K-11 students’ creative thinking ability on static fluid: a case study

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Abstract. Creative thinking is one of the fundamental components of 21st-century education that needs to be possessed and developed in students. Thus, the students have the ability to find many alternative solutions to solve problems in physics learning. The study aimed at providing the students' creative thinking ability on Static Fluid. A case study has been implemented through a single case, namely embedded design. Participants in this study are 27 K-11 students. The instrument utilized is Test for Creative Thinking - Static Fluid (TCT-SF) which has been validated by the experts. The result shows that 10.74 (approximately 35.8%) of the maximum scores. In conclusion, students' creative thinking ability on Static Fluid is still stumpy, hence, it is needed to develop creative thinking ability in K-11 students' context.

1. Introduction
Students as future generations need to be equipped with educational institutions with high-level ability, such as creative thinking, as stated in Framework of 21st Century Education [1, 2]. What is creative thinking? Creative thinking is not the same as intelligence [3] because creative thinking ability can be enhanced by being trained. Creative thinking can be defined as various things, such as a process, product, personality, or environmental conditions. As the process, creative thinking involves sensing problems, finding information, making hypotheses, testing the hypotheses, revising, and retesting them, and communicating the results. While as a product, creative thinking involves inventions, science theories, improving products, or even finding new relationships in nature [4]. Torrance [5] stated that in creative learning encompasses three principal abilities, namely evaluation (sensing problem or missing elements), divergent products (fluency, flexibility, originality and elaboration), and redefinition.

The instrument used to measure the ability of creative thinking generally used is TTCT (Torrance Tests of Creative Thinking) [5], and the development of TTCT is TCT-DP (Test for Creative Thinking-Drawing Production) [6, 7]. These tests are usually used to measure student psychology. Besides, the instrument that can be used to measure other creative thinking skills are Task-Specific divergent-thinking training [8], but furthermore, it turns out that this instrument still has a lot of criticism because it is considered less valid and can not assess the ability of certain creative thinking on a particular domain [9]. Moreover, these test instruments are extensively used in social and linguistic. It also has developed self-report instrument of creative thinking ability about the transition from associative thinking to analytical thinking, called Mode Shifting Index (MSI) [10]. Currently, digital media-based instrument [11] have been developed to measure creative thinking skills in Physics, but this instrument is used to test pre-service teachers on abstract concept. Therefore, we try to develop a creative thinking instrument that could be used to test secondary students on the concrete concept, that is Static Fluid. Concepts in
static fluids include density, surface tension, capillarity, viscosity, cohesion-adhesion, hydrostatic pressure, Archimedes principle, and Pascal's law. In this article, the Static Fluid material is focused on the concept of cohesion-adhesion, hydrostatic pressure, Archimedes principle, and Pascal's law. This is done by considering the aspects of creative thinking used in research, namely fluency, flexibility, elaboration, originality, and evaluation. These concepts are perceived to have phenomena in which most students have observed or experienced them, as well as its applications.

What is fluid? Fluid is a substance that can flow, can be gasses or liquids. Based on particle traits, there is an attraction between particles; i.e. cohesion, and adhesion. Cohesion is a force of attraction between similar particles, while adhesion is the force of attraction between unlike particles (see Figure 1). Static fluid discusses the nature and behavior of fluids in a stationary state.

![Figure 1. An illustration of adhesion-cohesion of particles.](image)

The pressure of the liquid at rest is called hydrostatic pressure. The pressure experienced by the fluid at a particular point depends on the depth of the point from the liquid surface because the fluid layer on top of it puts pressure on the fluid at that point. But, the pressure value on the horizontal dimension is the same. Actually, the atmospheric pressure gives effect to the pressure experienced by the fluid at a certain point, if the atmospheric pressure is considered then it is called absolute pressure. From this concept, students are asked to predict what happens if a certain situation is applied to the problem, and provide an assessment of the problems given in accordance with their own physics understanding. Archimedes principle stated that when the object is partially or fully immersed in liquid, the buoyant force of the surrounding liquid moves to the object. The force is moved upward and has a magnitude equal to the weight of the liquid that has been removed by the object. From this concepts, students are asked to expose a lot of questions and generate varying ideas, answers, or questions. While Pascal principle stated that change in the pressure applied to an enclosed fluid is transmitted undiminished to every portion of the fluid and to the walls of the containing vessel. From this concept, students are asked to enrich and develop the product of the given problem.

2. **Methods**

2.1. **Participant**

Participants in this research were 27 of K-11 students, consisting of 16 girls and 11 boys, whose age was around 16-17 years old. The students mostly have a good financial background, they have complete learning facilities from subject guidebooks to sophisticated gadgets that could help them to access the information about subjects from the internet.
2.2. Instrument
The instrument used in this research is TCT-SF (Test for Creative Thinking-Static Fluid). It was developed refers to Torrance, involved aspect of fluency (able to give a lot of questions), flexibility (be able to generate varied ideas, answers, or questions), originality (is able to produce new and unique phrases), elaboration (be able to enrich and build an idea or product), and evaluation (determine own assessment benchmarks based on a rational opinion that can be accounted for to reach a decision). The questions' distribution for the creative thinking ability test is shown in Table 1 below.

| Indicators of Creative Thinking Ability | Description of Creative Thinking Ability’s Indicator | Number of Problems | Question Number |
|----------------------------------------|---------------------------------------------------|--------------------|-----------------|
| fluency                                | able to give a lot of questions                    | 1                  | 1               |
| flexibility                            | be able to generate varied ideas, answers, or questions | 1                  | 2               |
| originality                           | able to produce new and unique phrases             | 1                  | 3               |
| elaboration                           | be able to enrich and build an idea or product     | 1                  | 4               |
| evaluation                            | determine own assessment benchmarks based on a rational opinion that can be accounted for to reach a decision | 1 | 5 |

The test instrument consists of 5 items of each aspect in the form of essays, with the maximum value for each item is 6. A sample of the rubric for creative thinking test is shown in Figure 2. The test results processed by calculating the average score obtained.

| Indicator | Question | Expected Answer |
|-----------|----------|-----------------|
| Evaluation: determine own assessment benchmarks based on a rational opinion that can be accounted for to reach a decision | Dino opens an aquarium of acrylic material with length, width, and height respectively 30 cm x30 cm x 30 cm as seen in the picture below. The four acrylic walls have the same thickness in each section and can withstand the pressure of 104 kPa. What is the maximum air that Dino should fill in the aquarium? What will happen if Dino fills it up? Explain! | The maximum air limit that Dino can fill in the aquarium is as high as 40 cm or its volume is 0.036 m³. The aquarium will be broken because the maximum pressure experienced on the lower acrylic wall can only hold 104 kPa. The deeper, the greater the pressure the acrylic wall is subjected to. |

![Figure 2. A Sample of rubrics for creative thinking test](image)

2.3. Technique of Analyses Instrument
Before implemented to the students, this instrument was tested for validity, both theoretical and criteria validity. Validity test, involved content validity, and face validity were done by checking the instrument by the experts, and there were several parts to be fixed. The criterion validity was done by using an
alpha-Cronbach correlation test with SPSS-24. The results of the validity test with alpha-Cronbach are shown in Table 2.

Table 2. The result of test instrument validity with Cronbach-alpha from SPSS output.

| Item   | Total Statistics | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item Total Correlation | Cronbach’s Alpha if Item Deleted |
|--------|------------------|----------------------------|--------------------------------|----------------------------------|----------------------------------|
| No_1   | 5.85             | 21.292                     | 0.802                          | 0.733                            |
| No_2   | 6.00             | 18.526                     | 0.847                          | 0.717                            |
| No_3   | 8.35             | 32.555                     | 0.517                          | 0.833                            |
| No_4   | 6.25             | 20.934                     | 0.693                          | 0.777                            |
| No_5   | 8.35             | 33.608                     | 0.508                          | 0.840                            |
| Cronbach’s Alpha for 5 Items | 0.826 | | | |

The result shows that the alpha value obtained is .825 greater than the r-table with a significance of 5%, i.e. .444 (N=20). That is, the items on the test instrument used can be said reliable. George and Mallory [12] provide a rule of thumb for alpha values above .8 are categorized as good. In other words, the Cronbach alpha value obtained shows a good internal consistency of the items used.

2.4. Research Design

The method used in this study was a single case study, namely embedded design. This design is not limited to one type of analysis, such as quantitative or qualitative ones, but allows for a multiplicity of methods that may be applied within the subunit [13]. The research school was selected in terms of the quality of the school and its students, not too low and not too high so that the results could be used as a representative and give a general overview. The research was done by taking data through giving the creative thinking ability test on static fluid material once. This test takes two hours of lessons, where one hour of lessons is 45 minutes. This test is given to students who have previously studied the concepts tested in this test. Then the results were processed statistically and then analyzed. Meanwhile, the research procedure performed is shown in Figure 3 below.

![Figure 3. Research procedure.](image-url)
3. Result and Discussion

The result of the students' creative thinking ability test on the static fluid material is shown by the average student score in general, that is 10.74. While the maximum mean score if all students answered correctly is 30, with the maximum value for each item is 6. In other words, the students' creative thinking ability gained from the test results were only 35.8%. Table 3 shows the average score of each aspect of creative thinking ability.

| Aspects of Creative Thinking Ability | Average score |
|-------------------------------------|---------------|
| Fluency                             | 3.30          |
| Flexibility                         | 3.33          |
| Originality                         | 0.33          |
| Elaboration                         | 3.19          |
| Evaluation                          | 0.59          |

Based on Table 3, the aspect with the highest profile is flexibility (3.33), that is students are able to generate various ideas, answers, or questions. Aspects with the second highest profile with the score difference only 0.03 of the highest aspect is fluency (3.30). These two questions relate to the concept of Archimedes principle. Some students can give the desired answer even though almost all the students answered did not reach the maximum score. It can be caused by teachers usually trained the flexibility and fluency by providing opportunities for students to ask questions and answer or respond to questions or statements that given by teachers in the learning activities.

The third highest aspect is the elaboration aspect (3.19), that is the students' ability to enrich or develop an idea. This question relates to the concept of Pascal principle. Based on the answers given by the students, it is known that almost all students cannot develop the product on the given problem. Only a few students can describe the product development design they want to create and explain the working principle of the product design. But few students can only describe the design alone without explaining the working principle of the product. In fact, most of the drawings of product development design are incorrect.

Meanwhile, other aspects that have the lowest score are in the aspect of evaluation (0.59) and originality (0.33). Evaluation is indicated by the students being able to determine the standard of his own judgment and have the reasonable rationale for making a decision. In Revised Bloom's Taxonomy [14], the evaluation aspect is in the second highest cognitive domain as the most complex of thinking spheres (C5). Most students cannot give answer to this indicator, they left the answer sheet with no answer.

The lowest is the aspect of originality, that is the ability of students to produce new and unique phrases. It is the most difficult aspect to be trained. It is a higher level of complexity than evaluating, requiring more complex thinking ability among other cognitive domains. This aspect is equivalent to the create an aspect of cognitive dimension of revision in Revised Bloom's Taxonomy. It is at the highest level of complexity of thinking, that is C6, in which the creating category is to integrate the elements into something new and whole or to make an original product. More than that, the originality aspect of creative thinking must have unique and effective (usefulness, merit, or eligibility) [2, 15]. The reason behind it is in the secondary school, most of the teacher does not familiarize the students to think until the stage of assessing/evaluating, usually the teacher only trained to the stage of analyzing. Even, the learning activity in the classroom as based on observations and interviews of high-level students, they learn Physics just with following instruction from Teacher. Besides that, students are rarely using other ways to solve a problem. Ideally, teachers should provide opportunities for students to do discussion, do lab experiments, work together as a group, both collaboratively and cooperatively, or occasionally
conduct learning activities such as lab work outside the classroom, in the open environment to help students spark their creativity [16]. Not only that, teachers also should build positive relationships between teacher and students, such as mutual respect, exemplify creative attitude, encourage students to leave their comfort zone, and growth their self-confidence in their own creative abilities [15, 17, 18, 19, 20]. Therefore, the creative thinking ability students’ average score is low, especially in the aspect of originality. It can be known from the student’s answer that most of the answer given does not match the expected answer.

4. Conclusion

Based on the results of research that had been conducted, it is known that the teacher had provided creative thinking ability in Physics learning activities. But only on the aspects of fluency, flexibility, and elaboration, and it is also very minimal. Students’ creative thinking ability is generally low, indicated by the average score of 10.74% or 35.8% of the maximum score. Similarly, the students’ creative thinking ability of each aspect is still relatively low. This is indicated by the average score of each aspect of students’ creative thinking ability, that is 3.33 for the flexibility aspect, 3.30 for the fluency aspect, 3.19 for the elaboration aspect, 0.59 for the evaluation aspect, and 0.33 for the originality aspect.

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