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# *The Development of Learning Model of Map Concept with Inquiry Strategy*

Ismono*, Sri Poedjiastoeti, Suyatno Suyoto
*Department of Chemistry*
*Universitas Negeri Surabaya*
Surabaya, Indonesia
ismono@unesa.ac.id

***Abstract*—Higher order thinking skills (HOTs) are needed by the students of chemistry education, because they will become teachers who will be teach HOTs for students. This research is research and development. this study has the aim to examine the feasibility of developing concept map learning models with inquiry strategies. The specific purpose of this research is to find out: (1) validity; (2) practicality; and (3) the effectiveness of the model. the research design used is the design of the plomp with steps: preliminary research, development, and assessment of model. the subject of this study is a concept map learning model with inquiry strategy. the research method used is FGD, observation, learning outcomes test, and student response. The instruments used include validation sheets, observation sheets, test , and questionnaire. analysis of research data using descriptive and inferential analysis using spss version 16. The results of the study are: (1) the concept map learning model with inquiry strategy has an assessment with a very valid category with a score of> 3,0; (2) practicality shown by the implementation of the learning plan> 90%, student activity > 90%, and student participation response> 90%; and (3) effectiveness, which is indicated by an increase in gain scores with median categories (0.3 < (<g>) <0.7, and high order thinking skills with good categories (51 – 75), as well as the ability to maintain knowledge (retention) within 4-5 months after posttest. The conclusion that the learning model of concept map with inquiry strategy is feasible.s electronic document is a "live" template and already defines the components of your paper [title, text, heads, etc.] in its style sheet.**

***Keywords—Development of teaching, higher order thinking skills, Concept map, Inquiry Strategy***

## I. 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 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 and the ability of 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) the use of concept maps can be develop students' abilities to analyze, evaluate, synthesize, inferences, and integrate information; (n) 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) 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), has opinion 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) Piaget understands that development as children's intellectual is like a spiral shape, where children must constantly reconstruct ideas formed at the previous level with higher new concepts obtained 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.

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).

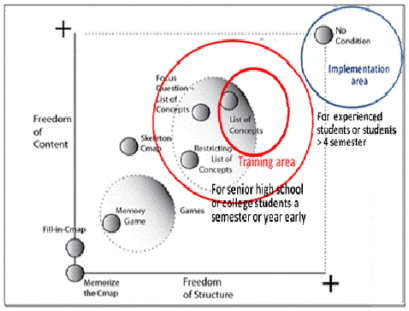


Fig. 1. The method used to implementation learning model of concept map with inquiry strategy (adoption and adaptation from Strautmane (2012).

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 concept map with inquiry strategy 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 ”Concept map with strategy inquiry” with the following five syntax; (Engagement, Assimilation-accommodation, Collabo ration, Simulation, implementation).

Model concept map with strategy inquiry 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 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].

Learning model 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).

## II. Experimental Design

The design of this study refers to the design of Plomp (2010) namely: preliminary study, model development, and assessment.

### A. Materials

The materials used in this research among others: (1) syllabus and lesson plan, (2) handbook of isomer; (3) student worksheet; (4) learning outcomes assessment rubric and; (5) learning of media (PPT and Molymod).

### B. Instrumentation

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

### C. Procedure

This research design is a research and development (R & D), to test the feasibility by Nieveen and Plomp [37] (validity, effectiveness, and practicality) of learning models and teaching of developed that are used, by adopting and adapting of the research design developed by Plomp [37], shown in the Figure 2.

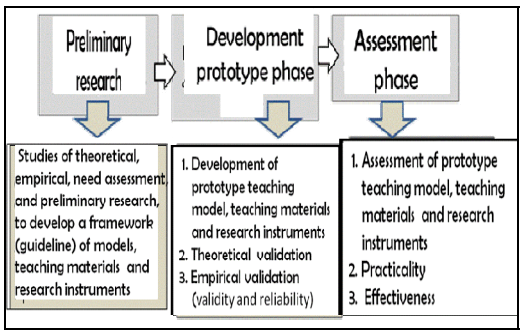


Fig. 2. The design of research and development in the development of teaching model and learning materials (adoption, adaptation and modification Nieveen & Plomp (2010) [37]

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 of concept map with inquiry strategy 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 3 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 learning models and teaching materials of EACSI (engagement, association-accommodation, collaboration, Simulation, Implementation)

## III. Result and Discussion

### A. Validity of The Theoretical Learning Model of Concept Map With Inquiry Strategy and Teaching Material

The results of theoretical validation from 3 experts on learning model of concept map with inquiry strategy consisting of (a) content validity: rational of issues, learning theories that support, student-centered, and curriculum; and (b) construct validation: learning objectives, social system. Based on the results of content validation and construct validation of the learning model, it appears that each components of content validity and construct validation of learning models of concept map with inquiry strategy have met the criteria, because each components are given a score>3.5 (> 3,0), thus is valid (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.

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

### B. Practically

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. Based on data, it appears that each component of teaching model of concept map with inquiry strategy i.e. engagement, assimilation-accommodation, collaboration, simulation, and implementation with support teaching material of obtain a score between 3.75-3.89 above score 3.75 (94% > 90) (very good). This means that learning with the learning model of concept map with inquiry strategy 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. Data from a questionnaire that can be shows that students college gave of a positive response to the learning process with concept map with inquiry strategy and the teaching materials used, obtain a score of 93-100% (> 61%). Therefore, based on data, the learning model concept map with inquiry strategy has practicality for use in HOTS training for Students College of chemical education, though it still needs to be improved.

### C. 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 concept map with inquiry strategy in terms of two criteria, namely the increase in gain scores and retention test. The Limited test of learning model of concept map with inquiry strategy to conducted on 68 students of higher education chemistry in an effort to improve higher order thinking skills (HOTS). Test scores are used to determine the gain increase between pretest to posttest. Based on data 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 concept map with inquiry strategy 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 concept map with inquiry strategy 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.

The retention test was conducted to determine the high-order thinking skills of learners in keeping his knowledge after 3 months retention test. Based on the data, 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.

## IV. Conclusion and Suggestion

### A. Conclusion

Based on data obtained from the validation of theoretical and empirical validation of the above, it can be concluded that "learning model concept map with inquiry strategy 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 (valid); (B) each component in the validation of teaching material, namely Eligibility contents and valid of construction obtained a score of> 3.50 (valid).

*2)* Practicality, the sixth component of learning from the learning model of concept map with inquiry strategy 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 concept map with inquiry strategy model of learning and the teaching materials used, obtain a score of 93-100% (> 61%).

*3)* Practicality of teaching models of concept map with inquiry strategy in terms of differences in gain scores and the ability to maintain a high level thinking skills (retention). Practicality concept map with inquiry strategy 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), evaluation, average normalized gain <g> = 0.67 (medium), and synthesis / create, average normalized gain <g> = 0.74 (high) and good; (b) based on spss 16 test, learners are able to maintain (retention) of high order thinking skills.

### B. Suggestion

Considering that isomeric material is a material that is rich in abstract concepts, organized hierarchically, and between concepts has relevance, then:

*1)* to facilitate learning of isomers, it is better to use molecular structure models and interesting learning media

*2)* It is necessary to educate prospective teacher candidates to be trained in higher-order thinking skills

*3)* It is necessary to research the concept map learning model with inquiry strategies on a large scale

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