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Development of Mole Concept Module Based on Structured Inquiry with Interconection of Macro, Submicro, and Symbolic Representation for Grade X of Senior High School

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Abstract. The research has created the module of mole concept based on structured inquiry with interconection of macro, submicro, and symbolic representation and determined the validity and practicality of the module. The research type was Research and Development (R&D). The development model was 4-D models that consist of four steps: define, design, develop, and disseminate. The research was limited on develop step. The instrument of the research was questionnaire form that consist of validity and practicality sheets. The module was validated by 5 validators. Practicality module was tested by 2 chemistry teachers and 28 students of grade XI MIA 5 at SMAN 4 of Padang. Validity and practicality data were analysed by using the kappa Cohen formula. The moment kappa average of 5 validators was 0,95 with highest validity category. The moment kappa average of teachers and students were 0,89 and 0,91 praticality with high category. The result of the research showed that the module of mole concept based on structured inquiry with interconection of macro, submicro, and symbolic representation was valid and practice to be used on the learning chemistry.

1. Introduction

Basically, chemistry describes the structure, composition, properties and changes of matter and energy that accompany it (Brady, 2012). One of the chemistry lessons learned in class X is Mole Concept. The mole concept examines the number of particles. Mol is used as the quantity that connects the mass unit of matter, the number of particles, and the volume of gases involved in chemical reactions. Chemical calculations will be easier to apply with mole concept.

According to curriculum of 2013, the right approach in the learning process is the scientific approach. The scientific approach is believed to be the golden tool for the development of the attitudes, skills and knowledge of learners (Kurniasih, 2014). One of the learning models that suits with application of a scientific approach is inquiry.

Based on the level of teacher involvement in the learning process, the inquiry learning model is divided into inquiry confirmation, structured inquiry, guided inquiry and opened inquiry. In structured inquiry, students investigate questions provided by the teacher through the steps or procedure and receive guidance from each step to achieve the desired result. Students conduct direct investigation and develop basic skills in the investigation, such as making observations, hypotheses, collecting and processing data, and creating conclusions (Zion, 2012).

Several previous studies on structured inquiry had reported that LKS experiments and non-experiments on chemical equilibrium materials help students understand the material well, do the experiment, and improve student learning outcomes (Maryati, 2012). Chemistry laboratory guide

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based on structured inquiry in grade XII of SMAN 1 Indralaya Utara can improve students' understanding (Ariningsih, 2014). Learning vibration and wave materials through structured inquiry learning can increase learning interest and active student participation (Sugiarto, 2015).

In addition, learning chemistry should be emphasized on three levels of chemical representation (macroscopic, submicroscopic, and symbolic). A person's understanding of the concept of chemistry is determined by his ability to transfer and to connect the three levels of representation. In this time, learning chemistry just represents in two levels (macroscopic and symbolic), while submicroscopic level is seldom touched. Previous research had shown that inability of the students to represent chemistry at submicroscopic level can inhibit their ability to solve chemical problems related to macroscopic or symbolic levels (Sunyono, 2013). When studying a complex concept, using the multiple representations such as diagrams, graphs, and equations can be applied to facilitate the learning process (Ainsworth, 2008). The interconnection of macroscopic, submicroscopic, and symbolic is one of the keys to teaching chemistry (gilbert and treagust, 2009). This research aims to develop of mole concept module based on structured inquiry with interconection of macro, submicro, and symbolic representations for class X SMA and reveal the validity and practicality of module.

2. Methode

The type of this research was Research and Development (R & D). This research was conducted to develop of mole concept module based on structured inquiry with interconection of macro, submicro, and symbolic representations for class X senior high school and reveal the validity and practicality of the module. The object of this research is mole concept module which was developed. The instrument of this research was a questionnaire consisting of validity sheet and practicality sheet. The data obtained were analyzed using kappa moment (Boslaugh, 2008).

$$\text{Kappa moment } (k)=(\rho-\rho_e)/(1-\rho_e) \quad (1)$$

Information:
k = Moment kappa shows the validity of the product.
ρ = The realized proportion, calculated by the sum of the values given by the validator divided by the sum of the maximum value.
ρ_e =Unrealized proportions, calculated by the sum of the maximum value minus the total number of validated entries divided by the maximum number of values.

Table 1. The decision category based kappa moment (k)

Interval	Category
0,81 – 1,00	Very High
0,61 – 0,80	High
0,41 – 0,60	Medium
0,21 – 0,40	Low
0,01 – 0,20	Very Low
≤ 0,00	Unvalid

The module was designed using 4-D development model which consists of four development stages such as define, design, develop and disseminate (Trianto, 2014). This study was limited to the development stage. In the Define stage, There are 5 analyzes. They are front-end analysis, student analysis, task analysis, concept analysis, and analysis of learning objectives. Front-end analysis aims to elicit and define the basic problems faced by teachers and students in chemistry learning, especially on the mole concept material. This analysis obtained a description of facts, expectations and alternative solutions problem. Front-end analysis was done by interviewing some senior high school chemistry teachers. Student analysis was conducted to know the characteristics of students that include academic ability and student learning motivation.

Task analysis included the tasks that students do in learning and rellated with the selected material, mole concept. The steps were analized the basic competence (KD) and divided into several indicators then become the learning objectives. Concept analysis was identification the concepts to be taught and to construct them in the concept hierarchy form. The concept analysis in this research was conducted by identifying the concepts analyzed based on college chemistry books and relevant high school chemistry books.

Analysis of learning objectives was done by analyzing basic competence (KD) which was translated into several indicators then the indicator was translated into several learning objectives. The results of the define stage was carried out to the design stage. The Design stage aims to design of mole concept module based on structured inquiry with interconection of macro, submicro, and symbolic representation for class X SMA. The final stage of this research is the Development stage. This stage aims to produce a mole concept module based on structured inquiry with interconection of macro, submicro, and symbolic representation that revised based on validator suggestions.

3. Results and Discussion

3.1. Define stage

In the defining stage obtained 5 data. They were front-end analysis, student analysis, task analysis, concept analysis, and analysis of learning objectives.

3.1.1. Front-end analisys. In front-end analysis, it was found that some students still have difficulties in understanding the mole concept material. If the questions or exercises given to the students are varied or slightly different from the example discussed, students were confused about the questions.Usually, students were fixated on the formula that available on the teaching materials so that there has been no meaningful learning yet. Multiple representations provide facilities for the occurrence of meaningful learning or deep learning. Teaching materials used in schools are books, LKS, and powerpoint. Learning material in module form is not yet available. Moduleis one of the teaching materials that can help students to find concepts and enable students to learn independently.

3.1.2. Student analisys. Based on interviews conducted, senior high school students generally aged 16-18 years old. According to Piaget, the level of thinking of children aged 12-18 years is at formal operational development. At this stage the child is able to think abstractly and logically and has the ability to interpret, develop hypotheses and draw conclusions (Budiningsih, 2012). The results of interviews with chemistry teacher SMAN 4 of Padang are ability of academic and learning motivation of the student classified as "moderate". Motivation of students in learning is influenced by several factors, such as time. Students are more eager to learn in the morning than in the noon. In addition, the results of interviews with some students indicate that they prefer the learning process by using interesting teaching materials that are pictorial, colorful, and arranged in easy-to-understand language.

3.1.3. Task analisys. The task analysis was done by analyzing the basic competence(KD) which was then translated into several indicators. Basic competences (KD) of mole concept materials are:

- 3.11 Applying the concept of relative molecular mass, reaction equations, fundamental laws of chemistry and the concept of mol to complete chemical calculations.
- 4.11 Processing and analyzing relative molecular mass related data, reaction equations, basic chemical laws and the concept of moles to complete chemical calculations.

Basic competence was spelled out into several indicatorssuch as:

- Explaining the mole.
- Determining the molar mass and molar volume of the gas of a compound.
- Applying the mole concept in determining the chemical formula.
- Determining the formula of hydrate compounds.
- Calculating substance levels in the mix such as (percent, ppm, molarity, molality and mole fraction).

Based on the basic competencies and learning indicators, a mole concept module is designed to fit the task analysis so that the expected competencies can be achieved by the students at the end of the lesson.

3.1.4. Concept analisys. The concepts in this material are arranged in hierarchy concepts form. The concepts are mole concepts, molar mass, molar volume, empirical formulas, molecular formulas, hydrate compounds, and substance levels. The concepts were analyzed based on college chemistry books and relevant high school chemistry books.

3.1.5. Analysis of learning objectives. The learning objectives on mole concept materials are achieved through observation, hypothesis, collection and organization of data, and draw conclusions. The learning objectives in mole concept materials are:

- Explain the mole with the given data.
- Determine the molar mass of an element and compound known the A_r / M_r.
- Calculate the molar volume of the gas that known the mole.
- Determine the empirical formula of a compound if known mass and percentage of elements.
- Determine the molecular formula of a compound if known to the empirical formula.
- Determine the formula of a hydrate compound if the mass of the hydrate compound is known.
- Calculates substance levels (percent, ppm, molarity, molality and mole fraction) appropriately.

3.2. Design stage

The module of mole concept had been designed consists of: cover, module usage manual, core competences, basic competences, indicators, learning objectives, concept maps, activity sheets, student worksheets, and evaluation sheets. Module cover, learning indicators and objectives, activity sheets, worksheets, worksheet keys are respectively observed in Figures 1 through 5.



Figure 1. Cover

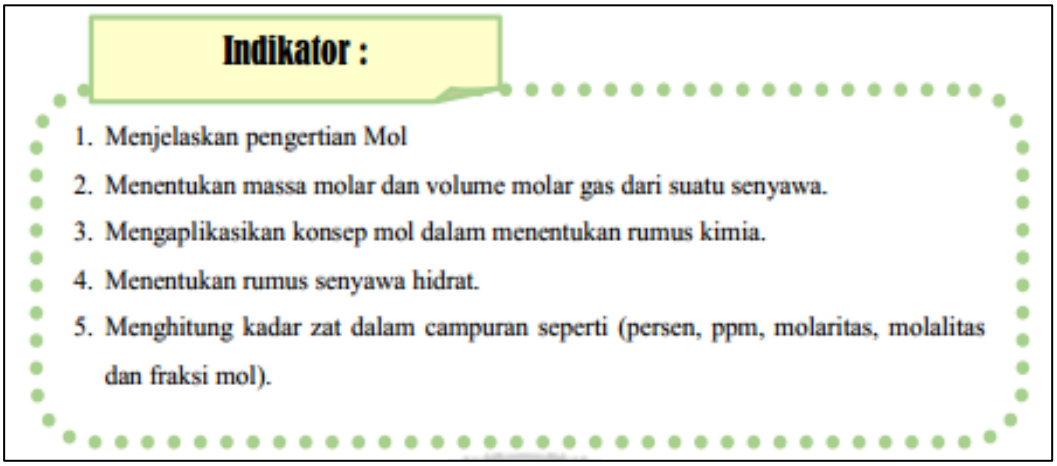


Figure 2. Indicator and Learning Objectives

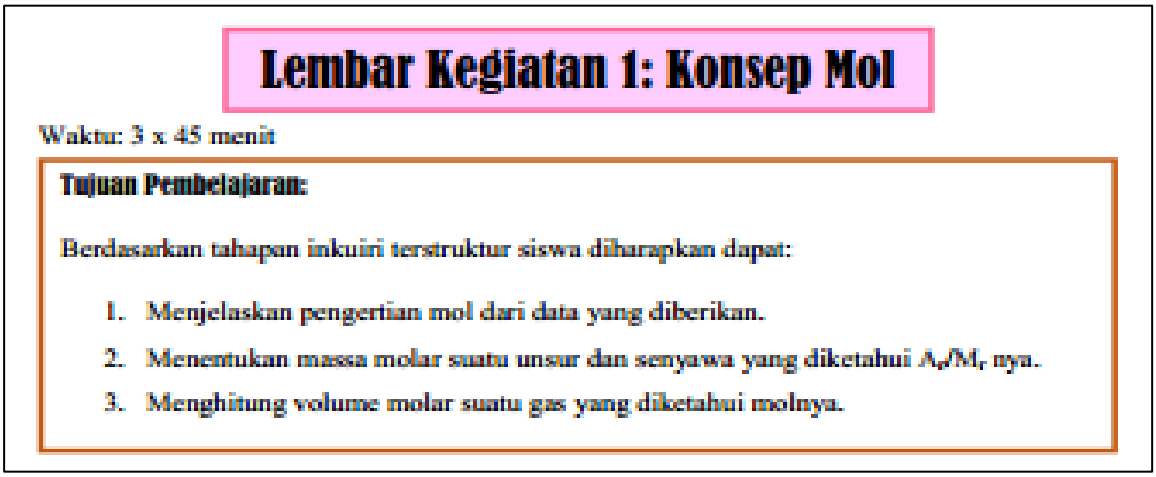


Figure 3. Activity Sheets

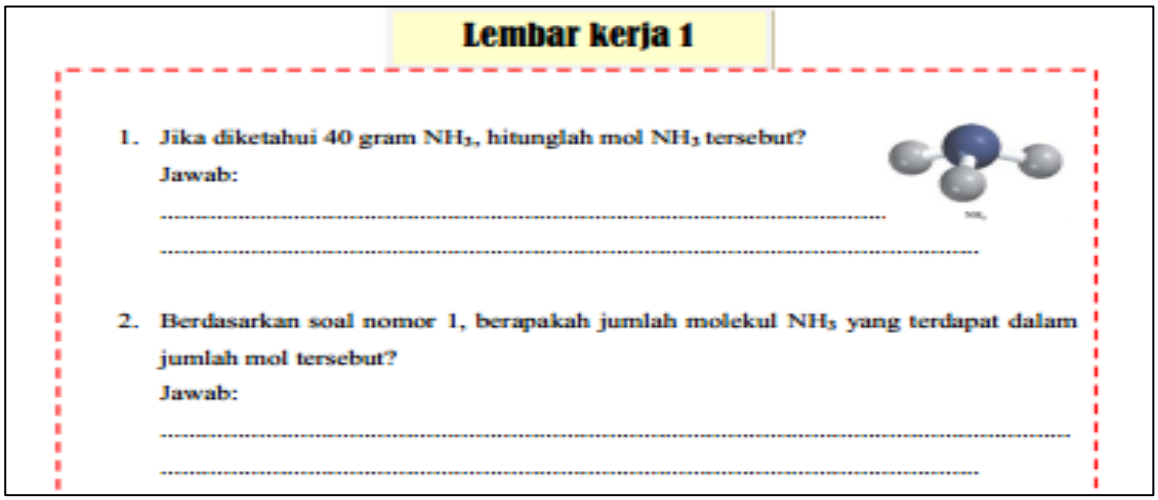


Figure 4. Worksheets

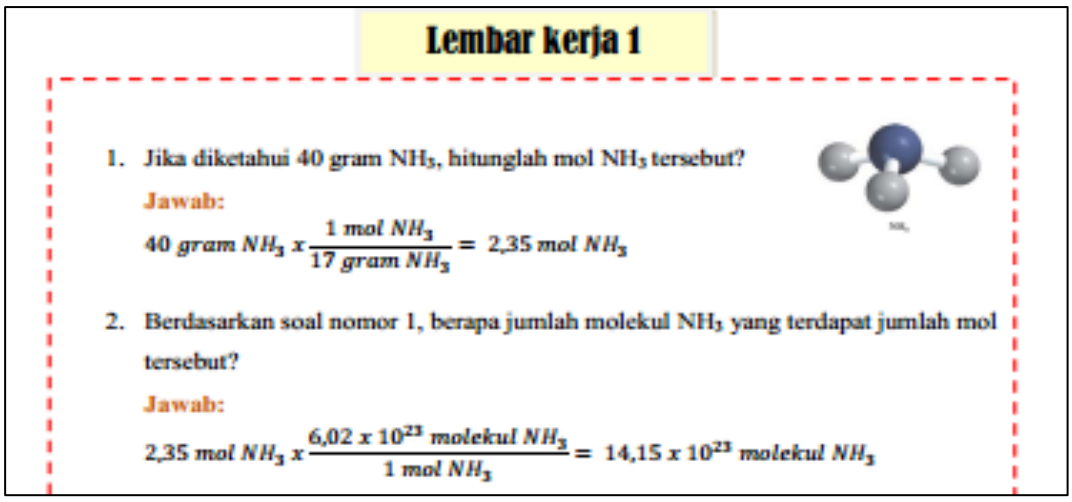


Figure 5. Worksheets Keys

3.3. Develop stage

This stage aims to produce the mole concept module based on structured inquiry with interconection of macro, submicro, and symbolic representations for class X senior high shcool based on the advice of the validators. This stage consists of three steps, such as the test of validity, revision, and practicality. The validity test aims to reveal the validity of the module. Validation was done by three lecturers and two chemistry teachers. The revision stage aims to improve the module that was considered still less precise by the validator before the product is tested. The revised module is given back to the validator for further discussion before it is tested. The revision is terminated when the validator has declared the module created is valid.

Product practicality test was done to teachers and students of SMAN 4 of Padang class XI MIA 5. This practicality test was aimed to find out the practicalities of mole concept module that developed include benefit, ease of use, and efficiency of learning time by using the module. The practicality of the module was done by using a questionnaire of practicality.

*3.3.1. Validity of the mole concept module based on structured inquiry with interconection of macro, submicro, and symbolic representation for class X senior high school.*The validity of mole concept module had a value 0.95 with very high category. This validity consists of four components, such as the components of content,component of module serving, language, and graphics.

Components of the contents of the module had a kappa moment 0.94 with very high category. This indicates that the modules are in accordance with the demands of core competence and basic competence. The questions contained in the module have led the students to find the concept. In addition, the exercise is direct application of the concept learned.

The component of module serving had a kappa moment 0.95 with very high category. This indicates that the module has been systematically arranged from the title, competency standard, basic competence, indicator, and in accordance with the structured inquiry stages of observation, hypothesis, collection and organization of data, and conclusions. Structured inquiry learning guides students to discover concepts by developing their basic abilities in investigation (Zion, 2012).

The linguistic component of the module had a kappa moment 0.96 with very high category. This indicates that the module use good and correct language according to Indonesian language rules and easy to understand. In addition, the questions asked in the module are clear and consistent in using symbols.

The graphic component had a kappa moment 0.97 with very high category. This indicates that the module has used a clearly observable image, the corresponding layout, which corresponds to the size of the letters, fonts, spaces, cover appearance, module content layout, and image illustration placement. The overall kappa moment value can be seen in Figure 6.

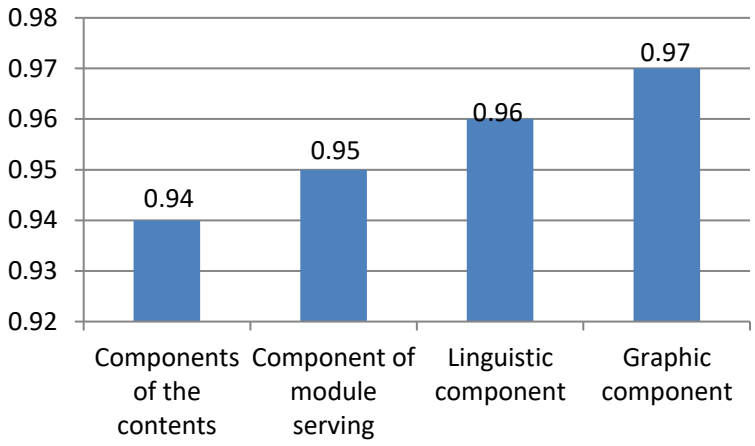


Figure 6. The curve of kappa moment value by validator

In Figure 6, it can be seen that from all aspects indicate that the value of the kappa moment is more than 0.81. The value of kappa moment 0.81-1.00 had a very high category so that the module developed otherwise valid (Sugiyono, 2013). A product is valid if product can indicate a condition that is in accordance with the contents and constructs (Arikunto, 2008).

3.3.2. Practicalityof the mole concept module based on structured inquiry with interconection of macro, submicro, and symbolic representatiosn for class X senior high school. Practicality of the module was assessed by chemistry teachers and senior high school students class XI. Assessment of practicality by teachers obtained kappa moment 0.89 with very high practicality and by students 0.91 with very high practicality. The Practicality consist of three components: ease of use, efficiency of learning time and benefits.

The ease of use component of the module had a kappa moment 0.90 from teachers and 0.91 from students with very high practicality categories. This shows the Module using easy language to understand, the questions are clear, the material is delivered in simple and portable size.

The learning time efficiency of the module had a kappa moment 0.86 from teachers and 0.88 from students with very high practicality. Learning by using modules can make learning time more efficient and students can learn at their own pace (Daryanto, 2014).

The benefit component of the module had a kappa moment 0.90 from teachers and 0.93 from students with very high practicality categories. This demonstrates the mole concept module help the student in finding the concept. The exercises allow students to have the opportunity to train themselve to learn independently. Module is also designed to attract students' interest in learning. Overall, value of kappa moments given by teachers and students can be seen in Figure 7.

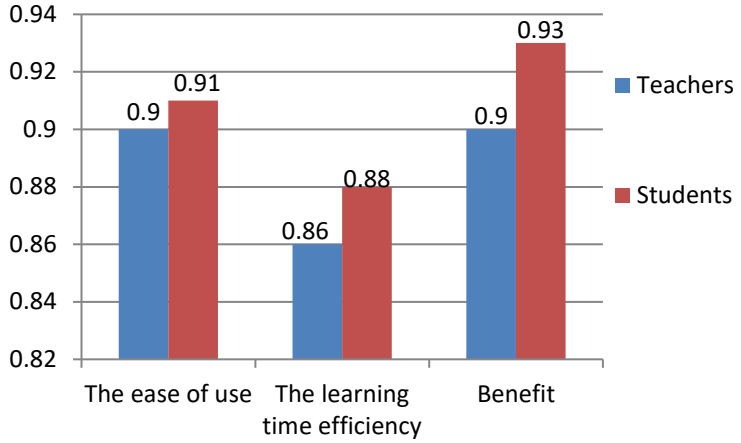


Figure 7. The kappa moment curve ofpracticality by the teachers and students.

Based on the above, it can be concluded that a mole concept module based on structured inquiry with interconection of macro, submicro, and symbolic representationhas beenpractice and can be used in the school.
follows:

- 11 point Timesor Times New Roman.
- The text should be set to single line spacing.
- Paragraphs should be justified.
- The first paragraph after a section or subsection heading should not be indented; subsequent paragraphs should be indented by 5 mm.

4. Conclusion

A mole concept module based on structured inquiry with interconection of macro, submicro, and symbolic representation has been produced using the 4-D development model. The module has a high validity and practicability both by teachers and students.

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