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Development of chemistry instructional materials based on Cooperative Group Investigation (CGI) to empower thinking skills

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Abstract. Thinking skill is important for students as it is the foundation for enhancing the mastery of concepts needed in the 21st century. Thinking skills that empowered in learning focuses on how students participate in solving problems. This research aims to develop chemistry instructional materials based on Cooperative Group Investigation (CGI) to empower thinking skills on colloidal system topic. The feasibility of chemistry instructional materials is evaluated based on its validity and practicality. The design of this research was four-D-model, consist of Define, Design, Develop, and Disseminate. Data of this research was analyzed by quantitative descriptive. The result of this research include: (1) The instructional materials that were developed which consist of lesson plan, students' book, worksheets, assessment, and power point media; (2) The instructional materials developed were valid with good category in construct, content, language, empirical validity, and contain principles of cooperative group investigation; (3) The teacher implemented the lesson plan well, the increased students activities were indicated by doing investigation, analyzed the result of investigation and presentation of final product that are empowering students' thinking skills. Based on the results of the research, the instructional materials of colloidal system topic can empower students' thinking skills.

1. Introduction

Education target at 21st century as the century of information technology has shifted traditionally to the knowledge which requires ability to think, and way of thinking [1, 2]. According to Piaget [3], the development of reasoning skills (empowerment process of thinking) is essential for mastery of concepts; because conceptual knowledge represents the result of a constructive process. ³

The instructional materials are one means of learning that can lead students to understand a concept and can improve retention of learning outcomes [4]. ³ This matter as according to result of research to develop instructional materials for empowerment of metacognitive skills on the topic of hydrolysis and buffer solution, can improve students' activeness in learning as indicated by the improvement of students' interactions and teacher's-students interactions, student enthusiasm in learning and their eagerness to joint to the next teaching-learning activity with the same way of learning [5].

The result of the research is strengthened by result of research that implements the model of Cooperative Group Investigation (CGI) with contextual approach oriented in the learning activities of Science. It suggests that the activity has centered to students, as indicated by the improvement of students' interactions and teacher's-students interactions, teacher responses, discussion among them, teacher's-students discussion, doing investigation, ¹ presenting the report's investigators, and volunteers (student expresses their opinion and responses)[6].

Most in all concepts, there are chemistry representing the abstract concept which tends to only be comprehended better by students who have developed the ability to think the abstract. One of the learning strategies used to empower students' thinking skills is a cooperative group investigation [7, 8], where class is divided to become the groups of 5-6 students with heterogeneous members. Further students choose the topic investigated, investigate on selected topics, and present the report investigated to the whole class.

The difficulty of obtaining the quality of instructional materials, time limitation, funding, as well as expert is owned progressively against the teacher task. Therefore, this research develops and applies the instructional materials chemistry which concern on CGI oriented that can ease the task of chemistry teacher. The instructional materials consist of lesson plan, students' book, worksheets, assessment and media of power point.

2. Methods

This research represented the development research using four-D Model consisted of four stages pervading define, design, develop and disseminate [9]. In principle, the developments of instructional materials development use the framework of mind with a few appropriate adaptations.

At the first year research, it has produced the instructional materials chemistry oriented CGI, including Lesson Plan, Student Book, Worksheet, and Assessment Sheet (cognitive, psychomotor and affective) and keys, and media of power point and its research instruments. The preparations of instructional materials through the stages of define, design and develop using a series of activities: field observations, curriculum analysis, literature review, development instructional materials, and review of instructional materials for linguist and expert.

In the second year through the stages of disseminate, it was conducted trials of instructional materials result of research in first year at Senior High School Sidoarjo, Indonesia for completion of instructional materials as prototype of effective final instructional materials. The effectiveness tested with the criterion of feasibility of learning chemistry which oriented CGI, the activity of thinking skills of students, and students' responses to the learning. Before trial, it was conducted training for teachers of chemistry in terms of the application of instructional materials. The method used in training are modelling. The final result of this study is the materials oriented CGI which is expected to be implemented /applicable at school, because it was through review, expert validation, and testing.

3. Result and Discussion

In general, the data is the mean score of the feasibility of lesson plans, students' book, worksheets, assessment, and power point media that developed by validators' evaluation which is presented in Figure 1, Figure 2, Figure 3 and Figure 4. The result of validators' evaluation of lesson plan, student book, worksheets, assessment and power point media is good with the mean score of 4.1 to 4.9.

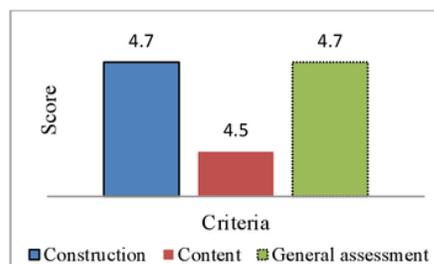


Figure 1. Validation results of Lesson Plan

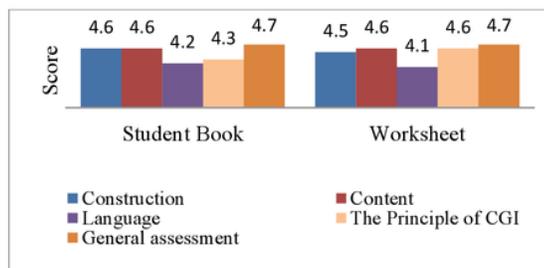


Figure 2. Validation results of Student Book and Worksheet

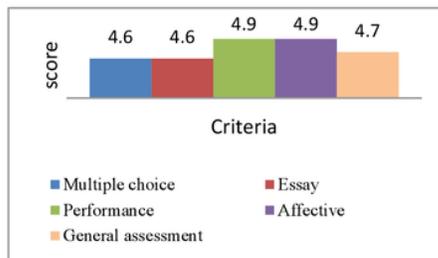


Figure 3. Validation results of Assessment

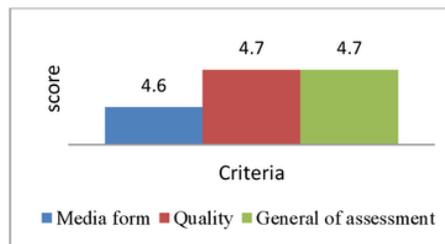


Figure 4. Validation results of Power Point

Based on the interpretation of feasibility according to the Likert Scale [10], it is said feasible if good and very good rating [6]. So it can be said that by Lesson Plan for colloidal system which have been developed have been **feasible to be used in the learning process** because they have fulfilled with the construct validity and content validity. In addition, the **student Book and worksheets for colloidal systems material** which have been developed have been **feasible to be used in the learning process** because have fulfilled with the construct validity, content validity, language validity and according to student book group with the principle of GIC. An assessment and power point medium that has been developed in colloidal systems have also been fulfilled to be used in the learning process.

At the dissemination stage, the performance data of teachers in implementing a prototype instructional material CGI oriented includes lesson plans, student book, worksheets, assessment and media of power point on the colloidal system. They are observed by two observers using the lesson plan format which is presented in Figure 5. The teacher activity affects the activity of student thinking skills which are presented in Figure 6. In addition, the percentage of time used by students learning to do the activities supported by student responses to the Student Book and worksheets that are implemented in the teaching and learning (Figure 7).

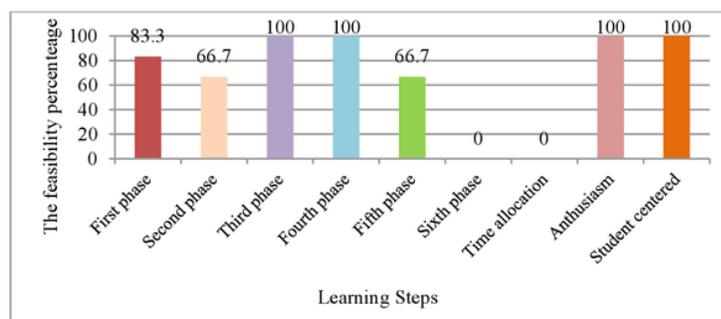


Figure 5. Feasibility of Lesson Plan based on observers' evaluation

7. description of phases:

1. Communicate goals and motivate students
2. Present the information (selection of topics)
3. Organize the students in learning (Cooperative planning)
4. Guide the group to learn and work (implementation, analysis and synthesis)
5. Evaluation
6. Reward

Result of evaluation the lesson plan feasibility by observer in stage disseminate is good and very good with the feasibility percentage of 66.7% until 100% (Figure 5). Based on the score interpretation according to Likert Scale [10], the observation result is good. Implementation of teaching and learning is student-centered, and teachers act as facilitators. So that, the Lesson Plan for colloidal system which have been developed, can be implemented better, that indicate teacher have communicated the indicators, motivated students, correlated the matter with the former concept, presented the outline of information, revealed common problems and the selection of topics,

explained experimental procedures in the worksheet, setting students group, assisted each group to make the transition efficiently, guided students to plan the learning procedure (cooperative planning), guided the group by using the worksheet (implementation, analysis, and synthesis), observed the activities of students in turn, evaluated students' learning outcomes through the questions and answers or each group presented the results of their work (presentation of final results), and provided feedback.

However, correlating the matter with the former concept has not been performing well. Because the matter is relatively quite a lot, so the teacher directly went to the explanation matter, without giving apperception. Similarly, at second phase, the activities of teacher reveal common problems and the selection of topics that has not been performing well. At sixth phase, teacher did not guide the student to subject matter, and gives awards to individual or group. It is because the amount of time used by student in activity minilab, chemistry laboratory, daily chemistry, and assessment cause the time allocation planned was not performing well (exceeding time planned).

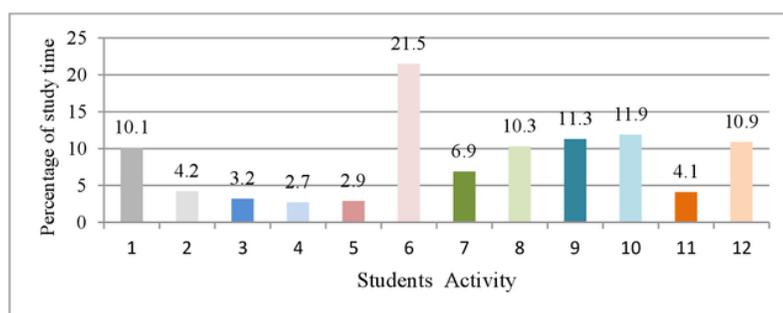


Figure 6. The Percentage of Students Thinking Skills Activity

Activities:

- | | |
|---|---|
| 1. Paying attention to the explanation of teacher/students | 7. Analyzing the result of investigation |
| 2. Reading (student book or worksheet) | 8. Preparing investigation reports |
| 3. Writing relevant to the learning activities | 9. Presenting the report of investigation |
| 4. Selecting a task in accordance with general problems | 10. Discussing within students |
| 5. Planning the procedure solving task | 11. Teacher's-students discussion |
| 6. Doing investigation (theoretical/observation/experiment) | 12. Volunteering (go forward, student express their Opinionand responses) |

The teacher activity affects the thinking students' skills, with an active student learn in class that they only kept quiet to listen to the teacher or friends. Based on the percentage of time in learning activity (Figure 6) that the time for 80,1% used by students to be active learning in class with the details activities are reading (student book and worksheet), writing, selecting a task in according to problems, planning the procedure solving task, doing investigation (theoretical/observation/experiment), analyzing and evaluating result of investigation, compiling a report, presenting the investigation report, discussing within student, teacher's-students discussion, and volunteering (go forward, student express their opinion and responses). While 10.9 % are used to listen the teacher or friend.

In empowering students' thinking skills, teaching and learning implementation have to strive in order not to solely relate to importance transfer the information and or even the discovery information but refers to the importance of higher-order thinking skill. It has been seen on the results of the implementation of the instructional materials, in which most student used to do the investigation (theoretical/observation/experiment), analyzing and evaluating the result of investigation, compiling the report and presents the investigation report. The activity can develop the ability of abstract thinking, providing the opportunity for students to interact with friends in the investigation for the discovery of the concept, and the existence of interaction between student – teacher in expressing an idea, asking and responses question. This means that the Cooperative Group Investigation (CGI) model can train students to explore and discover concepts because it involves many students during

the learning process to find their own concepts so that students can acquire knowledge and build concept independently [11, 12].

In the students' book, there are practice problems, daily chemistry, chemistry-discuss, and guessing term that guides and directs students in discovering concepts through questions. In addition, some communicative questions on the subject matter can also assist the students in constructing their own knowledge. Meanwhile, in the worksheet, the activities in mini laboratories and chemistry laboratory enable students to independently construct their own knowledge through experiments. The concepts of colloidal system material studied in the student book and worksheet were dispersion system, dispersed phase, medium dispersion, sol, aerosol, gel, emulsion, foam, lyophilic colloid, lyophobic colloid, hydrophilic, hydrophobic, Tyndall effect, Brownian motion, adsorption, coagulation, protective colloid, dialysis, condensation method, dispersion method, and peptization [13].

However, according to observers 'and researchers' notes, some students are less effective in selecting a task in accordance with problems, planning the procedure solving the task, and analyzing the result of the investigation. This happens when students conduct investigations on how to purify water and make colloid by condensation method. Some students are still wrong in selecting a task in accordance with the problem of purifying water. To purify water, students should use the following procedure: water can be purified by adding $\text{Al}_2(\text{SO}_4)_3$. In the water, $\text{Al}_2(\text{SO}_4)_3$ is hydrolyzed to form $\text{Al}(\text{OH})_3$. $\text{Al}(\text{OH})_3$ is a colloid. These can adsorb coloring matter or pollutant in water. As a result, the analysis the result of the investigation is not correct in making colloid by condensation method, because students are still confused in identifying the types of condensation reactions as follow:

- (a) $\text{FeCl}_3(aq) + \text{H}_2\text{O}(l) \rightarrow \text{Fe}(\text{OH})_3(sol) + 3\text{HCl}(aq)$
- (b) $2\text{H}_2\text{S} + \text{SO}_2 \rightarrow 2\text{H}_2\text{O} + 3\text{S}(colloid)$
- (c) $\text{Na}_2\text{SiO}_3(aq) + 2\text{HCl}(aq) \rightarrow 2\text{NaCl}(aq) + \text{H}_2\text{SiO}_3(colloid)$.

This means, students do not understand the difference between hydrolysis reactions, redox reactions and substitution reactions.

Nevertheless, activities in the Students' Book and worksheet can support feasibility in teaching and learning process to be more students centered so that students can independently construct their own knowledge (constructivist) while developing their skills of inquiry, through collaboration in study groups that can share their opinions. This means, students are trained to use thinking skills [14, 15]. In addition, the percentage of time used by students is supported by student responses to the Student Book and worksheets which are implemented in learning (Figure 7) that the majority of students have given the good evaluation with a percentage of approximately of 81.1% - 91.7%.

This means the student has given a positive response to the Students' Book and worksheets based on the aspects of construction including attractive physical appearance, size according to desire, and the letter used comfortably readable, interesting way of presenting the interests and concerns, and the illustrations (figures and descriptions) to support the understanding of the material. For the aspects of content, including the existence of students' book and worksheets, the subject matter is related to everyday life, the content may encourage active involvement in learning, examples of problems that presented are easy to understand, with the students' book and worksheet to learn on their own at home, interest to continue to study it, and in general students' book and worksheet have good category. For the aspects of language, including the language used is easy to understand/communicative, and the terms and symbols used is steady and easy to understand. For the aspects which are linked to principle of group investigation cooperative, by using the Students' Book and worksheets they can construct knowledge independently, concluded the concept of matter by observation, encourage cooperation, improve knowledge, thinking processes and laboratory skills, and encourage responding to events, activities and experience.

Based on the description above, Students' Book and worksheets have been feasible to be used in meaningful learning activities that have fulfilled the empirical validity.

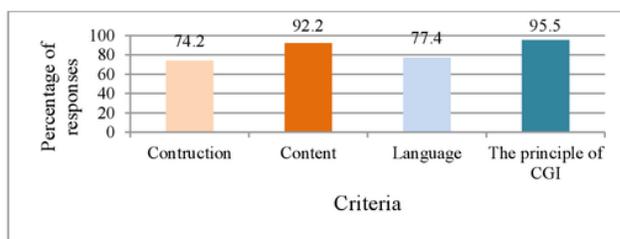


Figure 7. The percentage of student responses to student book and worksheet

Some of the comments and suggestions for improvement from students that can be used as a material consideration for revision are as follows: (a) Students' book and worksheet have goodness side, and attract students' attention, but the books need to be completed with chart/ diagram/ concept map figures, colors, chemical information of interest; a glossary at the end of the page, real concepts, content of more attention, full color and bilingual; (b) The size of the students' book and worksheet are less as according to students desire, because they are less minimize portable so that, (c) There are a few examples of questions presented in the student book which is not easy to understand, because it still needs glossary and sample questions, and (d) There are some phrases used in the students' book and worksheet which are less easy to understand, because it still needs glossary and should be in bilingual.

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4. Conclusion

Based on the objectives and results of research that has been described, it can be concluded that: (1) The instructional materials were developed consist of lesson plan, students' book, worksheets, assessment and power point media; (2) The instructional materials developed were valid with good category in construct, content, language, empirical validity, and contain principles of cooperative group investigation; (3) The teacher implemented the lesson plan well, the increased students activities were indicated by doing investigation, analyzing the result investigation and presenting the final product that can empowering students' thinking skills. Based on the results of the research, the instructional materials of the colloidal system topic which developed can empower students' thinking skills.

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