

Development of Guided Inquiry-Based E-Modules on Acid and Alkaline Solutions to Improve Critical Thinking Skills and Scientific Attitudes of High School Students

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Abstract: This development research aims to make and evaluate based on the E-module of guided inquiry on acid and alkaline solution material, knowing the similarities and differences effective contributions between critical thinking skills and student scientific attitudes simultaneously and each before and after the use of the E-module. E-module assessments are carried out by material expert lecturers, media experts, six chemical teachers, and students. E-modules are tested using the pretest-posttest two-group design with the sampling technique, namely simple random sampling in class XI IPA students. The research sample consisted of 36 experimental class students and 34 control class students. The instruments used include critical thinking skills and questionnaires of students' scientific attitudes that are declared valid and reliable using the Rasch model test. The results of students' responses were analyzed using Hotelling's T^2 test, while the percentage of effective contributions was known to use the partial Eta Squared value obtained. The results showed the E-module was very well used in learning activities, there were differences in the difference between critical thinking skills and student's scientific attitudes simultaneously and between experimental classes and controls before and after the use of the E-module, and there was an effective contribution of E-module Against critical thinking skills and student scientific attitudes simultaneously by 24%, to critical thinking skills by 17.4%, and to the scientific attitudes of students by 15.3%.

Keywords: E-module; Guided inquiry; Acidic and alkaline solutions; Students critical thinking skills; and Students scientific attitudes.

Introduction

Enter learning 21st-century development technology in Indonesia experienced more progress rapidly in a variety of fields including the field of education. One challenge to be faced by century students of knowledge and technology demands students for competent to use technology and process information in activities learning (Mahanani, 2019). I realize students who have the ability to use technology and information need teacher skills in linking the learning process that takes place in accordance with the demands 21st century. According to (Susilo et al., 2020) teachers also need to prepare other supporting factors for learning like skill use facility technology, mastery of material learning,

ability to see and judge activity students, as well ability to make instrument evaluation for measure understanding student during the learning process that takes place so that can form more education quality.

Currently, the problem faced by Indonesia is the quality of education which is still relatively low compared to other countries. One reason is the low quality of teachers in Indonesia. Even though these teachers already have educator certificates, many of them have inadequate pedagogical and professional competence. This is evidenced by data from Kemendikbud.go.id which shows that the results of the teacher competency test (UKG) in 2015 in the pedagogic and professional fields generally had an average of 53,02 below the national minimum competency standard of 55

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(Utomo, 2019). In addition, the reality on the ground today is that there are still many teachers who have not mastered technology in learning, so teachers are required to continue practicing in improving technology mastery skills to prepare quality education in the 21st century.

Technological advances can also be seen by the increased use of smartphones (gadgets) among high school students, which cannot be separated from the use of these digital devices every day. This is because smartphones have high attractiveness and various functions. In addition to communicating, it can also be used to obtain information, seek entertainment, display videos, writing, music and so on (Ainiyah, 2018). Unfortunately, excessive use of smartphones can have an impact on students' social interactions at school and can also cause a feeling of laziness so that students have difficulty understanding material at school (Sutisna et al., 2020). Therefore, teacher innovation is needed in making learning media that students can access with their respective smartphones, especially in subjects that are often considered difficult by students such as chemistry subjects. One reason is the concepts contained in chemistry or science lessons that are not easy for students to understand. The abstract nature of chemistry material, accompanied by the difficulty of content that demands chemistry learning, requires a higher level of critical thinking skills (Utami et al., 2017).

In line with the difficulty of learning chemistry which requires critical thinking skills, the demands of the 21st century also require students to have a higher level of critical thinking skills in absorbing information and in solving problems. Critical thinking skills are included in the domain or cognitive domain (knowing, applying, and reasoning) that students must have in this century (Afandi et al., 2019). This is because one of the ultimate goals of education is to give birth to a generation that has critical thinking in dealing with some of the challenges that may arise (Alkharusi et al., 2019). However, learning activities in schools in Indonesia have not been able to create learning conditions that can trigger students to think critically, be responsible, and have not provided space for students to channel their imaginative ideas. Several studies that have been conducted show that the level of critical thinking skills of students in Indonesia is at a very low level. One of the causes that is the trigger is that students are only asked to learn but are rarely taught how to learn properly and correctly, as a result students have difficulty solving problems, making decisions and critically thinking (Suarniati et al., 2018). The demands of the 21st century also require students to have a high scientific attitude. The scientific attitude of students is also in the low category, as evidenced by research

findings which show that there is still a lack of sensitivity of students' environment to the difficult situations that their friends have (Fitriani et al., 2020).

Seeing that there are several problems that arise in the world of education, the development of learning media such as electronic modules (E-module) can be offered as a solution that can be used. In an effort to improve students' critical thinking skills and scientific attitudes. The developed e-module can be made by adapting certain learning models such as the guided inquiry learning model. The guided inquiry model is a learning model that can make students more actively involved in the learning process so that students can connect the new ideas they have with existing knowledge.

Acid and base solutions are one of the core materials in chemistry learning. Based on research conducted by Hardyanti Arki et al. (2017) explained that the material for acid and base solutions is material that is difficult for students to understand, as evidenced by the low achievement results for the average student score of only around 65% obtained from data from school chemistry subject teachers who researched. Therefore, the material for acid and base solutions is used as material in the developed E-module, so students are expected to understand this material more easily and it is hoped that the development of guided inquiry-based E-modules on acid and base solution material can improve critical thinking skills and scientific attitude of high school students. The novelty contained in this study is the use of technology in learning which is more maximized by the use of smartphones, where students are inseparable from these digital devices every day. The developed e-module is also structured based on the syntax of the guided inquiry learning model by linking examples of phenomena in everyday life which are included in examples of acid and base solutions and is also equipped with a practicum video that students can access independently wherever and whenever students want to learn.

Method

This research is development research using the 4D model from (Thiagarajan, 1974) which consists of five stages, namely definition, design, development and dissemination. The research procedure can be seen in Figure 1.

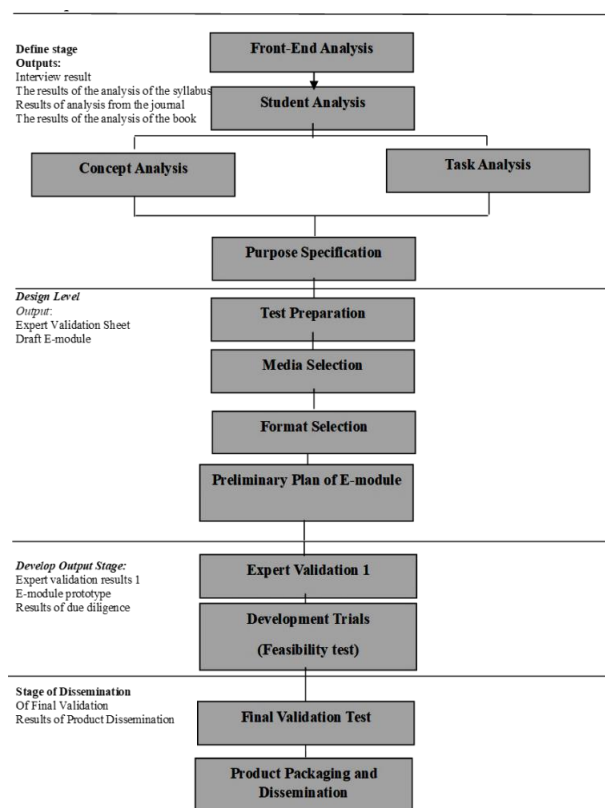


Figure 1. Development Procedure

The subjects of this research were 70 students of class XI Science at SMAN 1 Kopang. Class determination was carried out using a simple random sampling technique, namely randomizing the 3 existing classes so that 2 classes were obtained as 1 experimental class and 1 control class. The total sample was 70 students from class XI Science at SMAN 1 Kopang, consisting of 36 experimental class students and 34 control class students. Development trials were carried out in a quasi-experimental manner using a pretest-posttest two group design.

Data Collection

Data collection was carried out through observation, interviews, assessments and questionnaires. The instruments used include observation guidelines, interview guides, assessment sheets by expert lecturers and materials, assessment sheets by chemistry teachers, E-module readability test sheets by students and student scientific attitude questionnaires. The assessment sheet and questionnaire use a Likert scale which has a scale of Strongly Agree (SS) = 5, Agree (S) = 4, Undecided (RG) = 3, Disagree (TS) = 2, Strongly Disagree (STS) = 1. Meanwhile, for the description of critical thinking skills questions, the highest assessment value for each question is 4 and the lowest value is 1.

Data Analysis

Data analysis was carried out using two analyses, namely qualitative data analysis and quantitative data analysis. In the development process which aims to determine the feasibility of the product, it is explained using qualitative analysis. Meanwhile, to determine the effectiveness of the product and the percentage contribution of the product to improving students' critical thinking skills and scientific attitudes, it is determined using a quantitative analysis approach. Next, validity and reliability tests are carried out with expert judgment, namely experts in their respective fields. The validity of this theory is carried out in stages according to its level. The first stage is the validity of the E-module theory based on guided inquiry, critical thinking ability test questions and a questionnaire on students' scientific attitudes. The second stage is the theoretical validity of the chemical content used as an ingredient, namely the acid-base solution. Furthermore, empirical validity was carried out by testing E-modules based on guided inquiry, critical thinking ability tests and scientific attitude questionnaires outside the research sample, namely on class XII students who had previously received acid-base solution material. Data obtained from the validity test results were analyzed with the Rach Model using winstap software. Questionnaire reliability tests, critical thinking skills and scientific attitudes were analyzed using the Cronbach's Alpha model to determine the level of reliability (Hair et al., 2010).

The guided inquiry-based E-module feasibility test on acid-base solution material is processed based on quantitative data with a scale range of 1-5, with scale 1 meaning very poor and scale 5 meaning very good. Furthermore, the overall average score can be calculated using the following formula (Arikunto, 2009).

$$\bar{x} = \frac{\sum x}{n} \tag{1}$$

Description:

- \bar{x} = average score
- $\sum X$ = total score (each aspect)
- n = number of respondents

Calculation percentage for determine appropriateness E- module product can counted with use formula percentage results as following:

$$Result (\%) = \frac{Score\ obtained}{Maximum\ score} \times 100\% \tag{2}$$

Criteria appropriateness developed E - module product can seen based on category feasibility in Table 1.

Table 1. *Criteria E- module eligibility*

Score (%)	Category
81-100	Very Worthy
61-80	Worthy
41-60	Enough Worthy
21-40	Less Eligible
<21	Very no worthy

As for the readability of the E- module can seen also based on results percentage possible score counted use formula.

$$Score\ Percentage = \frac{Score\ obtained}{Maximum\ score} \times 100\% \quad (3)$$

According to Nasrudin et al. (2018) criteria range percentage score for know media readability such as the developed E - module can seen in Table 2.

Table 2. *Criteria Score Percentage*

Percentage	Category
81% - 100%	Very Good
61% - 80%	Good
41% - 60%	Enough
21% - 40%	Low
0% - 20%	Very Low

This research uses a one way multivariate analysis of variance (MANOVA) statistical test because it involves two dependent variables, namely critical thinking skills and students' scientific attitudes. In this study, data analysis was used, such as the One Sample Hotelling's T2 Test multivariate analysis, which was used to determine the difference values before and after treatment. Before carrying out the Hotelling's T2 test, the nine assumptions in the MANOVA test must be met. If the nine assumptions have been met, then Hotelling's T2 hypothesis test is carried out. If the statistical value of the Hotelling's T2 test is higher, the greater the influence. This research also uses the partial eta squared test which is multiplied by 100% to see the value of the effective contribution of using the guided inquiry-based E-module developed to students' critical thinking abilities and scientific attitudes simultaneously and individually.

Result and Discussion

Characteristics of Guided Inquiry Based E-Module

The development of guided inquiry-based E-module on acid and base solution material is based on conditions in the field (schools) which are known to still

have limited teaching materials, especially technology-based teaching materials such as E-modules which students can access on their respective smartphones, so researchers are interested in developing E-modules that can be accessed on each student's smartphone. The use of smartphones as learning media aims to make students not only use smartphones for social media or playing games but to access lessons so that lessons become more fun. In addition, technological developments in the 21st century according to (Mahanani, 2019) are one of the challenges that must be faced, such as the speed of progress in science and technology, which requires students to be proficient and skilled in using technology, processing information in learning activities.

The developed E-module makes students understanding of acid and base solutions more directed and orderly. This is because the E-module was developed using the syntax of the guided inquiry learning model. According to (Seranica et al., 2018) learning activities using the syntax of the guided inquiry learning model are able to involve students abilities to investigate and search for something, especially related to the material they are studying so that students are trained to formulate their own findings. Learning using the guided inquiry learning model emphasizes how students find information thus the syntax in this learning model can encourage student activity in learning and can also foster the ability to think like critical thinking. In addition to students critical thinking skills that can be improved using the developed E-module.

The scientific attitude of students can also be trained and improved. This is supported by group discussion activities that train students to have a good scientific attitude. In addition, in the E-module there is also a practicum demonstration video related to acid and base solution material and sequentially according to the material so that students are trained in using their scientific attitude.

There are five characteristics that a module or E-module must have according to Rahdiyanta (2018), namely: 1) self-instructional; 2) self contained; 3) stand alone; 4) adaptive; 5) user friendly. The developed module contains KI, KD, IPK, and learning objectives in the preliminary stage. Furthermore, there are learning objectives available in each learning activity for three meetings. At the end of the three meetings there are practice questions that students can work on. In addition, there is a practicum demonstration video that can be watched by students and there is a competency test that includes learning for three meetings at the end of learning in the experimental class that uses guided inquiry-based E-modules on acid and base solutions.

The E-module can also be used wherever and whenever students want to access acid and base solution material in the E-module so that it allows students to learn independently and not depend on the teacher alone, this fulfills the characteristics of the E-module, namely self-instructional. The developed E-module also contains all the acid and base solution material as a whole and is needed in the learning process so that it meets the characteristics of the E-module, namely self-contained. The use of guided inquiry-based E-modules can also be used without using other learning media and has been adapted to the needs of students (stand alone and adaptive). The characteristics of the last E-module, namely user-friendliness, are shown by the use of simple, easy-to-understand language, and also the availability of a glossary that can be used as a dictionary to find out terms that are not commonly found, as well as accompanied by navigation buttons to go to the next page or return to the previous page, so that students or guided inquiry-based E-module users on acid and base solutions can be assisted and made easier in using the E-module. The appearance of the guided inquiry-based E-module on acid and base solutions is shown in Figure 2.

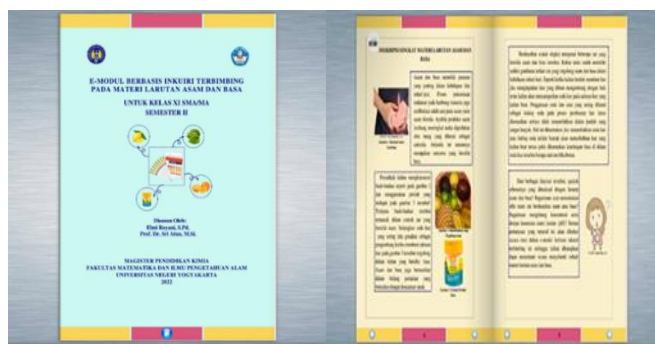


Figure 2. Display of Guided Inquiry Based E-Module

Quality and Feasibility of Guided Inquiry Based E-module

Prior to conducting the guided inquiry-based E-module trial on acid and base solution material, corrections were made by the supervising lecturer after being approved by the supervisor, followed by corrections by the expert lecturer (validator). The evaluation of the E-module by the validator aims to determine the quality and feasibility of the product being developed. Based on the results of the correction from the validator, it stated that the E-module product and assessment instrument that had been made by the researcher were declared fit for use with several revisions. The revised e-module according to suggestions from the validator was then followed by an initial field trial consisting of a product readability test by class XII IPA SMAN 1 Kopang and a feasibility or practicality test conducted by a chemistry teacher in Central Lombok.

The readability test is used to determine the quality of the developed E-module. The E-module readability test was carried out by 54 students of class XII IPA SMAN 1 Kopang in Central Lombok Regency. Some of the aspects assessed in the readability test include: 1) material aspects; 2) aspect of visual appearance; and 3) aspects of software engineering. Based on the results of the analysis of the data obtained the average value obtained for all aspects of the readability test is 4.27. These results indicate that the E-module based on guided inquiry on acid and base solutions is very good.

Furthermore, the feasibility or practicality tests assessed by educational staff practitioners were six high school chemistry teachers from schools in Central Lombok. There are five aspects of due diligence assessed including: 1) learning aspects; 2) material aspects; 3) the component aspects of the guided inquiry model; 4) graphic design aspects; and 5) aspects of software engineering. Based on the results of the feasibility test by the chemistry teacher obtained in Table 15 it is known that the E-module being developed is in the very feasible category with a feasibility percentage ranging from 88-92% so that an average percentage of 89.4 is obtained. According to Khotim et al. (2015) products that are developed have a minimum limit that is in the new feasible category can be continued to be tested on students. So that guided inquiry-based E-module product development research can be continued to be tested on students.

The guided inquiry-based E-module on acid and base solutions has received positive responses from both practitioners and students. This E-module has the advantage of being easy to access for students with their smartphones. The use of technology as a medium that can be used in the learning process makes this E-module have advantages compared to ordinary modules or conventional teaching materials. These advantages include that the E-module is equipped with audio, video, images, animation as well as several competency tests that students can easily access on the E-module (Cheva & Zainul, 2019). In addition, this E-module also follows the syntax of the guided inquiry learning model so that students are trained to build their own knowledge appropriately (Novilia et al., 2016). Therefore, the guided inquiry-based E-module on acid and base solutions is in a very appropriate category to be applied in chemistry learning at the senior high school (SMA) level. After the guided inquiry-based E-module product is declared very feasible, it can then be continued for field trials. Field trials were conducted on 70 students of class XI which were divided into two classes, namely the experimental class of 36 students and the control class of 34 students.

Application of Guided Inquiry Based E-module to Know Differences in Students Critical Thinking Skills and Scientific Attitudes.

The purpose of developing guided inquiry-based E-module products on acid and base solutions is to find out whether there are differences in students' critical thinking skills and scientific attitudes before and after using the E-module both simultaneously and individually. The trial of the E-module product was carried out on 70 students of class XI IPA at SMAN 1 Kopang. The research design used was a two-group pretest-posttest with control group design. The experimental class consisted of 36 students who were taught using guided inquiry-based E-modules while the other 34 students were part of the control class which were taught without the use of guided inquiry-based E-modules. Both classes were taught in three meetings using a different Learning Implementation Plan for each class. There are two instruments used to collect research data in the form of description questions to obtain data on critical thinking skills and a Likert scale questionnaire to obtain data on students' scientific attitudes. These two research instruments were given before and after learning in the experimental class and also the control class.

Tests using critical thinking skills description questions and students' scientific attitude questionnaires were carried out twice, namely during the pretest before learning was carried out and posttest after learning took place using guided inquiry-based models on acid and base solutions. Data from the pretest and posttest results of students' critical thinking skills and scientific attitudes were then tested using the Hotteling's T^2 test. Based on the results of the Hotteling's T^2 test it shows that there are differences in students critical thinking skills and scientific attitudes simultaneously before and after the use of guided inquiry-based E-modules on acid and base solutions. Based on the partial eta squared values obtained, it is known that the effective contribution given by guided inquiry-based E-modules to acid and base solutions is 24%. These results indicate that learning acid and base solutions in the experimental class using the E-module with guided inquiry syntax is more effective on students' critical thinking skills and scientific attitudes simultaneously than before using the E-module.

Furthermore, to see the effective contribution made by the guided inquiry-based E-module to acid and base solution materials respectively, it can be seen based on the results of the different tests shown which shows that there are differences in students' critical thinking skills between before and after use. E-module. The percentage of the effective contribution of guided inquiry-based E-module to each variable of students' critical thinking skills and scientific attitudes can be seen based on the

partial value of eta squared in the Table of Tests of Between-Subject Effects. The results of the acquisition of partial eta squared values in the following table are multiplied by 100%, so that it is known that guided inquiry-based E-modules make an effective contribution of 17.4% to students critical thinking skills and 15.3% to student's scientific attitudes. From the acquisition of effective contribution values respectively by the variables of students critical thinking skills and scientific attitudes, it is known that both of them provide an effective contribution which is categorized as medium (medium effect).

The percentage value of the contribution of the guided inquiry-based E-module on acid and base solutions to students critical thinking skills and scientific attitudes is quite good. This is also evidenced by the average score obtained by students in the experimental class which is higher than the control class which studies acid and base solutions without using the E-module. The results of these statistics can be concluded that the use of guided inquiry-based E-modules has an impact on improving students critical thinking skills and scientific attitudes. This is consistent with the results of research conducted by Budiarti et al. (2016) that students critical thinking skills in experimental class learning activities that apply guided inquiry based E-module learning are better than the control class which does not implement the use of E-module. The critical thinking skills developed in the guided inquiry-based E-module are the habit of thinking coherently, acquiring knowledge and applying this knowledge by doing the exercises contained in the E-module competency test. Students critical thinking skills are more directed with the syntax of the guided inquiry learning model so that students can find their own knowledge with the directions given by the teacher.

In addition, the scientific attitude possessed by students also experienced an increase after the implementation of learning using guided inquiry-based E-modules on acid and base solutions. The scientific attitude of students in both the experimental class and the control class was measured using a student scientific attitude questionnaire which consisted of several indicators before and after the lesson was implemented. A higher increase in students' scientific attitudes is found in the experimental class that applies learning using the developed E-module. This increase in scientific attitude is due, in part, to the application of the Guided Inquiry Learning model to the developed E-module, so that learning becomes more active and can train students' independence in learning using the steps of the guided inquiry learning model (Asda & Andromeda, 2021).

Conclusion

Based on the results of research and development of guided inquiry-based E-module products on acid and base solution material, it can be concluded that the developed E-module is very suitable for use in chemistry learning, especially acid and base solution material, besides that the use of E-module is also easily accessible on each student's smartphone. There are differences in students' critical thinking skills and scientific attitudes before and after using the E-module simultaneously or individually. The percentage of the effective contribution of guided inquiry-based E-module on acid and base solution material to students' critical thinking skills and scientific attitudes simultaneously was 24%, to students' critical thinking skills was 17.4%, and to students' scientific attitudes was 15.3%.

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Author Contributions

The lead author, Elmi Royani, contributed to designing development research, conducting research, and writing articles based on the results of development research. The second author, Sri Atun, played a role in guiding research and writing articles.

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Conflicts of Interest

The authors declare no conflict of interest.

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