Identifying of Student’s Creative Thinking Skill in Fluid Dynamics

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ABSTRACT
Fluid mechanics is studied in many different disciplines. Fluid dynamics as introduced in basic physics includes conservation of momentum or the equation of continuity, Bernoulli’s equation and ideas such as lift and thrust. Fluid dynamics combines concepts from kinematics and dynamics. Studying fluid dynamics requires the ability to connect knowledge from various laws and concepts in physics. The ability to integrate various disciplines in solving a complex problem is needed in this century. Creative thinking skills are needed to analyze problems, predict solutions, and evaluate results. This research aims to determine student’s creative thinking skills in fluid dynamics. The method that used in research is qualitative descriptive. Subjects were choosen by purposive sampling, based on student’s answers. Data collected from fluid dynamics tests and interviews. The result of this study indicates students who have conceptual understanding on fluid dynamics have high fluency and elaborated level, but for novelty aspect, students must combine the answers with various scientific disciplines such as biology, engineering and mathematics. While students with low fluency levels are caused by misconceptions on fluid dynamics so students are unable to provide detailed explanations of a case and there is no novelty of the solution given.

INTRODUCTION
Fluid mechanics is studied in many different disciplines. Fluid dynamics as introduced in basic physics includes conservation of momentum or the equation of continuity, Bernoulli’s equation and ideas such as lift and thrust. This is followed by many disciplines in engineering, and many from the natural sciences, with additional study of fluid mechanics (Martin, Mitchell, & Newell, 2015). Fluid dynamics combines...
concepts from kinematics and dynamics. Students who study fluids must integrate and apply basic concepts about lines of flow, pressure, propulsion and conservation of energy (Suarez dkk, 2017). Students have difficulty in learning fluid dynamics concepts due to lack of ability in connecting fluid concepts with other physics concepts. Students have difficulty in determining the relationship between the velocity and pressure in a pipe, and connecting kinetic energy and gravitational potential energy per unit volume with Bernoulli’s equation and many students failed to identify the forces acting of fluid and connect it to pressure (Loverude, Heron, & Kautz, 2010; Suarez et al., 2017). The research shows that many students have difficulty in solving problems and thinking creatively on fluids (Leniz, Zuza, & Guisasola, 2017).

Studying fluids requires the ability to connect various scientific disciplines. People who think creatively do not learn a concept limited to one subject, but are more inspired and can combine with various other disciplines (Mishra, 2012). STEM covers various disciplines subjects such as science, technology, engineering and mathematics (Massimo, 2015). The ability to integrate various disciplines in solving a complex problem is needed. Many students failed in solving physics problems because students are unable to connect knowledge from various subjects (Ersoy & Başer, 2014). The ability to think creatively is needed for analyzing complex problems, predicting the different and unique solutions, evaluating results and optimizing solutions (Hartiningtyas, Purnomo, Elmunsyah, & Nurmalasari, 2016). Students can solve complex problems and find solutions that depend on creative thinking (Doppelt, 2009). Creative thinking skills are built for students, this ability helps students deal with various challenges in life effectively, such as solving student’s daily problems at work in the future (Malik, Setiawan, Suhandi, & Permanasari, 2017; Wechsler et al., 2018).

The creative thinking indicators that used in the research can be seen in Table 1.

<table>
<thead>
<tr>
<th>Creative Thinking Skill Indicators</th>
<th>Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluency</td>
<td>Have many ideas or solutions to the problem given.</td>
</tr>
<tr>
<td>Originality</td>
<td>Able to provide unusual or unique solutions compared to the total answers of other participants.</td>
</tr>
<tr>
<td>Elaboration</td>
<td>Explain the ideas of the solutions in detail</td>
</tr>
</tbody>
</table>

Adapted from Torrance test of Classroom (Wechsler et al., 2018)

METHODOLOGY

This study aims to determine student’s creative thinking skills based on three indicators of creative thinking, such as fluency, elaboration and originality that are shown in Table 1. Fluid dynamics submaterials that will be measured are the principle of continuity and Bernoulli’s principle. The research method used is descriptive. Subjects in this research are XI grade high school students in Malang which were selected by purposive sampling based on student’s answers. Data collection in this study was conducted in two ways, dynamic fluid test and interviews. Students are given two questions with aspects of creative thinking: fluency, originality and elaboration. After
the test was done, an interview was conducted to check the student’s answer that not clear enough and not written on the answer sheet. The following dynamic fluid test instruments were adapted from Goszewski, Moyer, Bazan dan Wagner (2013).

**RESULT AND DISCUSSION**

Analysis of student’s answers to creative thinking skills is described as follows:

**Analysis of student’s answers to question no.1:**

In questions no.1, there is a question about rats, guinea pigs and rabbits that make more than two holes in the ground, where one hole is higher than the other hole. Students were asked to provide various kinds of solutions to the given case. These are the results of the analysis of student’s answers to the question no.1.

Interview analysis with YNH subject as follows:

<table>
<thead>
<tr>
<th>P</th>
<th>: Have you ever noticed wormholes or rat nests?</th>
</tr>
</thead>
<tbody>
<tr>
<td>YNH</td>
<td>: Yes, I have.</td>
</tr>
<tr>
<td>P</td>
<td>: In your opinion, why worm and rat make more than two holes on their nest in different heights?</td>
</tr>
</tbody>
</table>
YNH: In order to have air circulation. Air can flow because there is a pressure difference. Air flow from high to low pressure. If the height of the hole is same, there is no air flow inside the rat’s nest.

P: Any other reasons?

YNH: To anticipate flooding, when flood occurs, water flows from high places to low places so that rat can still live in high places.

P: What is the physics concept in this case? Please explain?

YNH: The concept of pressure difference in fluid.

P: Any other concepts?

YNH: No, I think that’s it.

Fluency Indicators
Based on the interview, it can be concluded that YNH can mention many reasons for making rat nests or wormholes with more than two holes with different heights. According to YNH, air can flow on the hole because of height differences. In addition, to anticipate flooding, rat can still live in higher places. Based on YNH’s answers, YNH’s creative thinking skill level on fluency indicator is high.

Elaborate Indicators
YNH can explain in detail the factors that rat or worms make nests with more than two holes in different heights. It shows that YNH has extensive and detailed knowledges of the case given. So, the level of YNH’s creative thinking skill on the elaborate indicator is high.

Novelty Indicators
The solution given by YNH is unique and different from most other students, so there is a novelty. YNH said that reason of making wormholes or rats nests in different heights are to anticipate flooding, so rats or worms can go to the higher part of their nest.

Interview analysis with WNR subject as follows:

Figure 4. The answers from WNR in question number 1

P: Have you ever noticed wormholes or rat nests?

WNR: Yes, I have.

P: In your opinion, why worm and rat make more than two holes on their nest in different heights?
Nadia: Identifying of Student’s Creative ...

<table>
<thead>
<tr>
<th>WNR</th>
<th>Because air flows from high to low pressure, and air can flow on the ground, so rat and worm can breathe. If the height of the hole is same, there is no air or oxygen flows on it.</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>Any other reasons?</td>
</tr>
<tr>
<td>WNR</td>
<td>No, I think that’s it.</td>
</tr>
<tr>
<td>P</td>
<td>What is the physics concept in this case? Please explain!</td>
</tr>
<tr>
<td>WNR</td>
<td>The concept of pressure difference, if the hole was made in different height, it cause a pressure difference.</td>
</tr>
<tr>
<td>P</td>
<td>Any other concepts?</td>
</tr>
<tr>
<td>WNR</td>
<td>No, I think that’s it.</td>
</tr>
</tbody>
</table>

**Fluency Indicators**

Based on the interview, it can be concluded that WNR can mention the reasons for making rat nests or wormholes with more than two holes in different heights, so that air can flow on the rat hole. However, when asked on other reasons, WNR could not mention it. WNR can only provide one solution from a given case so that the fluency level of WNR is sufficient.

**Elaborate Indicators**

WNR can explain in detail the solution of the case given. However, WNR only describes one idea in detail, so that the elaborate level of WNR is sufficient.

**Novelty Indicators**

The solution provided by WNR is the same as most solutions provided by students in the class, so there is no novelty of the solution delivered.

**Analysis of student’s answers to question no.2:**

Interview analysis with IKD subject as follows:

<table>
<thead>
<tr>
<th>P</th>
<th>Have you ever heard about hypertension in biology subject?</th>
</tr>
</thead>
<tbody>
<tr>
<td>IKD</td>
<td>Yes, I have.</td>
</tr>
<tr>
<td>P</td>
<td>What is hypertension?</td>
</tr>
<tr>
<td>IKD</td>
<td>Hypertension is high blood pressure.</td>
</tr>
<tr>
<td>P</td>
<td>In people with hypertension, the pulse rate becomes faster, what are the factors that cause it?</td>
</tr>
</tbody>
</table>

**Figure 5. The answers from IKD in question number 2**
IKD : Blood vessels of people with hypertension shrink, then the pressure given by the heart gets bigger so that blood can be channeled throughout the body with the same volume, the heart beats faster.

P : So, is there any relationship between blood vessels constriction and high blood pressure?

IKD : There is relationship between the surface area of blood vessels and pressure. Narrow blood vessels mean the crosssectional area of blood vessels is also getting smaller. To keep blood flowing with the same volume, the blood flow rate reduced, so that blood pressure become large.

P : What is the physics concept in this case? Please explain!

IKD : Fluid dynamic concept, there is relation between surface area with velocity, pressure and debit.

P : Any other answers?

IKD : No, I think that’s it.

**Fluency Indicators**
Based on the interview, it shows that IKD can mention various reasons of faster pulse rate in people with hypertension. IKD explained that in people with hypertension, blood vessels are reduced, it affects blood pressure. So it can be concluded that IKD can provide many ideas from the case given. The level of IKD's creative thinking on fluency indicator is high.

**Elaborate Indicators**
IKD can explain in detail the factors that cause the faster pulse rate in people with hypertension by connecting static fluid concept with biology concept, so it can be seen that IKD has a lot of information to answer questions. It can be concluded that the level of IKD's creative thinking on the elaborate indicator is high.

**Novelty Indicators**
The answers given by IKD in the question No. 2 are different from other students, so there is a novelty of the ideas given by IKD. It can be concluded that the level of IKD's creative thinking on novelty indicator is high.

Interview analysis with MAS subject as follows:

**Figure 6. The answers from MAS in question number 2**

P : Have you ever heard about hypertension in biology subject?

MAS : Yes, I have.
P: What is hypertension?
MAS: High blood pressure.
P: In people with hypertension, the pulse rate becomes faster, what are the factors that cause it?
MAS: If there is a lot of blood, the heart pumps blood faster, then the air pressure in the blood becomes low, so the arteries speed up the blood.
P: So, do you think people with hypertension have a lot of blood volume compared to normal people?
MAS: Yes, I do.
P: Then, does it affect the speed of the heart to pump blood throughout the body?
MAS: Yes, it does.
P: Are you sure?
MAS: Not really.
P: Do you think that people with hypertension have low blood pressure?
MAS: Yes, I do.
P: Are you sure?
MAS: Yes, I think so.

**Fluency Indicators**
Based on the interview, it can be seen that MAS was wrong in conveying factors that caused the arterial pulse rate of people with high hypertension, because MAS said that in people with hypertension, more blood volume flowed, blood flows rapidly and blood pressure becoming low. In addition, MAS is also not sure about the answers that were submitted.

**Elaborate Indicators**
MAS was wrong in making a solution to the problem. This caused MAS to misrepresent the reason for the rapid arterial pulse in people with hypertension. So it can be concluded that MAS's creative thinking level on the elaborate indicator is low.

**Novelty Indicators**
The answers given by MAS was wrong, and also there is no different and precise novelty of the solution provided, so MAS's creative thinking level on novelty indicator is low.

**CONCLUSION**
Based on the results of the analysis of answers and interviews, it can be summarized as follows.
In fluency indicator, most of students have been able to provide ideas of the questions with the correct fluid concept, but the the number of ideas given by students are not much, so the level of student’s creative thinking skills on fluency indicator is quite good (moderate).
In elaborate indicator, students who have high fluency level can describe in detail the factors that influence in the problem. But students with low fluency level cannot explain in detail.
In novelty indicator, students who have a high level of fluency and elaborate skills can provide answers that different from most other students, so there is a novelty. While
students with a low level of fluency and elaborate skills can not answer questions with different and unique solutions unlike most other students, so there is no novelty.

REFERENCES


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