Improving students' creative thinking skills through guided inquiry practicums learning with STEM approach

S Adhiriyanti*, H Solihin*, and M Arifin
Departemen Pendidikan Kimia, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudhi No. 229, Bandung 40154, Indonesia

*ririn.ariyanthi@yahoo.com, Hsholihin@upi.edu

Abstract. The main purpose of this study was to improve students' creative thinking skills through guided inquiry practicum learning with STEM approach. The method used in this study was a quasi-experimental with one group pre-test and post-test design. The sample of this study was 30 students from one of public senior high schools in the West Bandung Regency area. The instrument of this study was an essay for creative thinking skills. The test consisted of 11 questions with indicators of creative thinking skills according to Guilford, namely fluency, flexibility, originality and elaboration. The data were analysed by using n-gain scores and Wilcoxon Signed Rank Test. The result of this study showed that there was a significant difference between the pretest and posttest scores with p-value of 0.000 and the improvement of creative thinking skills on each indicator with n-gain scores was 0.73 for fluency (high), 0.34 for flexibility (medium), 0.03 for originality (low) and 0.19 for elaboration (low). All four indicators have improved even though the improved of originality and elaboration at a low criteria. This study suggested that the implementation of guided inquiry practicum learning with STEM approach could be used as an alternative for improving students' creative thinking skills.

1. Introduction
The 21st century skills have become a widely discussed topic in recent decades, especially in the field of education. Indonesia, one of the developing countries in the world, keeps trying to improve their education system in order to meet the demands of the 21st century, one of which is by implementing the 2013 Curriculum to create a generation who are ready to face the challenges and the needs of human resources in the future. This is set out in Minister of Education and Cultures Regulations number 20 of 2016 about the graduate competency standards of primary and secondary education which states that one of the thinking skills that student must have is creative thinking skills [1]. Creative thinking skills become one of the most important and necessary skills for the 21st century education as mentioned in Indonesian Partnership for 21 Century Skill Standard (IP-21CSS) [2]. Long before that, Evans (1985) had mentioned that creative thinking skills were very important for the success and contribution of science in the future [3]. Therefore, creative thinking skills are needed by students in building explanations or developing problem solving [4]. A study conducted by PISA (Program for International Student Assessment) in 2018 found that the thinking skills of Indonesian students were still relatively low, especially in the field of science. Indonesia was at the level 1, ranked 70th out of 78 participating countries on the average score of 396 for the achievement of learning outcomes in science [5]. This PISA’s result should be a reference for the level of student thinking skills in Indonesia as the test questions require high-level thinking skills where every student must be able to answer from what they
know, think across disciplines, apply knowledge in new situations creatively and demonstrate effective learning strategies [6]. The fact of the low thinking skills of Indonesian students, especially for creative thinking skills confirmed by some other researches which found that the results of students’ creative thinking skills were still in the low categories where the average percentage of students’ creative thinking skills obtained was 39.76% and 46.88% respectively [7, 8]. Another research stated that student creative thinking skills of senior high school must be a serious concern since the percentage was low on every indicator of creative thinking skills [9]. In the scope of education, an optimal development of creative thinking skills is closely related to the role of a teacher in the classroom [10]. The problem is not all teachers or not many teachers having an interest in using creative and unique learning models to enhance student creative thinking skills [11]. Besides, teachers should facilitate learning that is able to develop creative thinking skills for their students. One of learning models that can be used as an alternative for developing student creative thinking skills is the inquiry learning.

Inquiry learning has proven effective for the science learning in a laboratory (experiments), especially for the creativity [12] and the improvement of student creative thinking skills [13,14]. Yang et al. (2016) stated that inquiry-based practicum model let the students be involved in an authentic science investigation, state hypothesis, design procedures for the experiment, and identify the data and evidence than focus on the knowledge and concept learning only [15]. But, there is a research stated that inquiry learning done without any guidance will make the students difficult to design a procedure [16]. This is because not all students were familiar to inquiry. Guided inquiry-based learning can be an alternative for this situation since in guided inquiry-based learning the teacher acts as the facilitator who gives the problem and gives questions to students where the answer is guidance for the next process [17]. Other research on guided inquiry learning suggested positive results of the learning processes, of which are able to improve concept understandings and student creativities [18, 19]. In order to get more optimal goals, guided inquiry learning can be integrated with some other innovative approaches, one of which is STEM approach [20].

STEM education refers to the teaching learning process in the fields of Science, Technology, Engineering, and Mathematics. The integration of STEM subjects offers the students one of the best opportunities to learn in a real-world situation, instead of studying the subjects separately and then having to assimilate them on the other day [21]. STEM-based education links four disciplines to develop the student abilities with the strong emphasis on critical and creative thinking skills [22]. Learning processes with STEM approach aim to make students have hard skills balancing with soft skills as the learning processes involve an active learning method containing communication, collaboration, problem solving, and creativities, support the students to learn nature by exploration, inquiry and problem solving with their own experiences [23], help the students to apply their knowledge, create a connection across disciplines, improve their understanding and knowledge fully [24, 25] and develop their high order thinking skills [26].

According to the description above, it can be understood that guided inquiry-based learning and STEM approach, both, have possibilities to be an alternative of innovative learning option to improve students’ creative thinking skills. Therefore, this study aims to improve students’ creative thinking skills through guided inquiry learning using STEM approach.

2. Methods
Method used in this study was a quasi-experimental method with one-group pre-test-post-test design [27], the sampling taken was not done randomly but taking one of the available classes. Subject in this research consisted of 30 students from one of public senior high schools in the West Bandung Regency area. The instrument used for measuring students’ creative thinking skills was an essay test consisting of eleven questions. The students were involved in two tests, one for pre-test and the other for post-test with the same questions which included indicators of creative thinking skills proposed by Guilford, namely fluency, flexibility, originality, and elaboration [28]. The instrument of creative thinking skills was validated by five validators consisting of 3 chemistry lecturers and 2 chemistry
teachers. The pre-test and post-test was analyzed by using normalized gain ($g$), Shapiro-Wilk test and non-parametric test using Wilcoxon test with IBM Statistics SPSS 24.

3. Result and Discussion

3.1 Guided Inquiry Practicum Learning Using STEM Approach

The main strategy used in this research was implementing steps of guided inquiry with subjects of STEM approach where each of those steps contains at least one of indicators of creative thinking skills being developed.

The battery is a one of technology that is a science application and is often used in our daily life. The practicum carried out in learning activities is to make reused batteries waste by substitute electrolyte component in batteries using banana peel waste. The selection of the practicum because the researcher aimed to initiate students to be motivated to solve the problem of used battery waste in the environment by utilizing banana peel waste as a substitute for electrolytes in the battery. This practicum can initiate students to integrate the four disciplines that are part of STEM, namely Science, Technology, Engineering and Mathematics. This is in accordance with the objectives of the STEM approach which emphasizes the habit of students to use their knowledge and skills about science, technology, engineering and mathematics to find solutions of problems that exist in their real world and produce products to facilitate these solutions [29, 30].

On the Step 1, presenting questions or problems, students were given a phenomenon about the danger of battery waste. Next, the students were required to write down some formulations for the problem according to this phenomenon by means of their knowledge (Science). One indicator of creative thinking skills developed in this step was the indicator of fluency in where the students had a chance to state their ideas in the form of problem formulations as a result of inquiring the phenomenon.

On the Step 2, formulating hypothesis, students were involved in a discussion for formulating any hypothesis by means of their knowledge (Science) and other disciplines by taking advantage of internet (Technology) for collecting information they needed to answer the problem formulations they made. Next, of hypotheses students made, the teacher guided the students to pick one of hypothesis to be the main hypothesis which was relevant to the practicum. Indicators of creative thinking skills developed in this step were the indicators of fluency and flexibility.

On the Step 3, designing experiment, students designed their own steps in conducting their experiment as making bio-battery from banana peel (Engineering). The teacher asked some purposive questions to guide the students into the steps in conducting their next experiments. In this step, the students were trained to develop their skills of originality to create unique ideas in the choosing of tools and materials as well as in defining their sequence of working steps for conducting the experiment.

On the Step 4, conducting an experiment for collecting information, indicators of creative thinking skills developed in this step were fluency and flexibility where the students were trained to think fluently and smoothly by any possibility in conducting the experiment. In that situation, the students integrated their knowledge about science as designing bio-battery from banana peel (Engineering) and while measuring potential difference with a multi-meter instrument (Technology).

On the Step 5, collecting and analysing the data, students integrated their knowledge about science with analysis skills (Mathematics) to process their experimental data about the scores from potential differences of bio-battery that they made from some variables (kinds of banana peel, kinds of and amounts of salt they added) for answering questions from the teacher. In this step, creative thinking skills developed was flexibility (students discussed with their group to choose one possible answer) and elaboration (students were asked for giving more detail explanations in answering).

On the last step, step 6, making conclusion, students discussed with their group to make a conclusion according to the experiment that they conducted (Science). Creative thinking skills developed in this step was flexibility in which the students were required to make a conclusion from a variety of analysis
data and elaboration in which students were required to give clear and detail explanations related to the conclusion they made.

3.2 Students' Creative Thinking Skills

Students' creative thinking skill was measured twice, before and after student learning through guided inquiry practicum learning with STEM approach. The initial data analysis was carried out by conducting a normality test on the students' pre-test and post-test scores to determine the statistical test that would be used next. Then an analysis of the average score of the pre-test and post-test as a whole to compare whether an increase in the average scores of students from before getting treated with guided inquiry practicum learning with STEM approach and afterwards. The result of data analysis of average scores and normality test can be seen in table 1.

| The average value of pre-test and post-test | Shapiro-Wilk normality test results |
|--------------------------------------------|------------------------------------|
| N  | Average value | N-gain | Sig  | Criteria |
| Pre-test | 30 | 20.93 | 0.28 | 0.326 | Normal |
| Post-test | 30 | 42.71 | - | 0.014 | Not normal |

Based on table 1 shown the average score of the pre-test was 20.93 while the average score of the post-test was 42.71. This results indicated that students’ creative thinking skills were still relatively low, however the average score from the post-test was higher than the pre-test. Although the overall improvement with the n-gain score of 0.28 is in the low category. Furthermore, for the normality test conducted with the Shapiro-Wilk test showed that the pre-test data were normally distributed while the post-test data were not normally distributed. Therefore the next step was non-parametric statistic tests with the Wilcoxon Signed Rank Test to measure the significant difference between the average scores of students' pretest and post-test before and after carrying out guided inquiry practicum learning with the STEM approach. The result of Wilcoxon non-parametric test shown in table 2.

| Ranks | Test Statisticsa |
|-------|------------------|
|       | N   | Mean Rank | Sum of Ranks | Z   | Asymp. Sig. (2-tailed) |
| Post-test | Negative Ranks | 0a | .00 | .00 |
|           | Positive Ranks | 30b | 15.50 | 465.00 | 4.782b | .000 |
| Ties  | 0c |
| Total  | 30 |

Based on the results of the Wilcoxon Signed Rank Test presented in Table 2 shown a p-value of 0.000 which means that there is a significant difference between the pretest and posttest scores. Negative rank value is 0 means that none of the data has decreased from the pretest to posttest scores. Same results have also occurred with the value of ties obtained by the number 0, which means that there is no data where the pretest was the same as the posttest. This is because all data from 30 students increased from pretest to posttest value indicated by a positive rank value of 30 with a mean rank of 15.50 and a sum of rank of 465. In addition, the Wilcoxon Signed Ranks Test results show a Z value of -4.782 at the 5% significance level indicated that the calculated Z value is smaller than the Z value of the table which means H1 accepted. This shown that guided inquiry practicum learning can improve students' creative thinking skills.
Data analysis carried out next was data analysis for student creative thinking skills were taken from the average of pre-test and post-test scores on each indicator of creative thinking skills. The data were calculated for the n-gain scores and the criteria. The result of data analysis of student creative thinking skills overall was shown in the table 3.

Table 3. The result of data analysis of students’ creative thinking skills

| Indicator of creative thinking skills | Average score | Criteria |
|--------------------------------------|---------------|----------|
|                                      | Pre-test      | Post-test | <g>     |
| Fluency                             | 42.78         | 84.44     | 0.73    | High    |
| Flexibility                         | 21.11         | 47.59     | 0.34    | Medium  |
| Originality                         | 4.44          | 7.22      | 0.03    | Low     |
| Elaboration                         | 15.40         | 31.59     | 0.19    | Low     |

Table 3 suggests that the implementation of guided inquiry practicum learning with STEM approach can improve student creative thinking skills on the four indicators, namely fluency, flexibility, originality and elaboration. This can be seen in the n-gain scores that students achieved on the four indicators where the higher enhancement, 0.73, is on the indicator of fluency while the indicator of flexibility is on the medium category with n-gain score 0.34. The two other indicators, originality and elaboration, are on the low category with low n-gain score, 0.03 and 0.19. The high enhancement in the indicator of fluency than in the other indicators tells that the students tend to think fluently when they are given a phenomenon or problem, while for the indicators of originality and elaboration the students have difficulties in developing their skills. Moreover, in the indicator of originality, the students are required to create some unique and novelty ideas or any idea that is different from their classmates ideas as they are asked for designing an experiment or solution from one situation. Meanwhile, student’s answers reviewed in this study showed that the students tended to give some similar answers. As well as the indicator of elaboration, the students have difficulties when they are asked for adding some reasons or expanding their idea with more detail explanation. Most of the students were able to state their idea fluently and flexibly but they were not able to give any reason for the ideas they said. Other study has the similar result of which the lowest scores of four indicators of creative thinking skills are scores on the indicators of originality and elaboration [31]. Therefore, according to those findings, it is fair enough to say that the students should have many chances to improve their skills in creating their unique and fresh ideas as well as skills in giving explanation for their ideas or answers by means of innovative learning one of which is by implementing guided inquiry practicum learning using STEM approach periodically and intensively in order to keep developing their creative thinking skills on the four indicators. Other research showed that scores of student creative thinking skills on the implementation of inquiry-based STEM learning increased in second cycle [32].

4. Conclusion

According to the result of this study, it was found that the average of post-test scores is higher than the average of pre-test scores with p-value of 0.000 which means that there is a significant difference between the pretest and posttest scores. This indicated that guided inquiry practicum learning with STEM approach could be used as an alternative for developing student creative thinking skills on the four indicator; fluency, flexibility, originality and elaboration, even though for the indicators of originality and elaboration the improvement was still on the low category. This result suggested that students must be given more chances to develop their creative thinking skills especially for the indicators of originality and elaboration in their learning activity.

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Acknowledgments
We would like to say thanks to those who help in carrying out this research, especially to the teachers and students who are involved in this research.