Creative thinking skill for pre-service physics teacher: An investigation in the topics of radioactivity

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Abstract. Creative thinking skills are one of the 21st century skills that are important to support the long-term success of individuals, companies, industries, and countries, so they need to be provided to students. This study aims to examine the creative thinking skills of pre-service physics teacher students in radioactivity case. Quantitative descriptive method is used in this research. The subjects of this study were 22 final year pre-service physics teacher students at one of in Institute of Teachers Training Banjarmasin, South Kalimantan. The instrument used in this research is a creative thinking skill test in the form of an essay based on indicators objective finding, fact finding, problem finding, idea finding, solution finding, and acceptance finding. The results showed that the students' creative thinking skills were categorized as not creative. An improvement effort is needed in the lecture activities to improve students' creative thinking skills.

1. Introduction
In addition to critical thinking skills, creative thinking skills are one of the 21st century skills that are also important to provide with students [1], [2]. Creative thinking is generative or productive. Creative thinking is essential to the long-term success of individuals, companies, industries, and countries [3], [4]. Creative thinking or convergent thinking is one of the important things when scientists, engineers, or students are involved in building explanations or developing solutions [5].

Creative thinking can be developed through well-designed programs [5]. Developing creative thinking processes in learning can be done through creative problem solving, problem solving in the context of the Science Technology Society (STS), creative writing, creative science investigations and mystery solving [6]. Students' creative thinking skills and scientific attitudes can be improved through laboratory Project Based Learning (PBL) laboratory learning [7]. The science creative thinking skills can also be improved through inquiry-based science learning [5].
Several studies in Indonesia showed that creative thinking skills were not well developed in learning physics. The results of research showed that from the results of kinematics material written tests, the ability of students to describe the answers creatively in detail and accurately was below the standard [8]. Research conducted by [9] showed that based on the results of the creative thinking skills test conducted to 60.7% of students at one of the high schools in Bandar Lampung, the students were categorized as less creative. There were many obstacles encountered in improving creative thinking skills in physics learning; The obstacles were the lack of activities carried out by students in the physics learning process because the learning was still conventional [8] and students were not trained to solve various problems so that their creative thinking skills did not develop [9].

One branch of physics that is difficult for students to understand is nuclear physics. Radioactivity is one of the topics in nuclear physics which is very useful in various fields of human life. For example, natural and artificial radioactivity applications can be used in the fields of medicine, agriculture, energy, industry and so on [10]. Radioactivity material is an abstract material for practicum activities which require sophisticated equipment but is expensive and difficult to maintain [11], [12]. There were also concerns that teachers and students might be exposed to radiation when doing practicum [13].

Based on the above problems, it is necessary to do research examining students' creative thinking skills in the field of physics, especially in the field of nuclear physics. The purpose of this study was to examine the thinking skills of students in radioactivity case. Through this research, it was expected that a description of the creative thinking skills of pre-service physics teacher students would be obtained. This research was done to obtain improvements in the learning process so that pre-service physics teacher students could contribute as active citizens in providing solutions in the state and global problems.

2. Method
This research used descriptive quantitative method. This research was conducted in one of the Institutes of Teacher Training in Banjarmasin, South Kalimantan. The participants of this study were 22 final year students who had taken the introductory nuclear physics course, consisting of 16 females and 6 males. The instrument used was a test of creative thinking skills with essay type questions. The test used indicators of creative thinking skills in solving problems according to Osborne-Parnes [14]; objective finding, fact finding, problem finding, idea finding, solution finding, and acceptance finding. The validity of the instruments used was categorized as valid and the reliability of the instruments was high. Data analysis used quantitative descriptive. The results of the value of creative thinking skills were interpreted in the form of categories according to [15].

3. Result and Discussion
The problem presented to explore creative thinking skills in this study was a description of a challenging situation regarding abundant harvest yields that quickly rot. Through the knowledge about radioactivity that has been obtained by students, it was expected that students could solve problems according to the indicators of creative thinking skills in solving problems. The results of analysis of student answers based on the six indicators of creative thinking skills tested are shown in table 1. Creative thinking skills in solving problems of pre-service physics teacher students are categorized as not creative.

| Concept        | Value |
|----------------|-------|
| Objective finding | 30.45 |
| Fact finding    | 13.65 |
| Problem finding | 8.85  |
| Idea finding    | 25.90 |
| Solution finding| 11.60 |
| Acceptance finding | 6.60 |

Creative thinking skills of pre-service physics teacher students on the objective finding indicator are shown in table 2. The objective finding indicator stage was preceded by expressing thoughts and feelings
about the problem that was disturbing but still vague, so that students began to find the purpose of the problem. In expressing this vague problem, it could be started by answering the question, what was the real problem or what exactly was one trying to find here. In this section, students were asked to identify the challenges faced by farmers in overcoming abundant and perishable crops and to explain the reason why. The results showed that only 72.73% of students were categorized as less creative and 27.27% were categorized as not creative. Students were unable to express the challenges faced by farmers and determine the priority challenges.

| Table 2. Objective finding skill profile |
|----------------------------------------|
| Category                | Percentage  |
| Very creative           | 0.00        |
| Creative                | 0.00        |
| Quite creative          | 0.00        |
| Less creative           | 72.73       |
| Not creative            | 27.27       |

Creative thinking skills on the fact-finding indicator of pre-service physics teacher students are shown in Table 3. The fact-finding stage was the stage of registering all known facts about the problem to be solved and finding new data needed. This stage was preceded by a state of chaos and the problem was still vague. Students were asked to register all facts on reading material and determine priority facts. The results showed that 22.73% of students were categorized as less creative and 77.27% were categorized as not creative. Students were unable to find influential information from challenging situations and prioritize the influential information.

| Table 3. Fact finding skill profile |
|-------------------------------------|
| Category               | Percentage |
| Very creative          | 0.00        |
| Creative               | 0.00        |
| Quite creative         | 0.00        |
| Less creative          | 22.73       |
| Not creative           | 77.27       |

Creative thinking skills on the problem finding indicator of pre-service physics teacher students are shown in Table 4. The problem finding indicator stage was the stage where students were expected to develop their problems by finding sub-problems which could be reformulated or narrowed down. Students were asked to find problems and focus on the main problem of reading material. The results showed 9.09% of students were categorized as less creative and 90.91% were categorized as not creative. Students had difficulty finding problems and focusing on problems.

| Table 4. Problem Finding Skill Profile |
|----------------------------------------|
| Category               | Percentage |
| Very creative          | 0.00        |
| Creative               | 0.00        |
| Quite creative         | 0.00        |
| Less creative          | 9.09        |
| Not creative           | 90.91       |

Creative thinking skills on the idea finding indicator of pre-service physics teacher students are shown in Table 5. The idea finding indicator stage was the stage of finding ideas and developing as many problem-solving ideas as possible. At this stage, brainstorming techniques and checklists could be used to help find ideas by giving freedom to the imagination and deferring criticism, the most important thing at this stage was finding lots of ideas. Students were asked to find as many ideas as possible to solve crop yield problems faced by farmers through knowledge of the use of radioactivity. The results showed
that 59.09% of students were categorized as less creative and 40.91% were categorized as not creative. Students were not able to find as many ideas as possible and determine the main idea.

Table 5. Idea finding skill profile

| Category      | Percentage |
|---------------|------------|
| Very creative | 0.00       |
| Creative      | 0.00       |
| Quite creative| 0.00       |
| Less creative | 59.09      |
| Not creative  | 40.91      |

Creative thinking skills on the solution finding indicator of pre-service physics teacher students are shown in table 6. Solution finding indicator was the stage where the previous idea was selected based on the evaluation criteria related to the problem. The idea that was considered important was the one which was the closest to the criteria. The results showed that 13.64% of students were categorized as less creative and 86.36% were categorized as not creative. Students were unable to reinforce ideas and formulate ultimate solutions to help farmers cope with bountiful and rotting harvests through radiation technology.

Table 6. Solution finding skill profile

| Category      | Percentage |
|---------------|------------|
| Very creative | 0.00       |
| Creative      | 0.00       |
| Quite creative| 0.00       |
| Less creative | 13.64      |
| Not creative  | 86.36      |

Creative thinking skills on the acceptance finding indicator for pre-service physics teacher students are shown in table 7. The acceptance finding indicator stage is the last stage of finding acceptance or the implementation stage, an action plan is drawn up so that other people can accept the idea and implement it. The results showed that 100% of students were not creative. Students were not able to identify the strengths and weaknesses of the solutions offered in using radiation technology so that other people could accept the ideas offered.

Table 7. Acceptance finding skill profile

| Category      | Percentage |
|---------------|------------|
| Very creative | 0.00       |
| Creative      | 0.00       |
| Quite creative| 0.00       |
| Less creative | 0.00       |
| Not creative  | 100.00     |

Based on the research results, students were categorized as not creative on objective finding, fact finding and problem finding indicators. Based on the stages in the thinking process, namely the stages of forming understanding, forming opinions, and forming conclusions [16], [17] students had not been able to form a good understanding. Forming a good understanding could be done by preparing the preparatory stage, formulating important information about the challenge description, and rereading the challenge description. The purpose of rereading is to determine the author's intent by using the information provided in the text and assisted by the knowledge and experience of previous students [18],[19].

Based on the research results, students were also categorized as not creative on the indicator of idea finding, solution finding, and acceptance finding. Most students had difficulty in providing different ideas to complete the right solution. A good problem solver is someone who can provide a variety of problem-solving strategies [20]. In forming creative thinking involves forming previous and new
knowledge, expanding current knowledge with the help of new knowledge, and building unusual relationships to produce authentic solutions with the help of imagination [21].

A well-designed program is needed to develop creativity, for example through creative problem solving, problem solving in the context of the Science Technology Society (STS), creative writing, creative science investigations and mystery solving [6], inquiry-based science learning [5] and Higher Order Thinking Virtual Lab (HOTVL) learning [22]. Based on the results of research on students' creative thinking skills, raised problems were students were not creative, the abstract and complex characteristics of nuclear physics material, expensive real practicum equipment and difficult purchasing permits, thus it was necessary to improve lectures. Improvement can be made through virtual experiment-based inquiry activities. It is hoped that these improvements can improve students' thinking skills as their provisions in facing the 21st century and take an active role in problem solving.

4. Conclusion

Based on the results of the study, it can be concluded that the creative thinking skills of pre-service physics teacher students in the case of radioactivity from six indicators, namely objective finding, fact finding, problem finding, idea finding, solution finding, and acceptance finding are categorized not well developed. Therefore, it is necessary to develop lectures that can improve creative thinking skills. One of them is through virtual experimental based inquiry activities.

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