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Development of chemistry e-module based on critical thinking skills using 3D page flip professional at second-grade senior high school

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Abstract: Entering 21st century, implementation of learning system should be student center learning. Electronic learning resource can be used as a self-study for student learning and develop student's critical thinking skill by collecting information independently. This study was development research in order to identify the feasibility level and students' response of chemistry e-module based on critical thinking skills using 3D Page Flip Professional with the topic of buffer solution. The study was conducted at SMA Negeri 5 Bengkulu with the total of 9 students in main field testing and 36 students in operational field which conducted in the other class. Applying R and D study design with Borg & Gall model which modification into 9 stages development. The data of this study were obtained from expert validation questionnaire of material and media, module readability test, and students' response questionnaire towards developed e-module. The feasibility of e-module based on critical thinking skills had "very feasible" category from expert validation of material which was 89.68% and expert validation of media which was 96.15%. Module readability score in the main field testing was 92.47% which stated that the discourse of e-module was easy to understanding. Students' response towards e-module in the operational field testing was 88.3% which stated that students gave very good response toward developed e-module. It showed that the use of chemistry e-module based on critical thinking skills using 3D Page Flip Professional was very feasible to be used as student learning resource on the topic of buffer solution.

Keywords: 3D Page Flip Professional, Critical Thinking, e-Module, Buffer Solution

INTRODUCTION

Advances in science and information technology will help developing all types of thinking skills from the basic to the high level of critical thinking skills. Based on the "21st Century Partnership Learning Framework", critical thinking skills are one of the competencies and skills that must be possessed by 21st century human resources (Ross, 2007). Critical thinking is a skillful activity and mental discipline for reflective and reasonable thinking in evaluating arguments, solving problems, making decisions, persuading, analyzing assumptions, conducting scientific research and learning new concepts. Critical thinking is very important for students to learn so they have ability in solving problems, investigations and discoveries information. This learning process will make students skilled in solving problems which faced by students (Yonanda et al., 2018).

Critical thinking skills are closely related in learning science. One of the sciences that play an important role in students' critical thinking processes is chemistry. Chemistry is an abstract science in some matter, mathematics, and experiments, started from the simplest concepts to more complex concepts (Purwaningtyas, et al., 2014). Linkages by linking some of these concepts require critical thinking skills that can be developed in the learning process. Chemistry

learning that trains critical thinking skills can be achieved by updating the quality of learning through the implementation of the 2013 of curriculum in 21st century learning. 21st Century learning has the principle that the teacher acts as a facilitator and students are actively involved to find solutions in solving problems (Zubaidah, 2016).Therefore, student can link several concepts with self-study. The ability of students to connect several concepts to solve problems can be developed into one of the chemistry subject, which is buffer solution.

Buffer solution subject is a subject that contains many complex and interrelated concepts, so that many students have difficulty in understanding the material (Purnawa, et al, 2016). The lack of students' understanding of the buffer material is thought to be due to the 21st century learning process that exercises critical thinking skills have not been optimally applied. Critical thinking skills are not a skill that can evolve by itself in line with the physical development of human. These skills must be trained through the provision of stimulus that requires a person to think critically.

Based on the results of the student learning needs' questionnaire from second grade students and interviews with teachers at SMA Negeri 5 Bengkulu shows that the process of chemistry learning in schools is teacher-centered and only few students to be active in the learning process. Students tend listen the explanation from the teacher and only remember and memorize the concepts that have been obtained. In fact, students are required to understand and relate some of these concepts so they can practice their critical thinking skills. Beside of that, based on the analysis of teaching resource conducted at SMA Negeri 5 Bengkulu also shows that the use of teaching resource which supports critical thinking skills has not been applied. Teaching resources used are printed-based teaching materials such as textbooks from libraries and worksheets. In fact, the supply of textbooks in schools is still limited and students do not have their own textbooks.

Students in the 21st century now tend to use digital learning through social media / electronics in learning. Learning needs to involve the use of digital technologies to explore knowledge, discuss virtually, presentations in class discussions (Handayani and Sundaryono, 2020). Digital technologies, however, can afford learners more, and better, time for engagement than traditional learning spaces where responses and feedback are expected more immediately. Teaching material that can be used to develop students' critical thinking skills and based on digital technologies is module (Natalina, et al., 2016).

Module is a set of teaching resource that presented systematically and completely so that users can learn with or without the teacher, with module students can learn individually at school or home according to their respective learning speeds (Yerimadesi, et al., 2016). Setyosari (1991) said the advantages to use module in learning are students' motivation can be increased, students' task can be identified quickly, students' learning outcomes can be suited to students' ability, and it is more effective and efficient in learning. Current module is not only presented in printed form, but also in electronic form or often called e-module. E-module is a part of electronic based e-learning where learning utilizes information and communication technology, especially electronic devices. E-module is teaching resource in the form of a module that displayed in an electronic format so it is expected to increase students' interest and motivation to learn (Asmiyunda and Azra, 2018). Electronic modules are expected to attract students' interest in learning and can illustrate abstract material, can be accessed easily by students using computers and various types of gadgets anywhere and anytime, thus allowing students to get immediate feedback and understand the subject matter completely (Saraswati et al., 2019).

The application of e-module also can be used as a new alternative for transforming print-based teaching resource into electronic-based teaching resource (Anwar, 2010). Based on research that has been done, e-module have excellent criteria so it was very feasible to be applied in learning (UZ et al, 2019; Saraswati et al., 2019). Teaching resource in the form of e-module can be made by using several applications, one of them is 3D Page Flip Professional. 3D PageFlip Professional is an application software used to create e-books, digital magazines, e-paper and more by converting PDF files to page-turning digital publications like a real book. With this application, adding videos, images, audio, hyperlinks and multimedia objects have been available (Fitri and Handoko, 2015). Muliawati and Pathoni (2019) reported that the average results of students' perceptions for the display, presentation of material and the advantages of e-module using 3D Page Flip Professional were respectively 91.41%, 84.68% and 91.82% with all three categories are very good.

Related to those explanations, it is needed to do research about the development of interactive learning resources as self-study for student in chemistry learning especially to develop students' thinking skills. Based on the previous research show that chemistry e-module based on critical thinking skill using 3D Page Flip Professional especially buffer solution subject has not been developed. Hence, this research aimed to develop chemistry e-module based on critical thinking skill using 3D Page Flip Professional at Second Grade Senior High School and know students' response toward e-module.

METHODS

This study is a research and development that was done at SMA Negeri 5 Bengkulu. In this study, the product which developed is chemistry e-module based on critical thinking skills using 3D Page Flip Professional that adopted from Borg & Gall development model which cover tens stages as follows: (1) research and information collecting, (2) planning, (3) develop preliminary form of product, (4) preliminary field testing, (5) main product revision, (6) main field testing, (7) operational product revision, (8) operational field testing), (9) final product revision, (10) dissemination and implementation). However, in this study carried out the simplification phase of the ten stages into nine stages. Dissemination and implementation is not done due to consideration of time and cost.

The population in this study was second grade students of SMA Negeri 5 Bengkulu in year 2019/2020. The subject of this study was taken from the normal population by random sampling technique which obtained main field testing subjects (limited scale test), XI MIPA 5, amounted to 9 students and operational field testing (broad scale test), XI MIPA 6 amounted to 36 students. The instruments in this study were questionnaire validation of learning resource from expert, questionnaire of student's responses to e-module, and module readability tests. Data analysis techniques consisted of expert team validation tests, module readability analysis, and questionnaire analysis of student's response toward e-module. The validation test of the expert team was seen from the content or material and media or instructional aspects of e-module which assessed as feasible using a questionnaire based on a Likert scale (Table 1).

Table 1. Score of questionnaire based on a Likert Scale

No.	Statement of attitudes	Score
1.	Very Agree (SS)	5
2.	Agree (S)	4
3.	Less Agree (KS)	3
4.	Disagree (TS)	2
5.	Very Disagree (STS)	1

As a provision in providing meaning and decision making the results of the above calculations can be interpreted in the range as in Table 2.

Table 2. Success indicators for product validity

Validity Criteria	Validy level
85,01-100%	Very valid, very feasible and doesn't need revision
70,01-85%	Valid and feasible, need little revision
60,01-70,00%	Quite valid and quite feasible, can be used but need revision
50,01-60,00%	Less valid, is not recommended to be used because need many revisions
01,00-50,00%	Not valid, should not to be used because need big revision

Module readability analysis is known based on the results of the mortar test that has been done by students. The results of the module readability test were analyzed with the formulation proposed by Akbar (2013) as follows:

$$X = \frac{\text{exact number of content}}{\text{number of passes}} \text{ x } 100\%$$

Explanation:
a. The correct content is the same or synonymous with the original word released and in context, and
b. Incorrect content is not suitable with the original word, context, and not be answered

The results of assessment from the fill in the blank test sheet that have been filled out by students are presented as a percentage score and then described. The description used to interpret the percentage can be seen in Table 3.

Table 3. Assesment of fill in the blank test result

Score	Interpretation	Explanation
≥60%	Independent/clear	Doesn't need revision / material easy to understand indepedently
41%-60 %	Instructional	Need revision / need instruction from teacher as facilitator
≤40%	Frustation/fail	Need revision / material hard to understand

Analysis of questionnaire of student's response toward e-module based on Likert scale. The description data is recapitulated and every aspect of the responses from the whole student is presented. The formula used to calculate percentages proposed by Humairoh, et al., 2016) as follows:

$$\text{Score} = \frac{\text{number of student's score}}{\text{maximum number of score}} \text{ x } 100\%$$

The score (%) that has been conducted is converted in the form of the Table 4.

Table 4. Criteria for user response

No.	Score	Criteria
1.	86-100%	Very good
2.	76-85%	Good
3.	56-75%	Enough
4.	55-59%	Less good
5.	0-54%	Not good

RESULTS AND DISCUSSION

Research and Information Collecting

In this step, the author did a preliminary study to study, transfer, and gather initial information about filling out the questionnaire of, interviews with teachers and curriculum analysis. The results of the questionnaire of students learning need at second grade SMA Negeri 5 Bengkulu shows that 58.3% of students stated they sometimes repeat lessons. In fact, 88.9% of students also stated that the learning activities did in the classroom and the teacher dominated during the learning activities. It will cause a lack of students' understanding about a lesson, then 41.7% of students stated learning resources that are often used are textbooks obtained from the school library. This shows that students still do not have their own textbooks so that they only depend on the teacher's explanation. Beside of that, their chemistry textbooks were still difficult to understand and all students needed chemistry learning by e-module to support learning, whereas in reality the teacher had never made e-module as teaching materials and students had never learned by using e-module on chemistry learning. Whereas, 97.2% of students have gadgets / laptops so that the use of gadgets / laptops in the learning by using e-module can be implemented. Interview results with chemistry teacher show that in the learning process she often use discussion methods by utilizing learning resources such as textbooks, worksheets, and the internet, also never made and used teaching material such as module or e-modules. In fact, the availability of facilities and infrastructure in schools is more supportive in implementing digital-based learning with utilizing information and communication technology.

The results of the curriculum analysis found that the curriculum used at SMA Negeri 5 Bengkulu was curriculum of 2013. One of the important things focus in the implementation of the 2013 curriculum was 21st century learning that could develop students' competencies and skills, especially critical thinking skills. Based on the regulation of Ministry of Education and Culture of the Republic of Indonesia Number 81A of 2013 students should have attitude, skill and knowledge (cognitive, affective and psychomotor) competence. The learning process that has been implemented does not support 21st century learning yet where the learning process is still centered on the teacher and little discussion. One of the subjects that apply discussion during the learning process at school is buffer solution, but the discussion might not support to develop critical thinking skill so that student learning outcomes are less than optimal. Related to that fact, author develop chemistry e-module based on critical thinking skill on buffer solution subject.

Planning

In the planning stage, author make product development design plans as outlined in the Module Content Outline (GBIM). GBIM consists of the module title, general objectives of learning as outlined in basic competencies, specific learning objectives as stated in the indicators of achievement of competencies, topics or subjects material, details of material / sub-topics, and library / source of literature. Before the module is arranged, firstly the author creates a module framework so that module can be done regularly and in a structured manner. The module framework starts from the cover, preface, table of contents, module usage instructions, competencies and indicators, concept maps, activity 1, activity 2, summary, understanding test, answer key, glossary, and reference.

Develop Preliminary Form of Product

After the module framework is formed, the next step is the development of e-module. The module that the author developed is e-module using 3D Page Flip Professional application made in *pdf* format. After that, the module is converted to an application and published online as a link: http://online.3dpageflip.com/pewx/oecz/ and offline in format (*.exe*). After e-modules are published online and offline, students can access e-modules through laptop and smartphone. Display e-module using 3D Page Flip Professional seen in Figure 1.

Figure 1. Display e-modul on *3D Page Flip Professional* application

The parts of e-module that author developed are as follow:

Front cover section

Front cover consists of the title of the material, the title of the module, the picture, the name and institution of the writer, and the year of making e-module. The e-module cover page is packed with various images and colors and the layout of e-module cover appear to attract students' attention in learning by e-module.

Initial section

Initial part of the e-module consists of preface, table of contents, module usage instructions, Basic Competency (KD) mapping and indicators, also concept maps. The table of contents has been completed with a link so students more easier to access the pages in the e-module as they wish. The module usage instruction provides an overview of how students learn e-module and concept map aims to outline the contents of e-module

Content section

The author developed chemistry e-module which contained buffer solution subject based on critical thinking skills. The aspects of critical thinking skills in e-module use 5 aspects of critical thinking groups according to Ennis, namely providing simple explanations, building basic skills, concluding, giving further explanations, and managing strategies and tactics (Ennis, 2011). Aspects of critical thinking skills which used include 8 indicators integrated in learning materials, activities, and test questions of understanding. Learning activities include the stages which are “let's observe”,” let's experiment or let's analyze”, “let's read”, and “let's conclude”.

The section “let's observe” in e-module is asking questions or problems. At this stage students are required to formulate a problem based on what observed by students. This section is also adjusted to the indicators of critical thinking skills, namely focusing questions with sub-indicators of identifying or formulating questions, so the outcome to be achieved is problem

formations which created by students and guided by the teacher, also in this stage, students classify the data and formulate hypotheses. It is adjusted to indicators of critical thinking skills, namely inducing and considering the results of induction with sub-indicators expressing hypotheses, so the outcomes to be achieved is hypotheses which made by students by discussing through groups and guided by the teacher. Display e-module in "let's observe" section in Figure 2.

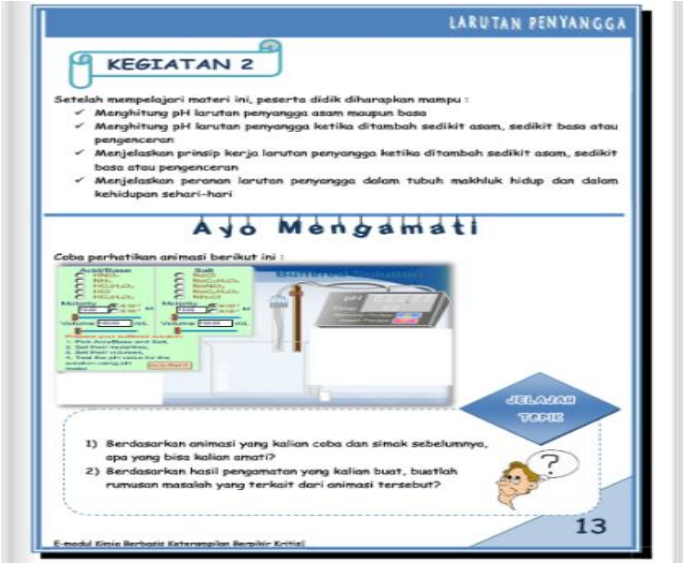

Figure 2. Display e-module in "let's observe" section

The section "let's experiment / let's analyze" in e-module is collecting data. The data generated in the form of tables so students can collect data, interpret data, and see relationships and hypotheses test that have been formulated. This section is also adjusted to indicators of critical thinking skills that are considering whether the source can be trusted or not with sub-indicators considering the use of appropriate procedures. Display e-module in "let's experiment / let's analyze" section in Figure 3.

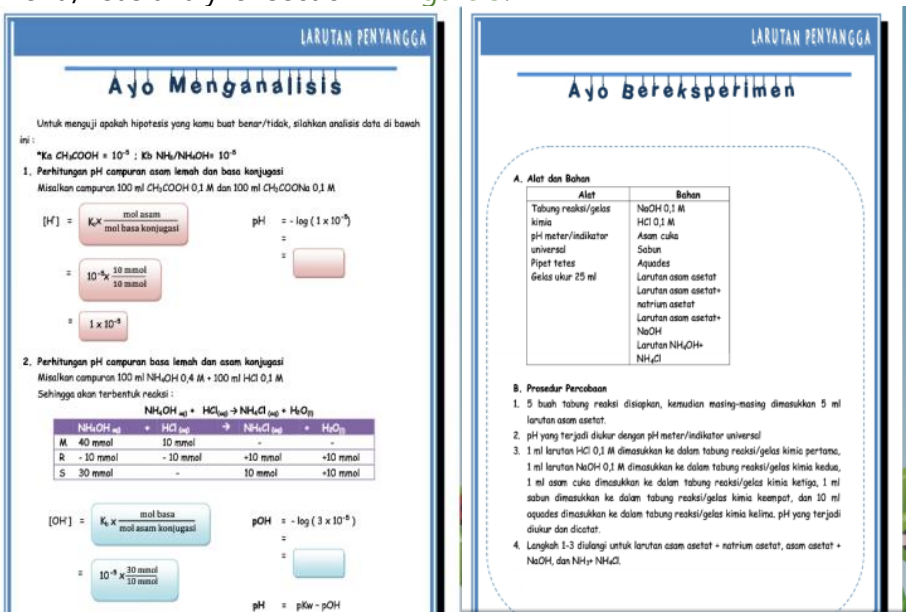

Figure 3. Display e-module in "let's experiment/let's analyze" section

The section "let's read" in e-module is adjusted with indicator of critical thinking skills, namely asking and answering questions with sub-indicators giving a simple explanation. After

students have done various activities, the questions that come to students' mind will be answered in the material description in this section. Display e-module in "let's read" section in Figure 4.

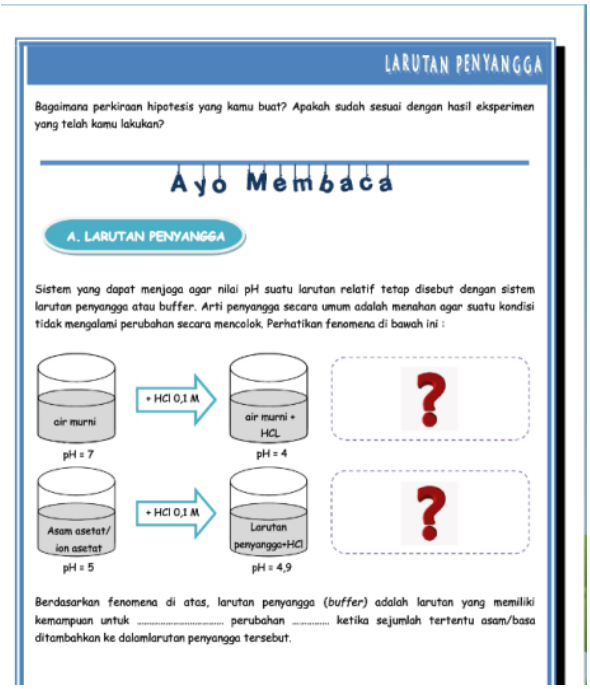

Figure 4. Display e-module in "let's read" section

Next, in the section, "let's conclude" in e-module is formulating conclusions. At this stage, students draw conclusions based on data that has been collected and analyzed. In addition, this section is also adjusted to indicators of critical thinking skills, namely inducing and considering the results of induction with sub-indicators drawing conclusions from the results of investigating. Thus, students can conclude the all the buffer solution material with their teacher and discussion with their groups. Display e-module in "let's read" section can be seen in Figure 5.

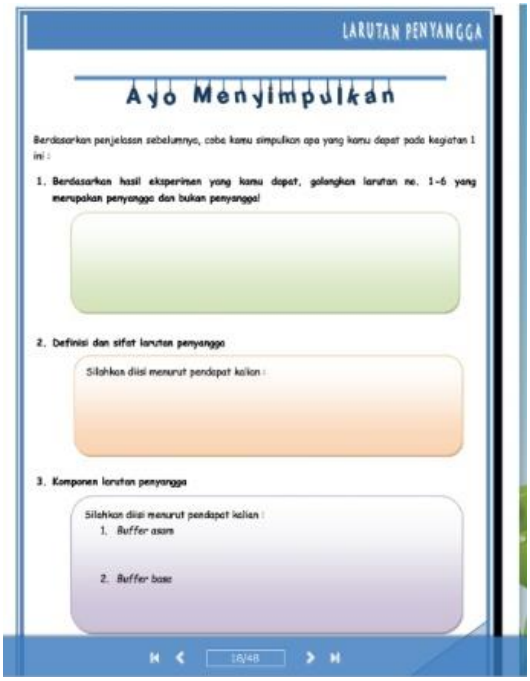

Figure 5. Display e-module in "let's conclude" section

Final section

The final section of the e-module consists of a summary, understanding test, answer key, glossary, and reference. The comprehension test questions in the e-module are made according to the critical thinking skill sub-indicator including identifying or formulating questions and proposing hypotheses based on the discourse presented in, providing simple explanations, reporting observations and strategies in making definitions and acting further.

Preliminary Field Testing

After the author developed the initial module product format, the next stage is preliminary field testing e-module based the feasibility level to the material and media aspects. In this stage, the module developed by the author was tested for its feasibility on the material aspects carried out by 2 content experts from each aspect and the media aspect carried out by 1 media expert from each aspect. For e-module validation of the content expert and media expert can be seen in Table 5 and Table 6.

Table 5. The result of e-module validation from content expert

No.	Items	Percentage	
		Expert 1	Expert 2
1.	Preliminary aspect	90%	90%
2.	Content aspect	91,25%	93,75%
3.	Summary aspect	93%	100%
4.	Critical thinking aspect	78%	85%
	Totality Percentage	87,74%	91,61%
	Average Percentage	89,68%	
	Criteria	Very valid, very feasible and doesn't need revision	

Table 6. The result of e-module validation from media expert

No	Items	Percentage
1	Display aspect	95%
2	Using aspect	100%
3	Utilizing aspect	95%
	Totality Percentage	96,15%
	Criteria	Very valid, very feasible and doesn't need revision

Overall, e-module validation assessment by material experts has a percentage of 89.68% so that it is included in the category of very valid, very feasible, and does not need to be revised. It shows that the chemistry e-module was feasible to be used in the learning process in terms of the material aspects, so that the material in the e-module was based on critical thinking skills and in accordance with the core and basic competencies used in SMA / MA with reference to the 2013 curriculum for buffer solution material.

Meanwhile, overall assessment of e-module validation by media experts has a percentage of 96.15% so that it is included the category of very valid, very feasible, and does not need to be revised. It shows that the chemistry e-module is feasible in terms of appearance and presentation. Based on previous research states that e-module by using 3D Page Flip Professional application have a good display design, because the appearance of e-module can attract students' reading interest and access to open e-modules that is very easy (Munawaroh, 2019). Thus, in accordance with previous studies, the results of the validation of content and media experts on e-modules indicate that learning chemistry using e-modules is appropriate for use in the learning process (Irwansyah, 2017).

Main Product Revision

The initial product revision based on the results of the validation test in the form of assessments, comments and suggestions from material experts and media experts. The results of assessment by validator on the questionnaire concluded that the e-module was feasible for field testing without revision, because of the results of expert validation had a percentage in the range of 85.01-100%, so the e-module did not need to be revised.

Main Field Testing

The e-module assessment process continued with the main field testing stage which involved 9 students by doing test. The purpose of this stage is to anticipate errors and obstacles that can occur during the application of e-module in the learning process on a broad scale. The result of e-module readability test can be seen in Table 7.

Table 7. The result of e-module readability test

No.	Student	Score
1.	AA	100
2.	FNH	100
3.	AF	100
4.	ADW	92,9
5.	YA	96,4
6.	AF	100
7.	IL	75
8.	NARP	75
9.	FDC	89,3
	Total	832,2
	Average	92,47
	Level of e-module readability	Independen/Clear
	Explanation	Doesn't need revision

The results of e-module readability test conducted by students obtained a percentage of 92.47% which is in the range of ≥60% which indicates that the e-module readability level is classified as independent which means the discourse on the e-module is easy to understand, so there is not need to be revised and not carried out to the operational product revision stage. This shows that e-module is very feasible to use for next stage which is operational field testing stage.

Operational product revision

Based on the results of field testing through the e-module readability test, it showed that the e-module readability score is 92.47%, so that the e-module that author developed does not need to be revised and ready to be tested.

Operational field testing

At the operational field testing stage, students are given an e-module in the form of a link to be accessed by online using smartphone in puffin browser and laptop via google chrome browser, in addition students are also given an e-module file with the format (.exe) so that students can access the e-module offline via a laptop. Therefore, using e-module by communication tools such as laptop or smartphone easier to access and more interesting as learning resources.

E-module is used before and after class learning. Before class, students study independently using e-module and answer all the question that contained in e-module and after class learning,

students with groups discuss the material using e-modules via smartphone or laptop. After students access the e-module, students did the learning process on the buffer solution material with two meetings in class. The first meeting, students carry out practicum and the next meeting students discuss the material buffer solution together with the teacher. Based on the observation in learning process at class, student very enthusiasm did practicum activity. Hence, students have given some instruction what should they do in e-module, so student easier did step by step that must be done. Furthermore, at the end of the trial, students are given a questionnaire of students' response toward e-modules that author develop.

The results of students' responses toward e-module have a percentage of 88.3%. If the value of 88.3% is interpreted, it is categorized as very good because it is in the range of 86-100%. This is in accordance with previous research showed that the response of students to e-Book teaching materials using 3D Page Flip obtained a percentage of 85.4%, so the developed e-module is very feasible to be applied in schools (Sirait and Trianauli, 2017). Thus, author did not make the final stages of product revision.

Chemistry subject contains complex and continuous material between one material and others, so it requires more understanding for students. This can make students practice their critical thinking skills. Learning chemistry cannot be done only with class meetings but must be studied continuously especially if there is a lot of material with calculations so it requires a lot of practice questions. The use of e-modules will make easier for students to understand chemistry subject because students can learn the material repeatedly anywhere and anytime.

Students' comments on chemistry e-module based on critical thinking skills based were easier for students to understand the buffer solution material because the material description was arranged in detail and clearly, the e-module display was interesting and not boring, the operation of the e-module was quite easy, and the use of e-modules by using 3D Page Flip Professional create a new atmosphere of learning. Teachers who use technology as a learning media such as e-module can make the learning process more interesting and seem more real, because e-module can help students to learn individually/independently in the classroom (Asrial et al., 2020). Implementation of the e-module based on 3D Page Flip is effective in increasing students' abilities and interests. Students can interact not only in two directions but can be multipurpose (Asrial et al., 2019).

In addition, in the chemistry learning process that takes place in class, students are more active in evaluating arguments, solving problems and constructing their own knowledge with an explanation of the material that contained in e-module. Students independently in finding solutions to the problems given and analyzing the solutions obtained. They did some activities between group members and discussion with the teacher. It proved by several students in each group can answer the questions contained in the e-module. This shows that some students can answer all indicators and sub-indicators of critical thinking skills contained in the e-module. Based on expert assessment of the material in e-module from aspects of critical thinking it is also feasible to use. Thus, chemistry e-module developed by author based on critical thinking skills so that 21st century learning that can make students develop higher-order thinking skills especially in critical thinking skills on buffering material can be achieved.

Meanwhile, the authors found difficulty while doing this research. The first difficulty was time management when implementing e-module to the trial subjects. Because only a few student access e-module before class learning, so teacher explain more information to students. The second difficulty was some students still difficult doing interactive learning especially in chemistry. However the use of e-module still has some weaknesses, such as e-module is very

dependent on the fast internet network and available facilities such as laptop and smartphone, also depend on students' motivation to learn independently at home.

Final Product Revision

Based on the results of operational field testing through the questionnaire students' 'response toward e-modules, showed that the percentage of all students' assessment scores on e-modules is 88.3% with a very good category, so the e-module that author developed does not need to be revised again and can be used as chemistry learning resource on buffer solution subject for second grade student at SMA Negeri 5 Bengkulu.

CONCLUSION

Based on the results of data processing, it was concluded that chemistry e-module based on critical thinking skills using 3D Page Flip Professional was effective to be used as learning resource at second grade senior high school. It was shown by in accordance with the criteria of feasibility based on assessment of the expert and was suitable to use for students, also easy to understand as independently learning resource based on students' response.

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