Implementation of basic chemistry experiment based on metacognition to increase problem-solving and build concept understanding

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Abstract. Implementation of the experiment have the three aspects of the goal: 1) develop basic skills of experimenting; 2) develop problem-solving skills with a scientific approach; 3) improve understanding of the subject matter. On the implementation of the experiment, students have some weaknesses include: observing, identifying problems, managing information, analyzing, and evaluating. This weakness is included in the metacognition indicator. The objective of the research is to implementation of Basic Chemistry Experiment based on metacognition to increase problem-solving skills and build concept understanding for students of Science Education Department. The method of this research is a quasi-experimental method with pretest-posttest control group design. Problem-solving skills are measured through performance assessments using rubrics from problem solving reports, and results presentation. The conceptual mastery is measured through a description test. The result of the research: (1) improve the problem solving skills of the students with very high category; (2) increase the students' concept understanding better than the conventional experiment with the result of N-gain in medium category, and (3) increase student's response positively for learning implementation. The contribution of this research is to extend the implementation of practical learning for some subjects, and to improve the students' competence in science.

1. Introduction
Experiment is an adequate form of teaching to teach skills, understanding, and attitudes [1]. According to Rustaman [1], in detail the experiment can be used to: 1) exercise the required skills; 2) allowing students to apply and integrate their enforcement and learning in practice; 3) to prove something scientifically or to conduct a scientific inquiry; 4) appreciate the knowledge and skills possessed.

Especially for science, according to Woolnough & Allsop there are at least four reasons that science education has raised about the importance of experiment activities. First, the lab drafts motivation to learn science. Second, the lab develops the basic skills of carrying out experiments. Third, the lab becomes a vehicle for learning a scientific approach. Fourth, the experiment supports the understanding of the subject matter.

Woolnough mentions that there are three aspects of the goal in the implementation of the experiment: 1) develop basic skills of experimenting; 2) develop problem-solving skills with a scientific approach; 3) improve understanding of the subject matter. Based on this, learning through practice is a must to be mastered by a prospective student science teacher.

Basic Chemistry Experiment I is main subject for Tadris IPA IAIN Salatiga (Natural Science Department). The practice is a basic practice that underlies students ability to observe, identify problems, manage information, analyze, and evaluate. Where these abilities are still a student's weakness during practice. The opportunity opportunities in the practicum are part of metacognition indicators.
Metacognition comes from the word meta which means after, or above, whereas cognition is defined as what one knows and thinks or includes skills related to the thinking process [2]. The metacognition development is significantly done because metacognition is the key in reaching the chemistry understanding in order to be more meaningful and long lasting. A teacher candidate must be accustomed with her metacognition, so that she can manage her next learning [3].

Metacognition development can be done by organizing the learning environment and the ability in overcoming the problem. As stated by Haryani that through chemistry practical work of problem based instrument analysis can be alternative approach to improve metacognition of chemistry teacher candidate [4]. Hmelo in Downing stated that problem based learning basically needed a different way in applying the knowledge to overcome the problem, and to get involve the metacognition process [5].

This research has implemented a Basic Chemistry Experiment I based on metacognition conducted through problem-based learning to increase problem solving ability and build concept understanding on prospective science teacher students, in hopes can give real contribution in improving the quality of graduate of science teacher candidate and quality of science learning. The basic topic of Basic Chemistry Experiment I raised is about the separation, purification and substance change.

2. Research method
A quasi-experimental method with pretest-postest control group design was used in this study. The experimental class is given treatment in the form of basic chemistry experiment based on metacognition, while the control class in the form of laboratory basic laboratory in laboratory with standard practice procedure. The research was conducted in IPA laboratory of Tadris IPA IAIN Salatiga, with 26 research subjects as control group and 29 students as experimental group of students of Tadris IPA who took Basic Chemistry Experiment I.

The learning of basic chemistry experiment with metacognition-based, developed based on metacognition indicators developed from the types of Metacognition by Schraw and Dennison [6], covering several metacognition skills: (a) declarative knowledge, (b) procedural knowledge, (c) planning, (e) information management, (f) monitoring, (g) debugging and (h) evaluation.

The data obtained consist of qualitative data. Those are problem solving skills, student response, and quantitative data in the form of test score of mastery of separation, purification, and substance change. Concept mastery data was analyzed using N-gain, while the qualitative data were analyzed descriptively. Measurement of problem solving skills adapted from [7] which includes assessment of problem solving reports, and presentation of results both using rubrics. Problem-solving indicators for problem-solving reports are: (a) identifying concepts and principles related to problem solving; (b) formulating problem-solving steps; (c) interpreting data; and (d) rational reasons.

Problems that students must complete through experiment can come from lecturers, but can also come from students after consultation with lecturers. It starts from the problem given by the lecturers as well as the problems that come from the students, then students, in groups, determine the problem of open ended as follows. (1) Purification of Spongy Salt, (2) Separation of Compounds by Distillation, (3) Separation of Substances by Chromatography, (4) Identification of Physical Changes, (5) Identification of Chemical Changes. The development of metacognition shown in this study is based on metacognition indicators developed from the types [6].

Indicators for presentation of results include: the appearance of the material to be displayed (power point), mastery of the material, ability to explain, the ability to argue / answer questions, activities, and respect the opinions of friends. To analyze the data, the whole group score is summed then divided by the number of groups to get the mean grade of problem solving scores.

3. Result and discussion
The study of basic chemistry experiment based on metacognition in this study is designed to improve the mastery of concept and problem solving skills of prospective teacher students on separation, purification, and substance changes material.
3.1. Problem solving skills

The problem-solving data of experimental group students is obtained from the report / work result of problem solving, and problem solving presentation with successive rate 85; 86.12; and an overall average of 85.56. Based on the results obtained it appears that the total problem-solving scores reach very high criteria i.e. each aspect is greater than 85%. The minimum success indicator in this research is 80%. The indicators for the problem solving report refer to the problem-solving pattern developed by Fogarty [7]. Overall problem-solving skills are measured through performance assessments using a rubric.

In order to solve unstructured, contextual, and open-ended problems, students must explore and understand a lot of information as well as students designing and conducting research in order to solve problems. Students should be "architects" for their learning. However, students are accustomed to learning "listening and taking notes and taking action if there is an instruction from the lecturer", as they often follow in lower classes, for example when they are studying in Senior High School. With the implementation of Basic Chemistry Practical Learning I based on metacognition along with this problem-solving tool, students obtain direct learning modeling which is very useful to be applied later as [8] has pointed out.

Observation by the observer (the researcher member) on the learning done by the lecturer (head of researcher) shows that the relevance of the problem presented with the competence required in the lecture, the systematic of the lecture material content, the timeliness of the lecture, and the student cooperation have been going well. Meanwhile, encouragement of students to discuss, ask, communicate, argue, lecturer services to problem solving by students, directing the course of discussion, learning motivation, and student learning responsibility still needs to be improved.

Performance results in problem solving assessed through student performance (observation sheet) on the purification, separation and substance changes show that the indicators know what is needed to learn properly. The indicators are included in metacognition skills: planning.

3.2. Build concept understanding

Figure 1 shows the pretest, posttest, and N-gain values of the concept of separation, purification, and substance changes for the overall concept in the control and experimental group. The data of the two groups were normally distributed, the N-gain variation between the homogeneous groups. The results of the N-g control and experimental groups were 0.4 and 0.6, respectively, with the medium category. Although the second category of groups was moderate, the achievement of N-g yield was significant, supported by different test results that the N-g learning of basic chemistry pract I based on metacognition showed significant differences (p <0.05).

![Figure 1](image-url)
The mean results of each concept for the separation, purification and change of control and experimental group substances is shown in Figure 2. The average gain of results of the experimental group is medium category (70%>R≥40%) with two concepts belonging to the high category (≥ 70%), whereas for the control group varies, the average is medium category with each concept of low (<40%) and medium category.

Based on the findings of research results, it appears that Basic Chemical Experiment I based metacognition separation, purification, and substance changes provide a good learning environment to improve the mastery of the concept of prospective teachers. Improved concept mastery data is determined by results measured by a test of the description form.

Improved conceptual mastery varies for each concept; however, the overall rate includes the moderate category for the experiment as well as for the control class, and both show significant differences. Based on the comparison of pretest and postes results, there is no student who master the concept has decreased, none are fixed. Although the increase is mixed, the data obtained show a moderately successful improvement (medium category). Through Figure 2, it can be seen that the highest results concept mastery occurs on the principle of salt purification material and the lowest on chemical changes material.

The highest increase in salt refining principle is caused by problem-based learning of prospective teachers is not only required to follow the steps in verificative guide but students are required to plan the experiment up to the presentation of the results. The concept of basic principles of salt purification has been obtained by students starting to write down as a theoretical study both in the proposal to the report of research results, so that in this concept the students gain direct learning experience which resulted in memory of event, an experience experience that has more optimal long-term effect. The low results understanding and understanding of chemical changes, allegedly due to the step-oriented solving problem of student attention focused more on tracking procedures related to the problem to be solved. In addition, this concept was not deliberately written in the literature review while drafting proposals as in the principle of purifying salt.

In contrast, the highest increase of results for the control group that was directly related to the experiment implementation was relatively low compared to the basic concepts; that is not directly related
to the experiment. The highest increase of results for the control group occurred in Chemical Change, and the lowest occurred in the concept of Physical Change. The low concept of physics change material, is possible so far in preparing student reports emulated on internet sources that cannot be accounted for; in addition, students are not required to present the results.

The findings in this study indicate that the Basic Metallurgical Practicalum I study based on metacognition provides a good learning environment in enhancing the mastery of student concepts for materials purification, separation and change of substances, and the results of this study are in line with previously reported findings [4, 9, 10]. At the stage of orienting the problem students in the group open-ended problem that will arouse students’ curiosity and motivate them to be able to solve problems [7].

The result of metacognition indicator achievement through essay test on pre and post learning, it can be seen that the result of metacognition indicator is highest obtained in the indicator of compiling and interpreting data or statement that exist, that indicator is one of the indicator found in metacognition skills: Evaluation.

3.3. Students response
Apart from the results of mastery of concepts and problem solving, researchers also observed the response of students in the implementation of basic metacognition based chemistry learning. Based on the results of the questionnaire self-assessment obtained a change to a positive direction on changes in students’ metacognition ability at the time of practice. In the self-assessment questionnaire at the lab, the most elevated metacognition indicators are: knowing the level of capability already possessed and making a summary of what has been learned (metacognition skills: evaluation), and linking information gained to existing theories (metacognition skills: management information).

The use of metacognition approaches to some of the problems that are given in an unstructured, contextual, and open-ended manner can improve students’ skills in problem solving. These problems can encourage students to actively engage in group discussions to find and determine the best problem solving for their group. This learning conditions students using some of their intelligence to determine real issues by beginning to define the problem, gather the necessary information, restate the problem, generate alternatives, suggest solutions, and determine recommendations [7]. In addition, these problems can also train students to solve contextual problems so that students have experience in solving problems encountered in real-life students. This finding is in line with previous findings [9, 11, 12].

Improved mastery of the concepts of the results of this study followed the problem-solving skills with the score reached very high criteria are built through the approaches of some metacognition indicators. The success of learning in the realm of cognitive and psychomotor influenced by the condition of students’ scientific attitudes and determine the success of one’s learning [13]. Furthermore, Popham states that according to some experts attitude / character of a person can be predicted change if someone already has a high level of cognitive mastery. In addition, basic chemistry experiment learning based on metacognition also improves students’ skills in terms of caution with chemicals, conducts careful observation, and seeks information relating to experiment.

4. Conclusion
Based on the results of research and discussion, it can be concluded as follows. First, the improve problem solving skills of prospective teachers with very good category with the mean of 85.56 and the indicators are included in metacognition skills: planning. Second, the implementation of the Basic Chemical Practical Learning model based on metacognition in addition to improved mastery of the concept better than the control group, indicated by the result of N-gain of control class 0.4 and experiment class 0.6 and that indicator is one of indicators found in metacognition skills: Evaluation. Finally, the general response of students to the implementation of learning is very positive, namely: (a) increase involvement; (b) provide direct experience through modeling; (c) practice doing fun research; and (d) expect it to be applied to other experiment.

Based on the results achieved in this study, it can be recommended as follows. The expansion of the implementation of metacognition-based experiment learning for other experiment courses needs to be
done so it is potential to provide academic atmosphere in order to achieve the competence of science teacher candidates through experiment. The experiment course instructor should always innovate to change the verification experiment-based paradigm to metacognition-based in the hope of coloring the student’s character as a person as well as in his duties as a teacher.

Acknowledgement

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