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Validity and Practitality of Acid-Base Module Based on Guided Discovery Learning for Senior High School

Yerimadesi*[1], Bayharti[1], S M Jannah[1], Lufri[2], Festiyed[3], Y Kiram[4]

[1]Department of Chemistry, Faculty of Mathematics and Science, Universitas Negeri Padang, Indonesia
[2]Department of Biology, Faculty of Mathematics and Science, Universitas Negeri Padang, Indonesia
[3]Department of Physics, Faculty of Mathematics and Science, Universitas Negeri Padang, Indonesia
[4]Department of Sport Coaching Education, Faculty of Sport Science, Universitas Negeri Padang, Indonesia

*yeri@fmipa.unp.ac.id

Abstract. This Research and Development(R&D) aims to produce guided discovery learning based module on topic of acid-base and determine its validity and practicality in learning. Module development used Four D (4-D) model (define, design, develop and disseminate).This research was performed until development stage. Research's instruments were validity and practicality questionnaires. Module was validated by five experts (three chemistry lecturers of Universitas Negeri Padang and two chemistry teachers of SMAN 9 Padang). Practicality test was done by two chemistry teachers and 30 students of SMAN 9 Padang. Kappa Cohen's was used to analyze validity and practicality. The average moment kappa was 0.86 for validity and those for practicality were 0.85 by teachers and 0.76 by students revealing high category. It can be concluded that validity and practicality was proven for high school chemistry learning.

1. Introduction

Acid-base is the topic studied in semester 2 of 11th grade. Based on curriculum 2013, students are expected to understand, implement, and analyze the factual, conceptual, procedural, and metacognitive knowledge by studying this topic [1]. To achieve these competencies, students are required to learn the independent, active, and scientific learning process. One of learning models that can make students active and independent is guided discovery learning.

Guided discovery learningis a model which guides and trains students to achieve active learning, acquire knowledge, and build scientific concepts that they find for themselves[2]. Bruner considered that discovery learning is in accordance to the active invention knowledge and automatically gives the best results. Bruner also suggested learning would be more meaningful for students if they were focused on understanding the structure of information. Students should active to obtain information structure, and had to identify the key principles rather than merely accepted the teacher's explanation[3].

The application of guided discovery learning could improve student learning outcomes in science learning, such as physics [4], biology [5], chemistry [6], and geometry [7] learning in high school.

Research results revealed that guided discovery learning instruction would affect learning achievement, would influence retention, and would achieve presented significantly positive effects on learning retention[8]. Application of learning guided discovery learning also increases eight learning activities, namely oral, physical, mental, visual, and emotional, writing, listening, drawing activity [9]. In discovery learning process, students would be able to develop a more positive attitude towards learning and will improve student learning outcomes.

In applying guided discoverylearning, the teacher acts as a facilitator and motivator [10] [11]. Teachers must provide a complete learning material for students [10]. One of the learning materials that can lead students to learn independently is module.

Chemistry learning module can increase student motivation better in learning than other learning materials [12].In the other hand, it canimprove students' learning outcome, such as in topic of electrochemical analysis [13],hydrocarbons and their derivatives[14], mole concept [15], chemical equilibrium [16], and a buffer solution [17].

Based on this background, it was necessary to develop module for the other topics in chemistry. This study aims to develop a guided discovery learning module on acid-base topic for senior high school, then tested its validity and practicality.

2. Method

This research was research and development (R&D) methods that was used to produce a particular product, and tested the affectivity of the product [18]. This research produced module based on guided discovery learning on the topic of acid-base for senior high school. The development model used four D model (4D model) that consists of four phases: define, design, develop and disseminate[19]. This new research carried out until the stage of development that was the validity and the practicality of the module.

2.1 Define

Define stageconducted five analysis that describes in the following explanation. (1) Front-end analysis aimed to raise and set the basic problems faced by teachers and students in the learning process. This analysis was done by giving questionnaires to chemistry teachers and high school students; (2) Learner analysis wasa study of student characteristics. This analysis was conducted through study literature and giving questionnaires to students. (3) Task analysis aims to reidentify and analyze the master of students' ability through the determination of contents and learning units in accordance with the curriculum. The task analysis was done by analyzing the basic competencies of acid-base material, so it could be formulated in the form of learning indicators. (4) Concept analysis wascarried out by identifying and arranging them in the form of hierarchy, and detailing the main concepts and supporting material of acids and bases, through several books related to chemistry concepts which were stated in a tabular analysis of the concept. This was the basis of the preparation of concept maps. (5) Specifying instructionalobjectives, was carried out by formulating the learning objectives of the acid-base materials, that baseon indicators that have been made previously. Analysis of learning objectives and task analysis were the result of the analysis of concepts into learning objectives.

2.2 Design

This stage included:(1) the product's objectivies, (2) the product's target audience, and (3) a description of the product's components and how they will be used[19]. The products designed was learning materials in the form of acid and base module based on guided discovery learning for senior high school student. The module was designed in accordance with the stages of guided discovery learning, which included five phases: (1) motivation and problem presentation, (2) selection of learning activities, (3) data collection, (4) data processing, and (5) closure[20]. Thepreparation module format was modified from guide books of learning materials development that stated by the Education Ministry [21] and creative guides in designing innovative learning materialsby Prastowo [22].

2.3 Develop
The develop stage aimed to generate acid and base module based on guided discovery learning and tested validity, practicality and effectiveness of this module. The validity of module was appraised by experts, and practicality was tested by practitioners, that were teachers and limited or a small group students.

The research instrument used was a questionnaire. The validity of the questionnaire addressed to three chemistry lectures of Universitas Negeri Padang and three chemistry teachers of SMAN 9 Padang. Practicalities questionnaire addressed to three people a chemistry teachers and 30 students of SMAN 9 Padang academic year 2016/2017. The validity of the questionnaire was useful to assess the preliminary design of modules developed based on aspects of content, presentation, linguistic and format. Practicality questionnaire used to assess the practicalities of useful products, in the form of ease of use, efficiency and benefits of learning time aspects [23]. Validity data and practicality data obtained were analyzed by using Cohen kappaformula (equation 1), so that the moment kappa values obtained [24].

$$moment\ kappa\ (k)\ = \frac{\rho_o - \rho_e}{1 - \rho_e} \tag{1}$$

Information:
k = momen kappa describing validity of the product.
ρ_o = Realized proportion; counted by summing the score given by validators and then divided it by maximum total score.
ρ_e = Unrealized proportion; counted by substracting the maximum total score with the sum of total score given by validator, which then divided by the maximum total score.

Kappa moment value *(k)* ranges from 0 to 1 [24]. Interpretation kappa moment value can be seen in Table 1.

Table 1. The category of decision based on Kappa moment (k) [24].

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
≤ 0,00	Invalid

3. Result and Discussion
Based on the purpose of research and development (R&D) by using a 4D model development, it was obtained results of the study for each stage of development. The results obtained at each stage that has been done were defined, design, and develop.

3.1 Define
At this define stage, it was found five data, those were front-end analysis, analysis of student, task analysis, concept analysis, and the analysis of learning objectives. The results were described in the following explanation.

3.1.1 Front-end Analysis Results. Based on the front end analysis, this information could be obtained. (1) Analysis of questionnaires that was given to 24 senior high school chemistry teachers in Padang, and the data showed that the learning materials used was that 63.6% of teachers used books, 66.7% of teachers used student worksheets, 6.1% of teachers used module, and 3% of them used handout. (2) The learning materials used in schools was presented verbally and concepts provided directly, even though there were pictures but had not been able to fully help the students to discover concepts independently in accordance with the demands of the 2013 curriculum. (3) 48.5% of the teachers had been still teaching in the conventional *(teacher center,* whereas in 2013 curriculum demanded learning process that was student center. Based on the above issues, it should be developed a learning materials that can make students active, creative and innovative that demanded to 2013 curriculum. This study developed a learning material, namely acid and base module based on *guided* discovery *learning* that was expected to lead students in concept invention, to enhance the activity of students in the learning process, and enhance the students' understanding of the material being studied.

3.1.2 Analysis of Students Results. According to Piaget, based on the age of high school students, theywere categorized into the formal operational stage. At this stage the child already has the ability to think abstractly, reason logically and draw conclusions from the available information. However, not all students in adolescence were be able to think abstractly as described by Piaget, but they were a lot of teenagers who still thought in concrete operations[3].Based on the analysis of questionnaires filled out by the students, it was obtained the data that the materials used had not fully make active students in learning. Students were more like-colored materials, display, and attractive which motivated students to learn. This wasone of consideration in developing and preparing materials in the form of module.Developed and designed module had a color display which was expected to make students attractive in learning process,increasestudents activity andmotivate themin learning.

3.1.3 Task Analysis Results. Based on analysis of core competencies and the Basic Competency that stated in chemical-interest syllabus of 2013 curriculum for senior high school, some indicators of learning were formulated. Acid and base material has 2 Basic Competencies, namely (1) Basic Competency 3:10 Analyzing the nature of a solution based on the acid-base concept and pH of the solution; and (2) Basic Competency 4:10 Ascore competencies the idea of using the appropriate indicators to determine the acidity of acid / base or titration of the acid / base[25]. Indicators were formulated based on both Basic Competency 3:10 and Basic Competency 4:10.There were five indicators gained. (1) Describing the nature of the solution using Arrhenius, Brønsted-Lowry, and Lewis theory; (2) Determining the nature of the acid-base solution using litmus paper and natural indicators; (3) Analyzing the nature of the solution by pH of the solution; (4) Determining the nature of the acid-base solution using natural and chemical indicators; (5) Connecting the degree of acidity (pH) with the degree of ionization, and acid-base equilibrium constant.

3.1.4 Concept Analysis Results. Based on analysis of the main concept of acid base, the concept obtained in the acid-base materials were acid-base (acid-base theory), the strength of acid and base (strong acid, weak acid, strong base and weak base), acid-base properties, and the pH of acid and base. The concepts obtained were created from a concept analysis table comprising label concept, the definition of the concept, the type of concept, the attribute of concept, the position of concept, example and non-example[26].This concept analysis table was useful to create concept map and guide preparing the chemistry content of the module. Concept map in the module would help students easily remember the core concepts of the acid base.

3.1.5 Specifying instructional objectives. Based on the task analysis and analysis of the concept, the learning objectives were formulated.There were 12 learning objectives. (1) Students can describe the nature of the solution based on the concept of acid-base according to Arrhenius theory through learning materialscorrectly. (2) Students can describe the nature of the solution based on the concept of acid-base according toBrønsted –Lowry theory through learning materials correctly. (3) Students can explain conjugate pairs based on reaction equation according to Brønsted-Lowry theory through learning materials clearly. (4) Students can describe the nature of the solution based on the Lewis acid-base theory through a given learning materials properly. (5) Students can determine the nature of the acid, alkaline, and neutral solutionby using litmus paper and natural indicators through experiment appropriately. (6) Students can determine the natural product that can be used as indicators of the acid base through the trial properly. (7) Students can distinguish between a weak acid and a strong acid and weak base and a strong base through a given instructional materials appropriately. (8) Students can analyze the nature of the solution by pH of the solution through trial. (9) Students can distinguish a weak acid with a strong acid and weak base with a strong base the same concentration using indicators or pH meters through a trial. (10) Students can determine the pH of the solution using several chemical indicators through experiments conducted properly. (11) Students can calculate the pH of acids and bases through the examples given correctly. (12) Students can connect a weak acid with a strong acid and weak base with a strong base to obtain the degree of ionization(α) or ionization constants (K_{α})through a given instructional materials appropriately.

The learning objectives that have been formulated were a basis in preparing the acid-base modulebased on guided discovery learning, especially in developing activity sheet, student worksheet, and evaluation sheets.

3.2 Design

This stage was the stage to producea preliminary draft of acid and base modulebased on guided discovery learning for teaching senior high school chemistry. The parts of the modules that were designed through modified from the components of the modules presented in guidebook for development of learning materials by the Education Ministry[21] and creative guides make innovative learning materials developedby Prastowo[22],There were nine parts of module,such as: (1) cover,(2) core competencies, basic competencies, indicators and learning objectives, (3) a concept map (4) learning instructions or instructions for using the module, (5) activity sheets (6) student worksheet, (7) evaluation sheets, (8) the evaluation key and (9) bibliography.

Acid and base module was designed and prepared based onmodel of guided discovery learning for teaching senios high school chemistry. Syntaxmodel of guided discoverylearning was reflected in the student activity sheet. Some students experience activities were designed to find concepts through activities in the laboratory and in the classroom. Itwas also designed how to use chemical learning approaches that emphasized at all three levels of representation. Three level of representation should be achieved by students in understanding the chemistry, and is known as the *chemistry*triangle such as macroscopic level, sub-microscopic and symbolic level[27].Example display on the module can be seen in Figure 1.

Instructions in module were a guideline for students to use the module in the learning process. Activity sheet contained activities conducted during the students' learning process and some of the question must be filled out by the students. Student worksheet contained practice questions that would be done after completing activity sheets students. The evaluation sheet contained questions related to the overall learning materials in modules.

3.3 Develop

On*develop phase,*two forms of data were obtained, the validity data were given by the expert and practicality data were resulted from test of practicality of module by teachers and students.

3.3.1 Validity of Module. Data validity of modulebased on *guided discovery learning* can be seen in Table 2. Table 2 showed that module developed had very high validity for all components of the assessment that incuded the feasibility in terms of content, presentation, linguistic, and grafics.

Table 2. Results of the module validity by 6 validators

No.	Aspects assessed	k value	Category
1	Eligibility contents	0.85	Very High
2	Presentation	0.90	Very High
3	Linguistic	0.81	Very High
4	Grafics	0.90	Very High
Average		0.86	Very High

This module had very high validity category of the contents and the feasibility aspects. It meant that: (1) the module was in accordance to the demands of core competencies and basic competencies material on the syllabus of acid and basedemanded by senior high school curriculum in 2013 as outlined by Ministry of Education Rule No. 59 in 2014; (2) the preparation of module was accordancewith the child's development; (3) the preparation of module was in accordance with the needs of learning materials; (4) module had the correct material substance, (5) the content of the module could add insight; and (6) the characteristics of the module were in accordance to moral and social values [23][28].

The module had a very high validity in aspects of presentation, and it meant that the module constructed based on learning materials development standards according to the National Education Standards Agency (BNSP) [28].This module had clarity of learning objectives, the order of presentation was coherent, structured activity sheet syntax based on guided discoverylearning model and information submitted was complete. The module also gaveapperseption and motivation. Syntaxmodel of guided discoverylearning lead students to discovering and understood the concept through self – learning, so that objectives were achieved. The module was based on the characteristics of high school students and the material characteristics of acid-base. Learning with this module was equipped with a lab activity supporting students' understanding of concepts to be learned. In addition, the topic contained in the worksheet and evaluation sheets on the module had been prepared in accordance with the learning objective, so it can be used as a measurement of achievement of the learning objectives. Evaluation questions could be used to deepen and test their understanding of the material being studied, because the modules werecompleted with an answer key.

The module had a very high validity in aspects of language which means that the module was communicative, clarity of information, in accordance with Indonesian Spelling and used the language effectively and efficiently. The module has a validity of a very high in aspect of grafics.The module developed used a type and font size in accordance with the assessment standards of learning materials, lay out or correct layout, illustration, drawings and photographs as well as the design looked clear and attractive as writing guidelines learning materials[21] [22][28].

3.3.2 Revision. Phaserevision aimed to fix the acid-base modulebased *guided discvery learning* that was considered and evaluated by the validators prior to the product being tested. Module that had been repaired and then given back to the validator to be discussedfurther before being tested. Revision was completed if the validators had been declared that module developed was valid. Some aspects were revised based on suggestions of validators including: (1) create a title of sheet activities to the contents of the module, fix the concept maps to be clearer and derivatives of each of these concepts must have properties that are equivalent, as a follow-up then register an activity sheet on the table of contents modules and concept maps revised as the validator advice; (2) adjusted ions in the drawings, the same charge ion will repel that its position is far apart, and vice versa different ions will charge mutual attraction so that the position of the ion adjacent[29];(3) given a description of the type of acid/ base on the sample table of acid / base. This module was prepared for Indonesian students, so that the module designed was in Indonesian language. Figure 1 to 4 were examples of a revised image of the module.

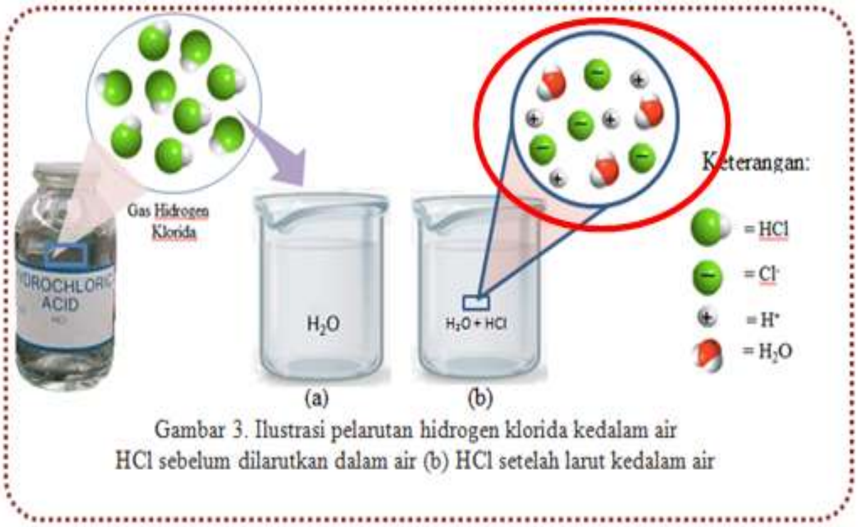

Figure 1. Location of ions in Figure Before Revision

Figure 1 needs to be repaired, the picture is a picture when the hydrogen chloride which is not an acid, but when dissolved in water will have acidic properties. With regard Pictures students are expected to explain the meaning according to Arrhenius acid. Define Arrhenius acid is a compound that releases H^+ in water and alkalis releasing OH^-[29].

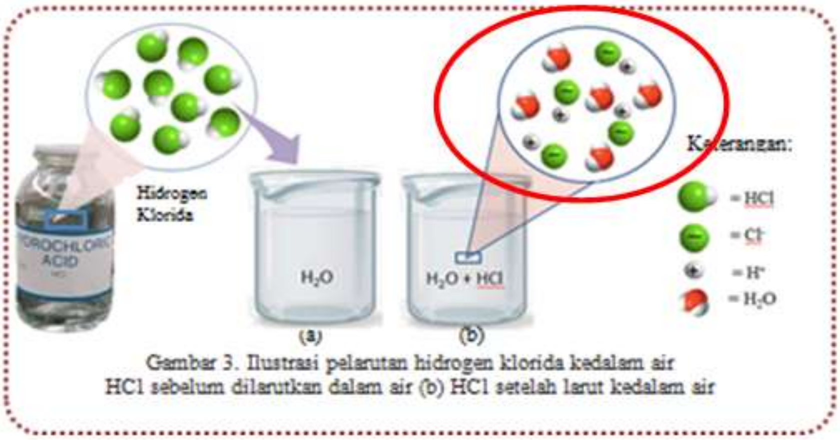

Figure 2. Location of Ions on the Image After the Revision

Rumus Basa	Nama Basa	Ionisasi Basa
NaOH	Natrium hidroksida	$NaOH(aq) \rightarrow Na^+(aq) + OH^-(aq)$
KOH	Kalium hidroksida	$KOH(aq) \rightarrow K^+(aq) + OH^-(aq)$
$Ca(OH)_2$	Kalsium hidroksida	$Ca(OH)_2(aq) \rightarrow Ca^{2+}(aq) + 2OH^-(aq)$
$Ba(OH)_2$	Barium hidroksida	$Ba(OH)_2(aq) \rightarrow Ba^{2+}(aq0 + 2OH^-(aq)$
NH_3	Amonia	$NH_3(aq) \rightarrow NH_4^+(aq) + OH^-(aq)$

Figure 3. Table Example Acid Alkali before Revised

Rumus Asam	Nama Asam	Reaksi Ionisasinya	
HF	Asam flourida	$HF(aq) \rightarrow H^+(aq) + F^-(aq)$	Asam monoprotik
HBr	Asam bromida	$HBr(aq) \rightarrow H^+(aq) + Br^-(aq)$	
HNO_3	Asam nitrat	$HNO_3(aq) \rightarrow H^+(aq) + NO_3^-(aq)$	
CH_3COOH (aq)	Asam asetat (cuka)	$CH_3COOH(aq) \rightleftharpoons H^+(aq) + CH_3COO^-$	
H_2S	Asam sulfida	$H_2S(aq) \rightleftharpoons 2H^+(aq) + S^{2-}(aq)$	Asam diprotik
H_2SO_4	Asam sulfat	$H_2SO_4(aq) \rightarrow 2H^+(aq) + SO_4^{2-}(aq)$	
H_3PO_4	Asam fosfat	$H_3PO_4(aq) \rightarrow 3H^+(aq) + PO_4^{3-}(aq)$	Asam triprotik

Figure 4. Table Example Acid Bases After Revision

3.3.3 Practicality of Module. Practicality of module was determined through testing of module by three chemistry teachers and 30 students of class XI IPA 4 SMAN 9 Padang. The results obtained were presented in table 4. It can be seen that the already practical module developed by teachers and students, in the form of the aspect ease of use, efficiency of learning, as well as benefits. The following table described the practicality of module based on the analysis of questionnaire responses of teachers and students.

Table 3. k value of the practicalities Test Module by teachers and students

No.	Aspect Assessed	k value	
		Teacher	Student
1	Ease of Use	0.84	0.77
2	Time Learning Efficiency	0.80	0.74
3	Benefits	0.90	0.79
Average of k value		0.85	0.76
category		Very high	High

3.3.3.1 Practicality of Teachers

Teacher questionnaire aimed to determine the extent of teachers' understanding of and response module that developed. Three aspects of the assessment provided by the teacher, and all aspects were considered to have a very high practicality category. These data indicated that the acid-base module guided discovery-based learning developed was easy to use and was practical in pilot schools. The module is easy to use and practical nature seen from the material presented that was very clear and simple. The module content was generally easy to understand. These data indicated that the modules developed in conformity with the practicalities of a resource criterion. Easy of using meant that product was practically used any time, matter and the language used in module was easily understood, the learning time become short, quick and precise, and learning steps provided on the module clear, and easily interpreted by the teacher[30].

3.3.3.2 Practicality of Students

Student questionnaire responses aimed to determine the extent of students' understanding of the material presented in the module. Based on the analysis of student questionnaire responses, obtained an average value of 0.76 kappa moment with high practicality category. These data indicated that students have started to exploit modules for independent learning, both individually and in groups without the presence of a teacher. The use of colors and images contained in the module made students interested in learning. The high interest or attention of students could occur because students were delighted with their communicative pictures as in Figure 2. The materials on module were also presented in accordance with the principles of chemical learning, so it can make students more systematic mindset and help in constructing understanding, and able to increase reading interest, motivation and curiosity of students. From Figure 2 showed that the material on the module were presented using the principles of chemistry triangle, namely (1) the level of macroscopic shows the real of hydrogen chloride acid in the bottle, (2) the level of sub-microscopic, seen from figure of the model of the HCl molecule, Cl^- ion, H^+ ion ,and H_2O molecule; and (3) the symbolic level indicated by the chemical formula. The formula of water is H_2O, the formula of hydrochloric acid is HCl, the formula of the chloride ion is Cl^-,and the formula of hydrogen ion is H^+.

Practicality module can also be seen based on the answers to questions in the activities and student worksheet by students that can be shown in Figure 5. This figure contained the score of activity sheet and student worksheet. It was obtained that the score of the student was above the minimum completeness criterion which was 80.

Data in Figure 5 showed that the learning module could improve student learning outcomes. The results obtained in accordance with the research done about modules on the learning other chemical materials, including: (1) the use of modules in chemical equilibrium based on scientific was effective the learning outcomes of students of class XI MIA SMAN 4 Padang, with the percentage of completeness of students 84%[16]; (2) the use of a buffer solution modules based on discovery learning was effective, and student learning outcomes in chemistry learning in class XI SMAN 7 Padang with an average value above minimum completeness criterion, that was 92[17].

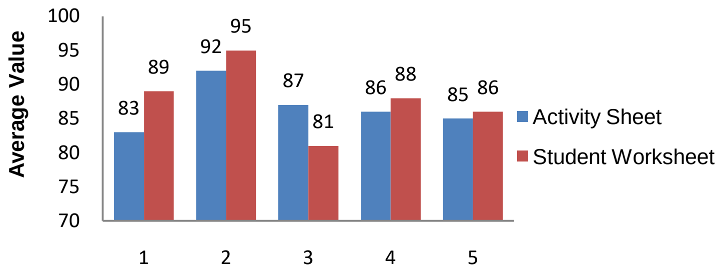

Figure 5. The Average Value Activity Sheet and Student Worksheet

Model guided discovery learning was used as a basis in preparing the proven module that can lead students to learn to find the concept and create a centralized learning to students. Student-centered learning methods by reinforcing the sense of group participation among the students motivate them to further study and enhance learning in higher levels of cognition [27]. Teaching methods promoted in guided discovery instruction are to cultivate learners' abilities of discovery, exploration, problem-solving and independent thin core competencies, and creation and invention or discovery through creative learning. Activity of students could encourage students in learning participation. It also made students construct knowledge by themselves. In other words, all knowledge was individually operated and explained, rather than passively acquired [8].

4. Conclusion

Based on the results of research and data analysis, it was concluded that the acid-base module based on guided discovery learning developed was valid and practical for high school chemistry teaching. Module developed had very high validity categories (k = 0.86) according to expert judgment, practicality was very high according to the teacher (k = 0.85) and high according to the student (k = 0.76). Therefore, this module can be recommended to use in a real learning in senior high school after this module tested in order to test the effectiveness. It is recommended that the continued study is aimed to test the effectiveness and disseminate the developed module .

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