Validity and practicality of buffer solution module based on discovery learning with a scientific approach to increase the critical thinking ability of 11th grade high school students

Ririn Ade Lestari*, Hardeli, Indang Dewata and E Ellizar

Department of Chemistry, Faculty of Mathematics and Natural Sciences, Universitas Negeri Padang, Jl. Prof Hamka, Padang 25131, Indonesia

*ririnadelestari@gmail.com

Abstract. The results of preliminary research indicate that there is no teaching materials integrated with the suggested learning model for the 2013 curriculum so that students' critical thinking skills can’t be developed yet. To improve learning outcomes and critical thinking skills of students developed a teaching material in the form of module-based discovery learning with scientific approach. The type of research used is Research and Development. This study aims to examine the validity and practicality of modules developed using the Plomp development model consisting of 3 stages: preliminary research, prototyping stage, and assessment phase. The module is validated by eight validators and is tested in two schools of medium and low ability respectively. The results of the validity data analysis show that the module generated meets the valid criteria in terms of content, constructs, graphics and language aspects. Module practicality is seen from teacher response questionnaire and student response questionnaire. The results of module practicality from aspects of attractiveness, ease of use, efficiency, and benefits for teachers and students with high module practicality categories.

1. Introduction
Critical thinking is now one of the important goals of education because it is a high-level thinking skill and is known to play a role in moral, social, mental, cognitive, and scientific development [1]. According to Ennis [2] critical thinking skills are high-level thinking skills that potentially increase the critical analytical ability of students in line with the improvement of intellectual ability. Critical thinking skills can be used by students to examine the opinions of others that are true or false based on scientific truths and knowledge so that students without any doubt can decide and judge correct and wrong opinions, ultimately students have intellectual independence.

The critical thinking indicators are classified into five aspects by Ennis: (1) elementary clarification, including: focusing questions, analyzing arguments, asking questions and answering questions that require explanations or responses. (2) basic support, including: consider the credibility of the source and make observation considerations. (3) inference, including: preparing and considering deduction, composing and considering induction, making decisions and considering the outcome. (4) Provide advanced clarification, including: identifying terms and considering definitions, and identifying assumptions. (5) strategies and tactics, including: determining an action and interacting with others [3].
Critical thinking skills are one of the personal skills that need to be developed through the education process. The students' critical thinking skills can be developed by teaching students how to search for answers to questions and problems objectively and with an open mind, then teaching students how to investigate the cause of an event [4]. These critical thinking skills should be trained in the learning process and teachers should facilitate students to think critically by implementing learning models and providing teaching materials that can improve critical thinking skills. According to research conducted by Kurniawan et al (2018) shows that the ability of teachers in managing the learning process can also affect student learning outcomes [5].

Based on the interview result of the writer with the chemistry teacher at SMAN 1 Padang, SMAN 5 Padang and SMAN 7 Padang, it was found that the learning process in school was still dominated by the teacher who delivered the material with the lecture method, group discussion and if there was enough time practicum, will only make learners save information provided by the teacher, in line with Andromeda et al (2018) research stating that if students are not directly involved in the learning process then the learning process students tend to memorize without developing critical thinking skills [6], while the teaching materials used by learners textbooks and worksheets containing only questions, and no integration of teaching materials with scientific approaches and suggested learning models for the 2013 curriculum.

This critical thinking ability still needs to be improved again, one way that can be done is to develop teaching materials that are integrated with scientific approaches and instructional models suggested for the curriculum 2013, so as to support the implementation of an active learning process and can develop scientific and process skills students' critical thinking skills. One of the learning models that can be used is the discovery learning model, the selection based on the characteristics of the buffer solution material which is factual, conceptual and procedural knowledge. Discovery learning can be interpreted as a learning model that can develop an active student's way of learning by self-discovery, self-investigation, the results obtained will be long lasting in memory, not easily forgotten by students [7]. Learning process with discovery learning model requires students to be able to find and find their own concepts and principles, from the stimulation provided with the direction of the teacher, so that the critical thinking process of students can be trained. Related research discovery learning module conducted by Ellizar et al (2018) shows that the discovery learning model is effective to help students understand the learning materials [8].

Teaching materials is an important part in the implementation of education because through teacher teaching materials will be easier in implementing learning and students will be more helpful and easy to learn. Teaching materials can be made in various forms in accordance with the needs and characteristics of teaching materials to be presented, one of the teaching materials that can be created and developed is a module. According to Depdiknas [9] the module is a set of teaching materials that are presented in a systematic and complete so that users can learn with or without teachers, with the module students can study individually at school and at home according to the speed of each learning. The module is also a resource that is not dependent on other media or should not be used together with other learning media so it is more efficient to use.

This study aims to produce discovery learning buffer based modules with scientific approach to improve students' critical thinking skills, and to see the validity and practicality of developed modules.

2. Research method
The type of research used is Research and Development (R & D) with Plomp development model consisting of three stages, namely preliminary research, prototyping phase, and phase assessment. In prototyping phase, formative evaluation is done, namely self evaluation, expert review, one to one evaluation, and small group evaluation.

Preliminary research stage aims to identify the problems that occur in the learning of chemistry so as to obtain a description of the product specifications required in developing the module. at the preliminary research stage, it is necessary to analyze the needs of teachers and students by conducting interviews and context analysis with literature review. In the context analysis is done curriculum
analysis and concept analysis. The curriculum analysis aims to study the scope of materials and learning objectives for developing teaching materials. The conceptual analysis aims to identify the materials to be discussed in the lesson. Then arranged systematically by linking one concept with another concept so as to form a concept map, so it can be known the main concepts needed for the next concept can be understood well.

Prototyping phase is designed module of buffer solution based on discovery learning with scientific approach based on analysis result at preliminary research stage. Modules that have been designed are formative evaluations. Formative evaluation is done by self-evaluation using checklist instrument, expert review using module validation sheet, one to one evaluation with interview and small group using questionnaire of student response practice.

The last stage is the assessment phase that is done field trials. The trial of this module aims to see the practicality of the modules developed in large groups, which are 58 students of high school XI grade by using questionnaire responses of student and teacher.

3. Result and discussion

3.1. Result
Research development of buffer solution module based discovery learning using the Plomp development model. The result is:

3.1.1. Preliminary Research
3.1.1.1. Needs Analysis

Needs analysis aims to gather information about the problems contained in the learning of chemistry, especially on the material of buffer solution. Needs analysis was conducted by interviewing 4 chemistry teachers and 9 students.

Based on the results of interviews with teachers can be concluded that the process of learning in schools is still centered on the teacher so that students' critical thinking skills can not develop properly. Teaching materials used by students in the form of textbooks and worksheets that contain only the questions and there is no integration between teaching materials with scientific approaches and learning models suggested for the curriculum 2013. Test the ability to think critically also conducted on 9 students and obtained the level of ability critical thinking students are in enough categories, so it needs to be developed again.

For that we need a chemistry teaching materials in the form of integrated modules with the learning model for the curriculum 2013 in order to meet the needs of students to actively find the concept independently so that students' critical thinking skills can be developed in the learning process. one of the learning model that can support the development of students' critical thinking ability is the discovery learning model

3.1.1.2. Curriculum Analysis

The curriculum analysis is done by analyzing basic competence (KD) on buffer solution material to formulate the indicator and learning objectives in buffer solution. Based on the indicators and learning objectives that have been formulated can be known what ability should be owned by students in learning buffer solution.

3.1.1.3. Concept Analysis

Concept analysis aims to identify the main concepts taught, detail and systematically construct concepts used to create concept maps and then be used as a reference in developing the module based discovery learning with scientific approach. The main concept of buffer solution is the meaning of the buffer solution, the acid buffer solution and the base buffer solution, the working principle of the buffer solution in maintaining the pH, buffer capacity and the range of acid buffer and base buffer.

3.1.2. Prototyping phase
Based on the results of the analysis at the preliminary research stage, it is designed discovery learning-based chemical module with scientific approach. This module is designed based on the stages of the discovery learning model whose stages can train students’ critical thinking skills. The initial module design results are then self-evaluated to see visible errors, such as typing errors, image size and module completeness using check list instruments. The results of self evaluation indicate that the module developed there are still errors in typing. After the revised prototype I was generated

3.1.2.1. Prototype I
The prototype 1 is then performed by expert review to get a valid scientific prototype in terms of content, constructs, language and graphics. The basis of this expert election refers to the opinion of Sugiyono [10] which states that to test the validity of judgment experts can be used.

Validation is done by four lecturers consisting of two chemistry lecturers, one lecturer of language and one lecturer of educational technology and three chemistry teachers. The instrument used in the validation phase of this module is the validation sheet. The validator assesses the module and provides suggestions for improvements to the modules already developed. The validator suggestion becomes a reference in improving the module. The validation results of the discovery learning module with the scientific approach by the validator were analyzed using kappa moment. The results of analysis can be seen in table 1. Table 1 show that the category of validity is very valid, it is seen from the total kappa moment value is 0.86. The revised module design and validated by experts is called prototype II.

| No | Measurement aspect | k (kappa moment) | Category |
|----|--------------------|-----------------|----------|
| 1  | Content component  | 0.86            | Very high|
| 2  | Construct component| 0.85            | Very high|
| 3  | Language component | 0.84            | Very high|
| 4  | Graffiti component | 0.85            | Very high|
|    | Total Validity     | 0.86            | Very high|

3.1.2.2. Prototype II
At this stage, the formative evaluation of One-to-One Evaluation was conducted by interviewing three students of grade XI MIPA SMAN 7 Padang with low, medium and high ability. There are three aspects that are evaluated at this stage that is clarity, appeal and obvious errors.

Based on the results of the interviews it is found that in terms of attractiveness, the cover used in the module is interesting, the module usage manual can be well understood, the presentation of the material inside is clear, the language used in the module is easy to understand, the students can understand the steps learning using modules and students are also interested in learning to use modules. Students with moderate and low skills still require direction from the teacher to identify problems at the stimulation stage and formulate hypotheses. Students with moderate and low ability also have difficulties and answer questions on collecting and processing data, so it is necessary to add questions that can lead students. After revision of the module design, we get prototype III.

3.1.2.3. Prototype III
In prototype III, small group evaluation is done by teaching the material of buffer solution to 9 students of SMAN 5 Padang class XI MIPA, where each student gets 1 module design, the learning activity is designed according to the learning in the classroom. At the end of the meeting students are asked to fill out a questionnaire related to the use of modules in the learning process. The purpose of this questionnaire is to see the practicality of modules in small group evaluation. The result of questionnaires students at small group stage can be seen in table 2. Table 2 show that the category of practicality is very practical, it is seen from the total practicality value is 0.85.
Table 2. Practicality results on small group

| No | Measurement aspect          | K   | Practicality level |
|----|-----------------------------|-----|--------------------|
| 1  | Ease of use                 | 0.92| Very high          |
| 2  | Efficiency                  | 0.79| High               |
| 3  | Benefits and appeal         | 0.85| Very high          |
|    | Total Practicality          | 0.85| Very high          |

3.1.2.4. Prototype IV
Prototype IV field test. Schools in the test site is SMAN 5 Padang and SMAN 7 Padang. Next is the Assessment Phase.

3.1.3. Assessment Phase
This assessment stage aims to see the practicality and effectiveness of the modules tested in the field test. Practicality data was obtained from questionnaire to 58 students and 2 chemistry teachers after conducting the learning process using buffer solution module. The result of students' practicality in the field test stage can be seen in Table 3.

Table 3. Practicality results on field test

| No | Measurement aspect          | K   | Practicality level |
|----|-----------------------------|-----|--------------------|
| 1  | Ease of use                 | 0.76| High               |
| 2  | Efficiency                  | 0.68| High               |
| 3  | Benefits and appeal         | 0.73| High               |
|    | Total Practicality          | 0.73| High               |

The result of questionnaire of teacher practicality in field test stage can be seen in Table 4.

Table 4. Practicality results on field test

| No | Measurement aspect          | K   | Practicality level |
|----|-----------------------------|-----|--------------------|
| 1  | Ease of use                 | 0.76| High               |
| 2  | Efficiency                  | 0.68| High               |
| 3  | Benefits and appeal         | 0.73| High               |
|    | Total Practicality          | 0.73| High               |

Based on the above table it can be seen that the learning module that has been designed has a high level of practicality, meaning that the learning module is practically used by teachers in the learning process.

3.2. Discussion
3.2.1. Validity
The validity of buffer solution module based on discovery learning with a scientific approach to improving students' critical thinking skills is obtained at the expert review stage using validated instruments. The module design was validated by six validators, consisting of two lecturers of FMIPA UNP, one lecturer of language, one lecturer of educational technology, one chemistry teacher of SMAN 5 Padang, one chemistry teacher of SMAN 7 Padang and one chemistry teacher of SMAN 1 Padang.

Validation of buffer solution modules can be viewed in terms of content, construct, language and graffiti aspects. Content validity means the suitability of the contents of the module with the material in the 2013 revision curriculum 2016. The validity of the construct means the suitability of the module developed with the learning model, the learning discovery learning model. Language validity means
the module uses a language that is EYD compatible and easy to understand. Graphic validity means the module has an interesting look.

The module contents component has an average kappa moment of 0.86 with a very high prevalence category. A very high category of kappa moments indicates that the discovery learning buffer-based buffering module with the developed scientific approach fits the demands of core competencies, basic competencies, indicators, and learning objectives to be achieved. Content validity indicates the product developed in accordance with the 2013 revision curriculum 2016. The problem given in the module is in accordance with the material being taught. In addition, the questions created can lead students to find concepts. This suggests that modules are developed on the basis of strong theoretical rationale [11].

The construct validity of a product indicates that the various components in the product are related to each other and connected consistently [12]. Based on the validation result by the validator of the module construction component has a mean of kappa moment of 0.85 with the category of very high prevalence, meaning that the learning activity in the developed module is in accordance with the stages of discovery learning (stimulation, problem identification, data gathering, data processing, making conclusions) associated with the scientific approach (observing, questioning, gathering information, associating and communicating). In addition, the concepts presented in this module are also related to one another.

The linguistic component of the module has an average of 0.84 kappa moments with a very high category. Component language with respect to the shape and size of the letters can be read by the students so that students are easier to learn modules, instructions and information conveyed in the clear module. The language used has been in accordance with the rules of Indonesian language is good and true, easy to understand and clear so as not to cause confusion.

The graffiti component has an average kappa moment of 0.88 with a very high category. A very high category of kappa moments indicates that the images contained in the module are in clear, illustrations, photographs, display designs presented on modules using attractive colors. A good layout can create a distinct attraction to students’ interest in learning [13].

The average validity of the whole buffer solution module based on discovery learning with the developed scientific approach is 0.85 with the category validity is very high. The module validation results show that the module designed is valid. A product is said to be valid if the product can indicate a condition that is in accordance with the contents and constructs [14]. Content validity shows the state-of-the-art knowledge component and construct validity (consistency) indicating that module components are consistently connected to each other [12].

3.2.2. Practicality

Practicality is related to the use of teaching materials used in the learning process. The teaching materials are said to be practical if they can be used to implement the learning logically, and continuously, without much problem. Practicality considerations can be seen from aspects of ease of use, efficiency of learning time and module benefits [15]. Modules are said to be practical if teachers and user targets (students) judge that modules can and are easy to use [12]. Practicality data were analyzed by using kappa moment obtained from questionnaire of learners' response practice and questionnaire of teacher's response practice. The following is an explanation of the questionnaire of practicality analysis.

The instrument used is questionnaire of practicality given to 9 students at small group evaluation stage, 56 students of experimental class and two chemistry teachers who accompanied the research on field test stage. At the small group evaluation stage, the module is tested in real learning condition with 9 students with different ability, high, medium and low. At the end of the learning the students are required to fill out the module's practical questionnaire. Field test were conducted at two schools, SMAN 5 Padang and SMAN 7 Padang.

The result of the students’ practicality assessment on the small group from the aspect of ease of use obtained the average kappa moment of 0.92 with a very high level of practicality and on field test
obtained 0.78 with high module practicality level. This means that the buffer solution module based on discovery learning with a scientific approach developed is easy to use by students because the usage instructions, language and questions used in the module are easy to understand and clear, the module size is also practical and easy to carry.

Effectiveness aspects of learning time obtained very high level of practicality with kappa moment 0.79 in small group evaluation and 0.68 in field test, with high module practicality level. This means that by using the buffer solution module based on discovery learning with a scientific approach, the learning time becomes more efficient. At the beginning of the learning by using the module students have difficulties because they are not familiar with the learning steps contained in the module so that the learning time becomes less efficient, but at the next meeting the students are familiar, so that the learning time becomes more efficient. According to Daryanto [16] learning by using modules can make learning time more efficient and students can learn at their own pace.

Module benefit aspect obtained the average of practice level for small group is 0.85 with very high practicality category, and 0.73 in field test of high practicality category. This means that the buffer solution module based on discovery learning with a scientific approach developed can help students find their own and understand the concepts learned, help students to learn independently, buffer solution module also improves students' motivation to learn because the module is a picture that can stimulate students. Arsyad [17] stated that the existence of image stimulate teaching materials will give better results in remembering, recognizing, recalling, and linking facts with concepts. Charts and color drawings make the brain more active and enhance students' sense of pleasure [18].

The module practicality assessment is also done by the teacher who accompanies the researcher during the learning process using buffer solution module. The results of teacher's practicality assessment at the field test stage obtained kappa moment for the ease of use aspect 0.80, the learning time efficiency aspect 0.67, the attractiveness aspect of the teaching materials to the student's interest 0.67 and the benefit aspect of 0.74 with the high level of practicality. This means that the material presented in the module is clear, easy to understand, and has a practical size. In addition, the learning time becomes more efficient because the student worksheets have been provided in the module and the students can fill out instantly. Learning with modules can support the teacher's role as a facilitator.

Overall average kappa moment for the practice of buffer solution module based on discovery learning with scientific approach developed was 0.85 from students for small group test with very high practicality level, 0.73 for field test with level high practicality and 0.74 from teachers with high practicality level. The result of module practice shows that the designed module has been practically used by students and teachers for the learning process of buffer solution.

4. Conclusion
Based on the results of research and data analysis done, it can be concluded that 1) Level of validity is very high in terms of content, constructs, graphics and languages with average kappa moment 0.85, 2) Very high practicality level from small group questionnaire results, high of field test result questionnaire and have high practicality level from result of questionnaire response teacher.

References
[1] Hashemi, SA, Naderi, E, Shariatmadari, A, Naraghi, MS, and Mehrabi, M. 2010. Science Production In Iranian Educational System By The Use of Critical Thinking. International Journal of Instruction January 2010.Vol.3, No.1.
[2] Ennis,R. H. 2011. The Nature of Critical Thinking: An Outline of Critical Thinking Dispositions and Abilities. Chicago: University of Illinois.
[3] Ennis, R. H. 1985. A Logical Basic for Measuring Critical Thinking Skills. Educational Leadership,43(2):44-48.
[4] Lang, Hellmut R. 2006. Models, Strategies, and Methods for Effective Teaching. Boston: Pearson Education Inc.
[5] Kurniawan, W., Se prima, S., Nirbayani, E. S., Ellizar, E., & Hardeli, H. (2018, April). Effect of
Chemistry Triangle Oriented Learning Media on Cooperative, Individual and Conventional Method on Chemistry Learning Result. In *IOP Conference Series: Materials Science and Engineering* (Vol. 335, No. 1, p. 012103). IOP Publishing.

[6] Andromeda, A., Ellizar, E., Iryani, I., Guspatni, G., & Fitri, L. (2018, April). Validity And Practicality of Experiment Integrated Guided Inquiry-Based Module on Topic of Colloidal Chemistry for Senior High School Learning. In *IOP Conference Series: Materials Science and Engineering* (Vol. 335, No. 1, p. 012099). IOP Publishing.

[7] Hosnan, M. 2014. Pendekatan Saintifik dan Kontekstual dalam Pembelajaran Abad 21: Kunci Sukses Implementasi Kurikulum 2013. Bogor: Ghalia Indonesia.

[8] Ellizar, E., Hardeli, H., Beltris, S., & Suharni. (2018, April). Development of Scientific Approach Based on Discovery Learning Module. In *IOP Conference Series: Materials Science and Engineering* (Vol. 335, No. 1, p. 012101). IOP Publishing.

[9] Direktorat Tenaga Kependidikan. 2008. *Penulisan Modul*. Jakarta: Departemen Pendidikan Nasional.

[10] Sugiyono. 2012. *Metode Penelitian Pendidikan*. Bandung: Alfabeta.

[11] Rochmad. 2012. Desain Model Pengembangan Perangkat Pembelajaran Matematika. Jurusan Matematika Fmipa Unnes, 3(1): 59-72.

[12] Plomp, Tjeerd dan Nienke Nieveen. 2013. *Educational Design Research: An Introduction*. Enschede: Netherlands Institute for Curriculum Development (SLO).

[13] Hamdani. 2011. *Strategi Belajar Mengajar*. Bandung: Pustaka Setia

[14] Arikunto, Suharsimi. 2015. *Dasar-Dasar Evaluasi Pendidikan*. Jakarta: Bumi Aksara.

[15] Sukardi. 2011. Evaluasi Pendidikan, Prinsip, Dan Operasionalnya. Yogyakarta: Bumi Aksara.

[16] Daryanto. 2014. Pendekatan Pembelajaran Saintifik Kurikulum 2013.Yogyakarta: Gava Media

[17] Arsyad, Azhar. 2013. *Media Pembelajaran*, rev.ed. Jakarta: RajaGrafindo Persada.

[18] Ellizar, Bayharti dan Andromeda. 2013. Pengaruh Motivasi dan Pembelajaran Kimia Menggunakan Modul dan Tanpa Modul terhadap Hasil Belajar Kimia di RSMA-BI. *Prosiding Semirata FMIPA Universitas Lampung*:117-124.