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# Validity and Practicality of Problem Based Chemical Bonding Module with Cognitive Conflict Strategies

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**Abstract— Failure to build a knowledge structure causes students to have difficulty in understanding the concept of chemistry. Problem-based learning models can help to build knowledge. Curriculum 2013 expects learning to be carried out by applying critical thinking skills. This research aims to determine the validity and practicality category of teaching materials in the form of modules on the material problem-based chemical bonding with cognitive conflict strategies. The type of research carried out is development research with the Plomp development model. This research involved 3 chemistry lecturers of Faculty of Mathematics and Natural Sciences UNP, 3 high school chemistry teachers and 41 students of class X and 128 students of class XI in academic year 2020/2021. Module validity tests from chemistry lecturers and chemistry teachers were processed using the Aiken's V formula. Chemistry teachers and students are processed using the likert scale percentage formula. The results of the study inform that the resulting chemical bonding module has an Aiken's V validity test value of 0.84 (valid category) and the percentage value of teacher and student practicality, respectively, namely 86% (very practical) and 76% (practical).**

**Keywords— Validity; Practicalit; Chemical Bonding Module; Problem-Based Learning; Cognitive Conflict Strategies**

## I. INTRODUCTION

The 2013 curriculum used in the education system in Indonesia expects learning to be implemented by applying critical thinking skills. Critical thinking is an activity that focuses on problems, finds solutions and makes decisions. Critical thinking skills can be improved during the learning process through cognitive conflict learning strategies [1]. Learning cognitive conflict strategies can create knowledge structures through the interaction of initial knowledge with the learning environment of students (teachers, teaching materials, learning atmosphere). The goal of cognitive conflict learning is to improve conceptual understanding and reasoning abilities [2]. Learning cognitive conflict strategies is carried out through the stages of uncovering preconceptions, creating conceptual conflicts and seeking cognitive accommodation [3].

The learning model used in accordance with the 2013 curriculum includes a problem-based learning model that focuses on learning activities through phenomena/ problems in life. According to Arend (2012), problem-based learning models are implemented through 5 learning steps, namely: problem orientation, organization of learning activities, guiding independent and group investigations, develop and present the results of work, analysis and evaluation of problem solving [4]. The results of the research conducted have a significant effect on the application of problem-based learning with cognitive conflict strategies on students' critical thinking skills in learning physics [5].

Preliminary research was carried out through teacher interviews, filling out student questionnaires and literature studies. The results of preliminary research showed that the learning outcomes of students still needed to be repaired and improved, had not been maximal in accustoming critical thinking skills in learning activities, 54% of students did not understand the concept of material, experienced difficulties in distance learning (Covid 19 pandemic conditions). Based on the results of preliminary research, the solution given is learning with module teaching materials that guide students to learn independently at home or at school. Learning using modules adjusts to the abilities and learning speed of individual learners. The advantages of using the module are concept maps, color images, and charts that help understand chemical materials [6].

This study develops teaching materials in the form of chemistry learning modules on the subject matter of chemical bonds. Chemical bonding material is studied in class X SMA semester 1 with submaterials, namely ionic bonds, covalent bonds, and metal bonds. The module is developed with a plomp development model through preliminary research stages, prototype design and prototype assessment. The developed module is tested for validity and practicality testing to determine the quality of the module.

## II. Literature Review

### 1.1 Module

Modules are teaching materials with a series of learning activities arranged systematically to help students achieve learning objectives. Modules are arranged according to the basic competencies in the learning curriculum. Teaching using modules is carried out by individual teaching and adapting learning to the learning speed of students [7]. The writing of the module follows the guidelines for writing the PPG learning module in 2019 [8]. The module is organized into 4 learning activities (KB) and each learning activity includes a cover component, a table of contents, an introduction, a core and a closing.

Learning modules can support student center learning [9]. Modules are designed and adapted to the abilities and learning speed of students. The research conducted concluded that the development of a chemical module based on a scientific approach with a discovery learning model on electrolyte and non-electrolyte solution material and acid-base material was declared valid, practical and effective for use in chemistry learning [10]. Modules have characteristics such as self instructional, self contained, stand alone, adaptive, user friendly [11].

The colloid learning module with a problem-based learning model is declared effective in learning with an average learning achievement in the experimental class higher than the control class [12]. Another study conducted by [13] concluded that critical thinking skills increased with the level of effectiveness (87.93%) in the use of guided discovery learning acid-base modules in secondary school chemistry learning.

### 1.2 Cognitive Conflict Learning Strategies

Cognitive conflict occurs through an imbalance between what is observed and what is owned in the initial knowledge structure. As a result, students will change the concept to suit new knowledge until a balance is produced [14]. The equilibrium that occurs is in the form of conceptual changes that involve changing concepts that students bring before learning.

Cognitive conflict strategy learning is delivered by comparing the initial knowledge with the knowledge conveyed by the teacher during learning activities. Cognitive conflict is characterized by the recognition of the mismatch of initial knowledge and new knowledge learned. Cognitive conflict resolution is carried out by examining existing problems through discussion and concluding the results of the discussion [15].

Cognitive conflict is a constructivist approach developed by Joseph Nussbaum & Novick, 1982. Nussbaum and Novick proposed three stages summarized in a learning model, known as cognitive conflict strategies. The cognitive conflict strategy consists of the exposing alternative framework phase, the creating conceptual conflict phase, and the encouraging cognitive accommodation phase [16].

### 1.3 . Problem-Based Learning Model (Problem-Based Learning)

This learning model comes from constructivist learning theory through direct participation of students during the active learning process and finding problem solutions [17]. Problem-based learning is carried out through real problems in life. The problems in this learning model require an explanation of a phenomenon. Learning with this model is always faced with contextual problems. The learning steps according to Arend (2012) can be seen in Table 1[18].

TABLE I. STEPS OF LEARNING THE PROBLEM-BASED LEARNING MODEL

| **Learning Steps** | **Teacher Activities** | **Students Activities** |
|---|---|---|
| Orient students to the problem. | The problems raised should be contextual and found through reading material or activity sheets | Observe and understand the problems raised or obtained from suggested reading sources. |
| Organizing students to learn | Ensuring students understand learning objectives. | Stating questions related to the problems that have been raised. |
| Guiding individual / group investigations | Observing students in gathering information during the learning process. | Carry out a process of information gathering and discussion |
| Presenting and developing the work | Observing and guiding the discussion | Conducting discussions to find solutions to problem solving and the results are presented. |
| Analyzing and evaluating the problem-solving process | Guiding presentations and giving awards and together with students making material conclusions | Presenting the results found based on the problems set and making learning conclusions. |

## III. METHODOLOGY

The module was developed using a plomp development model through 3 phases, namely preliminary research, prototyping and assessment.

### 3.1. Preliminary Research Phase

The preliminary research phase follows 5 steps, namely needs analysis, literature review, curriculum analysis, concept analysis and student analysis. Needs analysis is carried out by collecting data through chemistry teacher interviews and filling out questionnaires by students via google form regarding the chemistry learning process that has been implemented. Literature review is carried out to find solutions to problems that have been formulated in the needs analysis. Curriculum analysis is carried out by establishing competency achievement indicators and learning objectives from basic competencies. Concept analysis will produce concept maps that provide information on the relationship between concepts according to basic competencies. Student analysis was carried out to obtain information on the characteristics of students in the intellectual (cognitive) and learning style aspects [19].

### 3.2. Prototype Phase

The prototype phase is the development stage of the chemical bonding module teaching materials which will produce prototype 1, prototype 2, prototype 3 and prototype 4. The prototype stage is always evaluated using a self-assessment questionnaire, a validity questionnaire and a practicality questionnaire that has been declared valid by the validator. Prototype 1, namely the step of designing the module according to the module writing guide [8]. The module consists of cover, introduction, core activity and cover. Prototype 1 was evaluated by the researcher himself with a self-assessment questionnaire and resulted in prototype 2.

Prototype 2 is subjected to a validity test by an expert review and a one to one test. The validity test was carried out by 6 expert reviews consisting of 3 chemistry lecturers of FMIPA UNP and 3 high school chemistry teachers. The minimum number of expert reviews is 3 people with a minimum qualification of a doctorate degree [20]. One to one test by 3 students with low, medium and high cognitive abilities. The advice of expert reviews and students was used as the basis for module evaluation by researchers using a validity questionnaire and a practicality questionnaire. The results of prototype 2 evaluation resulted in prototype 3.

Prototype 3 was carried out by a small group trial by 6 students. This trial aims to obtain a response to the use of the module after the validation test by an expert review and one to one before being tested on a one-class scale. Students involved in the small group test stage were 2 people with cognitive abilities low, medium and high. These suggestions are used as the basis for the evaluation of the module by the researcher using a practicality questionnaire. The results of the evaluation of prototype 3 resulted in prototype 4 which would be tested on a field test scale in the assessment phase.

### 3.3. Assessment Phase

The assessment phase carried out a practicality test of using modules by chemistry teachers and students on a scale of one class (field test). At this stage students will work on modules for 1 learning activity and the percentage of proper use of the module and student learning outcomes is calculated in the formative test of module learning activities. Research data in the form of interviews and questionnaires are primary data obtained directly from data sources, namely chemistry lecturers, chemistry teachers and students. The results of the module validation test by expert review were processed using the Aiken's V formula with the formula:

$$V = \frac{\sum s}{n(c-1)}$$

The results of Aiken's V calculation are adjusted to the category of decisions with a value of $V \leq 0.4$ which is declared less valid, a value of $0.4 < V \leq 0.8$ is declared moderate and a value of $V > 0.8$ is declared valid [21].

The results of the practicality test of students at the one to one stage, small groups, teacher field tests and student field tests were analyzed using the following formula:

$$P = \frac{f}{N} x 100\%$$

The results of the calculation of the practicality of the module are adjusted to the category of decision making in accordance with Table 2 [22].

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TABLE II. CATEGORIES OF PRACTICALITY TEST DECISIONS

| **Value Intervals** | **Interpretation** |
|---|---|
| $\leq$ 54% | Not practical |
| 55% - 59% | Less practical |
| 60% - 75% | Practical enough |
| 76% - 85% | Practical |
| 86% - 100% | Very practical |

## IV. RESULTS AND DISCUSSION

### 4.1. Preliminary Research Results

Needs analysis: The results of the needs analysis show that the learning carried out has not maximized the ability to think critically in accordance with the demands of the 2013 curriculum. Students have difficulty understanding the concept of chemical bonding material in distance learning activities in July-August 2020 (Covid-19 pandemic). This is due to participants students have not been able to connect the initial knowledge with the knowledge learned.

Literature review: cognitive conflict strategies combined in problem-based learning models so that learning is carried out more contextually in life. Contextual learning can help in understanding subject matter through phenomena in life.

Curriculum analysis: The curriculum in module development is the 2013 curriculum on chemical bonding material. This main material is in the basic competencies 3.5 and 4.5 in class X SMA. Basic competencies that have been determined are reduced to indicators of competency achievement and learning objectives achieved.

Concept analysis: The results of the concept analysis will produce a concept map that describes the relationship between the concepts of chemical bonding materials. Chemical bonding materials consist of the concepts of chemical bonds, ionic bonds, polar covalent bonds, nonpolar covalent bonds, coordination covalent bonds and metal bonds.

Analysis of students: The analysis was carried out on the intellectual (cognitive) and learning style aspects. The cognitive aspects were known through the learning outcomes achieved in the formative assessments and mid-semester assessments that had been implemented which were still low and needed to be improved. Aspects of learning styles are known from questionnaires that students who like learning are carried out through learning phenomena in everyday life.

### 4.2. Prototype Phase Results

Prototype 1: The module was developed with the 2019 module writing guide [8]. The module consists of 5 learning activities with each learning activity consisting of a cover, table of contents, introduction, core and cover. The module cover design can be seen in Fig 1.

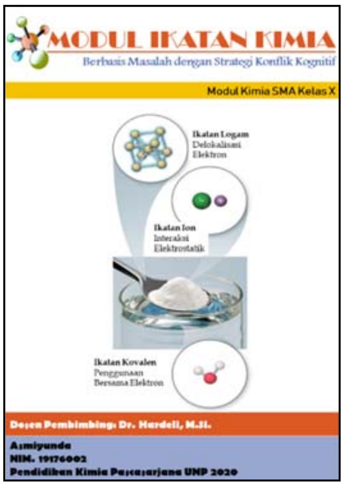



Fig 1. Cover Module

The introduction to the module learning activities consists of a brief description of the material, the relevance of the material and learning instructions. The design of the relevance of matter in life for the concept of the stability of the noble gas elements in chemical bonding material can be seen in Fig 2.

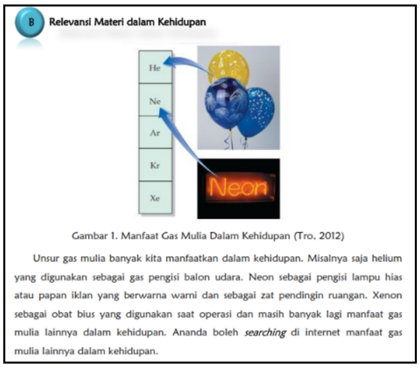
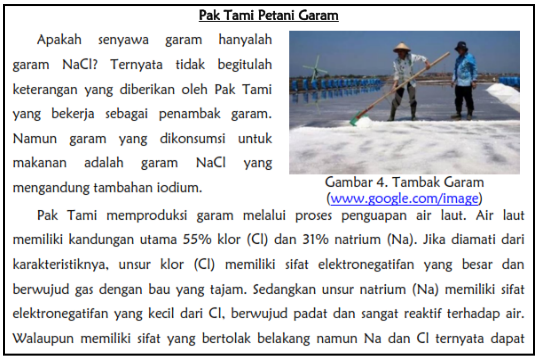



Fig 2. Relevance of Matter in Life

Core activities are learning stages that have been designed to achieve learning competencies. Core activities consist of learning objectives, subject matter and material descriptions according to the stage of the problem-based learning model equipped with cognitive conflict strategies. The design of the learning phase orientates students to the problem of ionic bonding material seen in Fig 3.



**Pak Tami Petani Garam**

Apakah senyawa garam hanyalah garam NaCl? Ternyata tidak begitulah keterangan yang diberikan oleh Pak Tami yang bekerja sebagai penambak garam. Namun garam yang dikonsumsi untuk makanan adalah garam NaCl yang mengandung tambahan iodium.

Gambar 4. Tambak Garam (www.google.com/image)

Pak Tami memproduksi garam melalui proses penguapan air laut. Air laut memiliki kandungan utama 55% klor (Cl) dan 31% natrium (Na). Jika diamati dari karakteristiknya, unsur klor (Cl) memiliki sifat elektronegatifan yang besar dan berwujud gas dengan bau yang tajam. Sedangkan unsur natrium (Na) memiliki sifat elektronegatifan yang kecil dari Cl, berwujud padat dan sangat reaktif terhadap air. Walaupun memiliki sifat yang bertolak belakang namun Na dan Cl ternyata dapat

Fig 3. Design Phase Oriented to the Problem

The closing activity consists of a summary of the material formulated by students, formative test questions to determine the achievements of students in each learning activity and bibliography to see reference sources for writing teaching materials. The initial design was carried out by self-evaluation tests by researchers using self-assessment questionnaires which compiled according to the module components with a problem-based learning model equipped with a cognitive conflict strategy. The results of this evaluation resulted in a module design with 1 prerequisite material activity and 4 learning activities that had fulfilled all module components. The results of prototype 1 evaluation resulted in prototype 2.

Prototype 2: The module design, hereinafter referred to as prototype 2, was tested for validity by an expert review, namely 3 chemistry lecturers and 3 chemistry teachers to get suggestions on the module being developed. Suggestions for improving expert review on module design can be seen in Table 3.

TABLE III. MODULES IMPROVEMENT BY EXPERT REVIEW

| No | Improvement Suggestions |
|---|---|
| 1. | Changing the supporting image of the module cover to suit the chemical bond material. |
| 2. | Improving the writing of the number of valence electrons in the prerequisite material learning activities. |
| 3. | Fix problems that are displayed in all learning activities to make them more contextual. |
| 4. | Changing the image supporting the properties of ionic compounds that conduct electric current in the solution phase. |
| 5. | Improve the type and font size of the module so that it can be read clearly. |
| 6. | Improve the instructions for using the module so that it is easily understood by teachers and students. |
| 7. | Improve the reference sources used in the supporting images in module learning activities. |
| 8. | Improve the writing of learning objectives. |
| 9. | Correcting errors in writing questions on formative test questions on prerequisite material learning activities. |

Based on the results of the improvements, the module validity test results were obtained through a validity questionnaire and filled in by an expert review. The results of the assessment can be seen in Table 4.

TABLE IV. AVERAGE MODULE VALIDITY QUESTIONNAIRE RESULTS

| No | Aspects Assessed | V | Category |
|---|---|---|---|
| 1. | Component Content | 0,82 | Valid |
| 2. | Serving Component | 0,76 | Medium |
| 3. | Language Components | 0,90 | Valid |

| | | | |
|---|---|---|---|
| 4. | Graphic Components | 0,88 | Valid |
| Average | | 0,84 | Valid |

Table 4 informs that the chemical bonding module developed was declared valid in the content, presentation, linguistic and graphic components with an average validity of 0.84 in the valid category.

The design of the module called prototype 2 was carried out by a one-to-one test on 3 students with low, medium and high cognitive abilities. This aims to get students' responses collected through practicality questionnaires. The practicality aspect with the aspects assessed is ease of use, efficiency of learning time and benefits. The results of the questionnaire calculation using the percentage formula obtained an average for the three aspects of 84% and are categorized as practical. Students think that the module being developed has an attractive appearance and the material displayed is clear enough. Based on the assessment of expert reviews and one to one trial, a prototype 3 is produced.

Prototype 3: Prototype 3 conducted small group trials with 6 students with 2 students each with low, medium and high cognitive abilities. This cognitive ability is known from daily assessments or suggestions from the class teacher. The results of the small group assessment were carried out the same as the one to one test, namely through a practicality questionnaire. This practicality questionnaire assesses the aspects of ease of use, efficiency of learning time and benefits. The average result of the questionnaire shows a value of 82% and is stated to be practical for use in small groups. The results of improvements in prototype 3 resulted in prototype 4.

### 4.3. Results of the Assessment Phase

Prototype 3 which has been evaluated produces prototype 4. Prototype 4 is subjected to large-scale trials (filed test). The trial was carried out on chemistry teachers and students at SMAN 1 Padang Class X Academic Year 2020/2021. The results of the processing of the questionnaire filed test for chemistry teachers and students can be seen in Table 5.

TABLE V. AVERAGE PRACTICALITY QUESTIONNAIRE FOR CHEMISTRY TEACHERS AND STUDENTS

| No | Aspects Assessed | Chemistry Teachers | | Students | |
|---|---|---|---|---|---|
| | | % | Category | % | Category |
| 1. | Ease of Use | 88 | Very Practical | 78 | Practical |
| 2. | Efficiency of Learning Time | 80 | Practical | 77 | Practical |
| 3. | Benefits | 90 | Very Practical | 77 | Practical |
| Average | | 86 | Very Practical | 77 | Practical |

Table 5 informs that the practicality of chemistry teachers is greater than that of students, namely 86% for chemistry teachers and 77% for students. The results of the processing of learning activities in the module and the results of the formative tests can be seen in Table 6.

TABLE VI. IMPLEMENTATION OF PRACTICALITY AND AVERAGE MODULE FORMATIVE TESTS

| No | Learning Activities | Practicality | | Average Test Module Formative | |
|---|---|---|---|---|---|
| | | % | Description | Average | Category |
| 1 | Prerequisite Materials | 84 | Implemented | 74,3 | Not complete |
| 2 | Learning Activities 1 | 77 | Implemented | 62,9 | Not complete |

| | | | | | |
|---|---|---|---|---|---|
| 3 | Learning Activities 2 | 93 | Implemented | 91,4 | Completed |
| 4 | Learning Activities 3 | 86 | Implemented | 76 | Completed |
| 5 | Learning Activities 4 | 84 | Implemented | 76 | Completed |
| Average | | 85 | Implemented | 76,12 | Completed |

### 4.4. Discussion on the Validity Test of the Chemical Bonding Module

The validity test was carried out by 6 expert reviews with a minimum number of 3 expert reviews [23]. The module validity test component consists of components of content, presentation, language, graphics [11]. The validity questionnaire used is also tested for validity before it is used to test the validity of the module. The validity test was carried out using the Aiken's V formula to obtain the validity category of the questionnaire and the validity of the module [21].

The average value of Aiken's V formula on the content component is 0.82 with the valid category. The average value of V informs that the module content is in accordance with the basic competencies of the cognitive and psychomotor domains of the subject matter of chemical bonds in KD 3.5 and KD 4.5. Quality modules are produced if they are in accordance with the learning competencies to be achieved in the curriculum [11]. The resulting module is in accordance with the learning abilities of students at the high school level (SMA) with the ability to reason and the ability to understand abstract concepts [24].

Modules are developed based on a problem-based learning model that has a problem suitability with the subject matter. Questions and formative test questions are in accordance with chemical bonding material. The truth of the facts, concepts and principles used can add to students' insight. Based on this it is concluded that the module developed is valid on the content and components. already in conformity with the material, model and characteristics of students.

The average value of Aiken's V formula on the presentation component is 0.76 in the medium category. This value informs that the presentation of the module with a problem-based learning model with this cognitive conflict strategy needs to be improved. The thing that needs to be fixed during validation is the problem discourse displayed at the stage of orienting students to the problem. The problems used must be contextual that students can observe or feel in their lives [12].

In addition, it still needs to be developed and conducted trials to assess the accuracy between the problem-based learning stage and the learning strategies used to support students' learning activities independently and train their reasoning skills [25]. Based on this, it is concluded that the resulting modules are valid categories that are currently in the presentation component.

The average value of Aiken's V formula on the language component is 0.90 in the valid category. This value informs that the resulting module has good legibility in terms of the typeface and font size used. The resulting module is in accordance with Indonesian spelling (EBI) with clear and consistent language on symbols or symbols. Based on this, it is concluded that the resulting module is valid for the linguistic component and is in accordance with the Indonesian spelling (EBI).

The average value of Aiken's V formula on the graphic component is 0.88 with the valid category. The average value of the Aiken's V formula informs that the display of the module is attractive in terms of font, font size, design, and images used in the problem-based chemical bonding module with the resulting cognitive conflict strategy. Based on this, it can be concluded that the resulting module is valid. on graphics with a good and attractive appearance. The average validity test results on each component of the problem-based chemical bonding module validity test with cognitive conflict strategies can be seen in Fig 4.

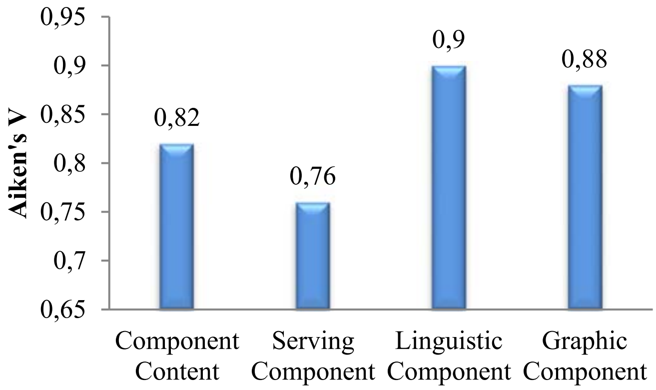



Fig 4. Aiken's V Average Score for Module Validity

Based on the average value of Aiken's V formula for the components of content, presentation, language and graphics, the final average for module validity is 0.84 (valid category). This informs the problem-based chemical bonding module with cognitive conflict strategies as valid in the opinion of the validator/ expert review.

### 4.5. Discussion on Practicality Test for Chemical Bonding Module

The practicality test was carried out to obtain information about the use of modules in teachers and students. The practicality test included components of ease of use, time efficiency and benefits of the module. This practicality test is divided into 3 stages according to the Plomp development model, namely individuals (one to one), small groups (small groups) and large groups (filed test).

Individual Stage (One to One): The one to one stage was carried out by 3 students. Information on academic abilities was obtained from daily assessments and recommendations from the chemistry teacher. Students were given an explanation of the research objectives and instructions for using the module. Students answer interview questions and practicality questionnaires via the google form link as feedback on module work. Based on the results of the questionnaire recapitulation, in general, students can use the module according to how it is used. Some of the suggestions and responses given include the developed module which is very interesting with the images and colors used and the use of practice questions that are made in a more efficient number for students to do.

Small Group Stage: The small group stage was carried out by 6 students. Information on academic abilities was obtained from daily assessments and recommendations from the chemistry teacher. Students were given an explanation of the research objectives and instructions for using the module. Students were asked to respond via a practicality questionnaire via the google form link.

Large Group Stage (Field Test): The filed test stage was carried out by teachers and students to obtain information on the implementation of the chemical bonding module that had been produced. The practicality test includes aspects of ease of use, efficiency of study time and benefits of using modules. This is in accordance with the objectives of the module draft trial in helping students learn and master lessons [11].

The results of the practicality test on the component of the ease of use of the module have an average Aikens V formula from the teacher questionnaire is 88% in the very practical category and 77% for students in the practical category. The characteristics of the learning module include stand alone, namely the use of the module is not accompanied by the use of other media, so it is easy to use. This provides information that the module usage component can be used in terms of clear learning instructions, the material shown is simple, the learning stage in the module can be implemented properly [11].

The practicality test results on the module time efficiency component have an average Aikens V formula from the teacher questionnaire is 80% in the practical category and 77% for students in the practical category. Based on this data, it can be concluded that the use of modules helps in learning time which is carried out online during the pandemic period.

The practicality test results on the benefit component of the module have an average Aikens V formula from the teacher's questionnaire 90% in the very practical category and 75% for students in the practical category. The module has been developed by paying attention to the layout and use of fonts and font sizes that can help students feel comfortable using them during learning. The practicality test results can be seen in Fig 5.

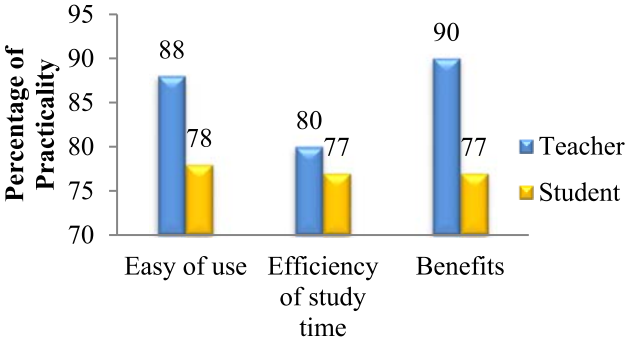



Fig 5. Results of Module Practicality by Chemistry Teachers and Students

Students do 1 learning activity in the module. Students complete all the practice questions and discussion sheets in the module and take formative tests to get student learning outcomes. This activity sheet is given an assessment by the researcher to get information on the practicality of the module. Based on the table 4 it is known that the developed module can be used by students with a percentage of 85% (implemented category) with the achievement of formative test results of 76.12% (complete).

## V. Conclusion

Based on the results of the research and data processing, it was concluded that the problem-based chemical bonding module with cognitive conflict strategies that had been developed was declared valid with an average Aiken's V value of 0.84 and the practicality level of the chemistry teacher and students at the filed test stage, namely 86% ( very practical) and 77% (practical).

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