Validity and practicality level of structured inquiry-based reaction rate module containing macro, submicro and symbolic representation

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Abstract. Reaction rate is chemical concept that must be understood in senior high school (SMA). Learning difficulties data of reaction rate were obtained using interviews with teachers and students. Learning materials did not use comprehensively portray the interconnection of macro, submicro and symbolic representations. Therefore, students did not possess the competence to connect the three levels of representation which then influenced their learning outcomes and mental models. The aims of this Research and Development were to develop reaction rate module based on structured inquiry and find out its validity and practicality. The module was developed with Plomp instructional design model using interview, self-assessment, validity and practicality sheets as research instruments. Subjects of this research were 69 students and 2 teachers from several SMA in Padang. The module was validated by 6 validators and then was tested in two SMA. Validity and practicality were analyzed by using Cappa Cohen formula. The results showed that the module developed had very high degree of both validity (k=0.89) and practicality (k=0.85 for teacher response and k=0.89 for students response). So, conclusion this research is the developed module was valid and practical for use of reaction rate learning in SMA.

1. Introduction
The study of the composition, properties and change an material and how the material affects that composition called chemistry[1]. The reaction rate is one of the chemical materials which includes from real concepts to abstract concepts. The reaction rate is considered difficult material by students in school[2]. Students' difficulties in understanding of the reaction rate concepts will prevent students from understanding the next concept. The concept of reaction rates is a prerequisite for understanding the concept of chemical equilibrium[3].

Previous research shows that understanding students’ concepts in the reaction rate material is still incomplete[4] and most students experience misconceptions[5]. Therefore, teachers need to use instructional materials that are interesting and easy to use by students, such as modules. Modules are teaching materials that are made to be learned by students independently[6, 7, 8].

Modules should use a model or approach in accordance with the 2013 curriculum, one of which is a structured inquiry model. Structured inquiry is effectively used in the science learning process[9]. In structured inquiry, students are given questions, problems, procedures and data analysis, then students must be able to find results and conclusions from solving the problem[10, 11, 12]. Structured inquiry
learning can make students better understand a concept and remember information for a longer time, and direct students to sustainable knowledge[13].

Module good se is also equipped with three levels representation namely macro, submicro and symbolic that can explain the concepts are real to abstract concepts. Level macro were all obtained through real observations (tangible) against a phenomenon that can be seen and perceived by sensory level (five senses), either directly or indirectly[14, 15, 16]. Described as a level that explains about structure and processes at the particle level (atoms / molecules) of the macroscopic phenomena observed called submicro level[15, 17]. The submicro level is used to explain the causes of a macroscopic phenomenon[18] and become an important point in learning. Symbolic level is a representation of chemistry in the form of symbols, chemical formulas, diagrams, reaction equations, stoichiometry and mathematical calculations[15].

Three levels of chemical representation can function to provide support and facilitate the occurrence of meaningful learning. Students' relational understanding can be formed or developed explicitly with learning using macro, micro, and symbolic representation and relationships between all three levels[19]. The competence of students to connect the three levels representation will produce a complete mental model of a concept so that the concept can be stored in long-term memory. A mental model is an individual's mental personal representation of an idea or concept during a cognitive process[20]. Mental models can produce various expressions[21] according to the construct of one's understanding. Each student can use his mental model in an effort to solve chemical problems.

Therefore, the development of structured inquiry-based structured inquiry-based reaction rate material modules uses three levels of important chemical representation. This study aims to produce valid and practical modules that are used in chemistry learning for class XI SMA.

2. Experimental Method

The type of this research that used is Research and Development (R & D) with the development model of Plomp. This model consists of 3 main stages, namely: (1) preliminary research, (2) prototyping stage, and (3) assessment phase[22]. The instrument of data collection used is the interview sheet as problem identification, self evaluation sheet used to check the complete components and module errors, validity sheet used to determine module validity, practical sheet to determine the response of the teacher and students about module, and test the learning outcomes to see the effectiveness of the module.

Quantitative descriptive techniques have been used as an analysis of this study. The indicator of success in developing a module is valid (percentage of the validation score is at least 61%). In addition, the practicality of the module is seen based on practical responses from users. The users in this research were teachers and students. The data obtained were analyzed by using a formula Kappa Cohen[23].

Kappa Cohen \( k = \frac{p - p_e}{1 - p_e} \) (1)

Description:

\( k \) = Kappa Cohen or product validity.

\( P \) = The realized of proportion (total of the values given by the validator divided by the total of the maximal value)

\( p_e \) = Unrealized of proportions (total of the maximal value minus the total number of validated entries divided by the maximal number of values)

3. Results and Discussion

The results of structured inquiry-based module development using three levels of representation include: 1) needs and context analysis; 2) validity of the module; 3) practicality of the module.
3.1 Needs Analysis and Context
In the first stage, needs and context analysis (need and context analysis) were carried out.

3.1.1 Needs Analysis. The first stage was preceded by an interviews with chemistry teachers. The interview result shows that the commonly used learning methods are experiments, discussions, exercises, demonstrations and question and answer. The application of the scientific learning model has not been well implemented. The teacher used are textbooks and student worksheets as teaching materials. Teacher not use module in the learning process because it is not yet available instructional materials in schools. In addition, materials teaching provided yet equipped with three levels of representation. Though three levels of representation can facilitate the occurrence of meaningful learning in students. Interviews are also conducted with students. Students forget about the material whereas the reaction rate them study it six months before the interview. Students also consider material reaction rates to be lit because there are calculations.

3.1.2 Curriculum Analysis. Curriculum analysis in the development of this module aims to determine indicators that must be achieved by students about achievement of competencies and learning objectives. Basic Competence (KD) for the reaction rate material consists of four, namely:
KD 3.6 explain the factors that influence the reaction rate using theory of collision
KD 4.6 presents the search results for information on ways to regulate and store materials to prevent uncontrolled physical and chemical changes
KD 3.7 determines the reaction order and reaction rate constant based on experimental data
KD 4.7 designs, performs, and concludes and presents the experimental results of the factors that influence the reaction rate and reaction order.

3.1.3 Analysis of Concepts. This analysis is carried out to identify, detail, and systematically arrange the main concepts needed and used as a reference in the development of structured inquiry-based of reaction rate modules using three levels of representation. The main concepts discussed in the reaction rate material are the concept of reaction rate, reaction order, theory of collision, activation energy, and factors that influence the reaction rate.

3.2 Module validity. After knowing the needs and context, the next stage is to manufacture or develop a prototype. The design phase (prototyping phase) produces structured inquiry-based learning modules adapted to the curriculum. The following modules design steps to produce valid modules according to structured inquiry stages.

3.2.1 Prototyping I. Prototype I was developed in the form of structured inquiry-based reaction rate modules using three levels of representation arranged in accordance with the model syntax of a structured inquiry learning. The components module that designed are: 1) cover, 2) introduction, 3) table of contents, 4) list of images, 5) instructions for using modules, 6) competencies, 7) concept maps, 8) learning material, 9) activity sheets, 10) worksheets, 11) answer keys, and 11) bibliography (Figure 1 to Figure 5 ).
Figure 1. Module Cover

Figure 2. Indicator

Figure 3. Activity Sheet
3.2.2 Prototyping II. Prototype II is obtained after conducting its own evaluation (self evaluation) on prototype I. Self evaluation focuses on visible errors or obvious errors such as errors in typing letters, use of images, completeness of modules such as elements that must be owned by a module, as well as the completeness of the stages of a structured inquiry learning model.

3.2.3 Prototyping III. The prototype II that has been produced is validated by experts and individual evaluations (one-to-one evaluation) with three XI high school students. Experts are lecturers and chemistry teachers. After revision, a prototype III is produced. Validity is an assessment of the design of a product. Assessment aspects are divided into several components which consist of content feasibility, linguistic components, presentation components (constructs) and graphic components[6]. Expert judgment aims to get a prototype that is scientifically valid. The results of expert assessment of prototype II were obtained by the level of validity. The module has been validated by four chemistry lecturers and two chemistry teachers. Minimum validity testing is carried out by three experts/experts[25]. The results about data analysis of the validity assessment are presented in Table 1.

Individual evaluation (one-to-one evaluation), the step taken were interviews with three students (grade XI) SMA with different abilities (low, medium and high). The aspects assessed in this evaluation are clarity, appeal and obvious errors. The interview results show that the cover display represented already represented of the module contents that is reaction rate material. In addition, the instructions for using the module are already well understood by the students, the presentation of material in the module is clear, the language used in the module is also easy to understand, the images and colors contained in the module attract students’ interest and the learning steps (structured inquiry) using in the module that can understand by students.

| No. | Rated aspect         | K   | Validity Category |
|-----|----------------------|-----|-------------------|
| 1   | Component of content | 0.90| Very High         |
| 2   | Component of construct | 0.90| Very high        |
| 3   | Language component   | 0.88| Very high         |
| 4   | Graphical component  | 0.87| Very high         |
|     | Average              | 0.88| Very High         |

The validity of module for all aspects is included in the kappa cohen of 0.88 (very high category). Based on Table 28, the component of content module has an average kappa Cohen of 0.90 (high validity category). The very high kappa cohen category shows that structured inquiry-based reaction
rate modules use three levels of representation developed in accordance with Core Competencies, Basic Competencies, Indicators and Indicators of Competency Achievement to be achieved. The material presented in the form of facts, concepts, principles and procedures. Then, the use of a three levels representation (macro, submicro and symbolic) is correct in accordance with the guidance of science curriculum, 2013. In addition, the problems given to students are investigated to guide students to find concepts that was in accordance with the material being taught. This is consistent with the theory that content validity shows products that are developed in accordance with the curriculum and based on strong theoretical rationality[26]. The validity of the product in term of content is seen if it meets the needs and the components are based on the latest scientific knowledge[27].

In the assessment component of construct, the module has a very high validity category (an average kappa cohen of 0.90). This assessment shows that there is a systematic match in the preparation of modules with structured inquiry model steps. In addition, the material is presented sequentially according to the Competency Achievement Indicators that have been formulated so that there are interrelationships between the concepts learned. This is in accordance with Rochmad's[26] opinion that product validity of construct shows that various components in the product are related to one another and have a consistent relationship. The validity of the product in terms of construct is seen when all components are consistently interrelated[27].

The module validity from the language aspect has k=0.88 with very high validity. This categories shows that language used in the module is in accordance with the rules of Indonesian. That means are good, correct and can be easily understood. In addition, writings and images can be read clearly. One of the module characteristics that said to be good was user friendly, meaning that the module developed used language that was easy to understand, simple and communicative[6]. In the graphics component, module validity has a very high validity category (K=0.87). Graphical components show aspects of the use of type and size of letters, layout modules, illustrations, images, designs and colors of products developed[6] so that the module is interesting as a whole. The module with pictures and visual symbols can help students understand the concepts learned[28].

The validity of structured inquiry-based reaction rate module containing macro, submicro and symbolic representation produced is high category, there are still some components that must be corrected according to the suggestions given by the validator. In accordance with the suggestions given by the validator, a revision of the module that will be developed is then tested.

3.2.4 Prototyping IV. Prototype IV is obtained after small group evaluation activities are carried out on prototype III. The small group evaluation was carried out by module of reaction rate to 9 students with high, medium and low abilities, where each student received a module design. The purpose of this evaluation is to verify the practicality of the module being developed. Learning using modules is done in 1 meeting according to implementing the learning process using the module developed. Practicality in small groups evaluating is known by asked students to fill out a questionnaire related to the use of modules in the learning process after the meeting ends. The aspects assessed are ease of use, efficiency of learning time and the benefits of the module.

The results of the practical questionnaire in small group evaluation indicate that all aspects (ease of use, efficiency of learning time and benefits) of the module have a very high level of practicality. Overall, the results of the student practical questionnaire obtained a kappa cohen, k=0.86 (very high category). After small group evaluation, prototype IV was obtained which was tested on a large group (field test).

3.3 Practicality of the module
After small group evaluation, the next step has been to do a large group trial (field test) to determine practicality of the module. Large group trials were conducted in two SMA in Padang with the criteria of high and low schools. In each school there are two sample classes namely the experimental class
(learns uses a developed module) and the control class (learns use textbooks from the school). Practical data obtained from giving questionnaires to chemistry teacher (teacher response questionnaire) and students (student response questionnaire). Questionnaire was given after carrying out the learning process using of the module. At this stage data obtained from the module's practical values.

3.3.1. Module Practicality from the Student Response Questionnaire. Student response about questionnaire for the module practicality filled by 69 students. The questionnaire was filled after learning using the module. The results of data analysis about module practicality in the field test stage are shown in Table 2. The average kappa cohen was 0.85. That's point mean is a very high degree of practicality.

Table 2. The Results of Student Practicality in the Field Test Stage

| No. | Rated aspect                                                                 | K     | Category       |
|-----|-------------------------------------------------------------------------------|-------|----------------|
| A.  | Attractiveness                                                                |       |                |
| 1   | The appearance of the module is interesting to learn                          | 0.89  | Very high      |
| 2   | The colors used are interesting and varied                                    | 0.87  | Very high      |
| B.  | Ease of Use                                                                   |       |                |
| 3   | The material presented is clear and simple                                    | 0.85  | Very high      |
| 4   | The letters and writing in the module are easy to read                         | 0.83  | Very high      |
| 5   | The instructions for using the module are easy to understand                  | 0.83  | Very high      |
| 6   | The module used makes me more active in learning                             | 0.84  | Very high      |
| 7   | The picture on the module makes me to understand the material is easy        | 0.85  | Very high      |
| 8   | Questions in the module can help me in my investigation                       | 0.86  | Very high      |
| 9   | The learning steps in the module lead me to collect data that aims to prove the hypothesis made | 0.83  | Very high      |
| C.  | Time efficiency                                                               |       |                |
| 10  | The time provided in the learning process is sufficient to understand the material contained in the module | 0.85  | Very high      |
| 11  | Learning using modules can save learning time                                 | 0.86  | Very high      |
| D.  | Benefits                                                                      |       |                |
| 12  | The training in the module helped me understand the material                 | 0.84  | Very high      |
| 13  | Question at in the module helps me find the concept                           | 0.85  | Very high      |
| 14  | I easily answer the evaluation test questions in the module                   | 0.85  | Very high      |
|     | **Overall Practicality**                                                     | 0.85  | Very high      |

3.3.2. Practicality of Modules from the Teacher Response Questionnaire. Teacher response about questionnaire for the module practicality filled by two chemistry teachers. The questionnaire was filled after learning using the module. The aspects assessed include ease of use, efficiency of learning time, benefits and attractiveness of teaching materials to students' interests in the teacher's opinion. The result from teacher response questionnaire shows that average kappa cohen for the practicality of modules was a very high degree of practicality, k=0.89 (Table 3). That results meaning a structured
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inquiry-based reaction rate module that was developed practically was used in the chemistry learning process by the teacher.

Table 3. Results of Teacher Practicality

| Item | Rated aspect | K       | Category   |
|------|--------------|---------|------------|
| 1-2  | Attractiveness | 1.00   | Very high  |
| 2-6  | Ease of use   | 0.89   | Very high  |
| 7-8  | Time efficiency | 0.93   | Very high  |
| 9-12 | Benefits      | 0.85   | Very high  |
|      | Overall Practicality | 0.89 | Very high |

Practicality assessed consists of four aspects. A product is said to be practical if the product user or representative of the target group can easily use the product as expected[27]. The product developed to be practical if it can be used to carry out learning sustainably and logically without many problems. Practicality is considered from three aspects, that aspects are ease of use, efficiency of learning time and attractiveness of teaching materials to students' interests[29].

The first aspect is attractiveness module. This aspect have average value of kappa cohen obtained in small groups evaluation was 0.87 and in the large group trials (Table 2) was 0.88. This results shows that structured inquiry-based reaction rate modules use three levels of representation having an attractive appearance to learn and the colors used vary (very high category). This is in line with what was conveyed by Ellizar[28] that learning using colored and illustrated modules can attract students' attention to teaching materials there by increasing motivation in learning.

The results of the practical assessment in terms of ease of use (second aspect), in the small group evaluation and large group trials (Table 2), obtained a very high practicality category (k=0.84). This results means that the module developed is easy to use because the material delivered is clear and simple and the instructions for using the module are easy to understand. In addition, the use of modules also makes it easier and makes students more active in learning. This is in accordance with the theory which states that the practicality of the product can be seen by considering whether the product is easy to understand and can be used by teachers and students in normal conditions[30].

Viewed from the aspect of learning time efficiency (third aspect) in the small group evaluation and large group trials, it was obtained a very high level of practicality with kappa cohen of 0.86 and 0.85 respectively. This shows that the time available is sufficient in understanding the material in the module and in the learning process can save learning time if used modules. Learning time more efficient and students can learn according to their respective speeds if learning by using modules[31].

Judging from the benefits aspect of the module (fourth aspect), the average value of kappa cohen was 0.87, k=0.87. This poin is very high practicality category in the small group evaluation and very high practicality category at the large group trials (k= 0.84). This shows that learning with modules can help students find concepts and exercises and evaluation questions useful in the process of stabilizing concepts. The use of modules in learning can help students improve their understanding, make students active in learning activities, and familiarize students with discovering concepts independently[32].The results of teacher practicality research in the field trials (Table 3) obtained 1.00 average kappa cohen for aspects of attractiveness, 0.89 for aspects of ease of use, 0.93 for aspects of time efficiency and 0.85 for aspects of benefit module with the practicality of each aspect which is very high category. The overall average kappa cohen was a very high practicality category (k=0.89). This shows that the module developed is easy to use, the material presented is clear, the learning time becomes more efficient, increases students' motivation and interest in learning, and supports the teacher's role as a facilitator in the learning process.
4. Conclusion
The structured inquiry-based reaction rate module is produced using three levels of representation for high school students using the Plomp development model. Module developed has a level of validity and practicality very high both by teachers and students.

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