Teaching Science Process Skills by Using the 5-Stage Learning Cycle in Junior High School

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Abstract. Science process skills are a set of skills used in scientific activities. Students with science process skills are actively involved in learning. Opportunities to be actively involved in learning can be obtained by students if the learning stage is designed in such a way. This article is about a lesson that is expected to teach students' science process skills and can help build their understanding of the concept of buoyant force. This learning can be carried out for students at the junior high school level. This learning process uses the 5-stage learning cycle consisting of observation, manipulation, generalization, verification, and application phase. Each activity is expected to facilitates students to develop science process skills such as observing, inferring, predicting, asking questions, constructing hypotheses, designing experiments, applying concepts, and communicating.

1. Introduction
The nature of science education involves students in scientific investigation. Scientific investigation includes the way thinking, attitude, and steps scientific activities to obtain products and knowledge of science. Students should be able to integrate between skills, knowledge and attitudes, to develop knowledge of conceptual understanding better [1]. One of the most important basic skills in scientific inquiry is the skill of the science process. Scientific process skills are a set of skills used in conducting scientific activities, producing and using scientific information, and problem solving [2]. Such skills can be a character in student’s self if they have the opportunity to do so in either learning or laboratory activities. The opportunity can be given to students if the learning environment is arranged in such a way that they can engage in science activities to improve their science process skills [3]. Therefore, in a learning’s plan teacher plays an important role in choosing an approach that can give students the opportunity to use these skills as widely as possible. So far, the results of the study of education practitioners are still lacking in incorporating lesson plans. The buoyant force learning plan by using this 5-stage learning cycle is structured in such a way that it can facilitate students to develop their science process skills.

2. Science Process Skills
Science process skills are process thinking skills using scientific processes and approaches [4]. Scientific process skills are very important for every individual, because they are almost always used in everyday life [5]. In science learning there are two groups of process skills, namely basic science
process skills include observing, classifying, inferring, measuring, communicating, and predicting, while integrated process skills include identifying variables, constructing hypotheses, tabulating and graphing data, defining variables, designing investigations, and experimenting [4]. In this article the skills of the process of science include the skills of observing, inferring, predicting, asking questions, constructing hypotheses, designing experiments, applying concepts, and communicating [6].

These skills can be assessed through the tests. The skills indicators on the test include: (a) observing: taking into account the properties of objects and events using the five senses, or a description of what is perceived; (b) provides an explanation of a particular object or event; (c) predicting: forecasting future events based on past observations or patterns of data formed; (d) asking question: requesting an explanation of a phenomenon; (e) hypothesizing: expressing suspected interim answers from observations or conclusions but ultimately subject to direct testing or by one or more experiments; (f) designing experiments: determine the tool or material of inquiry, investigation steps, and variables to be observed in the investigation; (g) applying concept: using a pre-built concept to describe an event in a new situation; and (h) communicating: using words, symbols, or graphs to describe an object, action or event [6].

3. Buoyant Force Learning Uses The 5-Stage Learning Cycle

This learning uses the 5-stage learning cycle of the Wenning version as an approach to buoyant force learning [7]. Five stages of the learning cycle include observation, manipulation, generalization, verification and application. In the five stages of this learning cycle, students play an active role in conducting learning activities.

Here are the general learning activities in the five stages of the learning cycle: Observation - Students observe interesting phenomena and are able to engage interest and elicit their responses. Students explain in detail what they see, do analogies and provide other examples based on the phenomenon. While the teacher makes the right questions for observation activities. Manipulation - Students propose ideas of investigations and develop approaches that can be used to study the phenomenon. After a discussion, they make plans to collect qualitative and quantitative data and then implement the plan. Generalization - Students build a new principle or law based on the results obtained in advance and provide a plausible explanation of the phenomenon. Verification - Students make predictions and test it using common law from the previous stage. Application - Students make conclusions and then apply to new situations [7].

In this buoyant force lesson plan, the five stages of the learning cycle are integrated into the learning and are designed in such a way as to enable students to use their science process skills. Here are the learning steps:

3.1. Observation

The series of activities at the observation stage, is expected to train students’ skills in observing, inferring, predicting, and asking questions. First, the teacher prepares some objects that can float or sink in water, such as plastic balls, pieces of wood, metal spoons, and others. Students are given the opportunity to use their senses maximally in observing activities, such as putting objects into aquariums of water, weighing objects immersed in water, or pressing floating objects into water and feeling the presence of buoyancy. Then the students are assigned to write their observations on the board. Examples of observations: ‘there are submerged objects and those floating in water’, ‘Objects that can sink more lightly after being put in water’, ‘floating objects are difficult to drown’, ‘there is a reaction force when the ball is pressed into the water’, and others.

After that, the teacher assigns students to infer the results of his observations. If necessary, the teacher can guide the student through referral questions until the student can conclude that any object immersed in the liquid will experience a buoyant force which is directed upstream of the liquid surface. Then, students are assigned to predict the existence of buoyant force on other objects if immersed in water. If students make observations and interpretations correctly, students should be able to predict that either in objects of mass or small mass, if they are in liquid they will experience buoyancy, whether they can float or sink in liquids. The teacher then encourages students to ask research questions. The questions should not be limited, students are given the widest opportunity to
practice their ability to ask questions. Of the many questions asked, teachers and students choose one of the questions to be investigated in an experiment, for example: ‘why the ship can float in the sea?’, ‘How is the relationship between the volume of objects with buoyant force?’. At this stage the student should be aware of the quality of the inquiry question.

3.2. Manipulation
At the stage of manipulation, students are given the opportunity to formulate research hypotheses. Students should be aware of the relevance of the hypothesis with the experimental design to be carried out next. In designing the experiment, students are given the opportunity to determine the tools and materials used. If this is not possible, then the teacher can provide tools and materials that are easily obtained in the environment. In this lesson plan with the theme of this buoyancy force, the tools that can be used to investigate the relation of the volume of objects to the buoyant force are the soda cans that can sink in the water and the spring balance [8]. Although the cans do not resemble perfect cylinders, however, we can determine the volume of cans based on the volume of soda in them.

Students can determine the experimental steps that will be done by writing it systematically. For example, the first student observe the volume of beverages listed on the can and are considered to be the same as the can volume, for example, the volume of the can is 330 ml. Then student signs the volume on the outside of the soda can, for a quarter, a half and three quarters of a part using a marker as in Figure 1.

![Figure 1](image1)

Figure 1. The soda cans that have been marked with volume boundaries to be immersed in water

Figure 1 shows that the mark on the can is made to provide a limit of the volume of the can to be immersed in water. The lowest mark indicates the volume of a quarter of a can, the middle mark showing the half-tin volume, and the topmost sign showing the volume of three quarters of a can.

Then the students measure the weight of the cans using the spring balance and get the weight of the object before dyeing 3.6 N (w_o) and then record the observations in a table. The next step students record the weight of the tin cans when dipped one quarter, half, three quarters, and all the parts into the aquarium containing the water as in Figure 2.
Figure 2 shows that by changing the volume of cans dipped in water, students can collect apparent weight data of cans. Based on the data of apparent weight cans, students can find that there is a weight difference before \( w_a \) and after dipped into water \( w_f \). The weight difference is a buoyant force \( F_b \). Thus students can create buoyant force formula that is \( F_b = w_a - w_f \). Examples of observation table can be observed in Table 1.

| Volume submerged (L) | Volume submerged (can) | Apparent weight can (N) | Buoyant Force (N) |
|----------------------|------------------------|-------------------------|-------------------|
| 0                    | 0                      | 3,6                     | 0                 |
| ¼ part               | 0,08                   | 2,3                     | 0,9               |
| ½ part               | 0,16                   | 1,6                     | 1,8               |
| ¾ part               | 0,24                   | 0,8                     | 2,7               |
| all part             | 0,33                   | 0                       | 3,6               |

From the data collected as shown in Table 1, students practice communicating the results of their experiments by changing the form of presentation from the table into Graph. Examples of graphs based on data in Table 1 can be observed in Figure 3.
Figure 3. Graph of the relationship between buoyant force ($F_b$) and the objects volume submerged in water ($V$).

Figure 3 shows that the relationship between buoyant force and the volume of a submerged can form a linear equation. The results of this experiment are then used as materials to construct knowledge at the generalization stage.

3.3. Generalization
In the generalization stage, students build their understanding of the concept of buoyant force based on the experimental results. Experimental results show that the buoyant force is directly proportional to the volume of objects submerged in water ($F_b \propto V$).

3.4. Verification
In the verification stage, the teacher assisted students determine the relation of buoyant force to the volume of submerged objects using the concept of hydrostatic pressure difference at different depths. The diagram of forces acting on a floating object can be observed in Figure 4.
Figure 4 shows a force diagram on a cylinder floating in a fluid. A cylinder with an elevation $h$ whose upper and lower edges have an area $A$ and are immersed entirely in a fluid with a density of $\rho_f$. The fluid gives pressure $P_1 = \rho_f g h_1$ on the top surface of the cylinder. The force caused by the pressure at the top of this cylinder is $F_1 = P_1 A = \rho_f g h_1 A$, and heading down. In the same way, the liquid gives the upward force at the bottom of the cylinder equal to $F_2 = P_2 A = \rho_f g h_2 A$. The total force caused by the pressure of the liquid, which is the buoyant force ($F_b$) works upwards, the equation is:

$$F_b = F_2 - F_1$$
$$F_b = \rho_f g A (h_2 - h_1)$$
$$F_b = \rho_f g A h$$
$$F_b = \rho_f g V$$

Thus, the relationship between buoyant forces proportional to the volume of objects immersed in the experimental activity can be verified through the equation.

3.5. Application
At the application stage, students are challenged to apply previously constructed concepts to new situations. For example, the teacher assigns students to make a plasticine boat design to accommodate marbles in large quantities. Students can design the project systematically and clearly. With prior knowledge built about the buoyant force, students should be able to explain the reasons for choosing the design of the plasticine boats they make.

4. Conclusion
Based on the literature review conducted by the author, this buoyant force lesson by using 5-stage learning cycle needs to be applied in learning and laboratory activities. This is done to get a picture of whether the learning can provide students with opportunities to use their science process skills.

References
[1] Zeidan A H and Jayosi M R 2015 Science Process Skills and Attitudes toward Science among Palestinian Secondary School Students World Journal of Education 5 (1)
[2] Aktamis H and Ergin O 2008 The Effect of Scientific Process Skills Education on Student’s Scientific Creativity, Science Attitudes, and Academic Achievements Asia-Pacific Forum on Science Learning and Teaching 9 (1)
[3] Akben N 2015 Improving Science Process Skills in Science and Technology Course Activities Using the Inquiry Method Education and Science (40) 179 111-132
[4] Rezba R J, Sprague C & Fiel R 2002 Learning and Assessing: Science Process Skills (Iowa: Kendall/Hunt Publishing Company)
[5] Hirca N 2013 The Influence of Hands on Physics Experiments on Scientific Process Skills According to Prospective Teachers’ Experiences European Journal of Physics Education 4 (1)
[6] Rustaman N 2009 Pengembangan Butir Soal Keterampilan Proses Sains (Bandung: FPMIPA UPI)
[7] Wenning C J 2011 The Levels of Inquiry Model of Science Teaching Journal of Physics Teacher Education Online 6 (2)
[8] Nelson J and Nelson J B 2015 Buoyancy Can-Can The Physics Teacher 53