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The Effectiveness of Multiple Representation Oriented Learning Material with Project Based Learning to Improve Students' Chemistry Learning Outcomes

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***Abstract*—Learning material is one of components in learning that its existence can improve students' learning outcomes. The Existence of learning material that has low quality, so making learning material needs consideration. The formulation of research problem is how the effectiveness learning material multiple representation oriented? This research for intended to analyze the effectiveness learning material multiple representation oriented towards improvement of students' learning outcomes and know the students' responses to learning material multiple representation oriented. The implementation of multiple representation-oriented learning material is done in colloid system chapter through Project Based Learning (PjBL). This research uses 46 of sample with mix method research design. The result show that implementation of multiple representation-oriented learning material is effective to improve students learning outcomes from 18.41% become 85.12%, N-gain is 0.82 include in high category.**

***Keyword*—multiple representation, PJBL, learning achievement**

I. Introduction

Learning is a process of planned change through a particular effort. One of the efforts that can be done is plan the learning. Learning needs to be planned well to improve students' learning outcomes. One of infrastructures which is needed in learning is learning material. The existence of good learning material is still minimal, so it needs to be taken into consideration in the preparation.

The observation results in one of senior high schools in Semarang city show that chemical learning material that be used in the learning presents the chemical material descriptively, less of pictures, and less of activities. Chemical material is presented by teacher with focus on test exercise. Chemical material is presented by teacher with focus on chemical exercise to prepare the students join national examination. It is not in accordance with the nature of chemistry learning, that is macroscopic, submicroscopic, and symbolic [1]. Based on this, it is necessary to develop chemistry materials that facilitate students skilled in doing chemistry through macroscopic, submicroscopic, and symbolic material in experimenting with natural phenomena.

A deep understanding of chemistry is required by students in complex, rapidly changing social life, and the availability of material in an abundant society. Deep understanding in chemistry can be obtained by reasoning from chemicals to the particulate level of a phenomenon. Students can do the reasoning to chemistry by linking macroscopic, submicroscopic, and symbolic phenomena in learning, so obtained a deep understanding [2]. In fact, students have difficulty learning chemistry because of the inability to explain structure and process at the submicroscopic level of a phenomenon [3]. The implications need to be made so that students are accustomed to confronting a submicroscopic phenomenon. The hope is student can understand chemistry in depth and can apply that understanding to solving the problems in daily life.

The restatement of chemistry by linking the macroscopic, submicroscopic, and symbolic of a chemical phenomenon to solve the chemical problem is called multiple representation [4]. Macroscopic is a chemical representation through observation of the phenomenon that the senses can perceive, submicroscopic represents chemistry at the particulate (atomic/molecular) level of a chemical phenomenon, and symbolic is a qualitative and quantitative chemical representation including a symbol, equation of reaction, graphs, chemistry [1]. The relation of submicroscopic, macroscopic and symbolic in chemical phenomenon can be illustrated by a triangle called Triplet Nature of Chemistry [4] in Figure 1.

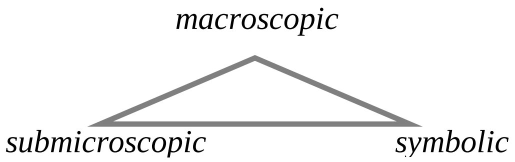

Fig. 1. Triplet Nature of Cemistry

Multiple representation has characteristics of: (1) experience is presentation of chemistry through direct or indirect observation; (2) models is the description and theoretical predictions of structural relations, compositions, or chemical reaction mechanisms; (3) visualizations is a qualitative or quantitative presentation as a link between experience with models [5]. Observation of a phenomenon can be represented symbolically to explain the nature and chemical reactions. Based on this study, the multiple representation in this study is the restatement of chemical material through observation of a phenomenon (macroscopic), and the particulate matter explanation of the phenomenon (submicroscopic) using images, symbols, or equations of reaction (symbolic).

The multiple representation of chemistry discussion in accordance with the implementation of the curriculum 2013 as the basis for education in Indonesia. Students are required to actively construct knowledge in the learning of curriculum 2013. It is in line with the function of multiple representation that gives encouragement to students to build a deep understanding when constructing knowledge. Multiple representation learning helps teacher to plan and use the strategies that can make a deep understanding.

Multiple representation has not been widely used as the focus of chemistry learning. In fact, the ability of macroscopic, submicroscopic, and symbolic students is still low. Submicroscopic representation has not been presented yet descriptively, causing less students' reasoning. Based on the above, it is necessary to apply multiple material representation, since multiple representation can improve students' conceptual understanding [6], [7].

Multiple representation-oriented learning materials are presented to students through PjBL. It is adjusted to the demands of the achievement of material competence colloidal system that students can make colloid-related products that are beneficial to life. One of the characteristics of PjBL is to produce the product as a problem solution [8]. PjBL is an innovative learning that emphasizes the context of complex activities [9]. PjBL is learning through projects to achieve learning objectives and is done with time limits [10]. PjBL can be done individually or during group [11]. PjBL is well suited to the curriculum 2013 in developing the skills of the 21st century.

PjBL in this research is a collaborative learning presented in certain steps and in certain time limit to achieve the learning goals. There are 4 steps of PjBL, namely: (1) Determination of fundamental questions, (2) Project planning, (3) Project implementation, and (4) Presentation of project results. Project that be done by students based on real life problems. The problem is investigated and presented multiple representation and the resulting product is the result of problem solving.

Application of PjBL on the learning make it easier for teachers to do the learning steps while reviewing the multiple representation-oriented material. The choice of PjBL model on applied learning is based on some predecessor research results. PjBL can improve student learning outcome [12]. The PjBL steps in learning with multiple representation-oriented materials are expected to facilitate the students' active learning. Students not only investigate the problem, review the resources of the solution deeply, and investigate the solution as a solution, but also practice the result in real life.

The PjBL Learning activity with multiple representation-oriented material is ultimately expected to improve student learning outcome. Learning outcome is understanding level that can be achieve after do the learning [13]. Learning outcome in this research is student's knowledge achievement, attitude, and skill after join the learning that be presented in mean value. Learning outcome in knowledge aspect is measured through test, while attitude and skills through observation.

The rest of this paper is organized as follow: Section II describes proposed research method of this work. Section III presents the obtained results and following by discussion. Finally, Section IV concludes this work.

II. Proposed Method

This result is done on 46 students of 11th grade science major senior high school in Semarang as sample. Sampling is done purposively with the consideration of students in the selected classes as subjects getting the same number of hours of study and relatively equal learning time. Mix method design is used in this research. Mix method design is activity that combine a set of qualitative and quantitative data within a design level and methodological framework to capture the complete research subject's information. Research is limited to the subject matter of the colloidal system. The steps taken in this study include: (1) Preliminary study, (2) Making learning set, (3) Feasibility testing of devices that have been made, (4) Learning material testing, (5) Pretest, (6) Learning implementation, (7) Posttest, (8) Analysis and data interpretation.

Preliminary study is done with syllabus analysis, lesson plan, learning material, and observation of learning activity. The result that is obtained that the learning has been planned well, use varied learning method with focus on student activeness during learning. Learning material that be used is printed learning material. Colloidal system material has been presented according competence demands, but minimal images and not yet associated macroscopic, submicroscopic, and symbolic. Learning material also minimal activity and less of contextual. Learning in the class also according with lesson plan. Students are less actively involved during learning activities. Learning activity still be focused on teacher explanation and exercise problems.

The learning set is made based on preliminary study result. The learning set was focused on making multiple representation-oriented learning material with PjBL framework, essay test, observation sheet, and student respond questionnaire towards learning material. Other sets were syllabus and lesson plan. The sets were consulted into expert then tested for feasibility analysis. The trial is conducted on 26 students for four meetings and obtained a description and validation sheet and a valid and then used as a research instrument. These essay tests are used to take the data of pretest and posttest learning outcome, while observation sheet is used to get the learning outcome data in attitude and skills aspect during implementation of learning.

The result of learning material test obtained that 81.39 % students agreed to the implementation of multiple representation-oriented learning material in learning. In the learning material test obtained pretest average 34.81, posttest average 70.19, and N-gain of 0.54 including the high category, but the classical completeness achieved in 57.69 %. Based on these, improvement in material learning is the addition of the number of evaluation questions, so the students can practice more troubleshooting as well as investigate macroscopically, microscopically, and symbolically. Improved learning material is distributed to students and used as learning tool.

The obtained result is analyzed to investigate the effectiveness of oriented multiple representation learning material that implemented with PjBL and illustrate student respond into multiple representation-oriented learning material. The effectiveness of learning material is illustrated with improvement of learning outcome in knowledge aspect based on pretest-posttest score and achievement learning outcome in attitude and skills aspect. Learning outcome achievement is categorized into low, medium, and high based in N-gain test that is:

$$\langle g \rangle = \frac{posttest\ score - pretest\ score}{maximum\ score - pretest\ score}$$

Category criteria of learning outcome improvement is stamped on Table 1.

TABLE 1. CATEGORY CRITERIA OF LEARNING OUTCOME IMPROVEMENT

Indeks	Criteria
$\langle g \rangle \geq 0.7$	High
$0.7 > \langle g \rangle \geq 0.3$	Medium
$\langle g \rangle < 0.3$	Low

Hypothesis in this research is: multiple representation-oriented learning material with PjBL is effective to improve student learning outcome in knowledge aspect.

III. RESULT AND DISCUSSION

Multiple representation-oriented learning material contain colloidal system learning material and presented in PjBL framework. Learning material is used during chemistry leaning in colloidal system main material that is 5 times meeting and one-time project at the outside learning time. Prepared learning material has been presented in a coherent manner according to PjBL steps, so that students in groups can determine the underlying problem based on real life-related problems that presented by teacher, plan the project that will be done to solve that problem, implement the project, and test the project outcome to determine the project's product harmonization on problem solving.

The result research obtained learning outcome average in student's skill aspect 84.48, learning outcome average in student's attitude aspect 87.68, and learning outcome average in knowledge aspect improve from 18.41 (pretest) into 85.12 (posttest). Improvement of learning outcome in knowledge aspect is analyzed using N-gain and the obtained 0.82, it can be interpreted that the improvement of learning outcome in the high category.

Presentation of colloidal system in learning material with coherent manner according learning activity make students easier to undertake the project. It has the impact in mastery of student skills on the project they undertake. Students are skilled in planning a colloid-making project, skilled in carrying out colloid-making project as evidenced by project reports, skilled in reporting the product making project, and can produce a colloid-related creative product with the correct technique.

Collaborative learning with PjBL-assisted multiple representation-oriented learning material facilitates students actively solving problems with macroscopic, microscopic, and symbolic investigation to create innovative products as problem solution. The learning is a novelty for students, so as to encourage the student interest in learning. The students feel that the learning is useful for them because can be implemented in daily life. The learning is impacted on achievement of student's attitude. The students show the responsibility, mutual cooperation, and self-confidence during learning implementation.

Multiple representation-oriented learning material that be used facilitate the students actively construct a deep understanding. The student reviews the colloidal system material in real life with observe the sensuous phenomenon which is then investigated more deeply about particulate matter related. The particulate is illustrated symbolically with the particulate molecular image, the chemical formula, and the reaction equation. Learning outcome improvement of each question indicator is listed in Figure 2.

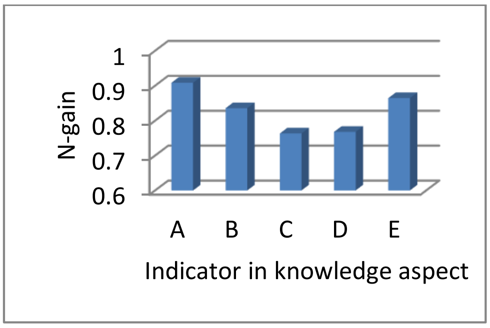

Fig. 2. Learning outcome improvement of each question indicator

The improvement of each indicator in more detail is as follows: (1) Students' ability to group the various mixtures into solution, colloids, and suspensions increases in the high category, i.e. 0.90 (indicator A). (2) Students' ability to classify medium type. The dispersion and dispersants increased in the high category, i.e. 0.83 (indicator B). (3) Students' ability to investigate colloidal properties increased in the high category, i.e. 0.76 (indicator C). (4) Students' ability to identify lyophile, lyophobe, and associate colloids increased in the high category, i.e. 0.76 (indicator D). (5)

Students' ability to explain the process of colloid making increase in high category, i.e. 0.86 (indicator E).

The achieved highest improvement in indicator A and the lowest improvement in indicator C. Classification of dispersion material with particulate molecular image is easier to be understood by students. Comparison of size and illustration of mixture form macroscopically facilitate students to reasoning rather than just by presenting descriptively. The process results in a high improvement in student learning outcome. The material of colloidal properties requires more complicated particulate illustration. The linkage of these concept to real phenomenon is also more complicated so that students need more effort to gain an in-depth understanding. This result in a lower learning outcome improvement compared to other indicators.

Learning-assisted multiple representation-oriented learning material with PjBL emphasizes more on problem solving and concept development. It trains students to reason about chemical phenomena and related concepts to come up with solutions. As a result, the more often students do learn activities so well the more problem-solving ability, so that learning outcome obtained through essay question as problem solving will more improve. The finding is in accordance with the research that be conducted Sunyono in [2] stated that multiple representation improves the students' reasoning. The similar research is conducted Dolfing, *et* al. in [14] obtained the result that use of multiple representation in project learning improve the creativity and understanding of the subject matter. Multiple representation also gives new perspective to students in chemical phenomenon understanding. The new perspective can be a provision for students in problem solving. Students not only investigate the descriptive phenomenon, but more deeply investigate until the particulate molecules. Such learning makes students more creative in thinking to solve problems.

IV. CONCLUSION AND FUTURE WORK

Based on data analysis, it can be concluded that learning-assisted multiple representation-oriented learning material with PjBL is effective to improve student outcome in knowledge aspect from average value 18.41 into 85.12 with the acquisition of N-gain score 0.82 include in high category. Learning-assisted multiple representation-oriented learning material with PjBL also effective in the achievement of learning outcome in attitude aspect with value average 87.68 in very good category and effective in achievement of learning outcome in skills with value average 84.48 in very good category. Based on these, learning-assisted multiple representation-oriented learning material with PjBL needs to be implemented in school to improve students' learning outcome. The teachers need to design learning material that facilitate the student construct the knowledge actively and obtain deep understanding.

Further research is needed on the effect of multiple representation on student creativity and is applied to a wider scope.

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