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The development of teaching material of concept maps based on inquiry as an effort to trained high-order thinking skills of chemistry education students

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Abstract. Higher order thinking skills (HOTs) are needed by the students of chemistry education, because they will become teachers who will be able to teach HOTs to the students. Teaching materials on selected learning tools are isomers (structural and stereochemistry isomers) because these subject matter are rich concepts with abstract characteristics and interrelated concept - concept, so to study it required the ability to higher order thinking, Such as the ability to analyze, evaluate, and synthesize (create). This research is in the form of research of development of teaching material of concept map based on inquiry with the subject research of 5 experts (content validation) and 30 students of chemical education year 2015 (empirical validation). The purpose of this research is to know the role of teaching material in: (1) to increase student's of HOTs and (2) ability to retention of HOTS. The results showed that the teaching material to developed: (1) has the effectiveness, because capable of improving learning achievement and higher level thinking skills shown by the increasing score gain in the category of medium to high; (2) The students had relatively good HOTs retention capability after retention test within two months after post test
Keywords: high order thinking skills (HOTs), Concept map, inquiry strategy

Introduction

Education in Indonesia today are faced with some very strategic issues, among others: (a) learning should involve learners actively in finding and building knowledge through higher order thinking and inquiry, problem solving and collaborative work and collaborative learning [1] ; (b) learners should possess the ability to think critically, to reason, to apply conceptual knowledge and procedures to solve problems, and presents the linkage concept of the material on lessons learned effectively and creatively [2, 3].

Based on these strategy issues, then in studying science (chemistry), the chemistry teacher and candidates of teacher must have the ability to higher order thinking skills, inquiry, and understand the concepts of chemistry that will be taught in depth and strongly, which in turn they will be able to teach their students.

Numerous reports support the view that the interplay between studying the chemistry concepts with inquiry and higher order thinking is a source of difficulty for many chemistry learners: (a) The concept of the chemical abstract it is necessary for higher level thinking skills in order to obtain a correct understanding. Rote learning (recall) is a relatively difficult learning to use in studying the chemistry concepts are abstract and difficult. Meaningful learning is a learning model that fits in studying chemistry teaching materials, the researchers found evidence that when students use rote learning, it will experience a misunderstanding understand chemistry concepts. [4]; (b) Chemical content (organic

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chemistry) generally have a lot of concepts that are abstract, organized hierarchically, and often between concepts are having relationship [5]; (c) Studying the chemistry concepts (concept in organic chemistry) is often perceived as a difficult subject, because the concept of abstract and require higher order thinking skills [5. 6]; (d) Learning of Chemistry (organic chemistry), requires much of inquiry, higher order thinking skills, and comprehension of concept, because teaching material in chemistry is many contains of abstract concepts, the concepts are arranged hierarchically, and generally between concept - concept have relationships [7]; (e) the acquisition of knowledge isomers (structural and stereo chemical) is very difficult and concepts confuse learners [8]; (f) The understanding of the teaching material of isomer especially of stereochemistry, learners are often difficult to understanding and confusing [9,10]; (g) In order to improve students' understanding of conceptual knowledge can use learning strategies that engage students in higher order thinking skill through of inquiry activities, collaboration learning, discussions, brainstorming, argument, and simulation [11]; (h) The learning process should be able to engage students actively in building of knowledge through activities to identify, analyze, synthesize, and evaluate learning materials studied, and simulate or explain back to the audience and onshore apply knowledge in other situations. Teaching strategies that can be used may be learning and work collaboratively in both the investigation and discussions, brainstorming, simulation, and implementation [12]; (i) The presentation of knowledge of concepts of students with concept mapping strategy can be enhances their performance and academic achievement in organic chemistry and retention of the knowledge [13]; (j) by introducing students of instruction based on concept with to use concept map to universal themes and engaging of students in active learning: (1) creates connections new knowledge with students' prior knowledge; (2) facilitates deeper understanding of content knowledge; (3) facilitates for students to respond of problems to use higher order thinking; (4) will be able to improve the ability to learning outcomes, higher order thinking skills of Bloom's taxonomy, and the ability to communicate [14]; (k) The concept maps (Cmaps) are valuable tools for assessing the effectiveness of the conceptual changes provoked by engagement activities of students and inquiry done of teaching materials at the classroom [15]; (l) the strategy of inquiry is one way to achieve conceptual understanding for students [16]; (m) Angelo and Cross (1993) indicate that the use of concept maps develop students' abilities to draw inferences from observations, analyze, evaluate, synthesize and integrate information. Concept mapping also enables students to make meaning out of information, make judgments and develop informed opinions [17].

Based on the opinion of several experts at above, then to study teaching materials chemistry which is rich with abstract concepts, arranged in a hierarchy, and often a relationship between concepts, it is necessary to meaningful learning with the strategy of inquiry and the ability to higher order thinking skills. The learning process should use the strategy of inquiry with collaborative learning to engage students actively in the activities of observing, analyzing, synthesizing and evaluating key concepts teaching materials, discussing, and brainstorming, so it will be able to provide concrete and meaningful experiences for students. The learning outcomes of concept map with strategy of inquiry are can expected to improve learning achievement, higher order thinking skills, communicate, and can have a retention time longer retain of concepts in cognitive long-term memory.

According to some experts, the concept is: (1) a process of mental functions and is used as a tool to facilitate communication and express ideas, (2) an order or relationship in a group of objects or events indicated by the word or words, signs or symbol. The concept has five essential elements: (a) the name of the concept, (b) the definition of the concept, (c) attributes determinants such as the attributes of critical and attributes variables, (d) the value, and (e) examples [18, 19, 20]. The process the find of concept is often referred to the concept of assimilation concept or acquisition concepts [21]. Alice and Glenda (2009), in detail found based learning acquisition and understanding of the concept of a multi-step process including: (1) specifies the name of the critical (main) feature concept; (2) mentions some additional features of the concept of (critical attributes and attribute variables); (3) the type of concept, (4) provide an example or non-sample or prototype or non-prototype concept (5)

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identify and hierarchy of concepts (main concept, super ordinate, ordinate, subordinate, sub-subordinate).Teachers can help by alerting students when a key concept is being introduced, and identifying the explicit characteristics of the concept [22]. Students need to understand whether the concept is concrete, abstract, verbal, nonverbal, or process. In any subject area, students should be aware of the key concepts they must learn. The students must be able to identify, analyze, synthesize, and evaluate key concepts and they must be practice them [23].

Learning theory of learning that can be used in learning concept that has characteristics that are abstract concepts, organized hierarchically, and the relationship between the concepts of having a theory of meaningful learning [24. (25]. Meaningful learning theory has three principles: (1) when the learner can visualize these concepts and classifying it in the cognitive structure of learners; (2) classification of the concept starts from the concept of the most general to the most specific; (3) the readiness of learners that includes the knowledge that learners have today and receive knowledge/new concepts and linking with prior of knowledge [20].

Based on the theory of meaningful learning that the concepts are arranged hierarchically and inter-concept has can be used in learning concept map (CM). CM is the visualization of relationships between concepts in the form of two-dimensional graphical representations and concepts are represented by rectangles or circles. The linkage between two or more concepts will be connected with the line of arrows (→ labeled conjunctive) called with a proposition that meaningful relationships between concepts [26]. Learning of concept map suitable for use on the knowledge they have the characteristics of a declarative (conceptual) and procedural. Declarative knowledge is knowledge that requires explanation; whereas procedural knowledge is organized procedures such steps hierarchically organize concepts. The steps in preparing a concept map requires investigation (inquiry) capabilities, the invention of the concept contained in teaching materials and higher order thinking skills [27]. The higher order thinking skills include of analyzing, evaluating and synthesizing [28]. Vygotsky (1978) states there are four principles of constructivist learning theory underlying concept mapping, namely: (1) students to actively construct knowledge through relationships between concepts/ideas and experience / prior knowledge; (2) learners will personally create meaning through analyzing and synthesizing the experience so that new understanding can be constructed; (3) learning activities should foster the integration of thoughts, feelings and activities (actions) that help learners in the development process of meaning; (4) learning is a social activity that can be enhanced through learning and collaborative investigation between facilitators and learners or between learners with other learners. [29].

Piaget (1964) sees cognitive development as.... while at the formal operational stage (12 years and above), they can engage in formal thinking as well as abstraction. Piaget believed that the process of thinking and the intellectual development has also two on-going processes: assimilation and accommodation. There is assimilation when a child responds to a new event in a way that is consistent with an existing schema. There is accommodation when a child either modifies an existing schema or forms an entirely new schema to deal with a new object or event [30]. Ormrod, J.E. (2012) in the model Piaget developed in stage three, he argued that intelligence develops in a series of stages that are related to age and are progressive because one stage must be accomplished before the next can occur. For each stage of development the child forms a view of reality for that age period. At the next stage, the child must keep up with earlier level of mental abilities to reconstruct concepts. Piaget conceived intellectual development as an upward expanding spiral in which children must constantly reconstruct the ideas formed at earlier levels with new, higher order concepts acquired at the next level [31]. Based on the theory of Piaget, the teaching learning based on concept map is an appropriate learning in developing the ability to construct and relate the concept of linkages between concepts has a hierarchical structure. Piaget believed that learners who have over 12 years of age have been able to be invited to formal thinking to understand concepts such abstract concepts contained in the science of learning materials, such as concept isomer of organic chemistry.

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A concept map is used to help students organize and represent knowledge of a subject. Concept maps begin with a main idea (or concept) and then branch out to show how that main idea can be broken down into specific topics. Concept mapping used as learning and teaching technique, concept mapping visually illustrates the relationships between concepts. Often represented in circles or boxes, concepts are linked by words and phrases that explain the connection between the concepts, helping students organize and structure their thoughts to further understand information and discover new relationships. Most concept maps represent a hierarchical structure, with the overall, broad concept first with connected sub-topics, more specific concepts.

Concept mapping is a powerful way for students to train of higher order thinking skills and to reach high levels of cognitive performance. A concept map is also not just a learning tool, but an ideal evaluation tool for educators measuring the growth of and assessing student learning. As students create concept maps, they reiterate ideas using their own words and help identify incorrect ideas and concepts; educators are able to see what students do not understand, providing an accurate, objective way to evaluate areas in which students do not yet grasp concepts fully. Concept mapping serves several purposes for learners: (1) helping students brainstorm and generate new ideas; (b) encouraging students to discover new concepts and the propositions that connect them; (c) allowing students to more clearly communicate ideas, thoughts and information; (d) helping students integrate new concepts with older concepts; (e) enabling students to gain enhanced knowledge of any topic and evaluate the information. Learning of concept map with inquiry strategies can be done at level 3 [32], in which learners must investigate and find their own concepts (No condition) in teaching materials or topics under the guidance of educators. This level is suitable for a given learners who "experienced" or students in the second year and above (Figure 1).

The means to training for the learners to understand the preparation of concept maps can be done on 2 levels (list of concepts), namely educators provide 15 to 20 key concepts, and then learners to construct of concept maps based hierarchy concepts. Whereas developed of learning model of EASCI for the training of higher order thinking skills used concept maps level 3 “no conditions”. Students in the learned process of concept map “no conditional” will be identify of the key concepts, analyze, evaluate from handout and synthesis to create/building of hierarchy concept map. Evaluation at concept map level 3 (no condition) is used way of Markham, et.al, 1994 [33] as a result of the development of the rubric developed by Novak and Gowin [34], with a scoring rubric as follows: concept (1); preposition (1); linked (1); cross linked (10); level (5), and example of concept (1).

Based on strategic issues currently of developing learning and learning theory developed meaningful learning (Ausubel), theory of cognitive development and constructivist (Piaget and Vygostky), information processing theory, and the concept map (Novak and Canas) above, it is necessary to develop innovative learning models. Learning to engage learners actively in the investigation, identification, analysis, synthesis, evaluation, discussion, brainstorming, communication, collaboration to understand, construction concepts, and has the ability to maintain an understanding of concepts (retention) is relatively long in structure learners cognitive learning model offered by the "*PAKSI” (Pelibatan, Asimilasi-akomadasi, Kolaborasi, Simulasi, dan Implementasi, Indonesia language*) or ”EACSI” with the following five syntax; (Engagement, Assimilation-accommodation, Collaboration, Simulation, implementation).

Model EACSI and teaching materials (containing are an outline plan of lectures, student handbook, student activity sheets, student activity observation sheet, and an evaluation sheet) to be developed that are organic chemical material (isomers), because teaching materials of isomers are materials that are rich in abstract concepts organized, the concept is generally arranged hierarchically, and there is often a relationship between concepts that require higher order thinking skills and inquiry of learners [35]. Prospective teacher or a chemistry teacher who studied chemistry (science) must have the ability in inquiry, higher order thinking skills, and understand the concepts of chemistry (organic chemistry) correctly, because they will be taught to students. In connection with the foregoing, this

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study aims to determine the feasibility study of learning model EACSI with teaching materials with eligibility based on three indicators: (1) validity; (2) effectiveness; and (3) practicality [36].

"We have been referring to quality of educational products from the perspective of developing teaching model and learning materials. However, we consider the three quality aspects (validity, practically and effectiveness) also to be applicable to a much wider array of educational product."[36].

Learning model of EASCI and teaching material as feasible if each criterion of the three criteria is fulfilled as of: (1) the validity of (at good or a minimum score of > 3); (2) effective when the increase in gains scores (minimal medium or 0.7> (<g>)> 0.3 [37] and retention scores (there was no significant difference between the posttest and retention test, significance level of 95%) and; (3) scores practicality (minimal good > 0.70).

EXPERIMENTAL SECTION

Materials

The materials used in this research among others: (1) handbook of isomer developed based on EACSI; (2) Student Worksheet, (3) syllabus and lesson plan; (4) learning outcomes assessment rubric and; (5) Learning of media such as LCD, PPT

Instrumentation

instruments used at this research are: (1) validation sheet of learning models for focus group discussion (FGD); (2) validation sheets of learning device; (3) observation sheets of learning process; (4) observation sheet of student activity during the learning process; (5) questionnaire sheet for student response; (6) instrument for academic test (objective and subjective test) for pretest, posttest, and retention test.

Procedure

This research design is a research and development (R & D), to test the feasibility (validity, effectiveness, and practicality) of learning models and teaching of developed that are used, by adopting and adapting of the research design developed by Nieveen [38], shown in the Figure 2.

This model is expected to be able to answer the problem formulation of the feasibility study learning model of EACSI (PAKSI) and teaching material. The development stage design of learning model can do theoretical validation by experts that includes validation of the contents and construction with the involvement of 7 experts (5 professors and 2 doctors, where 2 professors and 1 doctoral competent in accordance with the field). Validation was conducted to determine the validity of theoretical learning model that was developed based on the theory of learning and the impact that may occur when the model is tested to the learners. The validity of theoretical learning model includes six (6) components, namely: 1) learning objectives; 2) the social system; 3) Support System; 4) Reaction principle; 5) The impact of instructional and impact accompanist, and 6) Syntax [38]. Based on the theoretical of teaching learning and then learning model development EACSI (PAKSI) has five syntax: engagement, assimilation-accommodation, collaboration, simulation, and implementation. While the validation of teaching material to perform by 3 experts who are competent in the field, namely two professors and one doctor. instrument validation to used for validation of teaching material device that adoption and adaptation of the instrument validation teaching material was adoption and adaptation from developed by The Ministry of National Education Republic of Indonesia [39], which has been through a validation process of 2 experts are competent in accordance with the field.

Based on the results of theoretical validation, model of learning by teaching materials tested empirically on 24 students of chemical education' 2015 who follows off course of organic chemistry 1 (subject matter isomers). Empirical validation test is used to determine the practicality and effectiveness of teaching materials and learning models EACSI (PAKSI). The relationship between

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the data required and the methods and instruments used to collect data and research success criteria can be seen in Table 1.

RESULTS AND DISCUSSION

Validity of the theoretical learning model of EACSI and teaching material

The results of theoretical validation from 7 experts on learning model of EACSI consisting of (a) content validity: rational of issues, learning theories that support, student-centered, and curriculum; and (b) construct validation: learning objectives, social system. Supporting the system, reaction principle, the impact of instructional and impact accompanist, and syntax can be seen in Table 2 and Table 3.

Based on the results of content validation and construct validation of the learning model as in Table 2 and Table 3 above, it appears that each components of content validity and construct validation of learning models of EASCI have met the criteria, because each components are given a score>3.5 (> 3,0), thus gaining feasible criteria (40) . Although there are several proposals specific improvements in components such as: the principle of reaction and accompanist impact.

Validation of teaching material performed by 3 experts to validate the feasibility of theoretical of teaching materials device includes to the validity of the concept, regularity of concepts, grammar/ sentence, layout of picture and the format. The results of theoretical validation of teaching materials can be seen in Table 4.

Based on the results of the validation of each component obtained an average score of 3.3 – 4.00 (> 3.0) with category feasible, however, it still needs to be improvement as several small parts concept, grammar, typo. And layout drawings isomeric form.

The results validate of empiric of Learning Model of EACSI and Teaching materials

Practicality

The model and the learning device can be viewed from two components, namely the implementation of learning and questionnaire results learners. Observations were due by 3 observers. Result of observation. Involvement of Students College in the learning process by using EACSI learning model can be seen in the following Table 5.

Based on data from the Table 5, it appears that each component of teaching model EACSI i.e. engagement, assimilation-accommodation, collaboration, simulation, and implementation with support teaching material of obtain a score between 3.60-3.89 above score 3.50 in the category very good. This means that learning with the learning model EACSI able to motivate and to activate/engage learners in activities of discussion, expressing an opinion/ideas, collaborate, communicate the results of good performance through simulation and implementation, and the ability of higher-order thinking such as analyzing, evaluating concepts and synthesize (create) a concept map.

Overview of the activities of the learning model of EACSI (Engagement, Association – accommodation, Collaboration, Simulation, Implementation) can be seen in Figure 3.

Data from Table 5 is also supported by data from a questionnaire that can be shown in Table 6. Based on Table 6, shows that students college gave of a positive response to the learning process EACSI model of learning and the teaching materials used, obtain a score of 93-100% (> 61%). Therefore, based on tables 5 and 6, the learning model EACSI has practicality for use in HOTS training for Students College of chemical education, though it still needs to be improved.

Effectiveness

Effectiveness refers to the extent that the experiences and outcomes with the intervention are consistent with the intended aims (40). Effectiveness of learning model of EACSI in terms of two criteria, namely the increase in gain scores and retention test. The Limited test of learning model of EACSI to conducted on 24 students of higher education chemistry in an effort to improve HOTS. Test

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scores are used to determine the gain increase between pretest to posttest. The result of an increase in the gain scores on each component such as analysis, evaluation and synthesis can be seen in Table 7.

Based on table 7 shows that the students: a) in analytical (C4), the ability of analysis (C4) there are as many as four students (16.7%) who experienced an increase in gain scores with low category, nine students (37.5%) with medium categories, and eleven students (45.8%) with a high category. When viewed from the increase in gains scores of categories medium – high were 20 students (86%, 3%), yet still there are 13 students (54.2%) who have not mastery in the test of the ability to analyze, and average normalized gain <g> = 0.65 (medium category); b) in evaluation (C5), the ability of evaluation (C5) there are as many as sixteen students (66.7%) who experienced an increase in gain scores with medium category, and eight students (33.3%) with a high category, yet still there are 17 students (71%) who have not mastery in the test of the ability to evaluation and average normalized gain <g> = 0.67 (medium category); c) in synthesis/create (C6), the ability of synthesis/create (C6) there are as many as five students (20.8%) who experienced an increase in gain scores with medium category, and nineteen students (79.2%) with a high category, yet still there are seven students (29.2%) who have not mastery in the test of the ability to synthesis/create, and average normalized gain <g> = 0.74 (high category).

Therefore, based on the limited test EACSI learning model developed has been able to increase significantly the value of obtaining the analysis, evaluation and synthesis skills. Fixed to each component of the analysis, C4 (54.2%). evaluation, C5 (71%), and synthesis/create, C6 (29.2%) have not been able to mastery learning. So learning model of EACSI are still not able to classical mastery learning, because there are <75% of the number of students in the classroom have not reached a score of 75. This is consistent with the theory of Piaget and Novak that the students are still in the stage of "semi-beginner" to analysis and evaluation of key concepts from teaching materials and to construct of concept map from key concept. so the student are need for more intensive training to conduct an analysis of key concepts contained in teaching materials, evaluation of key concepts, and create a concept map. according of Vygotsky that it is necessary for the training stage by stage (scaffolding) to students so that they can be trained to analyze, evaluate key concepts in teaching materials and draw up a hierarchy of concept maps is good and right. Some examples of the results of the synthesis/create of concept maps can be seen in Figure 4.

The retention test was conducted to determine the high-order thinking skills of learners in keeping his knowledge after 3 months retention test. The results of retention test can be seen in Table 8 (analysis with SPSS 16, Figure 5). Based on the table 8, it appears that the learners after retested after a period of three months after the posttest, using test instruments equivalent to instruments post test, learners are able to maintain (retention) of each of the components of thinking skills such high levels analysis, synthesis, and evaluation. It is seen that the value of Sig (0.00-0, 02) <α (0.05), it can be concluded that there is a significant correlation between the results of the posttest – retention test. There are differences in average significantly between test scores post-test and retention test, and tends to increase high order thinking skills.

This indicates that the knowledge of higher order thinking skills of learners enter into long-term memory of learners. This premise is supported by the information processing theory to explain when the knowledge (concepts) are frequently used and have entered into long-term memory cognitive learners, then such knowledge will be stored in long term memory of students. While based on the constructivist theory and learning from Ausubel, knowledge learners will be able to continue to grow when the learner is able to link the knowledge that has been owned previously by new knowledge. Knowledge then this knowledge has entered into long-term memory of students, then such knowledge will be presented again when the time taken back again.

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CONCLUSION

Based on data obtained from the validation of theoretical and empirical validation of the above, it can be concluded that "learning model EACSI along with teaching material can be said to be feasible to use in the experiment is limited (24 students) because it has met:

1. validity of the construction and validation of content: (a) each component of the six components of the model of learning, such as learning objectives, the social system, supporting the system, reaction principle, the impact of instructional and impact accompanist, and syntax, given a score > 3:50 (feasible category); (B) each component in the validation of teaching material, namely Eligibility contents and feasibility of construction obtained a score of> 3.50 (feasible category).
2. Practicality, the sixth component of learning from the learning model of EACSI that engagement, assimilation-accommodation, collaboration, simulation, and implementation has met the criteria of practicality with a score above 3.50 (very good category). Students College of chemistry education gave of a positive response to the learning process EACSI model of learning and the teaching materials used, obtain a score of 93-100% (> 61%).
3. Practicality of teaching models of EACSI in terms of differences in gain scores and the ability to maintain a high level thinking skills (retention). Practicality EACSI models have a relatively good practicality because: (a) is able to increase the average score gain the ability to think critically learners i.e. for analytical skills, average normalized gain <g> = 0.65 (medium category), evaluation, average normalized gain <g> = 0.67 (medium category), and synthesis / create, average normalized gain <g> = 0.74 (high category); (b) based on spss 16 test, learners are able to maintain (retention) of high order thinking skills.

However, the learning model of EASCI with teaching material still needs to be tested or disseminated for the classes are larger root of the obtained results more evolved again to be used as learning models in the study of teaching materials that are rich in abstract concepts are arranged hierarchically and can to used of train ability of high order thinking skills for of learners.

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