impact on buoyant force.

(3) Conception of depth: students thought that buoyant force will be decreased if increase depth of object under the water. Buoyant force will be increased when cargo moves pass the greater depth. Buoyant force will be decreased when cargo moves pass the greater depth.

(4) Conception of pressure: students thought that the pressure impacts on buoyant force because there is more pressure in greater depth and that pressure is force that helps buoyant force to lift the object.

(5) Conception of density: students thought that density of object makes buoyant force increase or decrease. If the density of liquid increase, buoyant force in that liquid will be decreased. Density of liquid does not impact on buoyant force.

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