Validity and practicality of chemical equilibrium module based on structured inquiry with three levels representation for students grade XI of senior high school

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Abstract. Chemical equilibrium is an important material for understanding acid base and solubility concept. Based literature and interviews, this material is still considered difficult by student. The learning process that has not presented material with three level representation and interconnects it. Students ability to interconnect the three levels of representation will help students have a good understanding, so that a complete mental model is formed. The aims to develop chemical equilibrium module based structured inquiry with three levels of representation in terms of validity and practicality. The method used Research and Development through the use of Plomp model. The instrument was questionnaire form that consist of validity and practicality sheet. The module was validated by 5 validators. Practicality module was tested by 2 chemistry teachers and 69 students from two of senior high school in Padang. Validity and practicality data were analysed by using the Kappa Cohen formula. The results show that the module had very high degree of both validity (k = 0.82) and practicality (k = 0.91 for teacher response and k = 0.88 for student response). So it can be concluded that the module developed has been valid and practical for use in chemical equilibrium learning.

1. Introduction
Material about chemical equilibrium material is one of the difficult materials [1,2], because it is abstract [1]. The material about chemical equilibrium material is an important material to understand other chemical materials such as acid base and solubility [1], because the chemical equilibrium is a required material to understand that material. One of the student difficulties in understanding chemical equilibrium material is learning process that only embedded to the symbolic level, so that students cannot understand the concept of chemistry completely [1]. The chemistry learning generally more embedded to the macroscopic and symbolic level, while in the level submicroscopic is very little [3]. In reality, the phenomena that occur (macroscopic level) can be explained through submicroscopic level [4]. The chemistry learning should use three levels of chemistry representation and connect those three representation levels, so that one’s understanding in understand a concept becomes better [5,6].

The chemistry experts is easily connect the three chemical representation levels [7], but it is difficult for students to understand in its submicroscopic level [7,3]. Students difficulties in submicroscopic level has caused students are difficult to connect the three levels representation. That difficulty has caused students are difficult to understand the concept of chemical so that at the end students are learning by memorizing the materials. [3]. Learning by memorizing can block out meaningful learning [8]. One of
the efforts to help students understand about chemical concept in chemical equilibrium material completely is by providing learning material equipped with three levels of chemical representations. According to the result of interviews to three Senior High Schools in Padang City, learning materials used are not completely present three levels of chemical representations. The module is one of the teaching materials that can facilitate this deficiency. Module should be arranged based on the steps in the learning model as suggested by Minister of Education and Culture No. 65 of 2013, one of them is inquiry learning model. The inquiry model is in line with Constructivism approach that embedded to the ideas that knowledge is not given directly by teacher to their students, but is developed by students [9]. The inquiry learning can improve the critical thinking ability, independent learning, and intellectual growth [10, 11].

The inquiry learning model has levels based on teachers involvement in guide the students, starting from the mostly guided by teacher that are confirmation inquiry, structured inquiry, guided inquiry, and open inquiry [12]. The choosing of inquiry level that is compatible as learning model must be considered by students’ ability level in thinking scientifically and the level of difficulties to be taught. People who think as higher inquiry level (open inquiry), then previously they will through the inquiry stages with lower level. As Bell, et.al [13] states that students need stages to get to scientific thinking level, to help student achieve that level then should use the lowest inquiry level to the highest. If considering that chemical equilibrium material is a difficult material [1,2, 14, 15], then the use of structured inquiry learning model can be a solution in improving students’ ability in understanding chemical equilibrium material. Based on preliminary study that was conducted through interviews in three Senior High School of Padang City, structured inquiry learning model has never been used in chemical equilibrium learning.

The characteristic of structured inquiry learning is that teacher gives problems, method and material, but the final results are not given [16]. The steps in structured inquiry learning are observation, making hypothesis, collect and organize data, writing conclusions and find solutions from the problems given [9]. Structured inquiry learning model has been implemented in geometric learning and the result shows that structured inquiry learning model gives a better result. [17].The development of structured inquiry modules has also been carried out on the mole concept material with a very high level of validity and practicality, so that the module makes it easy for teachers and students to achieve learning goals [18].

The module that developed by providing three levels of chemical representations and written based on steps of structured inquiry learning model, it is expected can improve students understanding to chemical equilibrium material, because learning by connecting those three levels makes one’s understanding towards a concept becomes better [5] so that formed a complete mental model [19].Mental model represent ideas in an individual thought that are used to describe and explain the phenomena [4]. The mental model are built through experience, interpretation, and explanation when they are involved in learning. The mental model developed is used to predict, test new ideas and solve problems in chemistry learning [20]. If the teacher knows the mental model of the student, it can be seen how complete (intact) the students' understanding is in understanding the material that has been taught. Therefore, a research on structured inquiry-based module teaching materials was developed on chemical equilibrium material that’s valid and practical.

2. Experimental Method
The type of this research that used is Research and Development (R&D). The model of development that used is Plomp model that developed by Tjreed Plomp. This model consists of three phases those are preliminary research phase, development or prototyping phase and assessment phase [21]. The steps conducted in this research are: 1) Preliminary research consists of needs analysis, curriculum analysis, concept analysis and student analysis; 2) Prototyping stage consists of I, II, III and IV that followed by formative evaluation; 3) The assessment phase consists of practicality test and effectivity test. This research is limited to validity and practicality tests towards the developed model.

The instrument of this research was a questionnaire consisting of validity sheet and practicality sheet. Questionnaire validity is given to 5 validators. Practical questionnaire are given to 2 chemistry teachers and 69 students at State Senior High School 3 Padang. The questionnaire validation is useful in assessing
modules that are developed in terms of components of content feasibility, construct components, linguistic components and graphic components. Validated modules are revised according to the suggestions from the validator. Practical questionnaires are useful for knowing the practicality of modules that are developed in terms of components of attractiveness, ease of use components, time efficiency components and benefit components. The data obtained is analyzed using a formula Kappa Cohen [22].

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Kappa\,\text{Cohen}(k) = \frac{\rho - \rho_e}{1 - \rho_e}
\]

Description:
K = Kappa Cohen that shows product validity.
\(\rho\) = The realized proportion is calculated by the number of values given by the validator divided by the maximum value.
\(\rho_e\) = Unrealized proportions are calculated by the number of maximal values reduced by the total value given by the validator divided by the maximum value.

| Table 1. Decision Category based on Kappa Cohen. |
|-----------------|-----------------|
| 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        |
| \(\leq 0.00\)   | Invalid         |

3. Results and Discussion
Based on research which was conducted, a module of structured inquiry based chemical equilibrium with Plomp development model had been developed. The reason for choosing equilibrium material was that students found it difficult to understand the material [1,2]. In addition, this material is a prerequisite for understanding further material such as acid-base material and solubility [1]. The following describes the result of structured inquiry-based equilibrium module.

3.1. Preliminary Research
In this phase some analysis were conducted that are problems and needs analysis, curriculum analysis, concept and learners analysis. The findings in this phase are made into basic for developing preliminary module. The findings in this phase are as follows:
1. Eighty eight point eighty eight percent (88.88%) students in three State Senior High Schools of Padang City said that chemical equilibrium materials are difficult to understand.
2. The problems that often faced by students in chemical equilibrium material is that students often do not pay attention the form of substances in the substances that reacted and weak in calculation matter. Students are also often confused in understanding Le Chatelier principle.
3. Learning media that provided has not yet provide material with three levels of representations.
4. Teachers and students expect a learning media that interesting and easy to understand.

3.2. Development or Prototyping Phase
Based on the finding in the preliminary stage, the module is designed based on these findings. The results of this initial design are called prototype I. Module that are designed based on the findings in preliminary investigation phase is called prototype I. Prototype I include module components that are: cover, introduction, table of contents, list of images, module usage instructions, core competencies, basic competencies and indicators of competency achievement, learning material, concept maps, activity sheets, worksheets, evaluation questions, answer keys, and reference. Furthermore, self evaluation is
carried out on prototype I to evaluate visible errors such as errors in typing, use of images, completeness of module components, and suitability of stages of structured inquiry learning models. In general, many errors occur in writing errors (typo), adjusting image size, layout, and use of language in delivering material. Some display of module components can be seen in Figure 1 and Figure 2.

Figure 1. Cover of module

Figure 2. The Activity Sheet which follows structured inquiry syntax and three levels of representation.
The result of self evaluation improvement is prototype II. In prototype II conducted expert validation and *one two one evaluation*. The module developed was given to 5 validators and produced a very high level of validity (k=0.82). The module assessment component is validated as shown in Table 2.

| No | Assessed Aspects                | Kappa average moment | Validity Category |
|----|---------------------------------|----------------------|-------------------|
| 1  | Component of content properness | 0.88                 | Very high         |
| 2  | Component of construction       | 0.82                 | Very high         |
| 3  | Language component              | 0.81                 | Very high         |
| 4  | Graphics component              | 0.79                 | High              |
|    | **Average**                     | **0.82**             | **Very high**     |

Based on table 2, the component of content eligibility shows a very high level of validity (k = 0.88), this indicates that the module developed was in accordance with core competencies, basic competencies, and learning objectives to be achieved. The module content also presented material with three levels of representation that were scientifically correct. The product was said to be valid in terms of content if the content of the product developed is in accordance with the curriculum [23] and in accordance with science [21]. The module assessment constructed component also had a very high level of validity with a value of k=0.82. This assessment showed that there was a systematic match between the preparation of modules and structured inquiry steps. The product is said to be valid in its constructs if all components are consistently linked [21].

In the language component, module validity had Kappa moment value of 0.81 with validity level of very high. This showed that language used was compatible with Indonesian rule that were good and right so that it can understood well by users. One of the module characteristics that said to be good was user friendly, meaning that module that developed used language that was easy to understand, simple, and communicative [24]. The module validation from graphic aspects had a high validity level with a kappa moment value of 0.79. This category showed that the module developed had an interesting design. One element of module quality was attractiveness [25] which can increase students’ interest in learning it. The presence of images and visual symbols in the module could help students understand the concepts learned [26]. One form of improvement suggested by the validator can be seen in Figure 3. The validator suggests that concept maps use concept words and appropriate conjunctions.
Then one-to-one evaluation is conducted, this phase was done by conducting interviews with 3 students at State Senior High School 3 Padang with different abilities (high, medium and low). There are 3 aspects evaluated at this stage, that are clarity, attractiveness, and visible errors. Based on the results of the interview, it was found that the material presented in the module was quite clear and the
module display was interesting. However, there are still some typos. At the time of the interview it was also found that the low level students were more difficult to formulate hypothesis.

The improvements from prototype II produced prototype III. In prototype III small group evaluations were conducted, the purpose was to see the practicalities of the modules in small groups before being tested into large groups. At this phase the module is tested on 6 students with high, medium and low abilities in one learning process meeting. Then students are given a questionnaire to see the practicality of the module. Overall the practicality of the module is high with a kappa moment of 0.80. After doing small group evaluation, the prototype IV was obtained, which then conducted a large group trial.

3.3. Assessment phase

The assessment phase includes practical assessment and effectiveness. After a large group trial on prototype IV, students and teachers were given a practical questionnaire. Overall the practical value of the student and teacher response questionnaire showed a very high category with a value of $k = 0.88$ in the student response questionnaire and a value of $k = 0.91$ on the teacher’s response questionnaire. Overall the practicality of teacher and student response questionnaires can be seen in Table 3.

| No | Assessed aspects     | Teacher’s Kappa moment average | Students’ Kappa moment average |
|----|----------------------|--------------------------------|-------------------------------|
| 1  | Attractiveness       | 1                              | 0.89                          |
| 2  | Ease of use          | 0.86                           | 0.89                          |
| 3  | Time Efficiency      | 0.93                           | 0.86                          |
| 4  | Benefits             | 0.86                           | 0.86                          |
|    | Average              | 0.91                           | 0.88                          |

The product is said to be practical if the product user can easily use the product as expected. The practicality of teaching materials can be seen from aspects of ease of use, efficiency of study time, attractiveness [27] and benefits. Based on table 3, the attractiveness aspect of the module developed has a moment kappa value of 1 from the teacher and 0.89 from students which shows the value of practicality is very high. This shows that the modules developed are interesting for students to learn. The use of colors and attractive designs will be able to increase student learning motivation [28]. In terms of the ease of use of the module, both the response from the teacher and students showed a very high value of practicality with moment kappa values of 0.86 and 0.89. This shows that the module developed is easy to use. As one of the characteristics of the module, which is user friendly, it means that the module developed is easy to use, every instruction and exposure of information presented is helpful, users can easily give response and access as intended, the language used is easy to understand and uses commonly used terms [24].

In the time efficiency aspects, the module developed also has a very high practicality value with the kappa moment value of the teacher for 0.93 and from students 0.86. This shows that the available time in understanding the material in the module and the learning process using modules can save learning time. Learning by using modules can make learning time more efficient and students can learn at their own pace [25]. In benefits aspects of the module, the module that was developed has a very high value for benefit with a kappa moment value of 0.86 from both teachers and students. This shows that the module developed is useful for its users. Modules developed using structured inquiry learning models are designed so that students more easy to understand the material presented with a presentation of three levels of representation to form a complete mental model. In the module there are also practice and evaluation questions that help students measure their own level of mastery of the concept of the material contained in the module [29]. The use of modules in learning can help students improve understanding, make students active in learning activities, and familiarize students to find the concept independently[30].
4. Conclusion
The chemical equilibrium module resulted is a structured inquiry based-module using three levels of representation developed using Plomp model. Based on the conducted research, resulted chemical equilibrium module that have a very high validity and practicality level.

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