Empowering critical thinking skills with problem solving in higher education

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Abstract. Critical thinking skills are a necessary aspect of 21st century skills. Based on Facione, critical thinking skills include aspects of interpretation, analysis, evaluation, inference, explanation, and self regulation. The purpose of this study is to know the critical thinking skills of students with problem solving model in the scientific method course. The classroom-based action research was held in one of the science education programs in Central Java. Data sources are collected through portfolios, discussions and presentations and field observation records in the classroom. Student's critical thinking skills were observed and analyzed. the result of the research shows with problem solving model of students' critical thinking skill in interpreting, analyzing, concluding in very good category, and evaluating, explaining, and self-regulating in good category.

1. Introduction

Critical thinking skills are a necessary aspect of 21st century skills. Based on Facione, critical thinking skills include aspects of interpretation, analysis, evaluation, inference, explanation, and self regulation [1]. Components in 21st century learning include: a) Way of thinking: Creativity, critical thinking, problem solving, decision making, learning and innovation, b) How it works: Communication and collaboration, c) Tools for work: Information and communication technology (ICT) and literacy information, d) Life in the world: Citizenship, life and career, and personal and social responsibility [2].

To improve students' critical thinking skills can use problem solving model. Problem solving includes five stages, namely, orienting students to the problem, organizing them to study, guiding individual and group investigations, developing and presenting the work, analyzing and evaluating the problem solving process. The IDEAL problem solving system in independent learning involves five stages: 1) In problem identification, students have to identify the problems before solving them. In this stage, the students ask themselves whether or not they have understood the problems and state them clearly. 2) In definition of terms, the students check whether or not they clearly know every single word in the problem statement. 3) In exploration of strategies, the students collect relevant information to develop a strategy for solving the problems. Drawing diagram is the optimal choice for this stage. 4) In implementing the strategy, the students choose and use one of the strategies formulated. 5) In the final stage, that is determination of effects of the selected strategy, the students evaluate and analyses their collected data and processes they used [3].

Previous research reported that the implementation of problem solving learning method can improve students’ learning achievement [4]. Fatoke, Ogunlade, Ibidiran (2013) indicated that problem solving learning is more effective than conventional methods. Problem solving can also improve students' achievement in learning chemistry [5]. Festus and Ekpete (2012) concluded that problem solving
learning method encourages the students to be active and improve their thinking skills in learning chemistry [6]. Furthermore, problem solving can be used to change the activity and behavior of students in their chemistry lesson. Fisher (2001) defines critical thinking skills, according to Ennis, as reflective thinking that focuses on determining what should be believed or done [7]. According to Paul cited by Fisher (2001), critical thinking skill is a way of thinking about any subjects, contents or problems, this skill allows the thinker to improve their thinking quality and capability to determine other options beyond their intellectual. Learning builds effective critical thinking skills depending on the class atmosphere and enhances the acceptance of different viewpoints and free discussion.

Ali, Hukamdad, Akhter and Khan (2010) stated the significant difference between students’ learning achievement and the use of common learning model and problem solving model [4]. Yin and Abdulah (2011) emphasized that problem solving method can improve critical thinking skills by using control class that conducted the learning process without a problem solving model [8]. Tablab, Kazemi, Khaksaryazdi, Veyseh (2015) reported that problem solving learning in a group can improve opinion delivery, observation and conclusion drawing [9]. Therefore, the present research implemented a problem solving model in group during problem solving. While solving the problems in the group, the students can share knowledge and opinion with their peers to enhance their self confidence. Implementing the problem solving model is expected to improve students’ critical thinking skills.

Supriyanti, Hernani, Mulyanti (2015) applied problem solving learning model to genetic information flow material showed that (1) IDEAL problem solving model on genetic information flow material can be implemented well in every stage; (2) have a significant influence on the mastery of student concept; (3) have an effect on students’ problem-solving abilities [10]. Wahyuni, Indrawati, Sudarti, Suana (2017) suggests that the application of outdoor learning can be done as an alternative to teacher learning, making it quite effective in developing problem solving skills [11].

2. Methods
The course of scientific method is taken by students of science education semester two. The classroom based action research is held in one of the science education programs in Central Java. Students design experiments with scientific method. Students who took scientific methods were 21 people. By searching for sources of knowledge from previously published articles and from books in the library. Students make experimental design with scientific method. The steps in the scientific method are: Make an observation, ask a question, Form a hypothesis, or testable explanation, Make a prediction based on the hypothesis, Test the prediction and use the results to make new hypotheses or predictions. Each student in the group designed the experiment with a different title. There is a group of students designing an experiment with the title of reducing the surface tension with soap, knowing the growth rate of mushrooms in fresh bread, the influence of the mass of the body against the increase of spring length and spring constant, the application of the law of Archimedes (floating, floating, and drowning), the borax test on food, the effect of temperature on the speed of diffusion of sugar solution, the process of lime decomposition (CaSO\textsubscript{4}) in solution, measuring the pH of the solution, the effect of the field color on solar radiation, the influence of the temperature difference on the rate of diffusion of a substance. After the experiment, the students write laboratory work report individually. By experimenting with scientific methods, students can develop critical thinking skills. Assessment rubric adopted from WSU Rubric of critical thinking skills.
3. Result and Discussion
The result of the students' critical thinking skill score in the course of scientific method can be seen in Figure 1.

![Figure 1. The students’ critical thinking skills score in the course of scientific method.](image)

Table 1. WSU Rubric of critical thinking skills

| No | Component | Score | 1 | 2 | 3 | 4 |
|----|-----------|-------|---|---|---|---|
| 1  | Demonstrating higher level thinking by interpreting the meaning of the author (interpretation) | Not to explain, provide inaccurate information, not to infer meaning | Not to explain, provide inaccurate information, give a little meaning inferred. | Accurately identify the meaning and give a brief explanation. | Accurately identify the author's meaning and / or potential bias and provide a well-developed one explanation. | |
| 2  | Analysis | 1 indicator appears | 2 indicator appears | 3 indicator appears | | |
| 3  | Identify and evaluate Inference, implications, and consequences | Not identifying or evaluating any conclusions, implications or consequences. | Not explaining, providing inaccurate information, or simply providing a list of ideas; or just discuss one area | Accurately identify conclusions, implications, and consequences with short evaluative summaries. | Accurately identify conclusions, implications, and consequences with well-developed explanations. It provides an objective reflection of its own statement. | |
| No | Component rubric                      | Score                                           |
|----|-------------------------------------|------------------------------------------------|
| 4  | evaluation                          | 1 Indicator appear                              |
|    |                                     | 2 Indicator appear                              |
|    |                                     | 3 Indicator appear                              |
|    |                                     | 4                                                 |
|    | 1. Inform the result of experiment  |                                                 |
|    | 2. Shows the success rate of the    |                                                 |
|    | experiment                          |                                                 |
|    | 3. Shows obstacles during the       |                                                 |
|    | experiment                          |                                                 |
|    | 4. Noting all experimental          |                                                 |
|    | observations and analyzing          |                                                 |
|    | experimental results                |                                                 |
| 5  | Identify and consider the effect    | Not identifying or consider any contextual      |
|    | of contextual problems              | issues.                                        |
|    | (explanation)                       | Not explained contextual problems; provide      |
|    |                                     | inaccurate information; or just provide a list   |
|    |                                     |                                                 |
|    | 6. Self regulation                  | 1 Indicator appear                              |
|    |                                     | 2 Indicator appear                              |
|    |                                     | 3 Indicator appear                              |
|    |                                     | 4                                                 |
|    | 1. Accurately identify and provide  |                                                 |
|    | potential contextual problems with  |                                                 |
|    | a clear understanding of the scope. |                                                 |
|    |                                     | 2. Accurately identify and provide a well       |
|    |                                     | developed explanation of contextual problems    |
|    |                                     | providing an explanation about potential         |
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|    |                                     | 3. Accurately identify and provide an           |
|    |                                     | explanation of contextual problems.             |
|    |                                     | 4. Accurately identify and provide an explanation|
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|    | By writing laboratory work report, students gather evidence that accumulates that participating in research experience enhances undergraduate science skills related to critical thinking, problem solving, and applying knowledge [12]. Informal assessments during the previous semester that run inquiry-based classes reveal that some students without previous active learning experiences can struggle with a lack of textbooks, the idea that processes can be more important than content, and what they consider to be a lack of items to memorize. When presented with new material, the brain learns to search for patterns while processing information. Because the rubric provides structure and patterns for this process, it not only helps students with organizational strategies, but also reflects the way the brain truly learns [13]. For this purpose, structure and support during learning promote cognitive processes of selecting, managing, and integrating knowledge [14]. Through laboratory work, critical thinking skills can be developed, including metacognitive understanding [15]. The results of this research with problem solving model, students design experiments, experiment in the laboratory and write laboratory work reports, can empower students' critical thinking skills. From the assessment results with the rubric of the preparation of the experimental report in Figure 1, it is known that students' critical thinking skills in the aspects of interpreting, analyzing, concluding are very good. Students can design natural science experiments, can interpret experiments, use known knowledge to give good experimental meaning. Students can analyze the results of the experiment, examine the results of the experiment and conformity with the theory, relevance, completeness, can explain the causes and consequences of the results of the experiments obtained and conclude the results of the experiment well. The students' critical thinking skills on the evaluating, explaining, and self-regulating aspects are good. Students still have difficulty connecting facts, experimental results with theories and concepts. Students lack confidence in evaluating the results of the experiment. 4. Conclusion The results of this research with problem solving model, students design experiments, experiment in the laboratory and write laboratory work reports, can empower students' critical thinking skills. Critical
thinking skills of students on aspects interpreting, analyzing, concluding in very good category, and evaluating, explaining, and self regulating in good category.

5. References

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