

THE DEVELOPMENT OF TEACHING MATERIAL BASED ON MACROSCOPIC AND SUB-MICROSCOPIC APPROACH TOPIC CHEMICAL EQUILIBRIUM FOR SUPERIOR SENIOR HIGH SCHOOL

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Abstrak

Telah dilakukan penelitian yang bertujuan untuk mengetahui kelayakan bahan ajar pada materi pokok Kestimbangan Kimia SMA yang diujicobakan secara terbatas di SMA Negeri 2 Lamongan. Rancangan penelitian mengikuti model pengembangan Thiagarajan (model 4D) tanpa melakukan tahap penyebaran (*disseminate*). Rancangan Bahan ajar ditelaah oleh dua dosen kimia dari Universitas Negeri Surabaya, satu guru kimia SMA Negeri 2 Lamongan, dan divalidasi oleh 3 dosen kimia Universitas Negeri Surabaya dan 3 orang guru kimia SMA Negeri 2 Lamongan. Hasil penelitian menunjukkan bahwa bahan ajar yang dikembangkan layak digunakan sebagai salah satu sumber belajar. Penilaian dosen kimia terhadap bahan ajar sangat layak dengan persentase rata-rata jawaban terhadap aspek materi secara umum sebesar 85,42%, aspek kesesuaian materi dengan level makroskopik dan sub-mikroskopik sebesar 81,25%, aspek penyajian sebesar 87,5%, dan aspek bahasa sebesar 80%. Penilaian guru kimia terhadap bahan ajar sangat layak dengan persentase rata-rata jawaban terhadap aspek materi secara umum sebesar 83,34%, aspek kesesuaian materi dengan level makroskopik dan sub-mikroskopik sebesar 83,33%, aspek penyajian sebesar 85,83%, dan aspek bahasa sebesar 83,33%. Respon siswa terhadap bahan ajar sangat layak dengan persentase rata-rata jawaban terhadap aspek materi secara umum sebesar 95,56%, aspek kesesuaian materi dengan level makroskopik dan sub-mikroskopik sebesar 98,09%, aspek penyajian sebesar 93,33%, dan aspek bahasa sebesar 80%.

Kata Kunci: *Pengembangan Bahan ajar, Pendekatan Makroskopik dan Sub-Mikroskopik, Kestimbangan Kimia*

Abstract

This study had been conducted to know the feasibility of teaching material topic of Chemical Equilibrium of senior high school. The teaching material has been tested to the limited group in SMA Negeri 2 Lamongan. Design of this research based on Thiagarajan development model (4D model) without the *disseminate* stage. This teaching material was analyzed by 2 chemistry lecturer of Surabaya State University, 1 chemistry teacher of SMA Negeri 2 Lamongan, and was validated by 3 chemistry lectures of Surabaya State University and 3 chemistry teachers of SMA Negeri 2 Lamongan. The result of research show teaching material which is developed is feasible to be used as learning resources. Lectures evaluation about teaching material is very good with average percentage answer for matter aspect in general is 85,42%, for suitability with macroscopic an sub-microscopic aspect is 81,25%, presentation aspect is 87,5%, and language aspect is 80%. Teacher evaluation about teaching material is very good with average percentage answer for matter aspect in general is 83,34%, for suitability with macroscopic an sub-microscopic aspect is 83,33%, presentation aspect is 85,83%, and language aspect is 83,33%. Students response for teaching material is very good with average percentage answer for matter aspect in general is 95,56%, for suitability with macroscopic an sub-microscopic aspect is 98,09%, presentation aspect is 93,33%, and language aspect is 80%.

Keywords: *Development of teaching material, Macroscopic and Sub-Microscopic Approach, Chemical Equilibrium*

INTRODUCTION

Superior School is a school that used to be the pioneer international school. Teaching and learning process at superior schools use

English as the language of instruction in delivering learning material. Thus, it is needed teaching materials appropriate with the curriculum during the learning process, that is teaching materials use English as the language

of instruction. This school uses Kurikulum Tingkat Satuan Pendidikan (KTSP) as the national curriculum, combined with the Cambridge International Examination (CIE) as a reference for international curriculum and the curriculum is commonly referred as adaptive and adoptive curriculum.

The existence of teaching materials must be considered because teaching materials is one of the leading cause of misconceptions in students. Materials that contain the wrong formula or description can cause misconceptions [1]. Beside of teaching materials, one that cause a misconception in learning, especially in chemistry learning is characteristic of the material in the chemical sciences [2].

Many people assume that chemistry is too difficult, abstract, mathematical, and can only be understood by intelligent students [3]. Chemistry concepts have specific characteristics, Sastrawijaya (2002) states that the concept in chemistry is simple concept tiered to a higher level concept. While Kean and Middlecamp state that: (1) most of the chemistry are abstract concepts, (2) chemistry concepts is a simplification of the real situation, (3) chemistry concepts are consequential. Based on such opinion, the most common problem is the inability of students to interpret the abstract concepts become scientific concepts [4]. This fact allows students difficult to learn chemical concepts and there are misconceptions happened frequently in understanding the concepts in chemistry.

To overcome these difficulties, Johnstone (2003) stated that in studying chemistry needs to pay attention to represent the chemical phenomena into three levels, namely the macroscopic, sub-microscopic, and symbolic level. Based on the exposure, some studies suggest that the learning and teaching of chemical concepts should relate the three levels of chemical representation of the macroscopic, sub-microscopic and symbolic [5]. Three level of representation must be understood correctly association learning, especially in chemistry. Linking the three levels of representation, the students' understanding of chemistry concepts will be more complete and chemistry will be more easily to be studied. Three level linkage is illustrated by the following figure.

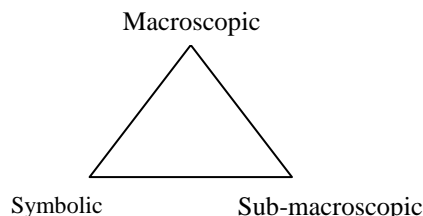


Figure 1. Chemistry Representation

Macroscopic level is the level in accordance with the real object observed. Sub-microscopic level is an abstract level but can be observed in accordance with the phenomenon at the macroscopic level. This stage is indicated by concepts, theories and principles used to explain what is observed at the macroscopic level. While the symbolic level is used to represent the chemical processes and macroscopic phenomena by using chemical equations, mathematical equations, graphs, analogies and models. Three level of representation must be understood correctly its association in learning, especially in chemistry [6].

One concept in chemistry which includes the phenomenon of macroscopic and sub-microscopic level is Chemical Equilibrium. Chemical Equilibrium is one of essential material which has abstract concepts. One of the basic competencies in Chemical Equilibrium is explain equilibrium and the factors that influence the shift towards equilibrium by doing experiment. Abstract concepts in Chemical Equilibrium potentially give risk of misconceptions. This is supported by the results of pre-study questionnaire. The questionnaire was completed by 30 students of SMA Negeri 2 Lamongan who have learned Chemical Equilibrium matter. The result is the percentage of students who have misconceptions on Chemical Equilibrium materials is 54%. The results shows that misconception students on Chemical Equilibrium is at the sub-microscopic level materials that have a relationship with a macroscopic level.

Based on the explanation above, using of teaching materials based on macroscopic and sub-microscopic in Chemical Equilibrium materials will greatly assist the process of learning and understanding the concepts in chemistry correctly. Russell (2007) learned the influence of macroscopic and sub-microscopic approach integrated in the learning process and the results show that students significantly increase in the understanding of concepts in Chemical Equilibrium [7]. Thus, the teaching material is developed based on macroscopic and sub-microscopic approach to enhance

students' understanding of both macroscopic and sub-microscopic.

Based on the description above, teaching material based on macroscopic and sub-microscopic approach on chemical equilibrium materials had been developed. Through teaching materials based macroscopic and sub-microscopic approach, students are expected to understand the concept more scientific and improve student conceptions both macroscopic and sub-microscopic.

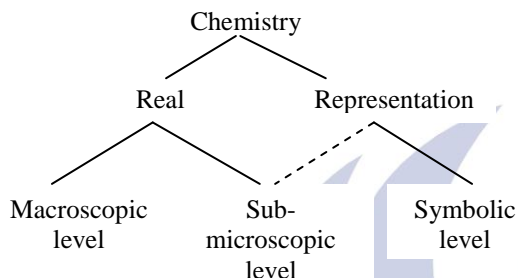


Figure 2. Relation Between Three Level of Representation

From the Figure 2 above, the links from the sub-microscopic level to the theory and representational level is shown with the dotted line. The real and visible characteristics of the macroscopic level and the real and invisible characteristics of the sub-microscopic level show the same substance only on a different scale. Symbolic representations including chemical diagrams of the sub-micro level are important in communicating these characteristics. The unique duality of chemical representations such as chemical diagrams, with links to both the macroscopic and sub-microscopic levels simultaneously, focus the complex nature of chemistry and the significant intellectual challenge facing any newcomer to the discipline who could be overwhelmed by the conceptual demands of shifting between the three domains of representations. So, to understand properly the chemical linkage between the three levels especially level of macroscopic and sub-microscopic must be appeared in the learning.

Sub-microscopic level is the real thing but it can't be seen so it is very difficult to understand. Explanation of chemical reactions requires a mental image that is developed for sub-microscopic representation that reviewing the nature of particles. Chemical diagram is one form of representation that contribute to mental models [8].

Teaching materials developed are tested for feasibility using the theory of validity. There are two basic reality that shows the level of validity, which is considered through

rational and empirical procedures. Rational analysis can be done on the topic and subject that was tested, that is the contents of the teaching materials.

The second type of validity is the fact that is both empirically and statistically. This type is obtained by taking the existing relationship between the teaching materials studied by measurement or other realities [9].

METHOD

This research is development research. Development of teaching materials based macroscopic and sub-macroscopic approach in Chemical Equilibrium refers to the model of 4-D proposed by Thiagarajan [10]. This study consisted of three stages, namely, define, design and develop stage.

The target of this study is teaching material that was used in class XI Senior High School and source of the data in this study were obtained from 3 lecturers in chemistry, 3 chemistry teachers and 15 students of class XI IPA 2 SMA Negeri 2 Lamongan. The research was carried out from 18 February to 1 March 2013.

Data collection techniques used in this study there are reviewer sheet, validation sheet, and student responses questionnaire sheet. Reviewer sheet is given to the two chemistry lecturer of Surabaya State University and one chemistry teacher of SMAN 2 Lamongan. While the validation sheet given to 3 chemistry lecturer of Surabaya State University and three chemistry teacher of SMA N 2 Lamongan. While student responses questionnaire given to 15 students of class XI IPA 2 at the end of the activity.

Data analysis techniques used are qualitative and quantitative. Qualitative descriptive analysis was used to analyze data from the reviewer and student observations made by the observer. Quantitative descriptive analysis was used to analyze the results of validator and student responses.

The result analysis of lecturer and teacher validation conducted on every aspect of chemistry related to the format and quality of teaching materials. Percentage of the questionnaire data obtained based on Likert scale as in Table 1.

Table 1. Score of Likert Scale

Assessment	Score
Very Good	4
Good	3
Bad	2
Very Bad	1

[11]

The formula used to obtain the percentages:

$$K = \frac{F}{N \times I \times R} \times 100\%$$

Explanation:

K = the percentage of feasibility

F = total number of respondents

N = the highest score in the questionnaire

I = the number of questions in the questionnaire

R = number of assessors

Analysis results of chemistry teacher and lecturer used to determine the feasibility of teaching materials by using interpretation score as follows:

Table 2. Score Interpretations

Percentage	Criteria
0% - 20%	Very less
21% - 40%	Less
41% - 60%	Enough
61% - 80%	Feasible
81% - 100%	Very feasible

[11]

Based on these criteria, teaching materials said to be feasible if the percentage of $\geq 61\%$.

Student response questionnaire that is compiled by the Guttman Scale is expressed in the form of a question. The questionnaire was assessed using the criteria of scale that can be seen in Table 3.

Table 3. Criteria of Guttman Scale

Response	Score
Yes	1
No	0

[11]

To know the student response, the formula used as follow:

$$P = \frac{F}{N} \times 100\%$$

Explanation:

P = response percentage

F = amount of response

N = amount of student

(Arikunto,2003)

Based on these criteria, teaching material of this research is feasible if the percentage $\geq 61\%$.

RESULT AND ANALYSIS

The feasibility of teaching materials based on the two theories, as mentioned, the rational and empirical validity. Rational validity are from chemistry lecturer and teacher. Validation indicators are covering by three criteria include

material, presentation, and language. Matter criteria are divided into two criteria, those are general material and the suitability of the material with the macroscopic and sub-microscopic level. Both are divided into four aspects. The presentation criteria consist of ten aspects and language criteria consists of five aspects. The results of the questionnaire assessment by the expert can be seen in Table 4 below:

Table 4. Validation Result

No	Criteria	Lecturer validation	Teacher validation
1.	General material	85,42%	83,34%
2.	The suitability of the material to the macroscopic and sub-microscopic level	81,25%	83,33%
3.	Presentation	87,50%	85,83%
4.	Language	80%	80%

From the analysis of the chemistry lectures and teachers, it is known that the feasibility of teaching materials in detail described as follows:

1. Criteria of General Material

Feasibility of general material have percentage 85.42% and 83.34%. Based on the scale, the value of the feasibility of the teaching materials is very feasible.

The contents of the teaching materials had been appropriate with the standards of competence, basic competence and learning indicators that have been formulated. The truth of the material had been appropriate with the facts, concepts, principles, laws, theories and actual scientific process. And the supporting materials in the teaching materials have systematic structure of knowledge, attention to the relationship of science, technology and society. Descriptions, examples, and exercises are presented dealing with everyday life so it can attract the desire of students thinking deeply.

2. Criteria of the suitability of the material to the macroscopic and sub-microscopic level

The feasibility of the material to the macroscopic and sub-microscopic level, the feasibility obtain percentage of 81.25% and 83.33%. Based on the assessment scale, the value of teaching material is very feasible.

The material have been shown by macroscopic and sub-microscopic representation contained in Chemical Equilibrium. A concrete example that is used to represent the macroscopic level have represented macroscopic representation of material. Illustration and graphs also represent the sub-microscopic level well and can clarify the matter. Symbols, reactions, and analogies that are used also represent the symbolic level. And, linking between the three levels in the teaching materials are good and can clarify the matter.

3. Criteria of Presentation

Based on the assessment chemistry lecturers and teachers, teaching materials which is developed have been fulfilling the presentation criteria feasibility with percentage of 87.50% and 85.85% (very feasible). Chemistry lecturer and teacher validation for the presentation criteria consist of ten aspects.

4. Criteria of Language

Validation of language criteria include the use of language with the level of learner development, the use of language to convey a message, and constancy use of terms and symbols, grammar and spelling is used in accordance with English, and the transfer of messages between sub chapters reflect the integrity of the content.

In general, the use of language in the teaching materials is using good English and so easy to understand (communicative), the phrase is used in accordance with the maturity level of the student's age, the use of symbols and terminology is standard and steady, and the transfer of messages between sub-chapters are already visible. Generally, the results of chemistry assessment in the criteria of the language have percentage of 80%.

For the empirical validity that is the students' responses after using the teaching material through a limited test phase. Limited testing conducted on 15 students of class XI IPA 2 SMA Negeri 2 Lamongan was taken heterogeneously by the chemistry teacher with details five students are smart, five students are capable students, and five students are less intelligent. The trial was conducted from February 11 to March 1 2013. Limited test of teaching materials is done with the following scenario:

1. First Meeting

Students were given an explanation of the teaching materials for five minutes. Next, the student study independently using teaching materials for 45 minutes, the material studied includes material on Chemical Equilibrium, the equilibrium constant expression, and manipulate the state of equilibrium. The next stage is the researcher describes examples of questions contained in each section. Then students work on exercises that are following the example problems. The next stage, the exercises done by students discussed together.

After the first meeting of the trial is completed, students are required to study next material to be discussed at the second meeting.

2. Second Meeting

On the second meeting of the trial, researchers gave questions about previous section and sub-section will be studied to check student understanding. The next phase, students learn the material back on the teaching materials section Kc and Kp relationships, equilibrium constants and units, and the relationship between chemical equilibrium and chemistry kinetics. The next stage researcher explained the sample questions that are available in each section and followed by students working on exercises. The next stage, the exercises done by students discussed together.

3. Third Meeting

On the third meeting of trial, researchers gave questions about previous section. Then study teaching materials about factors affecting the Chemical Equilibrium and phenomena that can be encountered around us with topic Chemical Equilibrium. The next stage researcher explained the sample questions that are available in each section and followed by students working on exercises. The next stage, the exercises was done by students then discussed together.

Once the test is completed, students are asked to complete questionnaire responses. This questionnaire covers three criteria, same as validation. Data result of student responses are presented in following table:

Table 5. Student Response Result

No	Criteria	Student Response
1.	General material	95,56%
2.	The suitability of the material to the macroscopic and sub-microscopic level	98,09%
3.	Presentation	93,33%
4.	Language	80%

Based on the results of analysis in the student questionnaire limited trial, all criteria have been met the standards that is very feasible.

CLOSING

Conclusion

Based on the results of research and discussion, it can be concluded that the teaching material based on macroscopic and sub-microscopic approach topic Chemical Equilibrium in Class XI Senior High School developed have reached the percentage of $\geq 61\%$ for all criteria. It can be described as follows:

1. Feasibility of teaching materials based on macroscopic and sub-microscopic approach topic Chemical Equilibrium according to chemistry lecturer assessment meet the rational validity of the general material and the suitability of the material to the macroscopic and sub-microscopic level amounted to 85.42% and 81.25%, the validity of the presentation is 87.5%, and the validity of language by 80% with a very feasible category. Based on the chemistry teacher assessment, the general material and the suitability of the material to the macroscopic and sub-microscopic level amounted to 83.34% and 83.33%, 85.83% for the presentation validity, and the validity of the language is 83.33% categorized as very feasible.
2. Feasibility teaching materials based on macroscopic and sub-microscopic approach topic Chemical Equilibrium according to student response meets the feasibility criteria received a positive response with an average percentage of 91.75%

Suggestion

From the results of research on the development of teaching materials, researchers can give the following suggestions:

1. It is needed to be done further research needs to be done until disseminate stage to determine the effectiveness of the development of teaching materials teaching materials based on macroscopic and sub-microscopic approach topic Chemical Equilibrium in Class XI senior high school by using an appropriate learning model.
2. For the researchers that continue this research should add examples of problems associated with daily life and show the linkage between the three levels to clarify the concept and attract the students interest more.
3. It is needed to develop learning tools that can support the use of teaching materials based macroscopic approach and sub-microscopic Topic Chemical Equilibrium In Class XI senior high school using animations to represent the third level and attract the students interest.

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