Implementation of Small-Scale Chemistry Lab to Improve Student Cognitive Abilities on the Subtopic of Colloid Properties

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ABSTRACT

This study aims to investigate the effect of the Small-Scale Chemistry Lab to improving the cognitive abilities of students who are studying colloid properties. Cognitive abilities studied are arccoding to Bloom's taxonomy. The research conducted was pre-experiment with one group pre-test post-test design. Participants involved in this study were 40 students of class XI high school in Bandung Regency. The instruments used in the study included a written test and questionnaires. The instruments in this study used the content validity test by supervisors who are experienced in small-scale chemistry lab. Beside that, a reliabilty test was also carried out with value 0.79. The increased cognitive abilities calculated based on the difference pre-test and post-test scores using the N-gain formula, the data has been processed are then analyzed descriptively. The results showed that most of the students' cognitive abilities had increased as indicated by the N-gain value 0.63. Based on these findings, it is recommended that small-scale chemistry lab can be applied to the learning process of other chemistry topics that have a characteristic compatibility between the learning material and small-scale chemistry lab for the development of students' cognitive abilities.

Keywords: *Small scale chemistry lab, Cognitive abilty, Colloid, Suistanble environment, Green chemistry*

1. INTRODUCTION

Chemistry is a core science which is often considered difficult because some of its concepts are abstract [1]. Student perspectives on chemistry need to be addressed with a correct concept of knowledge, so that student can provide predictions or explanations about chemistry correctly [2]. Student-cantered teaching approaches has a lot of advantages for teaching of chemistry topics [3], [4] said that meaningful learning is possible in the laboratory because student is given the opportunities to manipulate equipment and materials in an environment suitable for them to construct their knowledge of phenomena and related scientific concept. [5] provide an opinion that practicum has an important role in science education and he suggested that there are a lot of benefits in learning derived from that activity.

In any levels of chemistry learning practicum activities are important because chemistry is an experimental science [6]. According to [7] said that chemistry laboratory activities should gained understanding because that activities help students to define something about chemistry by their experience. Although practicum has a lot of advantages, in fact practicum is still rarely implemented on chemistry learning activities for several reasons.

In general, practicum activities carried out in schools today are practicum using macro-scale. Because the practicum uses materials on a macro scale, the waste that will be produced is in large quantities and it caused environmental pollution. Small-scale chemical lab has the advantage of reducing the use of chemicals substances so the amount of waste produced is reduced [8]. The reduced waste generated from practicum activities according to principles of green chemistry, [9] the application of green chemistry is an approach in chemistry learning that is accordance with the principles of education for suistanble development.

In previous research, small-scale chemistry lab activities contributed to improving students' cognitive abilities. Research on cognitive abilities through small-scale chemistry lab that have been carried out include [10] – [16]. Based on the results of research [11] – [13] suggested that research related to small-scale chemistry lab should be carried out more extensively. This is an opportunity for the author to conduct research on the implementation of small-scale chemistry lab improving students' cognitive abilities on the sub-topic of colloid properties.

The formulation of the problem that will be studied in this research is "How Implementation Small-Scale Chemistry Lab to Improve Students' Cognitive Ability in the Sub-topic of Colloid Properties". These general problems are described into several specific research questions as below:

1. How the enhancement cognitive abilities of high, middle and low group students through the small-scale chemistry lab on the topics of colloid properties?
2. What is the students' response about implementation of small-scale chemistry lab on the topics of colloid properties?

The purpose of this research is to analyze the implementation of small-scale chemistry lab to improve students' cognitive abilities on the topic of colloid properties.

2. RESEARCH METHOD

This study conducted as pre-experiment with one group pre-test post-test design. [17] stated that research design is a plan or strategy in conducting a research. The subjects in this study consisted of one class of XI grade high school students who came from one of the secondary schools in Bandung district, these students were learning about colloid properties. The subject in this study were 40 people. The small-scale chemistry lab was carried out using a lab kit specially designed by supervisors, the chemicals used in small-scale chemistry lab activities were ± 1mL for liquid and 0,001 gram for solids [18].

Instruments are used in this study consisted of multiple choice questions and a questionnaire. The multiple choice instrument consist of 12 closed multiple choice question, these question are related to colloid properties with a focus on the process of purifying sludge water. Mean while,a questionnaire was used to determine student responses to the implementation of small-scale chemistry lab on studying. This instrument has value reliability 0.79 and the content validity has been tested by supervisors who are expert on small-scale chemistry lab.

The increase students' cognitive abilities was obtained from the difference on the post-test and pre-test scores. The N-gain data obtained from the calculation results are then translated according to the improvement criteria proposed by [19] as bellows:

Table 1. N-Gain score classificationn

N-Gain Score	Interpretation
N-Gain > 0.70	High
0.30 < N-Gain > 0.70	Medium
N-Gain < 0.30	Low

Meanwhile, students' responses regarding the implementation of small-scale chemistry lab in learning activities of colloid properties were obtained from a questionnaire. The interpretation of the percentage of learning responses according to Scaeffer [20] is shown in the following table:

Table 2. Interpretation of student responses on questionnaires

Percentage (%)	Interpretation
0-20	Very Low
21-40	Low
41-60	Medium
61-80	Strong
81-100	Very Strong

In the early stages of research, students as subjects were given a pre-test, then after that students carried out learning activities through a small-scale chemistry lab. Practical activities are carried out in groups. In the next stage, after carrying out the practicum, students are given post-test questions with the same questions during the pre-test, besides that students are also given a questionnaire. The collected data is then analyzed descriptively.

3. RESULT AND DISCUSSION

3.1 Cognitive Abilities

The changes of student's cognitive abilities of students were measured using multiple choice questions. The difference in scores obtained by students during the pre-test and post-test after learning through a small-scale chemistry lab was used to describe whether their cognitive abilities changed significantly or not. Based on the N-gain formula used, the improving of students' cognitive abilities can be seen in the table below:

Table 3. N-gain of students on each category

Students Category	N-gain
High	0.62
Medium	0.42
Low	0.26
Total	0.43

Based on the data above, it can be seen that the cognitive abilities of students generalyhave increased with the medium category, which is indicated by an N-gain value 0.43. In addition, the data in the table also shows the changes on cognitive abilities of students for each category class, high class students had greater changes on cognitive abilities than middle and lower class. According to Krathwohl [21] cognitive ability is divided into six levels consisting of remembering (C1), understanding (C2), applying (C3), analyzing (C4), evaluating (C5), and creating (C6). In this study, cognitive aspects were observed included aspects of C1-C3.

A learning will be easier to understand and last longer in the memory of students if it is done through practicum [5], this is according to statement [22]. Meanwhile [6] states that practicum activities are carried out so that students are able to verify the theories they have received and then after that they can reconstruct their understanding of a material.

The effectiveness of chemistry learning activities is influenced by student experience [6] Practicum is one of the activities in learning that facilitates students to gain experience by making their own observations, according to Gagne [23] is a technique to encourage conducive learning activities so that material is easily understood.

The practicum carried out in this research is a small-scale chemistry lab, this practicum aims to reduce waste generated from practicum activities. The difference between a small-scale chemistry lab and a macro, semi-micro, and micro-scale practicum lies in the number of samples used. Macro scale practicum generally uses a solution volume ranging from 10-100mL, semi-micro used volume of solution ranges from 1-5mL [24] Meanwhile, micro-scale practicum according to [17] used ± 1mL for liquid. [25] stated that the waste from conventional practicum activities carried out in schools is generally not treated first because schools do not have a special waste treatment facility so if the practicum is carried out continuously it will damage the environment.[26], [27] stated that if the environment is damaged, education for sustainable development cannot be achieved. Science learning should not only be successful in teaching scientific literacy to students, but also ideally science learning should facilitate students to contribute for protecting their environment in the future, either individually or in groups [28]. Reducing the use of chemical substances through small-scale chemistry lab is an alternative on science learning that supports environmental preservation in the future because it is in accordance with the principles of green chemistry. This is in aligned with the opinion [29] which states that all fields, especially chemistry, must adhere to the principle of green chemistry. This is because chemistry is very closely related to daily life [30].

3.2 Student Responses

Student responses about the implementation of small-scale Practicum were collected through a questionnaire consisting of 15 items, thus devided into three indicators. Based on the calculation obtained theaverage percentages student response is 77.3%. The average of student response on each indicator can be seen in Table below:

Table 4. Student responses on each indicators

Indicators	Score
Small-scale chemistry lab facilitates students to understand matterial easily	78.5
Small-scale chemistry lab facilitates students to improve their cognitive abilities	77.3
Module practicum lead students to do Small-scale chemistry lab	76

Based on above data can observed that all indicators have score more than 70, the first indicator got score 78.5 is indicate that student easier to understand material through small-scale chemistry lab. It is caused small-scale chemistry lab gave the students opportunity to observe phenomenon directly and it helped them to makes understand material easily. Beside that, small-scale chemistry labare improvingstudents' laboratory skill and boosting their confidenceby conducting experiments in smallerquantity of chemicals [11].

The second indicator gets a score 77.3, it can be concluded that the implementation of the small-scale chemistry lab on the subtopic of colloid properties helps students to improve their cognitive abilities. While the third indicator which consists of 6 question items gets a score 76. This third indicator contains student responses regarding the practicum module used whether the module used can guide students in doing practicum properly or not. Based on the results obtained from the student responses, it can be concluded that the module used is quite good, but still needs improvement to make it more perfect.

4. CONCLUSION

The conclusion of this study students' cognitive abilities generally has increased with medium category. High group has greater increased cognitive abilities than medium and low groups. The implementation smal-scale chemistry lab in learning had a good response from students.

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