Improving students’ creative thinking skill through local material-based experiment (LMBE) on protein qualitative test

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Abstract. This study aims to enhance chemistry students’ creative thinking skills using material from local resources on protein qualitative test experiment (LMBE). In this study, a quasi experiment method using one group pretest-posttest non-equivalent control group design was carried out on the effectiveness of local material-based experiment approach. The data was collected using the test consists of five assay test and student work sheet (LKM). The effectiveness of the local material-based experiment was tested by means of percentage of normalized gain <g> and score percentage of students’ worksheet. Comparison of creative thinking skills pretest and postest scores showed that the implementation of local material-based experiment (LMBE) enhanced students’s creative thinking skills in experiment class with the value of normalized gain (<g>=0.77) at high category, while in control class reached to <g>=0.44 at medium category. In addition, the LKM shown the enhancements of all aspect of creative thinking skills, including fluency, flexibility, and elaboration skills with the score of <g> in experiment class are 0.79; 0.75; and 0.87 at high category, respectively. In contrast, the only the elaboration skill of control group was improved at high category (<g>= 0.76), while fluency and flexibility indicators enhanced at medium category (<g>= 0.48 and 0.56, respectively).

1. Introduction
Biochemistry courses is a compulsory subject at chemistry program of UPI which consist of theoretical and experimental subjects. Biochemistry experiment was taught to deepen the students’ understanding on theoretical knowledge and proof [1]. Through biochemistry experiment course, students was encouraged to discover their new concepts and to get comprehensive understanding. An improvement in conducting biochemistry experiment for chemistry students has been conducted by designing a semi-open experiments. However, this approach found to be fail to develop students’ practice and thinking skills, since it was observed the students particularly do laboratory works in a series of cookbook-style activities. This support the previous research that questioning the effectiveness of the cookbook-style laboratory education [2]. On the other hand, Indonesia National Qualification Framework (KKNI) put forward the higher requirement for students not only to understand some concepts but also able to create new concepts, creative, inovative, and has broaden horizon.

It has been known that an experimental material is expensive [3]. Utilizing the local material resources may serve alternative to overcome thus challenge. The use of indigenous material could lead
students’ creativity and thinking skills ability. The use of local materials makes teachers and learners aware of the resources to be found in their environment and stimulates their creativity [4]. The use of local material also enables learners to improve the materials will be used for the experiment. Again, local-based materials experiments bring home to the classroom, and clarify unfamiliar principles and concept of science to learners [5,6].

Creative thinking skill is new combination of ideas which generates the precise originality and product [7]. Creative thinking skills’ indicator: fluency, flexibility, originality, and elaboration [8,9]. Having this competencies, students will be able to create the original ideas, such as finding and selecting the local resources that can be utilized as alternative materials for conducting experiments as well as for replacing the scarcity of commercial material and cost [10]. Protein analysis test is one of the important topic which is given to the students, since protein plays many important role in living organisms. Therefore, this study aims to develop local-based material experiments (LMBE) and its effect on enhancing students’ creative thinking skills on qualitative test of protein in natural product. In this research-based experiment, students were boosted to develop their creative thinking skills in exploring, analyzing, and deciding proper alternative local material resources that can be used for replacing the standard chemicals used for qualitative test experiment of protein. The feedback shows that the LMBE approach has successfully improved students’ creative thinking skill by providing new venue for students to develop their creativity.

2. Methods

This study was conducted by quasy experimental with pretest-posttest non-equivalent control group, and involved a fourth-year undergraduate students at a certain national university in Bandung, Jawa Barat who are taking biochemistry experiment course. The research subject was comprised of control group and experimental groups of 22 and 18 students, respectively. The experimental group was carried out with guided-inquiry experiment using LMBE approach, while the control group was followed a semi-open experiment as particulary done. The effect of LMBE approach on students’ creative thinking skill was evaluated by creative thinking instrument test consisted of five assay test and student worksheet of creative skill performance. The data was analyzed by comparing the normalized gain (N-gain) of both classes after the treatment. The indicators used for measuring students’ creative thinking skills are fluently thinking skills (fluency), flexible thinking skills (flexible), and elaborative thinking skills (elaboration). Table 1 shows the distribution of creative thinking skills and learning indicators.

| Aspect of creative thinking skills | Indikator | Learning indicator |
|-----------------------------------|-----------|--------------------|
| Fluency                           | Smoothly express an idea | Give ideas to identify the alternative material which can be used for substituting the comercial chemical particularly used for protein qualitative test experiment |
| Flexibility                       | Applying concepts to solve the daily problems | Analyze which materials local are give proper to be used as alternative substitutes based on the optimization results |
| Elaboration                       | • Explain the ideas  • Record the data in detail | Explain the reason of the chosen materials  Write the data and observation results of the experiment using local materials in detail compared to particular chemicals used |

Table 1. Distribution of the creative thinking skills and learning indicator
3. Results and Discussion

3.1. Local-material Resources for Qualitative Test of Protein from Natural Product

Local material-based used in the experiment of protein qualitative test covered the source of protein and the chemical used for protein analysis. The samples of protein employed for this experiment are meat of chicken, Ikan mas (Cyprinus carpio), Ikan Patin (Pangasius sutchi) shrimp, and eel. On both experiment groups, students were experienced to have skill on preparing sample of protein for the next qualitative analysis. The preparation consisted of unhydrolyzed samples which will be used for initial test of protein content and hydrolized samples that proposed for amino acid residues analysis. The hydrolisis was conducted by applying sample with 6M hydrocloric acids (HCl). After students of both classes finished on preparing their samples, the students on experiment class conducted qualitative test using local material chemicals as shown in the Table 2, while the control class carried out the qualitative test of protein using the standard chemicals.

Table 2. Local-material resources for chemicals alternative of protein qualitative test

| Kind of qualitative test | Basic principal | Standard chemicals used | Local material chemicals |
|-------------------------|-----------------|-------------------------|-------------------------|
| Peptide bond            | The complex formation of Cu²⁺ with amine group on amino acids | Biuret (CuSO₄) under basic conditions of Potassium sodium tartrate solution | Terusi |
| Amino acid with benzene group | Nitration of benzene | Xanthoprotein: - HNO₃ - NaOH | Aqua regia |
| Tyrosine residue        | The complex formation of mercury with phenolic amino acid of protein | Millon: HgNO₃ | Lotion for face whitening which contain mercury |
| Triptohfan residue      | The condensation reaction of triptofan with aldehydes using strong acid as catalyst | Hopkins Cole: - Oxalic acids - Magnesium | Magnesium powder obtained from fireworks “drop type” |
| Cystein residue         | The deposition reaction of sulfide with lead (Pb) | PB-acetic under basic (NaOH) conditions | Pb-acetic was replaced by balck hair-dye |

Table 2 shows that the limitation of the standard chemicals for qualitative test analysis in the laboratory can be replaced by certain local material resources that available in our surrounding. Yet, the optimization for the utilization of each local materials should be conducted to confirm the accuracy of the observation. In this study, the local-materials used for the experiments has been optimized (data not shown). The usage of alternative materials in the experiments can improve students’ creative thinking skills by providing students to scientific inquiry skills by facing to the situation of the low-cost experiment either the scarcity of the standard chemicals in laboratory. This experience stimulated students’ creativity [4] in the experimental group to think what kind of alternative materials that can be found in their daily life for replacing the standard chemicals and give proper observation for the identification.

3.2. Students’ creative Thinking Skills

Students’ creative thinking skills on both classes were analysed by comparing the score of pretest and posttest between control group and experimental group as can be seen in the Table 3. Score pretest
shows the students' initial conception prior the treatment, while the posttest was given after the students followed the learning process. As has been discussed above, students in the control group carried out semi-open experiment, while the students in the experiment group followed the guided inquiry approach.

Table 3. Students' creative thinking skill in the control and experimental groups

| No. | Creative thinking skill’s indicator | Pretest | Posttest | N-gain |
|-----|------------------------------------|---------|----------|--------|
|     |                                    | Experiment | Control | Experiment | Control | Experiment | Control |
| 1   | Fluency                            | 30.20    | 58.60    | 85.00    | 78.60    | 0.79       | 0.48     |
| 2   | Flexibility                        | 21.70    | 29.20    | 80.56    | 69.20    | 0.75       | 0.56     |
| 3   | Elaboration                        | 29.80    | 26.60    | 90.56    | 82.25    | 0.87       | 0.76     |
|     | Average                            | 27.23    | 38.13    | 85.37    | 76.68    | 0.80       | 0.62     |

Table 3 shows the higher improvement in students’ creative thinking skills of experiment group who learned with the local material-based experiment (LMBE) using guided inquiry approach compared to the students in the control class who did experiment using semi-open protocol experiment. The different results also found on each indicator of creative thinking skills: fluency, flexibility, and elaboration. As can be seen in the Table 2, students’ creative thinking skill in the experiment class show high category for all indicators, while in the control group, only elaboration skill improved in high category and the rest two others are reached in medium category of enhancement.

In the experimental class, it is shown that fluency skill of the students in the experimental class significantly improved with the category of n-gain is high (<g>=0.79). This skill was measured by evaluating the number of relevant ideas which is expressed by students during completing student’s worksheet and answering the assay test. The inquiry based approach supplemented with local-material based experiment (LMBE) facilitate students to develop their scientific inquiry by facing students to the scenario where they have to determine some requested inquiries in the students’ worksheet. For instance, what samples can be selected for protein analysis experiment; what kind of alternative local materials that can be used for identifying the protein and amino acid residue to replace the standard chemicals used in the laboratory; how is the result of the test of protein and amino acid residues detected by local material chemicals compared to the standard chemicals; what hypothesis can be proposed that related the problems given in the experiment; what is the results and conclusion of the experiment of qualitative test of protein using LMBE. It is similar to an authentic inquiry process in which questions are not defined, experiments are not predesigned, and data are not provided to students [3,11].

The same higher improvement also observed on flexibility skill where students were encouraged to think alternative material resources in their environment that is proper to substitute the standard chemical used in the laboratory. Since the control group carried out using semi-open experiment with partially used “cookbook-style” experiment, the increased of the students’ creative thinking skills also observed though the category of their achievement reached to medium (<g>=0.48 and 0.56 for fluency and flexibility skills, respectively). The higher increased of flexibility skill in the experiment class was facilitated when students guided to design their experiment using LMBE. The third indicator of creative thinking skill observed on both classes is elaboration skill. This skill was measured by the ability of students in developing ideas, explaining in detail, expanding the ideas, and record the data completely as well. Surprisingly, students on both classes show the high increased of elaboration skills (<g>=0.87 for experimental group and <g>=0.76 for control group). From the above findings it can be concluded that LMBE is able to generate creative thinking skills.
4. Conclusion
In summary, the guided inquiry supplemented with material local based experiment (LMBE) approach support students to acquire scientific inquiry skills and fosters creative thinking skill by innovating the local material chemicals. The LMBE also engages students in many activities and thinking processes. Both approaches are encouraging students to design the experiment based on their interest. However, the guided inquiry with LMBE has different distinguishing features. First, guided inquiry with LMBE explicitly guided the students in designing the experiments which encourages students to construct ideas for finding alternative local materials for protein test and to create the proper material and new experiment. Second, the scientific steps in guided inquiry approach with EMBL guided students to promote their creative thinking skills through the scientific methods as used by scientist. Finally, the LMBE can be implemented to improve students’s creative thinking skills in biochemistry experiments.

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