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Development of Guided Inquiry-Based Science E-Modules to Improve Students' Critical Thinking Ability

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Abstract: This type of research is development research that aims to determine the characteristics, feasibility and effectiveness of the guided inquiry-based respiratory system E-module to improve students' critical thinking skills. The development model used is research and development which refers to the Borg and Gall development model which has been modified and adapted to conditions in the field, which consists of nine stages, namely: Research and informing collecting, Planning, Develop preliminary form of product, Preliminary feed testing, Main product revision, Main field testing, Operational product revision, Operational field testing, E-module final product. The data analysis technique used is descriptive analysis which is used to describe the characteristics of the e-module to be developed, the feasibility analysis of the e-module based on the N-gain score obtained. The results of the N-gain test score in the control class, which is 0.65, are included in the medium category, while for the experimental class the average N-gain score of 0.78 is included in the high category. Based on these results, guided inquiry-based E-modules are very feasible to be used in learning and have proven effective in improving students' critical thinking skills.

Keywords: Electronic module; Guided inquiry; Critical thinking skills; Respiratory system.

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Introduction

The development of science and technology has changed the world as the industrial revolution turned human power into machine power. The industrial revolution that started from industry 1.0, 2.0, 3.0, has now developed into the industrial revolution 4.0. In facing the industrial revolution 4.0, preparation is needed in all aspects of life, one of which is preparing an education system that is more innovative, creative and able to improve the competence of graduates who have 21st century skills or commonly called Learning and Innovation Skills (Zubaidah, 2018).

21st century education demands more modern and professional learning, so it takes empowerment from every type of education level. One of them is that it can be improved from the aspect of procurement of learning resources that can be pursued by developing learning resources that utilize technology (Yayang & Eldarni, 2019). Technological advances are able to make learning resources easy to access, flexible, and accessible to the public (Rahmi et al., 2017). This is expected to facilitate the learning process because teachers can combine learning and technology, learning with intensive teaching and learning activities using communication technology (Abudlhak, 2017).

21st century education demands teachers to understand technological developments. However, there are obstacles faced by teachers in dealing with IT-based learning, namely the lack of knowledge in utilizing information technology that can be integrated in the learning process (Yuniar et al., 2021). So that

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efforts are needed to improve the ability of teachers creatively, namely by using the use of interactive multimedia (Kustyarini et al., 2020).

The solution needed in dealing with these problems is that teachers can maximize the use of technology in learning effectively by making teaching materials that are appropriate and tailored to the needs of students (Nalasari et al., 2021). Teaching materials that can be developed by teachers must be able to support learning activities and can be easily used independently and easily accessed by students. Electronic modules (e-modules) can be one of the innovations in teaching materials that are developed as effective teaching materials.

Electronic modules (e-modules) simply have similarities with e-books. The electronic module is one of the innovative media that can improve students' learning abilities and active independence. This is because the E-module is a module in digital form that contains several things, such as text, images, videos equipped with simulations that are suitable for use in learning (Puspitasari, 2019). In addition, the development of E-modules that have attractive designs can increase students' interest and motivation to learn (Mahmudin et al., 2022).

Based on the needs analysis conducted by direct observation, questionnaires and interviews at SMP Muhammadiyah 2 Surakarta, it shows that the science teacher class VIII has never used teaching media or technology-based teaching materials such as electronic modules (e-modules) in learning activities carried out in the classroom. in the classroom and in the laboratory. Teachers still use teaching materials in the form of textbooks, Student Worksheets and supporting books obtained from schools for each student. The teaching materials used only improve cognitive aspects and pay less attention to the psychomotor aspects of students. In addition, in the teaching materials, activities that can improve students' higher-order thinking skills are not taught, one of which is students' critical thinking skills which are very much needed by students in dealing with 21st century learning.

Critical thinking skills are one of the life skills that are developed through education and are competencies needed to face the 4.0 revolution era and the development of the 21st century (Zubaidah, 2018). Critical thinking is an ability that cannot be separated from learning activities because critical thinking skills are cognitive abilities that play an important role in learning activities (Ennis, 1987). Critical thinking is a higher-order thinking process that uses the basis to analyze someone's arguments and generates insights from each meal and is able to interpret to develop a logical and cohensive mindset (Jemaun et al., 2019). The ability to think critically is an important element that must be possessed by students in science learning (Wiyoko, 2019).

Based on the results of interviews with science teachers at SMP Muhammadiyah 2 Surakarta, there is a gap between expectations and reality, where students are still not able to optimize their critical thinking skills. The low critical thinking ability of students has a negative impact on the education system (Nuryanti et al., 2016). Based on the results of the tests tested on students, it can be concluded that students' critical thinking skills are still low, students have not been able to solve HOTS type questions. This can be caused by several things, including the lack of structured teaching media and able to improve students' critical thinking skills. In addition, learning is still centered on the teacher (teacher center), the teacher only uses the lecture method when providing material to students. (Indah et al., 2019) stated that the cause of the low critical thinking ability of students was because the learning model used by the teacher was less varied. Therefore, it is necessary to improve students' critical thinking skills by using interesting learning models, one of which is by using the inquiry model.

Inquiry learning can facilitate students to become active and critical thinkers in constructing conceptual understanding through the scientific method (Lalang et al., 2017), so that students are trained to solve problems and make decisions. Inquiry learning is oriented to process activities and emphasizes student engagement in active learning in dealing with a problem (Callahan & Clark, 1977). The guided inquiry model facilitates students in carrying out activities directly and independently, so that students more easily understand the material because it is based on their own experience (Nasution, 2018).

Students act as learning subjects and teachers only as facilitators (Muliani & Wibawa, 2019) who help students to find concepts, facts, principles, and procedures that students will learn (Fitriyani et al., 2017). Thus, inquiry learning is a creative and systematic thinking process and focuses on the search and discovery process. The steps of guided inquiry learning include orientation, formulating problems, formulating hypotheses, collecting data, testing hypotheses, and drawing conclusions (Sanjaya, 2011). Based on the steps of guided inquiry learning, it can be seen that the guided inquiry learning model can help students improve critical thinking skills in the learning process.

Based on the results of observations and interviews with the Science Teacher Class VIII conducted at SMP Muhammadiyah 2 Surakarta, Surakarta Regency, it is known that there are several materials that are considered difficult by students, including the material on the human respiratory system. The respiratory system is very close to students' lives, but many students find it difficult to understand the material because it is

still abstract. Therefore, the development of an electronic module (e-module) based on guided inquiry is expected to improve students' critical thinking skills. This study has three objectives which include: knowing the characteristics of the guided inquiry-based e-module to improve students' critical thinking skills, knowing the feasibility of the guided inquiry e-module, and knowing the effectiveness of the guided inquiry e-module.

Method

Research design and method should be clearly defined This research is Research and Development which refers to the Borg and Gall development model that has been modified and adapted to conditions in the field, which consists of nine stages, namely Research and informing collecting, Planning, developing preliminary form of product, preliminary feed testing, main product revision, main field testing, operational product revision, operational field testing, final product e-module. The selection of this model is based on this model developed systematically and in accordance with the theoretical basis and learning design used.

The research was conducted at SMP Muhammadiyah 2 Surakarta, Banjarsari District, Surakarta Regency, Central Java. The subjects of this study were 111 class VIII students from both the Special Program class and the Regular Class. While the object under study is a web-based electronic module (e-module) which is specially designed using Google Sites. The data collection technique used a validation sheet given to 6 validators and a questionnaire given to 50 class VIII students.

The first stage in this research is to analyze the needs of both students and teachers at SMP Muhammadiyah 2 Surakarta by collecting some of the information needed for this research. The next stage is to analyze some of the problems found in the field and will be developed as background problems in this study. After finding the problem, the next stage is planning the development of learning products in the form of web-based electronic modules (e-modules) that are adapted to the characteristics and syntax of guided inquiry that are integrated with critical thinking skills. Then at the product validation stage which aims to get product validation developed by the validator consisting of six experts according to their respective fields, including media, material and language experts. The limited trial stage was carried out to determine the legibility of the e-module being developed, at this stage the trial was conducted on 35 students who were students of class VIII PK-Language SMP Muhammadiyah 2 Surakarta.

The operational trial stage aims to determine the effectiveness of the guided inquiry-based e-module with the subject of this research being 111 class VIII students from both the Special Program class and the Regular Class at SMP Muhammadiyah 2 Surakarta. The operational trial phase uses a Quasi-Experiment Design research type with the form of a Nonequivalent Control Group Design design. The following form of research design Nonequivalent Control Group Design can be seen in table 1.

Table 1. Nonequivalent Control Group Design

Group	Pretest	Treatment	Posttest
Control	O1	X	O2
Experiment	O3	X	O4

(Sugiyono, 2012)

Description:
O1 = pretest value of control group
O2 = control group posttest score
X = treatment using e-module
O3 = pretest value of the experimental group
O4 = posttest value of the experimental group

The population used in this study was class VIII students with a total of 111 students, consisting of 4 classes, namely class VIII PK-A, VIII PK-B, VIII A, and VIII B. treatment, namely the control class as many as 56 students and the experimental class as many as 55 students. The sample selection in a quasi-experimental was done using a non-random sampling technique so that the technique used was a purposive sampling technique. According to (Sugiyono, 2012) purposive sampling is a sampling technique with certain considerations.

This study uses several instruments including the electronic module validation sheet (e-module) which consists of validation of media experts, linguists and media experts. In addition, this study also uses a questionnaire sheet given to students, a science teacher interview sheet, and a test instrument sheet consisting of pretest and posttest questions which are used to determine the extent of students' critical thinking skills. The critical thinking test instrument used for the pretest and posttest questions had previously been empirically validated in classes that had received subject matter for the respiratory system by involving 22 students in class IX.

The data analysis techniques used in this study were normality test, homogeneity test and n-gain score test. Before being used as an evaluation tool, 11 essay questions were tested to determine the level of validity, reliability of the items, the level of difficulty of the questions, and the discriminating power of the questions. The validity of the items is sought by using the product moment correlation formula with rough numbers. From the results of the product moment calculation with a significant level of 5%, if the value of r count > r table product moment then the items tested are declared valid. Validity testing using SPSS for Windows version 25.0 program.

E-module feasibility data analysis technique uses descriptive analysis. The feasibility of the developed inquiry-based e-module was analyzed based on the results of expert validation which included media experts, media experts and linguists, each category consisting of two validators. The eligibility criteria for e-modules can be seen in table 2.

Table 2. Eligibility criteria for e-module

Score	Criteria
81-100	Very Good
61-80	Good
41-60	Enough
21-40	Not Good
0-20	Not very good

(Arikunto, 2013)

Data analysis techniques to determine the effectiveness of the e-module can be seen by looking at the gain score (N-gain score). The increase in students' critical thinking skills that occurs before and after learning can be calculated using the N-gain formula which is determined based on the normalized average N-gain score, namely the comparison of the gain scores. The formula for finding the N-gain score according to Hake is equation 1.

$$g = \frac{S_{post} - S_{pre}}{S_{maks} - S_{pre}} \quad (1)$$

Description:
g = Score gain
S_{post} = average posttest score
S_{Pre} = average pretest score
S_{max} = maximum score

Interpretasi kriteria tingkat N-gain pada Tabel 3.

Table 3. Category of N-gain tingkat level

Limitation	Criteria
g > 0.70	High
0.30 ≤ g ≥ 0.70	Medium
g < 0.30	Low

Result and Discussion

The research and development that has been carried out has resulted in a product in the form of an electronic module (e-module) as a digital teaching material that uses the guided inquiry learning method on the human respiratory system material which is specially made for class VIII. The output of the product developed is web-based developed with google sites, so that students can access it easily and without having to download applications on their respective gadgets.

The module developed in this study refers to the Human Respiratory System material which contains Basic Competence 3.9, namely analyzing respiratory organs in humans and understanding disorders of the respiratory system, as well as efforts to maintain a healthy respiratory system, as well as Basic Competence 4.9. namely presenting a work on efforts to maintain a healthy respiratory system. The respiratory system material is considered important to be understood by students, so it takes students' seriousness to understand and learn it. To facilitate students in learning, e-modules are arranged systematically by integrating the guided inquiry learning model and adapted to the syntax of the guided inquiry learning model.

The guided inquiry-based e-module was developed and adapted to the syntax and characteristics of the guided inquiry learning model. Furthermore, the e-module is validated by experts to find out whether the e-module developed is feasible to be used as teaching material in learning activities. The e-module validation is carried out by media experts, material experts and linguists.

Based on the development of guided inquiry-based e-modules that have been carried out, the data obtained from the feasibility validation results from material experts. The validation results from material experts are presented in table 4.

Table 4. Results of material expert validation

Aspect	Σ P	Category
Introduction	80	Good
Content	90	Very Good
Evaluation	80	Good
Closed	85	Very Good

The results of the feasibility analysis in terms of material for the guided inquiry-based e-module on the respiratory system material from material experts obtained an average value of 83.75 with a very good category. As for suggestions from expert validators regarding the opening, namely the opening sentence at the beginning of the material is incomplete, besides that it is necessary to complete descriptions and connecting sentences between the material and the images presented. Furthermore, all suggestions given by the validator have been corrected in order to improve the developed e-module. Furthermore, the results of the feasibility validation analysis from media experts can be seen in Table 5.

Table 5. Media expert validation results

Aspect	Σ P	Category
Media introduction	95	Very good
Media display	87	Very good
Media help	80	Well
End of media	70	Enough

The results of the feasibility validation analysis in terms of media for guided inquiry-based e-modules on respiratory system material from material experts

obtained an average value of 83 with a very good category. The suggestion from the validator is to clarify the instructions for using the e-module so that it is easier for students to understand.

Furthermore, the validation results from linguists are presented in Table 6.

Table 6. Linguistics expert validation results

Aspect	Σ P	Category
Straightforward and Communicative	90	Very good
Dialogic and Interactive	80	Well
Suitability with student development	100	Very good
Conformity with Language Rules	90	
Coherence and Coherence of Thoughts	95	Very good

Based on the results of the validation of linguists, the guided inquiry-based e-module material on the respiratory system was declared feasible to be used as teaching material in learning activities at school because the average percentage value was 91. The suggestions given were paying attention to the spelling that was adapted to the EYD, adding sentences to more motivating students. e-modules that have been developed can be seen in Figure 1-3.

Figure 1. Home e-module

Figure 2. Student Activity Page

Figure 3. Material Page

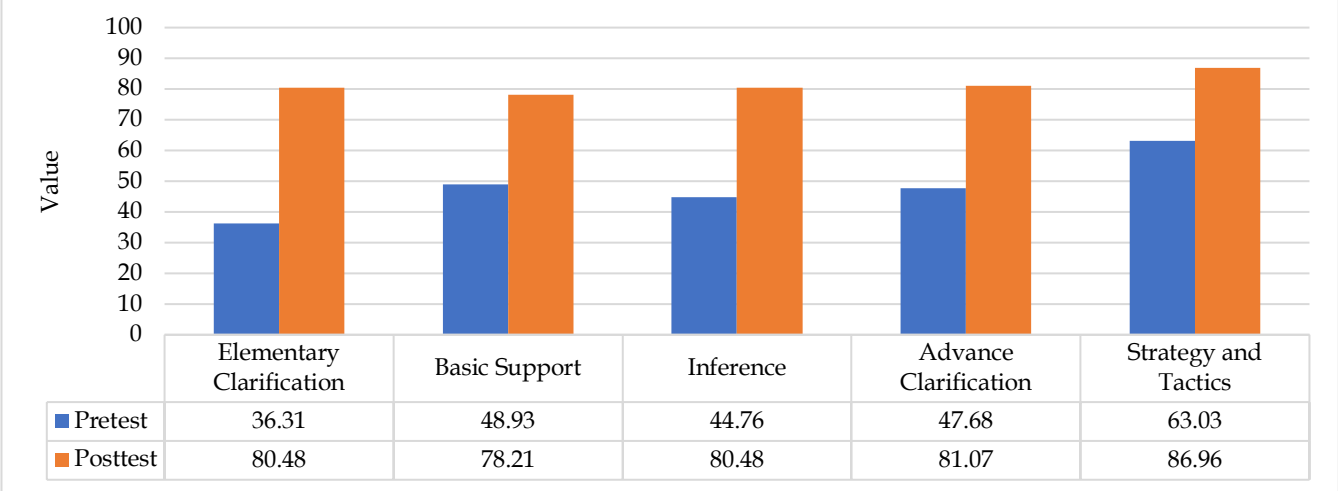
After the e-module has been validated by material, media and language experts and has been revised according to the suggestions given, so that the e-module is ready to be used. The next step is the limited field trial phase which aims to determine the readability of the e-module, which is carried out on 35 students of class VIII D. The results of the readability test analysis can be seen in Table 7.

Table 7. Readability test analysis

Validation	Persentage (%)	Category
Theory	96.7	Very good
Media	94.6	Very good
Language	90.9	Very good

The results of the limited test or readability test that have been carried out get good results, which in terms of material get a percentage value of 96.7 with a very good category, in terms of media get a value of 94.6% with a very good category and in terms of language get a value of 90, 9% with very good category. Based on these three results, the guided inquiry-based e-module is feasible to use in the next stage, namely operational testing. The operational test stage is used to determine the effectiveness of the guided inquiry-based e-module.

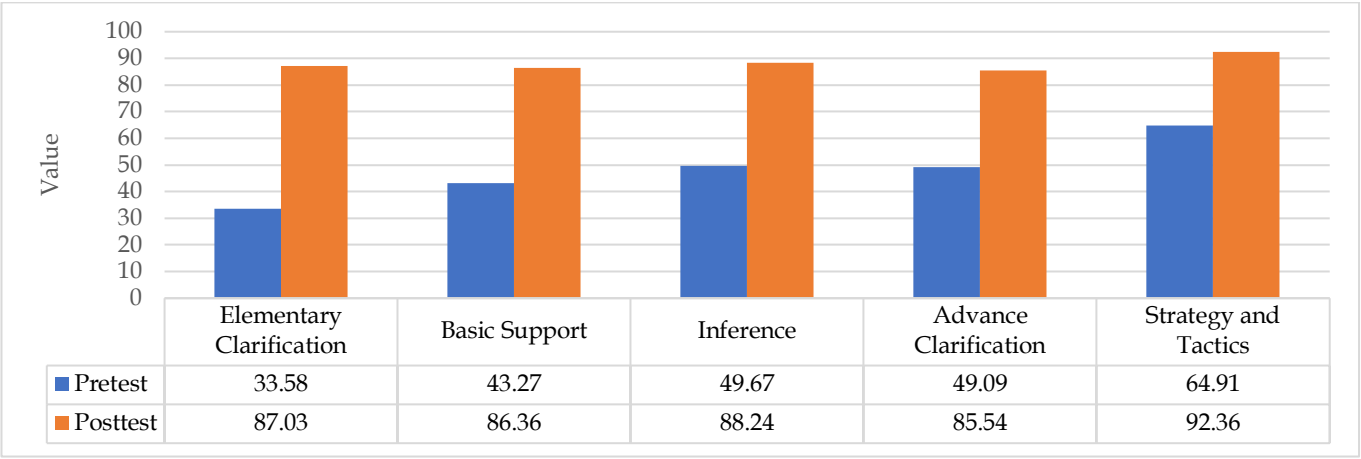
Indicators of critical thinking skills according to Ennis 1898 in (Supriyati et al., 2018) consist of five indicators, namely providing simple explanations, building basic skills, drawing conclusions, providing further explanations, setting strategies and tactics, The results of the average value of each indicator of thinking ability critical students in the control class can be seen in Figure 4.



	Elementary Clarification	Basic Support	Inference	Advance Clarification	Strategy and Tactics
Pretest	36.31	48.93	44.76	47.68	63.03
Posttest	80.48	78.21	80.48	81.07	86.96

Figure 4. Average Score of Critical Thinking Ability of Control Class Students

Meanwhile, the results of the students' average scores for each critical thinking ability indicator in the experimental class can be seen in Figure 5.



	Elementary Clarification	Basic Support	Inference	Advance Clarification	Strategy and Tactics
Pretest	33.58	43.27	49.67	49.09	64.91
Posttest	87.03	86.36	88.24	85.54	92.36

Figure 5. Average Value of Critical Thinking Ability of Experiment Class Students

Based on Figure 5. above, it can be seen the difference in the average value of students on each indicator of students' critical thinking both in the control class and in the experimental class. This proves an increase in the average score of students from the five critical thinking indicators. Based on the results above, it can be seen that there is a difference between the average posttest scores between the control class and the experimental class, where of the five posttest results indicators, students who were treated using guided inquiry-based e-modules were superior when compared to students who did not use e-modules. module. This shows that there is an increase in students' critical thinking skills after being given an e-module based on guided inquiry on the respiratory system material.

The values obtained from the pretest and posttest both the control class and the experimental class were then used to calculate the N-gain score. The results of the N-gain score serve to determine the effectiveness of the guided inquiry-based e-module on the respiratory system material. The results of the N-gain score can be seen in table 8.

Table 8. N-gain Score Results

Class	N-gain	Category
Control	0.65	Currently
Experiment	0.78	High

Based on the results of the calculation of the N-gain score in the control class and the experimental class. In the control class, the N-gain score was 0.65 which was included in the medium category. While in the experimental class obtained an N-gain score of 0.78 with a high category. In accordance with the results of these calculations, it was concluded that the N-gain score in the experimental class was higher than the N-gain score in the control class. This proves that learning using

guided inquiry-based e-modules is effective in improving students' critical thinking skills.

Several things that support critical thinking skills in students are the use of learning strategies and the use of learning models that require students to be active (active learning) (Wardany & Ramli, 2017). So, it can be interpreted that the use of guided inquiry-based e-modules on the human respiratory system material can improve students' critical thinking skills.

The results of this study are empirically in line with research (Seranica et al., 2018) (Nisa et al., 2018) which states that the application of guided inquiry can improve students' critical thinking skills. In addition, the guided inquiry model also has a positive effect on learning outcomes (Amijaya et al., 2018). Research (Parwati et al., 2020) also shows learning outcomes and critical thinking skills of students who apply the guided inquiry learning model are better than students who use conventional learning.

Conclusion

The development of guided inquiry-based e-modules on the human respiratory system material can improve students' critical thinking skills. Based on the results of expert validation, it can be concluded that the guided inquiry-based e-module is very feasible to be used in learning activities, this can be seen in the average validation results, which is 85.9% which is included in the very feasible category. Based on the results of field operational trials, the average N-Gain score of 0.78 is included in the high category. These results indicate that the e-module developed is effective in improving students' critical thinking skills.

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