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Development of the Chemistry Teaching Material Using the Cooperative Learning Model with STAD Type Based on Multiple Representation to Improve the Students Learning Outcomes on the Molecular Geometry Topic

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Abstract: *This research aims to obtain the feasible chemistry teaching material using the cooperative learning model with STAD type based on multiple representation to improve students learning outcomes on the molecular geometry topic. The teaching materials consist of lesson plans, student book, worksheet, and concept mastery test were developed using the four D models. The subjects of the research were twenty four students of science class at 10th grade of SMA Trimurti Surabaya, Indonesia, at academic year of 2018/2019. The tryout of the teaching materials used one-group pretest-posttest design. The data were analyzed descriptively. The results showed : (1) the validity of the lesson plans, student book, worksheet, concept mastery test were very valid category (2) the readability of student book and worksheet were good category (3) learning performance was good category; (4) students activity refered to students centered learning; (5) majority of students gave the positive response to learning process; (6) students achieved mastery of learning of 83.33 % with high gain scores (0.78). Based on the results of research it could be concluded that the chemistry teaching materials developed were feasible to improve the students learning outcomes on molecular geometry topic.*

Keywords: *The chemistry teaching materials, cooperative learning model, STAD, multiple representation, molecular geometry topic.*

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I. Introduction

The chemistry subject is still considered difficult by most students at senior high school. It is caused by the charateristic of chemistry concepts, namely abstract and tiered. A chemistry teachers must have a strategy for learning chemistry to be easily understood by the students. One of them is multiple representations, namely the use of representation in various ways to present a phenomenon. The focus of study on learning and teaching in chemistry is more emphasized on interconnection between three levels of representation, such as macroscopic, submicroscopic, and symbolic representation (Johnstone, 2000). Macroscopic representation is obtained through real observations of a phenomenon that can be observed and perceived by the five senses. Submicroscopic representation explains the structure and processes at the particle (atomic/ molecular) level of the macroscopic phenomena observed. The representation mode at this level is expressed symbolically from the simple to using computer technology, which uses words, two and three-dimensional images both silent and moving (animation) or simulation. Meanwhile, symbolic representations are representations qualitatively and quantitatively, such as formulas, diagrams, drawings, reaction equations, and mathematical calculations.

Sunyono (2014) was developed a model of multiple representation-based learning to produce practicality (feasibility and attractiveness) and high effectiveness in building mental models and increasing mastery of student's chemical concepts at basic chemistry course with topics of stoichiometry and atomic structure, as well as molecular shape. Molecular shape is also taught to senior high school students of 10^{th} grade at the chemical bonds. Based on the 2013 Indonesian Curriculum, the molecular shape is delivered with basic competence: Applying the valence shell electron pair repulsion theory (VSEPR) and electron domain theory in determining molecular shape. Based on the preliminary study, it was obtained the information that chemical bonds, especially molecular shape, is one of the topic that is considered difficult by students. Based on observations 120 students of SMA Trimurti Surabaya were randomly chosen to give their opinions on the difficult material ever studied at 10^{th} grade. As many as 26% of the students stated that chemical bonding, especially molecular geometry topic, is a difficult material.

According to a statement from the teacher, one of the problems is the difficulty in understanding the subject. Based on learning outcomes, many students get score below the standard, so that they have to take remedial program. The chemistry learning that is currently only limits two levels of representation, namely macroscopic and symbolic (Tasker & Rebecca, 2006). The submicroscopic thinking level is studied separately from two other levels of thinking. Students also learn more about solving mathematical problems without any deep comprehension. On the other hand, the backgrounds of SMA Trimurti students vary from religion, ethnicity, and economy, so that in the class there is a social gap.

Teachers should design the learning models by implementing multiple representations so that the effectiveness of the learning model used increases. The learning model that is appropriate to facilitate learning using multiple representations is cooperative learning model with STAD (Student Team Achievement Divisions) type. It can help students to understand the chemical concepts, especially the molecular geometry concept. It is also very useful for developing cooperation and willingness to help friends in linking new knowledge with previous knowledge, finding and developing understanding of a concept or strategy when they observe, explore, discuss, explain, and question ideas in groups.

II. Methodology

Research Model

This research is a type of developmental research which refers to the 4-D model (Thiagarajan, 1974). The teaching materials developed consist of lesson plan, worksheet, student book, and concept mastery test. The tryout of the teaching material used one-group pretest-posttest design. The trial was started with giving a pretest (O_1), then applying learning using cooperative learning model with STAD type based on multiple representations using teaching materials developed, and at the end of learning given a posttest (O_2).

Subjects

The subjects of this study were twenty four students of 10^{th} grade at SMA Trimurti Surabaya, Indonesia, at academic year of 2018/2019.

Research variables

The variables of this study are as follows: (1) The validity of teaching material (2) The practicality of teaching material, including (a) Readability of student book and worksheet (b) Implementation of lesson plan (c) Student responses (3) The effectiveness of teaching materials, including (a) Student activities, (b) Student learning outcomes.

Collecting data techniques

The collecting data process involved some techniques such as validation, observation, questionnaire, and test. Validation are used to determine validity of teaching materials. Observation aims to collect research data on the implementation of learning and student activity. The questionnaire is used to measure students responses to learning process. Test is used to determine the effect of learning on improving the mastery of student concepts. This test is given in two stages, the pretest and the posttest to determine the students' before and after the learning process. Differences of pre-test and post-test students were analyzed using an N-gain score.

Data analysis

The data obtained from this research including validity of teaching materials, readibility of student book and worksheet, learning implementation, student activity, student response, and student learning outcomes were analyzed descriptively

III. Result and Discussion

Validity of teaching materials

This research was begun by developing the teaching materials, such as lesson plan, student book, worksheet, and concept mastery test. The validation of them were carried out by experts: two chemistry lecturers and a chemistry teacher. The following are the validity of the teaching materials developed.

Table 1: Validity of the teaching materials

Teaching Materials	Score (V)	Category
Lesson plan	3.6	Very valid
Student book	3.6	Very valid
Work sheet	**3.8**	Very valid
Concept mastery test	3.7	Very valid

Note: Very valid ($3.6 \leq V \leq 4.0$), valid ($2.6 \leq V \leq 3.5$,
Less valid ($1.6 \leq V \leq 2.5$), not valid ($1.0 \leq V \leq 1.5$)

Based on the Table 1, it could be explained that all teaching materials developed were very valid and appropriate for learning process. Lesson plan was prepared in a complete and systematic manner so that learning took place interactively, inspiring, fun, challenging, efficient, motivating students to actively participate. The student book was categorized as feasible and good book which had criteria: accurate, appropriate, communicative, complete, systematic, and oriented to student-centered (Akbar, 2013). While the worksheet was categorized as good materials, because it had eight important elements, namely the title, basic competencies to be achieved, completion time, tools and materials needed to complete the task, brief information, procedures, tasks to be done, and reports to do (Prastowo, 2013). As well as the previous teaching materials, concept mastery test (content validity, language and writing) was good category, because it was reliable, valid, objective and practical.

Readability of student book and worksheet

Readability of student book and worksheet were measured using questionnaires given to students after learning. The aspect of readability assessed in terms of (1) the attractiveness of the material or content (2) the attractiveness of the appearance, (3) the difficulty of the description or explanation, (4) the illustration or picture and (5) the difficulty level of the questions. The results of readability of student book and worksheet could be presented at Fig. 1 and 2.

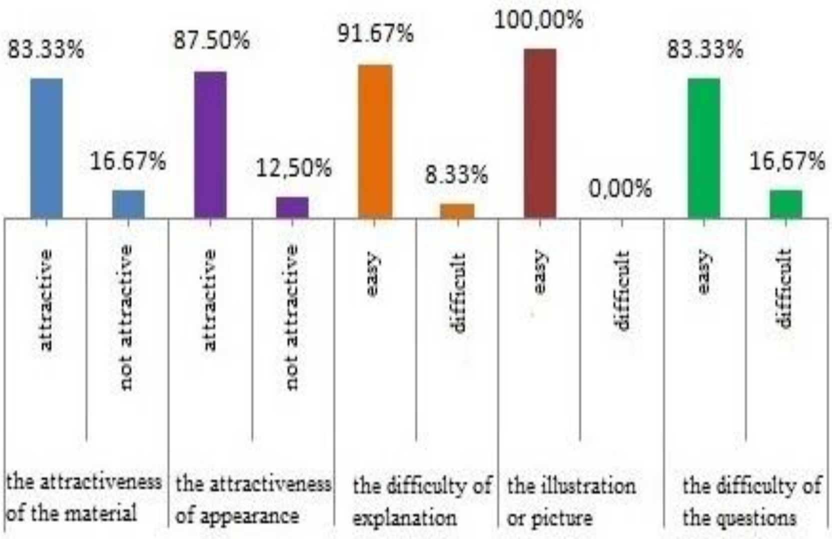

Fig. 1: Readability of student book

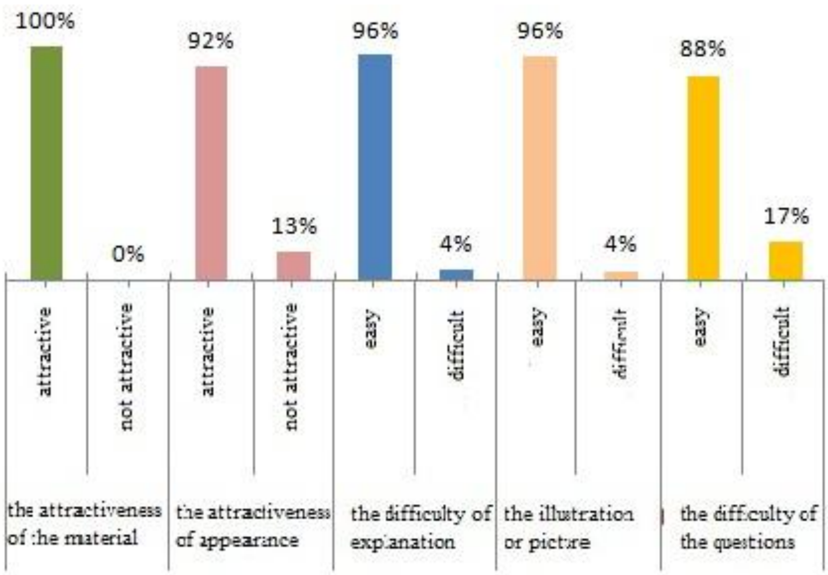

Fig. 2: Readability of worksheet

Based on the Fig. 1 and 2 it could be stated that student book and worksheet developed were acceptable for students, even though there were some students found a little difficulty. The image or illustration could clarify the description of the student book and worksheet could increase student's comprehension to the material being studied and increase student's motivation to learn, so that it could help students improving mastery of molecular geometry topic that could be observed from the student learning outcomes.

This high level of readability was caused of the impact of internal and external representations. Internal representation is defined as an individual cognitive configuration that is thought to originate from human behavior that describes several aspects of physical processes and problem solving. On the other hand external representation could be described as a structured physical situation that could be seen by realizing physical ideas (Slavin, 2008). In the constructivist view, internal representations exist within the learner's head and external representations are situated by the environment (Arend, 2008). The importance of representation is said that "Without external aids, memory, thought, and reasoning were all constrained (Hamalik, 2008).

Ainsworth (2008) states that conceptual analysis of the existence of a learning environment with multiple representations shows that there are three main functions of multiple external representations used in learning situations to complement and build understanding of concepts. The first function is to use representation to obtain additional information or support existing and complementary cognitive processes. Second, representation can be used to limit those who experience interpretation errors that might occur. The three multiple external representations can be used to encourage students to develop deeper comprehension.

Learning implementation

The implementation of learning was measured using observation sheet which was filled by three observers for three meetings. The observed aspects include preliminary activities, core activities, closing activities, and classroom management. The results of the observations were presented at Fig. 3.

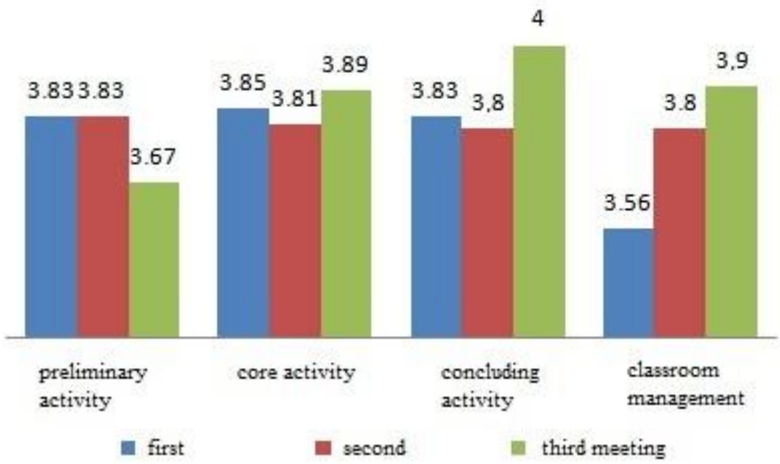

Fig. 3: The Average of observer assesment on the learning implementation

Based on Fig. 3, it could be seen that the average assesment on the learning implementation from three observers was 3.81 with a very good category. These results indicated that learning activities had been carried out well by the teacher, in this case the students had been actively involved in learning activities. According to Slavin (2008), cooperative learning is a method in learning where students work in groups together and help each other as a team and each person in a group achieves a predetermined goal or task. Cooperative learning models are developed to achieve at least three important learning objectives, namely academic learning outcomes, acceptance of diversity, and the development of social skills (Arend, 2008).

In preliminary activity, the teacher lead Phase 1 of cooperative model, delivering objective and motivate students. Delivering all the learning goals to be achieved in these subjects and motivating students. The core activity started from phase 2 to 5. Phase 2 was presents information, teacher presented the information to students by demonstrating or through reading materials. Phase 3 was organizing students into groups to learn. Explain to the students how to form study groups and assisted each group in order to make the transition efficiently. Phase 4 was guiding groups working and learning. Guiding groups working and learning groups learned by the time they do their work. Phase 5 was evaluation, evaluating the learning outcomes of the material that had been taught or each group present their work. Phase 6 inserted to closing activity. Phase 6 giving reward was one of ways to appreciate the effort and the learning outcomes of individual and groups.

Not only on the teaching material, multiple representation also had described almost in every phases. For example, when motivated students using image or picture (Heuvelen & Zou, 2001). Piaget said, that the main factor that drives cognitive development of students is the motivation or power of the students themselves to want to learn and interact with their environment (Arend, 2008). The dual coding theory states that, the information presented visually and verbally will be remembered better, compared to only one way. The learning experience carried out by the teacher by presenting multiple representation can provide a stimulus to students to make perceptions of the objects being studied. If this is done continuously and regularly, the concepts formed in students will increase students' interest in learning. According to the theory of information processing when there is an acceptance process, information can be stored in long-term memory, so that it can improve mastery learning (Arend, 2008; Meltzer, 2005).

Student activity

During learning process, observations were conducted on student activities. The results of observations for each meeting could be presented at Fig. 4.

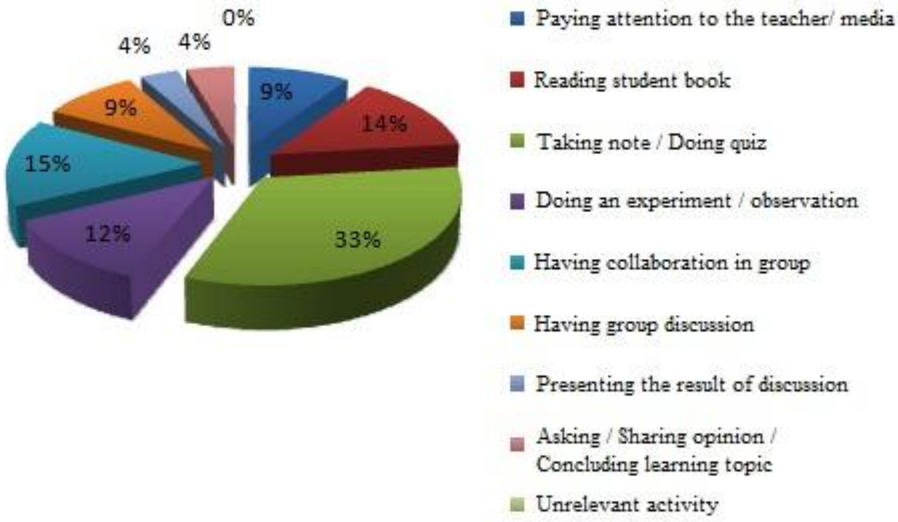

Fig 4: The percentage of student activities during learning

The results of observation on student activities during the learning process using the cooperative learning model with STAD type based on multiple representations could be seen at Fig. 4. The average percentage of student activity when paying attention to the explanation delivered by the teacher and observing the media by 9 %. The average number of percentages of student activities when writing ideas / questions, reading textbooks, conducting experiments, discussing and collaborating, presenting the results of group work, asking questions / expressing opinions, and closing learning was 91%. During the learning process, students did not show irrelevant behavior (0 %).

Based on the student activities data could also be explained that implementation of the chemistry teaching materials designed by the teacher were student-centered learning (SCL). During the learning process students were given the freedom to build their own knowledge independently so that the formation of knowledge was more meaningful. STAD type cooperative learning model based on multiple representation was in accordance with Vygotsky's constructivism theory because in learning activities students were faced with the process of thinking of their peers who had heterogeneous cognitive abilities. Tutorials by more competent friends would be very effective in encouraging the growth of their Zone of Proximal Development (Slavin, 2008; Zhang & Norman, 1994). Piaget's theory also strongly supported cooperative learning, this theory viewed the importance of study groups so that every students had a sense of responsibility and feels a positive interdependence because each member has a role in achieving the success of the group (Arend, 2008).

Student response

The response from students were obtained after the teacher completes the learning activities for three meetings, by using a questionnaire of the learning that had been carried out. The results of the percentage of student responses were presented at Fig. 5.

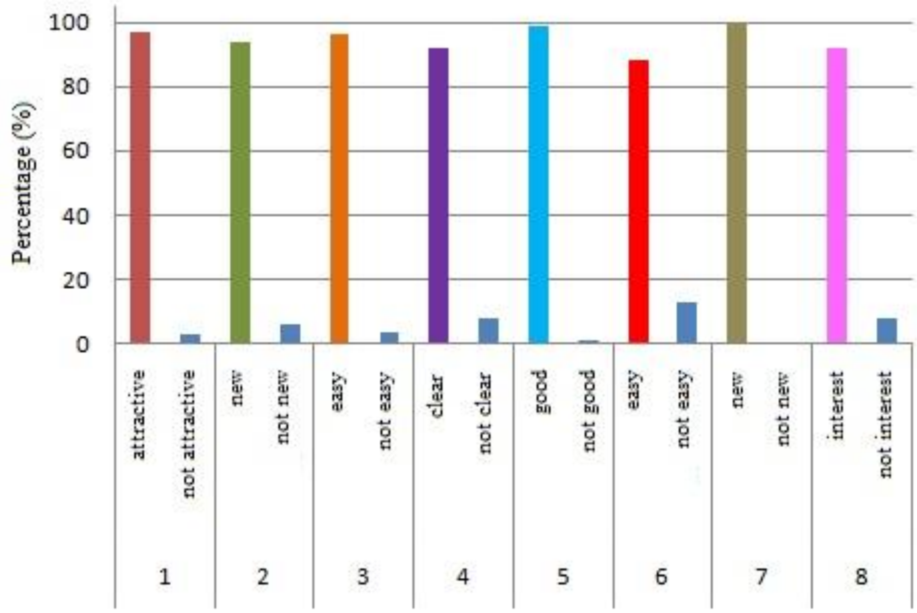

Fig. 5 Percentage of student response

Based on Fig. 5, it could be said that implementation the chemistry teaching material using cooperative learning model with STAD type based on multiple representation get positive responses from students. This was indicated by the percentage of attractiveness of teaching materials, learning management, teacher teaching methods, and so on. The students interested in the STAD type cooperative learning model based on multiple representations received a positive response with value of 92%. Students argue that the learning process did not limit their creativity in learning and they felt to have an active role working in groups. The opinions of students were supported by the statement of Hamalik (2008) about youth learning, that was learning would be accepted if teenagers had a balance between freedom and limitation, when their voices were heard in groups / classes, when they played an active role in the learning process.

Student learning outcomes

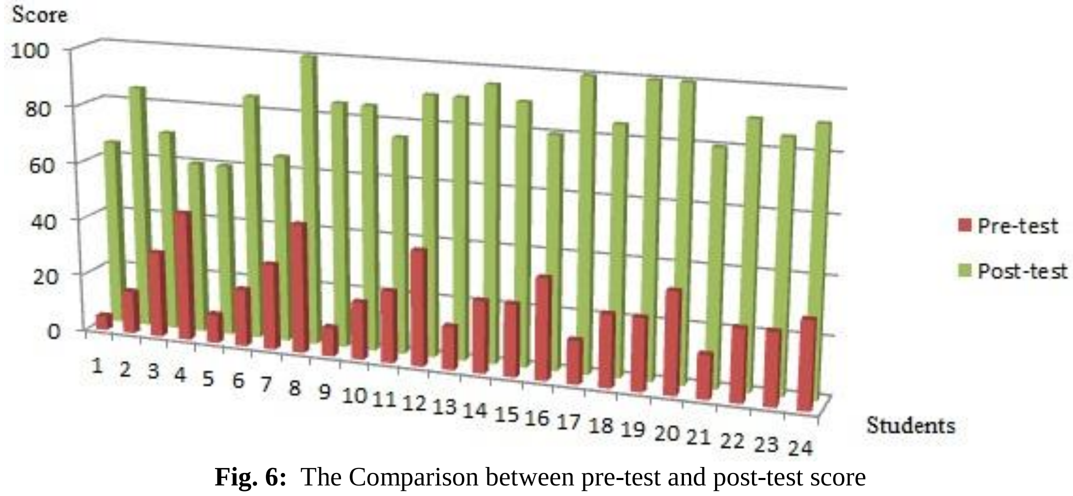

Fig. 6: The Comparison between pre-test and post-test score

The average pre-test score of students were 14.80 and no students had reached the standard score (≥ 70). After learning using the cooperative learning model of STAD type based on multiple representation, it was obtained that the average post-test result was 83.3 and the mastery learning of the class reached 83.33%. The gain score for learning outcomes was categorized as high with an average value of 0.78 or 71% of the total score. The sensitivity value of twenty items tested was ≥ 0.30. This means that the items tested had good sensitivity to the learning process. The item with the highest sensitivity value was 0.78 and the lowest was 0.35.

The results of this research was supported by the previous study. Herawati, et al. (2013) stated that student learning achievement with multiple representation learning on reaction rate topic was higher than conventional learning. Sunyono (2014) said that the development of multiple representation based learning models on the stoichiometry and atomic structure topic, produced a level of practicality (feasibility and attractiveness) and high effectiveness in building mental models and increased the students concept mastery on chemistry.

IV. Conclusion

Based on the analysis of the results, it can be concluded that the chemistry teaching materials using cooperative learning model with STAD type based on multiple representations were reasonable to be used at learning process to improve student learning outcomes on the molecular geometry topic at senior high school.

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