Development of Chemical Bonding Module Based on Multiple Representation

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A B S T R A C T

This study aims to develop a valid chemical bonding material module and can be used as independent learning materials for students in learning activities. This study is based on teaching materials used in some schools, representation of the phenomenon used only macroscopic and symbolic, while submicroscopic phenomenon has not been seen in the teaching materials used and some teachers have just heard the term. This study uses model of research and development Plomp. Data collection techniques in research are validation sheet, teacher response questionnaire, and student response questionnaire. The results of data analysis obtained validity on the aspect of content feasibility, linguistic aspect, presentation aspect, graphic aspect, and characteristics aspect of multiple representation validated by three validators, respectively for 97.14%, 89.52%, 93.33%, 95.24%, and 97.78% with valid categories. Evaluation result of small group was taken teacher response and learner response as user of chemical bond module based on multiple representation. looking at the questionnaire of teacher's response to the chemical bond module based on multiple representation, the average score was 90.22% with very good categorization. Questionnaire response of students to chemical bonding module based on multiple representation is 89.37% with good categorized.

1. Introduction

How to find a phenomena, facts and theories related to learning sciences. actually learning science is not just learning ideas, reality or speculation but also a cycle of experiences that will deliver direct meetings that can grow student's abilities. One of the Sciences is chemistry, which studies the descriptions of the structure and composition of substances, changes that occur with substances, and various other events that accompany changes in substances.

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Jansoon, N., Coll, R. K., & Somsook, E. (2009) said science has attributes displayed by chemical representation consisting of three levels, namely macroscopic, submicroscopic and symbolic level. The macroscopic level is a representation of events found in everyday life or in science laboratories that can be seen directly by utilizing the five senses and laboratory equipment. The submicroscopic level is also a real representation, but at the molecular level it is like describing, explaining and giving birth to estimates about the properties of chemical matter and the process of movement of electrons, particles or atoms. While the symbolic level is a depiction to clarify about the observed such as chemical equations, numerical equations, illustrations, the process of occurrence of reactions, animations or demonstrations. Students should understand the concept of chemistry as a whole if students can relate the three levels of representation.

Gkitzia, V., Salta, K., & Tzougraki, C. (2011) said that chemical representation on teaching materials is important in developing understanding of chemistry. However, the presentation of chemical representations on teaching materials is so simple and does not meet certain requirements that it does not support the understanding of students in understanding the concept. Chandrasegaran, A. L., Treagust, D. F., & Mocerino, M. (2007) in his research stated that textbooks generally do not present chemical concepts proportionally. In addition, some of the representations found in textbooks also do not correspond to the scientific model (Lin, J. W., & Chiu, M. H, 2007). The results of the analysis of the type of representation in the textbook conducted by Nyachwaya, J. M., & Wood, N. B. (2014) shows that in textbooks more display symbolic level while the rest macroscopic and submicroscopic level. The submicroscopic level is less than macroscopic level. This problem causes learners to be mistaken in understanding the concept of chemistry perfectly.

In accordance with research conducted by Jannah, M. (2019), Khasyyatillah, I (2019), dan Rosalina, Y. (2021), talking about the development of teaching materials by producing valid teaching materials, so that it can be effectively and appropriately used in the learning process. One form of teaching materials used in schools is the learning module. Modules are teaching materials that contain a set of learning materials or substances that are arranged systematically, which fully demonstrate the skills that students will have in the teaching and learning process. Dengan terdapatnya modul akan memungkinkan siswa untuk mempelajari kompetensi dasar secara sistematis sehingga mereka secara total siap untuk mendominasi semua kompetensi secara utuh dan terpadu (Djamarah, S.B dan Zain, A, 2013). However, module has an important part in teaching and learning process, especially as an independent teaching material.

Based on the results of observations in some SMA / MA in Kabupaten Kampar, during this teaching and learning process is still utilizing teaching materials such as printed books that must be used by students and most teachers have not made their own teaching materials to be used in the teaching and learning process. In teaching materials, the representation of phenomena used macroscopic and symbolic level. While the submicroscopic phenomenon has not been seen in the

teaching materials used and some teachers have just heard the term. in the learning process for learning to take place effectively and efficiently teachers must be good at determining teaching materials in accordance with the demands and developments of the times (Nufus, H, 2020). in general, it is recommended to use more appropriate teaching materials in the learning process, which is based on multiple representation in order to help students understand the concept perfectly and students can connect the learning gained with everyday life so as to get the best grades in class and be ready to apply the knowledge gained in their daily lives.

Based on the explanation that has been presented, the author developed a module based on chemical bonding multiple representation. The results of the study in the form of modules that are expected to be one of the alternative teaching materials on chemical bonds.

2. Methodology

In this research, Plomp development model is used to expand the module. the Plomp development model consists of four development phases (Figure 1) are 1) first investigation phase; (2) design phase (3) realization phase; and (4) test, evaluation, and revision phase. First investigation phase, Researchers in this phase collect, identify and analyze data or information in the field. Collection of data and information is aimed at strengthening background of problem, purpose of research and benefits of developing modules on chemical bonding materials. In this process it conducted problem analysis, analysis of teaching materials, students analysis and curriculum analysis.

Design phase, in the second phase is designed module teaching materials and instruments that will be needed in research. The steps taken in this draft phase are module design and instrument design (module validation sheet for experts, response questionnaire for teachers and response questionnaire for students). Realization Phase, this stage is a continuation of the design stage. At this stage, the necessary modules and instruments are made. After obtaining a variety of literature and sources relevant to the module to be developed. At this stage, researchers began to develop a module based on multiple representation on chemical bonds. Results of the development of modules prepared at this stage are still in the form of first Draft or called draft 1.

Test phase, evaluation and revision, in this activity that is done is an evaluation of module that has been in form of draft 1. Evaluation used is formative evaluation. Formative evaluation aims to find weaknesses in modules developed. There are several forms of formative evaluation stages that can be used according to Suparman, M. Atwi (2012) mentions there are four forms of formative evaluation, that is: Expert Validation, One-to-One Evaluation, Small Group Evaluation. Formative evaluation form is supported by the opinion of Dick, W., Carey, L., & Carey, J.O. (2016) dan Morrison, G. R., Ross, S. J., Morrison, J. R., & Kalman, H.

K. (2019) that basically every model of evaluation submitted is the same and there are only slight differences in terms.
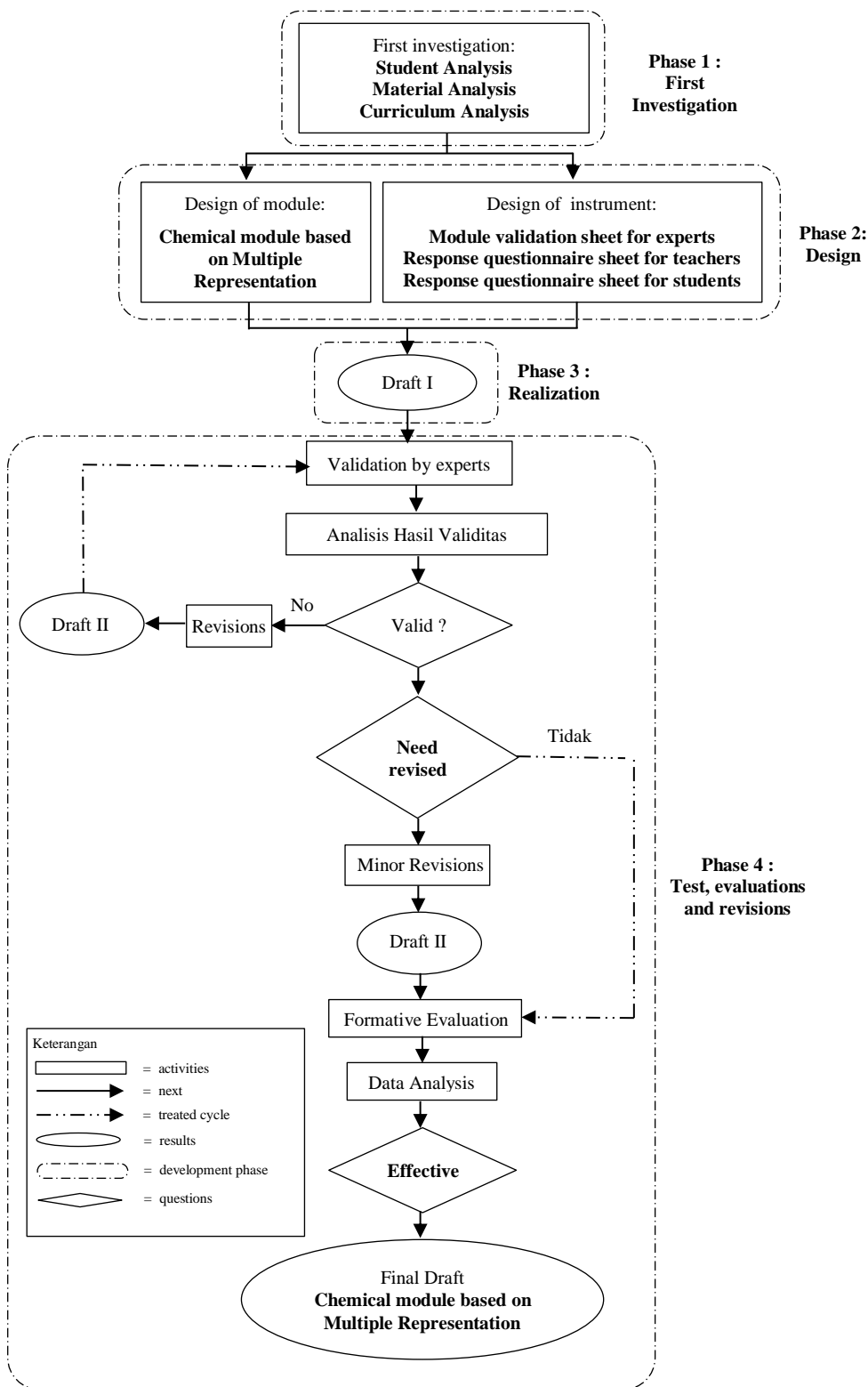

Figure 1. Development cycle of Plomp Model on chemical bond module based on Multiple Representation

Validation experts aim to determine, whether draft 1 which is a chemical bond module based on muliltiple representation is feasible to apply or not. Instrument used is a validation questionnaire instrument for experts consisting of aspects of content feasibility, language, presentation, graphicity and characteristics of multiple representation. Module validation sheet assessment is performed by three validators. The data analysis technique used in the expert validation questionnaire is to provide a score based on the Likert scale with a score of 1 to 5, where 1 is the lowest score and 5 is the highest score. Validation results are calculated using the average score formula :

$$Percentage = \frac{score\ obtained}{maximum\ score} \times 100\%$$

Criteria in making decisions for module validation can be seen in Table 1 (Riduwan, 2012).

Table 1. Criteria In Decision Making For Module Validation

Percentage	Description
80,00 – 100	Good/valid/decent
60,00 – 79,99	Good enough/valid enough/decent enough
50,00 – 59,99	Less good/less valid / less decent
0 – 49,00	Not good (replaced)

One-to-one evaluation is an assessment relating to students to review the rough form of the chemical bonding module being made accompanied by an assessor. The number of students that we can use on a one-on-one evaluation there is no clue. Dick, W., Carey, L., & Carey, J.O. (2016) said that two or three students are enough. Similarly, as delivered Suparman, M. Atwi (2012) which states that this assessment is done with two or three students individually. It can be concluded that two or three students are considered sufficient to obtain information from this one-to-one evaluation.

Small group Evaluation is an evaluation conducted on a group of students who assess the development of unfinished teaching materials. Small group Evaluation is one of the most popular forms of formative evaluation and is usually done after expert validation and one-to-one evaluation. This evaluation aims to generate further revision suggestions. In this evaluation the instrument used is response questionnaire for teachers and response questionnaire for students. The data analysis techniques used are the same as the data analysis techniques used in expert validation. The responses of teachers and students in the response questionnaire were given an answer score based on a Likert scale of 1 to 5. Then the number of response scores are processed and interpret the percentage of teacher and student responses. To express the response of students then used percentage interpretation criteria. Criteria for interpretation of response values for teachers and students to modules in Table 2 (Nana Sudjana, 2014).

Table 2. Response Assessment Criteria For Teachers And Learners

Percentage	Description
p ≥ 90%	Very Good
80% ≤ p < 90%	Good
70% ≤ p < 80%	Enough
60% ≤ p < 70%	Not Enough
p < 60%	Very Less

3.   Results and Discussion

The study used model of research and development Plomp consisting of four phases. Results of the first investigation are problem analysis, analysis of teaching materials, and curriculum analysis. Problem analysis can be seen from the observations, it is known that most teachers have never made a module. Teaching materials used by teachers are textbook, power points, and teaching materials from internet. Many things are difficulty of teachers to make modules one of which is difficulty in using a computer.

Results of analysis of teaching materials used by teachers and students showed that teaching materials used are mostly not based on multiple representations and coverage of less detailed material. Result of curriculum analysis is to examine the analysis of Core Competencies (KI), Basic Competencies (KD), syllabus, and RPP. The selection of chemical bonds is based on the results of a preliminary study in which students consider that chemical bonds include materials that are difficult to understand. These results in the form of mapping learning materials that can be seen in Table 3 (Kebudayaan, K. P. D., 2016).

Table 3. Chemical Bonding Learning Mapping

Core Competencies	Basic Competencies	Learning Indicators
4.1.1. Understand, apply, and analyze factual, conceptual, procedural, and metacognitive knowledge based on his curiosity about science, technology, art, culture, and humanities with insight into humanity, nationality, state, and civilization related to the causes of phenomena and events, and apply procedural knowledge to specific areas of study in accordance with his talents and interests to solve problems	3.5 Comparing ionic bonds, covalent bonds, coordination covalent bonds, and metal bonds and their relation to substance properties 4.5 Design and conduct experiments to demonstrate the characteristics of ionic compounds or covalent compounds (based on melting point, boiling point, electrical conductivity, or other properties)	1. Explain Lewis theory of bonding and write down the Lewis structure 2. Explain the presence of molecules that do not meet the octet rule 3. Describes process of formation of ionic bonds and covalent bonds. 4. Comparing the process of forming single covalent bonds and double covalent bonds. 5. Describes the process of formation of covalent bonds coordination and differences from the length of covalent bonds. 6. Comparing polar covalent bonds with nonpolar covalent

	bonds and polar compounds with nonpolar compounds.
	7. Analyzing the properties of metals is associated with the process of forming metal bonds.
	8. Explain difference in the properties of ionic compounds and covalent compounds
	9. Concluded that type of chemical bond affects the physical properties of matter
	10. Design and conduct experiments on polarity of some compounds that are associated with differences in electronegativity of elements that make up the bond

Instruments needed in this study consists of a module validation questionnaire sheet for experts, response questionnaire for teachers, and response questionnaire for students. In the design and realization phase, a module is produced that is still in the form of the first draft or called draft 1 and module validation questionnaire sheet for experts, response questionnaire for teachers, and response questionnaire for students.

Validation by Experts

The modules that have been developed are validated by three validators. Validation is done to assess aspects of feasibility content, language, presentation, graphic and characteristics of multiple representation. Validation results can be in the following diagram:

Recapitulation of Average Assessment Score for Five Aspects of Feasibility Module Based on Multiple Representation

97,14 89,52 93,33 95,24 97,78

■ Aspects of Feasibility Content
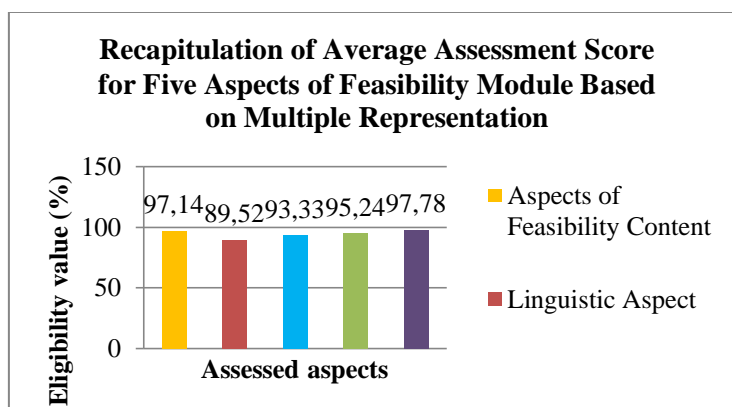
■ Linguistic Aspect

Figure 2. Average Assessment Score for Five Aspects of Feasibility Chemical Module Based on Multiple Representation

Based on diagram above it is seen that five aspects of feasibility in module is valid. Recapitulation of Average Assessment Score for Five Aspects of Feasibility Module by validator, aspects of feasibility content, linguistic aspect, presentation aspect, graphic aspect, and characteristics aspect of multiple representation

respectively for 97.14%, 89.52%, 93.33%, 95.24%, and 97.78% with valid categories. So the overall average score of multiple representation based model validation on chemical bond was 94.60%. Thus modules can be interpreted in valid categories. This is in accordance with the results of research conducted by Julia, D., Rosilawati, I., & Efkar, T. (2016) that module validation has a very high category so module is said to be valid. Revision results of the draft module based on suggestions by validators as follows :

1. In the module before revised on front cover page there is only one image and after revised the image is added to four images related to chemical bonds.

a   b

Figure 3. Page for module cover a. Before revision b. After revision

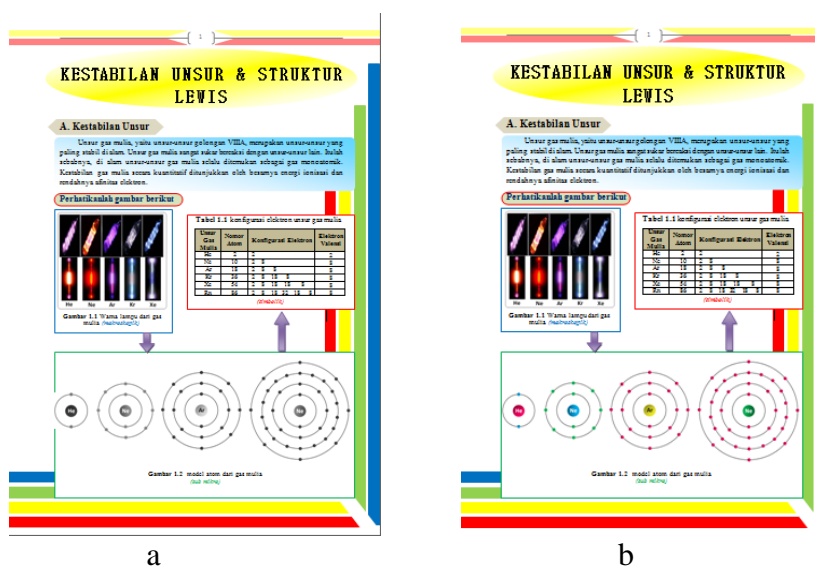2. In learning activities 1 on page 1 the image is added color so that it can distinguish them

a   b

Figure 4. Learning activities1 a. Before revision b. After revision

3. In module on metal bond there is addition of a real picture of metal forging process

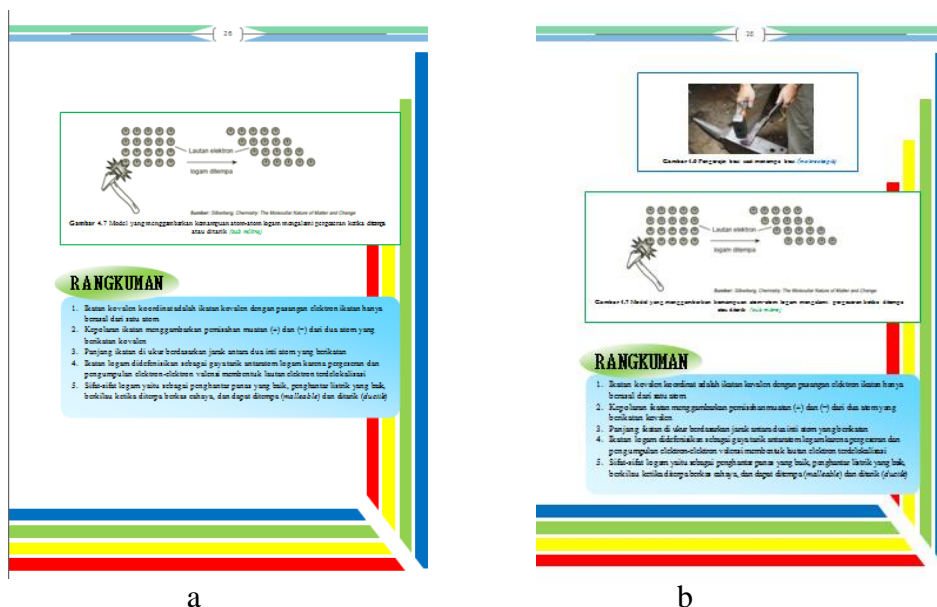| a	b

Figure 5. Metal Bonding a. Before revision b. After revision

Validator gives valid value to chemical bonding module based on multiple representation developed by the author in accordance with the assessment instrument. Modules developed have been prepared based on indicators of competency achievement that have been developed. According to Arikunto, S. (2021) that a product is said to be valid if the product can show a condition that is in accordance with its content and construct.

One-to-One Evaluation

One-to-one Evaluation is conducted on three students who can represent the target population of modules already created. Modules are presented to them individually. Results of evaluation obtained information, as follows:

Table 4. Data results of One-to-one Evaluation

No	Student Name	Comments On Module
1.	Student 1	There is a wrong page number, the picture is not clear, the answer key is wrong
2.	Student 2	in the table of Contents, the page contains errors and unclear pictures
3.	Student 3	Picture looks small, the concept map writing is too small

In the table it can be seen that the developed module still has shortcomings, which deficiencies will be corrected to produce better modules.

Small Group Evaluation

On results of small group evaluation in form of a response questionnaire for teachers and a response questionnaire for students to determine response to chemical bonding module based on multiple representation developed. Results for the questionnaire response for teacher and student can be seen in Table 5.

Table 5. Response data for teacher and student

Responden	Percentage	Category
Teacher	90.22%	Very Good
Student	89.37%	Good

In Table 5 that results of assessment of chemical bonding module based on multiple representation in form of a response questionnaire for students as users of the developed module is 89.37% with good categories. Meanwhile, response questionnaire for teacher on assessment of chemical bonding module based on multiple representation developed was given to three chemistry teachers. The average result of questionnaire response analysis for teachers by three teachers is 90.22% with the category of very well used. With the results of the questionnaire response for teachers and students, the modules developed get a good response and very good, so that the modules developed in form of chemical bonding module based on multiple representation can be used or implemented in actual learning process.

4. Conclusion

Based on results of research and discussion concluded that chemical bonding module based on multiple representation already has a valid quality seen from aspect of content feasibility, linguistic aspects, presentation aspects, graphic aspects and characteristics aspect of multiple representation with the meaning that the module has been worthy of use in learning activities. This is based on validation results from team of expert validators who achieved an average percentage of eligibility of 94.60% with valid categories. Average result of response questionnaire analysis for students to chemical bonding module based on multiple representation developed is 89.37% with good category. Average result of response questionnaire analysis for teachers to the chemical bonding module based on multiple representation developed is 90.22% with very good category.

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