Stoichiometry using guided inquiry model for enhancing creative thinking skills

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Abstract. This study aims to enhance creative thinking skills of students using guided inquiry model through Stoichiometry. This study used quasi-experimental methods, with pretest-posttest non equivalent control group design. Subjects of this study were biology students enrolled in basic chemistry, consist of 35 students in experimental class and 35 students in control class. Instrument in this study were essay test that involves 3 indicators of creative thinking skills (i.e. fluency, flexibility, and elaboration) and also student worksheets. The results showed that Stoichiometry using guided inquiry model have been enhance for creative thinking skills in medium category with a value of $g < 0.48$.

1. Introduction
An inquiry is a process of finding knowledge through a systematic thought process based on search and discovery. Inquiry can occur in the learning process in lectures and also experiments conducted by students [1]. In the learning process in lectures, inquiry aims to develop the ability to think systematically [2], logically, and critically or develop intellectual abilities that are part of mental processes [3]. Inquiry learning involves maximally all the abilities of students to search for and investigate something (objects, people, or events) systematically, critically, logically analytically so that they can formulate their own findings with confidence. The process of inquiry learning provides the opportunity for students to have a real and active learning experience so that students are trained in solving problems while making decisions.

Guided inquiry learning is a learning model in which educators provide broad guidance to students. These instructions can be in the form of questions so that students are able to find or find their own information about the question or action to be taken to solve the problem. The process can be done independently and in groups.

Guided inquiry creates an environment that motivates students to learn by providing opportunities for them to construct their own meaning and develop deep understanding. Based on the results of research using guided inquiry models can improve student learning processes, improve thinking skills, teamwork, leadership, and offer more benefits compared to other models.

Stages of guided inquiry are observation, manipulation, generalizations, and applications [4]. The guided inquiry stage, creating an environment that motivates students to learn actively by providing opportunities for them to construct meaning and discover concepts, thereby building a higher-order framework [5]. The higher-order thinking framework that can be developed is creative thinking skills.
Creative thinking skills are processes or abilities that reflect fluency, flexibility, and originality in thinking, as well as the ability to elaborate an idea (develop, enrich, and detail) [6]. With creative thinking skills, students will have their way to solve a problem independently. Creative thinking skills help students go beyond recalling information, exploring and understanding the world to think and solve problems independently [7].

The creative potential of students can be recognized through the characteristics: 1) considerable curiosity, 2) being open to new experiences, 3) length of sense, 4) curiosity to find and research, 5) tend to look for broad answers and satisfying, 6) having a dedication to carrying out the task, 7) thinking flexibly, 8) responding the question and tending to give more answers, 9) the ability to make analysis and synthesis, 10) having the spirit of asking and researching, 11) has good abstraction, 12) has an extensive background [8]. With a variety of characteristics that can be observed in students, the ability to think creatively which is a creative potential can be developed.

There are several ways that are done in developing creative thinking skills, namely through the process of science, science content, and science scenarios. But based on the results of research teaching creative thinking through science scenarios will make students complain and it is not useful, learning creative thinking through science processes will fail in combining science content in parallel, where learning creativity in applying science content will be very difficult for students, where they have limits in concepts and creative thinking abilities. Creative thinking is divergent and open in nature. The most influential understanding of divergent thinking includes the part of Guilford’s known as the Structure of the Intellect (SOI) model, namely: fluency, flexibility, originality, and elaboration [9].

This is in accordance with the opinions of some experts who state that creative thinking skills require standards and indicators as a reference for assessment. Standards and indicators for assessing creative thinking skills include 1) fluency (assessment of skills for generating ideas); 2) flexibility (assessment of skills to express various solutions or approaches to problems); 3) originality (assessment of the skills to come up with ideas in original ways); and 4) elaboration (assessment of skills to describe in detail) [10].

The part of Chemistry that can develop students' creative thinking skills is stoichiometry. Stoichiometry is a branch of chemistry that studies the quantitative relationship of the composition of chemicals and their reactions. Stoichiometry studies the basic laws of chemistry, the concept of moles and reaction chemistry equations. Based on the results of students' grades in basic chemistry courses for biology education study programs, stoichiometry material is material that is difficult for students to understand. This is because the material requires higher thinking to solve problems in applying concepts in calculations.

The purpose of this study is to find a guided inquiry model in stoichiometry that can improve students' creative thinking skills and find out the extent to which students' creative thinking skills increase using a guided inquiry learning model in stoichiometry.

2. Methods
This study used quasi-experimental methods, with pretest-posttest nonequivalent control group design. Subjects of this study were biology students enrolled in basic chemistry course, consisted of 35 students in the experimental class and 35 students in control class. Instrument in this study were essay test and also student worksheets. The essay test was used to measure the creative thinking skills of students in stoichiometry. The research procedure is describe in Figure 1.
3. Results and discussion

The experimental class and the control class discuss stoichiometry. In the experimental class using the guided inquiry model, while the control class is studied using another model. In guided inquiry students are helped using discussion sheets. The discussion sheet developed is used to see how students' creative thinking skills developed.

Based on the results of the normality test, it was found that the experimental class and the control class were normally distributed at the time of the pretest and posttest. The value of significance showed $\geq 0.05$. Result Tests normality of experimental and control class can be seen in Table 1.

Table 1. Tests normality of experimental and control class.

|                    | Tests of Normality |
|--------------------|--------------------|
|                    | Pretest | Posttest |
| Experimental class | 0.430    | 0.073    |
| Control class      | 0.165    | 0.069    |

On the discussion sheet, students solve existing problems by answering difficult questions. The questions presented have been designed to be able to measure higher-order thinking skills. The discussion sheet covers the concept of moles, the equalization of chemical reactions, and the application of the concept of moles in the calculation of chemical problems.

For each section of stoichiometry, students explain the results of the discussion in front of the class, then other friends will respond to how they are explained. In this process, students are interested and participate a lot so learning becomes more effective.

The assessment of creative thinking skills carried out was adapted from Munandar [6] whose indicators were fluency, flexibility, and elaboration. Students' creative thinking skills on each indicator were analyzed in both classes based on the acquisition of pretest, posttest, and % N-gain scores between
the experimental class and the control class that can be seen in Table 2. N-gain value shows an increase in students’ creative thinking skills.

![Table 2. Analysis of students creative thinking skills in stoichiometry.](image)

Based on analysis of research results, it can be stated generally that two classes of study have been increased in creative thinking skills. The creative thinking skills improvement that occurred in the experimental class was higher than in the control class, this is evidenced by the value of $<g>$ respectively for 0.48 and 0.24.

Increased of creative thinking skills are influenced by several things, with a guided inquiry, students are guided to find answers and develop concepts so they can understand them clearly. The learning model used has a good impact on students. In guided inquiry, students develop concepts using discussion sheets to improve students' creative thinking skills. The discussion sheet is answered by students and contains questions whose level has been adjusted.

Creative thinking skills on the indicators of fluency seen from the answers to the discussion sheet, students can determine which theories are used to solve problems so they can answer the questions on the discussion sheet appropriately. Flexibility is expressing various ideas with a variety, interpreting a picture from different points of view so as to produce away or approach with different directions of thought. In this study, the flexibility of students can be seen from the many alternative solutions that can be done to find answers to the questions on the discussion sheet. While elaboration is the ability to develop, detail details, add, enrich, and expand an idea. In this study, students are skilled in analyzing the application of the use of stoichiometry theory in daily life, as well as the answers explained by students have been clearly.

The application of guided inquiry model on experiments of enzyme kinetics based on local materials improved generic science skills overall students in high category. With four indicators of generic science skills classified as high category that direct observation, causality, symbolic language, and mathematical modeling. While one indicator in generic science skills concepts formation in medium category.

4. Conclusion
The results showed that stoichiometry using guided inquiry models had improved creative thinking skills in the medium category with an average value of $<g>$ 0.48 in the experimental class and a low category with an average $<g>$ value of 0.24 in the control class. Indicators of creative thinking skills that are examined are fluency, flexibility, and elaboration.

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