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Exploring Science Students' Creativity and Critical Thinking Skills through Fluid Learning

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Abstract

Amid rapid technological Development, creative thinking skills are highly sought after. Creativity enables individuals to generate new ideas, find innovative solutions in complex situations, and adapt more easily to change. This study aims to determine the level of creative thinking skills of prospective science teachers through four primary indicators: flexibility of thinking, fluency in generating ideas, originality of ideas, and the ability to elaborate ideas. This study used a quantitative descriptive approach and involved 20 prospective science teachers at Lamongan Islamic University. The research instrument was a Likert-scale questionnaire. Data were analyzed by assigning a score to each statement, followed by descriptive statistics including averages, frequency distributions, percentages, and standard deviations. Furthermore, students' abilities were categorized by score, and creative thinking skills received the highest score on the fluency indicator (81.20%), while flexibility received the lowest (53.40%). For critical thinking skills, indicators of giving building (55.55%) and organizing strategies and explanations of inference skills are in the low category (54.70%). This condition is caused by students' difficulties in generating new ideas or generating various alternative solutions when facing a problem. Therefore, the results of this study are expected to inform educators in developing learning strategies that stimulate the creativity of prospective science teachers, for example, through learning modules that train 21st-century skills, discovery-based approaches, or the use of media that encourage students to be more daring in their creations.

INTRODUCTION

The Development of education in Indonesia in the 21st Century demands the presence of 4C competencies, namely the ability to think creatively, think critically, solve problems, and communicate and collaborate. 21st-century students need to be equipped to learn and innovate, collaborate, master digital literacy and information technology, and develop life and career skills to navigate the modern world of work [1]. Creativity is an important part of contextual learning because it enables students to face increasingly competitive global challenges. Developing creativity requires attention to creative thinking skills, creative attitudes, and creative character. Creativity reflects a flexible mindset, can be honed through problem-solving, and is related to higher-order thinking skills [2].

The role of creativity in 21st-century education is significant, particularly in science, technology, the environment, and mathematics. One key aspect of fostering creativity is providing students with space for divergent thinking. Through divergent thinking skills, students are encouraged to express opinions, reason, and develop alternative conclusions based on observations and data, as well as the processes of clarification, analysis, and evaluation they undertake [3].

Science learning itself aims to help students understand the facts and concepts of natural science, apply them to real-life situations, foster a scientific attitude, and discuss natural phenomena systematically through observation and experimentation [4]. However, in reality, students' understanding of science in Indonesia is still relatively low. This requires a learning approach that encourages higher-order thinking skills, including creative thinking.

Creative thinking is evident when students connect ideas with new information, create fresh combinations, and express their imagination and understanding in meaningful ways [5]. The stronger the creative thinking skills, the easier it is for students to master science concepts. To support this, the government has implemented the Independent Curriculum (Kurmer), which encourages the achievement of competencies in the Pancasila Student Profile, one of which is creativity. This goal aligns with the demands of 21st-century skills, namely the 4Cs: creativity, critical thinking, problem-solving, communication, and collaboration [6]. These four skills can be integrated into science learning so that students can address the various problems that arise in everyday life.

Creative thinking is defined as the ability to generate and develop original ideas [7]. Creative individuals are characterized by a strong sense of curiosity, a wealth of ideas, imagination, self-confidence, a willingness to adhere to rules, persistence, sensitivity to problems, and a love of challenges [8]. They are also generally active in asking questions, expressing opinions, offering solutions, working independently, and enjoying trying new things [9]. Torrance then formulated four indicators of creative thinking: elaboration (the ability to describe ideas in detail), originality (the ability to generate unique ideas), fluency (the ability to generate many ideas), and flexibility (the ability to see problems from multiple angles) [10]. Creative thinking is typically measured by fluency, flexibility, originality, and elaboration [11]. Implementing student-centered learning and providing meaningful challenges can stimulate creative thinking.

Critical thinking skills refer to the ability to analyze information logically, evaluate arguments, and make decisions supported by data and strong reasoning. These skills include providing simple explanations, building rationales, making inferences, providing further explanations, and organizing strategies and tactics [12]. Critical thinking indicators include the ability to identify problems, evaluate evidence, draw rational conclusions, and make informed decisions. These skills are crucial for individuals to think independently and solve complex problems. Without critical thinking skills, individuals are easily misled and struggle to make decisions. In learning, educators can stimulate these skills by encouraging students to generate hypotheses and develop evidence-based arguments [13].

In fluid learning, the aim is to deepen students' mastery of natural principles while fostering critical thinking, a scientific attitude, curiosity, and the ability to formulate problems creatively. Learning about fluids in science has a strong effect on developing students' scientific reasoning. The concept of fluids is closely related to natural phenomena and everyday life, such as water flow, hydrostatic pressure, and the working principles of fluid-based devices. Through learning about fluids, students can be trained to observe phenomena, identify problems, analyze relationships between variables, and formulate solutions based on scientific principles.

However, various studies show that physics learning in schools still focuses on conveying formulas and solving routine problems. This type of learning tends to position students as passive recipients of information, thus providing little opportunity for critical and creative thinking. Science learning practices that lack higher-order thinking activities lead to low analytical and evaluative skills among students. Several efforts have been made to improve students' critical thinking skills and creativity through various innovative learning approaches. Contextual-based science learning can significantly improve students' critical thinking skills [14]. These results indicate that learning that links concepts to real-world contexts can encourage students to think more deeply and reflectively.

Furthermore, studies that explicitly explore the creativity and critical thinking skills profiles of science students in the context of fluid learning are relatively limited. Most studies emphasize cognitive learning outcomes, while aspects of students' thinking processes have not been explored in depth. However, mapping students' creativity and critical thinking skill profiles is crucial as a basis for designing more effective physics learning that develops 21st-century skills.

However, some students still demonstrate low levels of creativity and critical thinking. They struggle to understand fluid concepts and apply them to problem-solving. Observations show that in practical work, students tend to copy textbook steps and hesitate to try new methods. This low level of creativity can hinder the emergence of innovative ideas, especially if learning still focuses on delivering material and provides little opportunity for exploration[15]. A similar trend is seen in critical thinking skills: students struggle when problems differ from examples, especially when they require reasoning. They also lack confidence in expressing opinions, especially when they align with the textbook. This situation is exacerbated by learning models that do not adequately allow students to think critically.

Several studies have examined the Development of creativity and critical thinking skills in science learning. However, most of these studies examine these two skills separately, thus failing to provide a comprehensive picture of students' creativity and critical thinking skills within a single learning context. Furthermore, the focus of science learning research remains predominantly on improving cognitive learning outcomes, while exploration of students' thinking processes as indicators of 21st-century skills remains relatively limited.

In the context of physics learning, particularly in fluids, empirical studies specifically exploring students' creativity and critical thinking skills are also rare. However, fluid concepts possess contextual and applicable characteristics that offer significant potential for developing analytical, evaluation, and creative problem-solving skills. Existing research generally focuses on conceptual mastery or problem-solving skills, rather than on mapping students' thinking profiles.

Based on these findings, previous research generally only focuses on one skill, creativity or critical thinking, in isolation. This study offers novelty by examining both skills simultaneously in the context of physics learning, specifically static fluids. This research is crucial to address the low levels of these skills among prospective science teachers, which ultimately affect their ability to understand physics concepts, solve complex problems, and meet academic and professional demands. This study aims to capture students' creativity and critical thinking profiles during fluid lectures and to provide insights that can serve as a basis for developing more effective learning materials and strategies.

METHOD

This research employed a quantitative descriptive approach, involving 20 students in the Science Education Program at Lamongan Islamic University as subjects. Data collection involved creativity tests and critical thinking skills tests. Before use in the study, both instruments were reviewed and analyzed by expert lecturers. In addition, the researchers conducted direct classroom observations of activities that demonstrated various aspects of creativity during the viscosity experiment. Each aspect of creativity had two indicators, each assessed through one or two observational aspects. Assessments were conducted on a scale of 1–4 for each indicator, according to its criteria. The data were then analyzed descriptively and grouped by creativity aspect, with an average score calculated for each. The students' creativity categories are displayed in the Table.

The critical thinking skills test was administered after students studied the static fluid material. The instrument consisted of essay questions developed from critical thinking indicators. Each question was scored on a 0–4 scale using an assessment rubric. Each indicator was represented by a single question, yielding five essay questions in total. Students' answers were analyzed descriptively and then grouped according to critical thinking aspects. Next, the average value of each indicator was calculated to determine its contribution to students' critical thinking skills. The overall results are presented in Table 2.

RESULT AND DISCUSSION

Student Creativity in Fluid Learning

The analysis of student creativity data yielded an average score of 25 out of 40 (62.50%), which falls within the sufficient category. The percentage of students in each creativity category is shown in Figure 1.

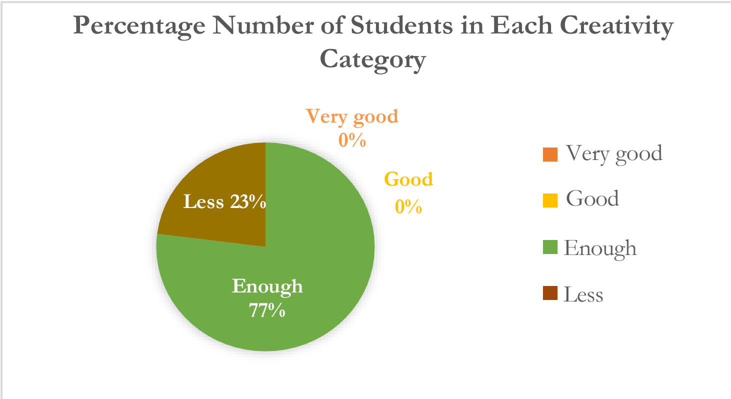

Figure 1. Pie Chart of the Percentage of Students in Each Creativity Category

Based on Figure 1, only 77% have sufficient creativity, while 23% are in the insufficient category. This ability is in dire need of improvement. This level of achievement can also be reviewed in each aspect, as shown in Figure 2.

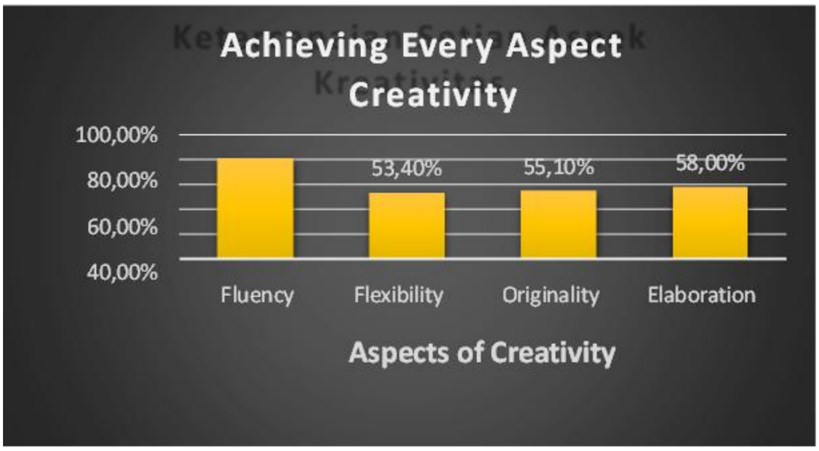

Figure 2. Diagram of Achievement of Each Aspect of Creativity

Based on the data analysis in Figure 2, the average score across the four aspects of creativity was 61.93% (a score of 2.48 out of 4), indicating sufficient performance. The achievement of each aspect of creativity indicates that fluency, at 81.20% (a score of 3.2), falls into the good category. Flexibility, at 53.40% (a score of 2.1), falls into the poor category. Originality, at 55.10% (a score of 2.2), and elaboration, at 58.00% (a score of 2.3), fall into the poor category.

Students' Critical Thinking Skills in Fluid Learning

The data analysis of students' critical thinking skills yielded an average score of 38.4 out of a maximum score of 100, which falls into the very low category. The number of students in each category of thinking skill level is shown in Figure 3.

Data analysis of students' critical thinking skills yielded an average score of 38.4 out of 100, placing it in the very low category. The number of students in each critical thinking skill category is shown in Figure 3.

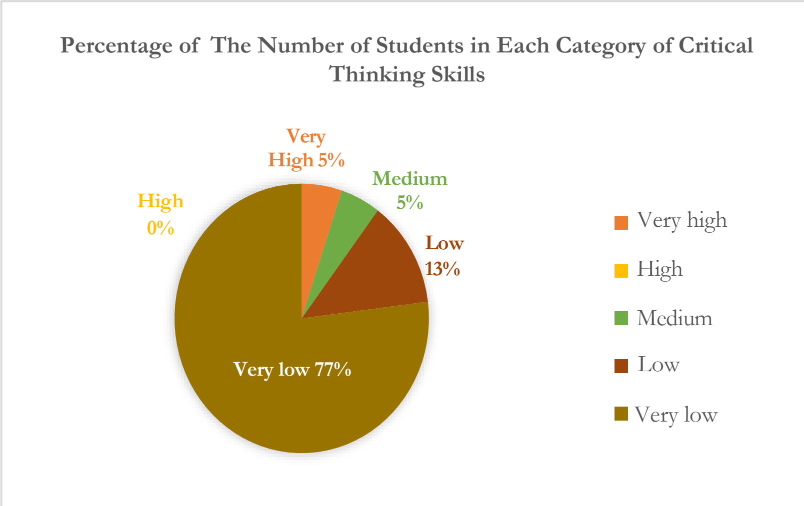

Figure 3. Level of students' critical thinking skills

The initial profile of students' creativity in learning physics was considered adequate, with the highest proportion of creativity observed in flexible thinking skills, while the lowest was in fluency. The initial profile of students' critical thinking skills was very low, with the highest proportion in the aspect of providing simple explanations, while the lowest was in the aspect of making inferences (concluding). The students' adequate creativity and the lack of critical thinking skills in fluid learning require active Development of these abilities throughout the learning process. Furthermore, the teacher's role is crucial in training and guiding students to develop these abilities.

Based on Figure 3, 5% of students have very high critical thinking skills, and 5% are in the moderate category. The remaining 90% still have low and very low levels. This ability is in dire need of improvement. This level of achievement can also be reviewed in each aspect, as shown in Figure 4.

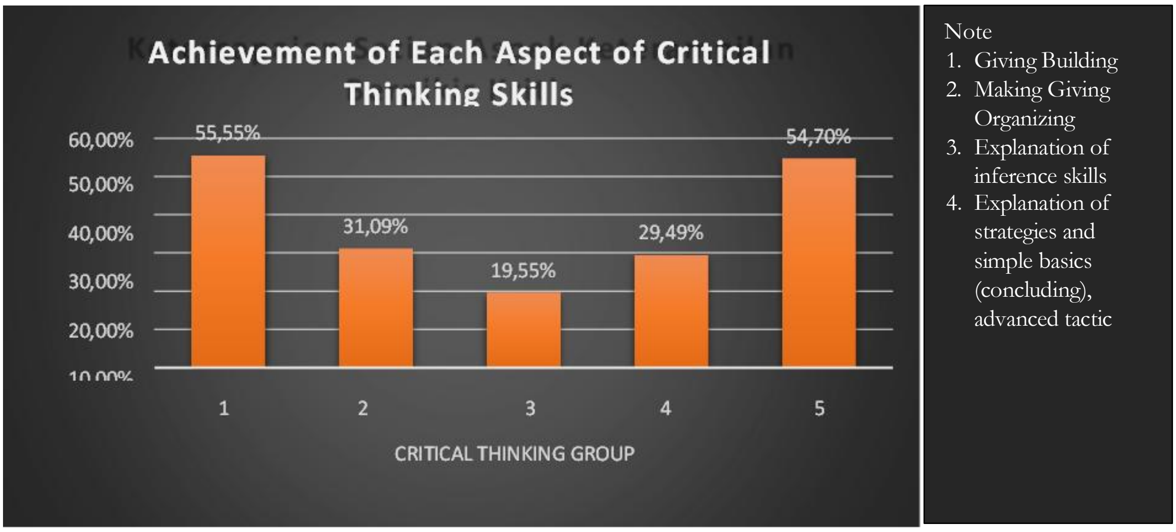

Figure 4. Diagram of Achievement of Each Aspect of Critical Thinking Skills

Based on the data analysis in Figure 4, the average of the five critical thinking groups is 38.08% with a very low category. Based on the critical thinking group, students' skills in building basic skills (31.09%), making inferences (concluding) (19.55%), and providing further explanations are included in the very low category (29.49%). Students' skills in giving building (55.55%) and in organizing strategies and explanations of inference skills are in the low category (54.70%).

Discussion

This study describes the initial creativity of prospective science teachers as they learn about fluids through observations of salted egg-making activities, an application of fluid concepts in the preservation process. The observation instrument consisted of 10 aspects, each based on creativity indicators. During the project planning stage, the observation sheet included three aspects of flexibility and two aspects of originality. During project implementation, the assessment focused on the three aspects of fluency, while the final stage assessed the two aspects of elaboration. The observation process was conducted over two weeks, following all student activities in completing the project.

The analysis showed that students' creativity levels were in the sufficient category, with an average score of 35.20 (70.41%). This finding is that student creativity tended to be low, with flexibility as the weakest indicator and elaboration as the highest. The different observations likely influence this difference in focus. This study assessed creativity through observation data during salted egg-making practices, whereas previous research used questionnaires to assess students' perceptions of the creative thinking process [16]. Real-life, collaborative activities often facilitate student creativity. This difference may be due to differences in materials, instruments, and educational level. Making salted eggs involves capillarity in fluids, whereas previous research assessed junior high school students' responses to the solar system. Factors such as intelligence, knowledge, motivation, social environment, culture, and personality also influence a person's creativity, and creativity can also be enhanced through character Development and an individual's creative status[17].

The highest score was shown in the fluency indicator, at 81.20%, which is considered good. This reflects students' ability to overcome obstacles such as preparing tools and materials, completing the salting process, and managing time effectively. Simple tools and materials, along with easy-to-understand procedures, help students generate a variety of ideas and solutions, thus supporting their creativity [18]. Conversely, elaboration skills were in the low category, at 58%. Students were still not optimal in combining their peers' ideas to produce aesthetically appealing products. They tended to view product completion as the final responsibility, thus paying less attention to aesthetic elements such as color, images, or decoration. They also lacked initiative in combining different ideas within the group.

Originality was also low, with a score of 55.10%. Students chose readily available immersion media, such as ash, fine bricks, or salt solution, and determined their effectiveness through experimentation. However, the product designs they produced still copied examples from the internet, books, or other media. The ability to generate new ideas was not yet apparent, and the manufacturing process was still strictly adhering to available procedures, with no alternative innovations. The lowest-achieving indicator was flexibility, at 53.40%. This indicates that students are not yet proficient in utilizing additional tools, adding variations to the final product, or producing multifunctional products. Barriers such as lack of confidence, minimal motivation, and limited problem-solving experience are contributing factors [19]. Students tend to follow procedures without trying variations and hesitate to express ideas if a group member is more dominant. However, flexibility is crucial to help students see problems from multiple perspectives (Firdaus et al., 2018). This situation indicates that students' creativity has not developed optimally due to several obstacles, including inadequate learning models and limited learning resources, such as books or teaching aids.

This study also provides an initial overview of the critical thinking skills of prospective science teachers in the fluids course. Data were obtained through a 10-item essay test administered after students studied static fluids. The analysis revealed that the average critical thinking score for students was 38.4 out of 100, placing their skills in the very low category. However, critical thinking skills in studying simple machines scored 17.3 out of 40. The most prominent aspect in the study was the ability to provide simple explanations, which reached 55.55% and was still considered low. This aspect includes three indicators: focusing questions, analyzing arguments, and asking and answering questions. The majority of students (92.31%) demonstrated good ability to focus on the questions, while 66.67% provided correct answers. However, 33.33% still gave incorrect responses when comparing the density of objects to that of fluids. In the argument analysis indicator, only 7.69% of students gave correct answers, while 43.59% gave incorrect answers and 48.72% did not answer. This situation indicates that most students still struggle to analyze arguments, possibly due to difficulties with problem-solving. Strategic and tactical skills were also low (54.70%). Only one indicator fell into this category: determining the proper steps. Only 10.26% of students answered correctly, while 87.18% gave incomplete answers, and 2.6% gave no answers. Nevertheless, most students attempted to respond to this indicator, though many were inaccurate.

Students' ability to develop basic skills was also very low (31.09%). This category encompasses two indicators: the ability to assess the credibility of a source and the ability to conduct observations and evaluate observation reports. Only 2.56% of students answered the first indicator correctly, while 87.18% provided inaccurate answers, and 20.51% did not answer. Although they could provide simple affirmative answers, most were unable to offer more detailed explanations. In the observation indicator, only 20.51% of students demonstrated correct understanding, 23.08% answered incorrectly, and 56.41% provided no answer. This finding indicates that students were not thorough in their observations of the experiments shown in the images.

The ability to provide further explanations was also weak, with a very low score (29.49%). This category includes the ability to define and consider the meaning of a term, as well as to identify assumptions. Only 7.69% of students provided correct answers, while 20.51% answered incorrectly, and 71.80% provided no answer. The lowest score was the ability to draw inferences (conclude), which only reached 19.55%. This aspect consists of two indicators: inducing and evaluating the results of induction, and deducing and evaluating the results of deduction. In a question asking students to propose a hypothesis about the influence of plants on the greenhouse effect based on experimental images, only 15.38% answered correctly, 12.82% answered incorrectly, and 71.80% did not respond. Most students still view physics as solely related to classroom calculations and irrelevant to everyday life. Overall, this situation illustrates that students' critical thinking skills have not been optimally developed. Furthermore, conventional teaching methods and a lack of varied learning activities contribute to this low achievement [20]. Therefore, teachers play an important role in designing learning that can develop critical thinking skills.

CONCLUSSION

The initial profile of students' creativity in fluid learning is considered adequate, with the highest proportion of creativity seen in the aspect of flexible thinking skills (flexibility). Creative thinking skills received a high score on the fluency indicator (81.20%), and the lowest score was on flexibility (53.40%). For critical thinking skills, indicators of giving building (55.55%) and organizing strategies and explanations of inference skills are in the low category (54.70%). This condition is caused by students' difficulties in generating new ideas or generating various alternative solutions when facing a problem. Therefore, the results of this study are expected to inform educators in developing learning strategies that stimulate the creativity of prospective science teachers, for example, through learning modules that train 21st-century skills, discovery-based approaches, or the use of media that encourage students to be more daring in their creations.

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