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DEVELOPMENT OF GUIDED INQUIRY-BASED ELECTRONIC MODULES AND ITS EFFECTS ON STUDENTS' CHEMICAL LITERACY

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ABSTRACT

One effort to present abstract concepts is the use of learning media. Electronic can provide opportunities for students to learn independently without relying on them. This study aims to determine the feasibility and practicality of guided inquiry-based electronic modules, the difference in students' chemical literacy abilities in each class, and the effectiveness of learning using guided inquiry-based electronic modules on students' chemical literacy. This research is a 4D development model consisting of Define, Design, Develop, and Disseminate. This study was conducted at Senior High School 1 Tembilahan Hulu, and the participants were 60 high school students and five chemical teachers, and two validators– data collection in questionnaires and tests. This study used a quasi-experimental method and a post-test-only control group design. The data analysis technique in this research is a descriptive statistical analysis technique of percentages. The results showed that the feasibility of the product assessed by validators showed that the guided inquiry-based electronic module was proper to use in this research. The practicality of the chemistry teacher assessment shows a very good category, the chemical literacy of students who use guided inquiry-based electronic modules in learning is better than students who do not use guided inquiry-based electronic modules in learning. The effectiveness test showed that learning using an electronic module based on guided inquiry scored 0.74 in the medium category.

Keywords: *Electronic module, guided inquiry, and reaction rate*

INTRODUCTION

The era of the industrial revolution 4.0 is a stage of the development of knowledge where the physical, digital and biological realms interact with renewable technology [1]. Rapid changes in knowledge require educators to prepare new strategies and innovations [2] better. Learning that presents different experiences can make students more active in participating in learning [3]. Technology can be an effective method to increase student interest [4]. However, technology and communication have not been used optimally in the learning process [5].

The use of smartphones in learning has positive benefits for students, especially those who initially have no interest in learning [6]. Indonesia got 5th ranked with approximately 83 million smartphone users worldwide [7]. However, based on a study, as many as 121 of 207 students use smartphones to access social media and play games, either online or offline [8].

Chemistry is generally still considered difficult by most students [9]. According to research results, most chemistry topics are still difficult for students to understand [10]. One of the sub-concept of chemistry is the rate of reaction. The reaction rate sub-material has abstract chemical concepts [11] and is one of the sub-materials considered difficult by students [12]. Chemistry has three levels of representation, namely macroscopic, sub-microscopic, and symbolic, that require an excellent ability to learn to avoid misconceptions [13]. The micro-complexity inherent in chemical concepts requires combining several tools to represent concepts to improve students' understanding of concepts [14].

Learning media, such as electronic modules, can represent abstract concepts. Most students who only use books as a source of independent learning have difficulty understanding chemistry lessons that have been explained by a teacher [15]. Using learning media in the teaching and learning process can generate new interests and desires, generate motivation, stimulate learning activities [16], and not be boring [17]. Students often have difficulty finding innovative alternative learning media as independent learning resources to help overcome problems in understanding chemistry [18]. Modules can provide opportunities for students to learn independently without depending on the teacher and adjust each student's pace and learning ability. Modules are not only printed but can also be electronic (e-modules). The learning process with electronic modules is an alternative source of information for learning chemistry concepts and does not make the teacher the main source of information. The hope is that learning can take place interactively and be student-centred. Today's students are more interested in using technology-based learning content or media than chemistry textbooks.

Another factor is the lack of variation by teachers in using learning models when teaching and learning activities occur [22]. Chemistry is getting more challenging every day since the 21st-century goal is to conduct chemistry learning involving creativity in deciding the learning model [23]. The teaching and learning process must have a reciprocal interaction between students and educators, and this can be done using a student-centred guided inquiry learning model [24]. This model is considered effective in improving student learning outcomes [25].

Scientific literacy is one of the disciplines in the Program for International Student Assessment (PISA) study that focuses on the ability of students to use scientific knowledge and skills [26]. Chemical literacy in students is determined by understanding the basic concepts of science or chemistry [27]. However, most of the achievement of chemical literacy of students in Indonesia is still not optimal [28-30].

Previous research has shown that using a multimedia-based guided inquiry education module can improve the understanding of concepts in chemistry [31]. Other results show that applying the guided inquiry model in learning can improve students' scientific literacy [32]. In this article, the developed media pays attention to appropriate and contextual chemical content features related to text, static, dynamic 2D images, and video problems. It is hoped that the developed media can attract and build students' interest in learning to improve their chemical understanding and literacy.

METHODS

Participant

Participants in this study were 60 students of Senior High School 1 Tembilahan Hulu, Indragiri Hilir Regency, Riau, Indonesia. Students as participants were divided into two classes, the control class and the experimental class. Class selection in this study uses a cluster random sampling technique. The feasibility of the product uses expert judgment from two lecturers as a validator in the form of suggestions and comments for product improvement. A practicality questionnaire was used with five chemistry teachers to determine the practicality of the guided inquiry-based electronic module. The data analysis technique in this research and development is a descriptive statistical analysis technique of percentages to process data from teacher responses, student responses, and test results.

Development Model

The procedures for developing a guided inquiry-based electronic module using the 4D model are presented in Figure 1.

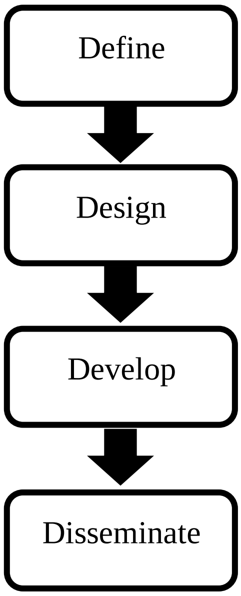

Figure 1. The stages of the 4D Model

This study uses the research and development (R&D) method that shows the steps to be followed in producing a product. The product produced in this study is a guided inquiry-based electronic module that will be installed on an Android-based device. The development model in this study uses a 4D model, which consists of four stages, define, design, develop and disseminate [33]. The first step in this study is to precede the study with interviews and observations to determine the state of student learning in the classroom. The information obtained will meet the needs of students in class. The second step is the development of a guided inquiry-based electronic module. The electronic module has a role in increasing students' interest and understanding of learning. The electronic module will be distributed and used by students in the experimental class, while students in the control class will only do conventional

learning as usual. Both classes will learn the concept of reaction rate, and at the end of the lesson, there will be an exam using a chemical literacy test to measure students' chemical literacy. The last step in this study was determining the effectiveness of guided inquiry-based electronic modules.

In this research, the design, and development stages werstages Meanwhile, the dissemination stage is planned to be carried out in the following year.

RESULTS AND DISCUSSION

Define

The purpose at this stage is to define and determine what is needed in the learning process. Preliminary analysis obtained by interviews conducted with chemistry teachers who teach chemistry in class XI MIPA SMAN 1 Tembilahan Hulu, interview questions and answers can be seen in Table 1.

Table 1. Interview questions and answers

Questions	Teachers	Answer
What learning models are often used in the classroom?	Teacher 1	Often use direct learning such as lectures
	Teacher 2	Usually use lectures, and sometime using cooperative learning if needed.
What learning resources and learning media are often used in learning?	Teacher 1	Textbooks and another valid source like internet
	Teacher 2	mainly using textbooks and some from the internet
What are the supporting facilities for learning in the classroom?	Teacher 1	Students are allowed to use smartphones in class with the teacher's permission
	Teacher 2	In some situations, students use smartphones in class or laptops
How does the learning process take place at school?	Teacher 1	Depending on the situation, it can be fully offline or interspersed with online learning
	Teacher 2	Following school policies, can be full offline or limited face-to-face and interspersed with online learning
How is the chemical literacy of students in class?	Teacher 1	So far, there has been no measurement of students' chemical literacy in class
	Teacher 2	There are no special skills to develop students' chemical literacy

Table 1 shows that the impact of the covid-19 pandemic has made learning activities in schools carried out with restrictions, students are divided into two study groups in one class. The teacher conducts learning twice in one day for the same class. The implementation of learning is also carried out online at certain times using Google Classroom, WhatsApp, and Google Meet. Learning media during class are still limited to printed books, power points, laptops, and smartphones. The chemistry teacher also explained that the school had never implemented learning using guided inquiry-based electronic modules in the classroom. The use of learning media in classrooms taught by chemistry teachers is still limited. As for chemical literacy, based on the results of interviews with chemistry teachers, it was stated that no effort had been made to measure students' chemical literacy in schools.

The second analysis was obtained by observing student activities in class. Based on the observations, it is known that students are still less active during the learning process and lack student initiative, and there are still students who are less focused when learning chemistry.

Design

The second stage is to design an electronic module based on guided inquiry. Make an electronic module design based on guided inquiry consisting of a cover, instructions for using the module, a table of contents with hyperlinks according to page numbers, and learning materials. In addition, it also adds features in the form of sample questions with an answer button with the name Investigate, images in .gif format, youtube videos that can be directly played in electronic modules, summaries, and a bibliography. Utilization of digital technology as a learning media and learning resource, such as the use of android smartphones that use images, text, and videos, in addition to having an interest in learning for students to learn, is also able to improve the quality of learning for students [33-34].

Develop

The third stage is developing a chemical literacy test and an electronic module based on guided inquiry following the design that has been made and its application in learning. Chemical literacy tests are developed based on aspects that have been synthesized based on the explanations of experts [35-38]. The questions are divided into three literacy topics with twelve questions. Each question is divided based on the chemical literacy dimension, two questions for the chemical content, three questions for the context chemistry, four questions for the high-level learning ability, and three literacy questions for the affective aspect. The chemical literacy test was declared valid with corrections by experts. The instruments were tested empirically on 94 students who had previously studied the topic of chemical reactions. Empirical results show that all questions are declared valid by having an INFIT MNSQ value in the range of 0.77-1.30 [39] and a reliability of 0.79 with reliable criteria [40].

The guided inquiry-based electronic module was created using the Inkscape design program to create pages and content in the electronic module. The draft that has been made from Inkscape is an image with a .png format which is then converted into a .pdf format and then converted into a flipbook using the Flip pdf professional program. The Flip pdf program is also used to complement electronic modules, such as adding moving images in .gif format and

YouTube videos that can be played directly in the module. The product of the Flip Pdf program is in the form of HTML5, which is then converted into .apk format using the Website2apk program so that it can be installed and directly used using an android-based smartphone. The results of the guided inquiry-based electronic module that had been developed are presented in Figures 2 and Figure 3.

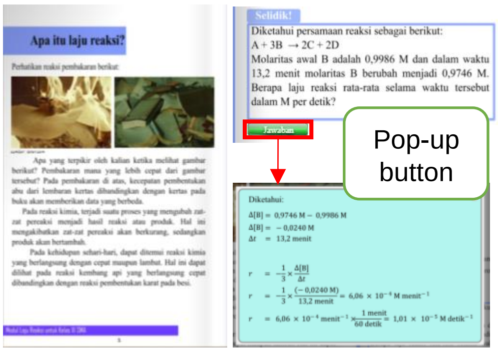

Figure 2. Content and Sample Question

Figure 3. GIF Format Image and YouTube Video

The content in the electronic module is adapted to the syntax of guided inquiry learning: observation, manipulation, generalization, verification, and application. Statements are made by viewing the video problems that have been presented in the electronic module. Next, the teacher will ask questions about the situation in the video related to the topic being studied and ask students to solve the problem at the manipulation stage. At the generalization stage, students will be directed to find answers to questions through the electronic module and guided by the teacher. Then. Students will be asked to record the observations obtained from the electronic module (verification) and provide answers to questions posed by the teacher (application) [41].

The guided inquiry-based electronic module that has been developed is then carried out with theoretical validation or expert judgment in the form of corrections by two experts on the material and media aspects contained in the electronic module. The experts are chemistry lecturers who will provide a feasibility assessment and comment on the electronic module and the contents of the electronic module itself. The product was then revised based on the advice of two experts. Finally, the guided inquiry-based reaction rate electronic module was declared feasible to be used in research after improvements were made.

The stages then continue with practicality assessments and readability tests by practitioners and students. First, five chemistry teachers evaluated the electronic module's practicality. The practicality of the guided inquiry-based electronic module has four aspects to asses, (1) Learning, (2) Theory, (3) Visual Displays, and (4) Software Engineering. Meanwhile, readability has three aspects of assessment, (1) Theory, (2) Visual Displays, and (3) Software Engineering. The results of the practicality and the readability are presented in Figure 4.

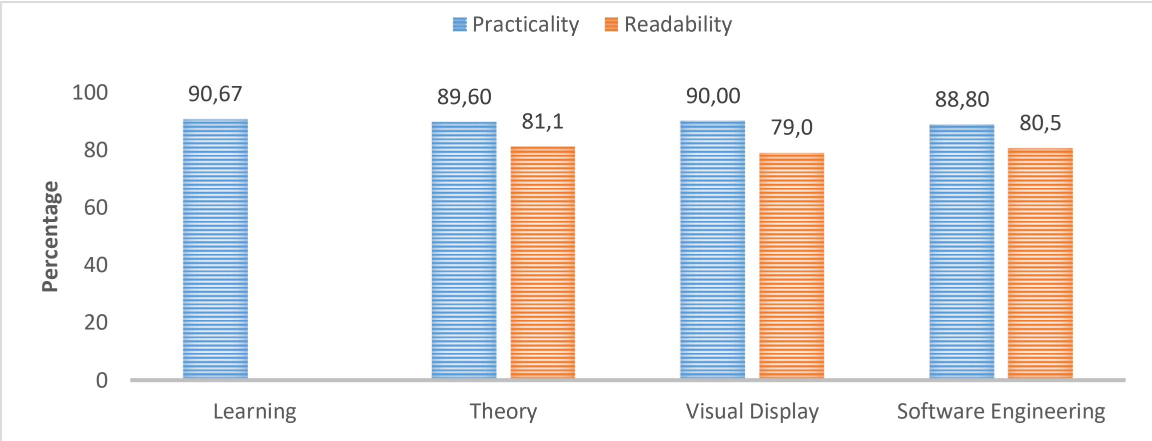

Figure 4. The Percentage of the Practicality and the Readability of Guided Inquiry-Based Electronic Module

Based on Figure 4, the four aspects of a chemistry teacher's practicality test of the guided inquiry-based electronic module show an excellent category, with an average percentage of 89.8%. Meanwhile, the readability test showed that the three aspects were in the excellent category with an average percentage of 80.1%. The results of the practicality test and product readability show that the guided inquiry-based electronic module is suitable for chemistry learning, especially in the topic reaction rate. Furthermore, the electronic module is attractive and compatible with students' learning use [42-44].

The guided inquiry-based electronic reaction rate module is declared valid by expert judgment and tested both practicality and readability before being used in the experimental class. Therefore, treat the control class not using a guided inquiry-based reaction rate electronic module.

Students in the experimental class will use electronic modules installed on their smartphones as learning resources and as learning media by the teacher. Based on observations during learning, students became more active in the classroom, especially in finding answers to teacher questions after seeing the video presented in the electronic module. Meanwhile, students in the control class who studied using textbooks did not give as many good responses as students in the experimental class. Most of the students in the control class only received an explanation of chemistry concepts from the teacher.

After learning about reaction rates, students in both classes will be given an exam with the same chemical literacy test to measure their chemical literacy skills after completing the lesson. The results of the class statistical analysis obtained are shown in Figure 5.

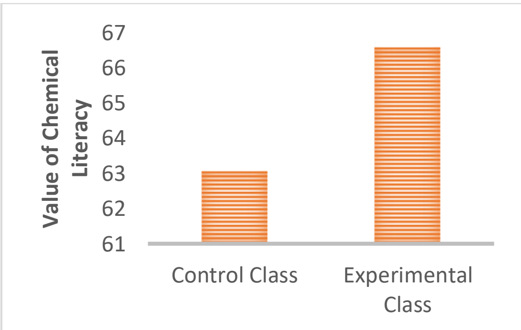

Figure 5. Average of Chemical Literacy

Based on Figure 5, the average value is 63.0557 for the control class, and the average value is 66.5727 for the experimental class. In addition, based on the percentage of the ideal category of chemical literacy of students in each group (control class and experimental class), by counting the number of students who have excellent to very poor chemical literacy criteria for each group. Next, the ideal percentage is compared between a number of the two groups used as research samples. The distribution of chemical literacy categories between the control and experimental class can be seen in Table 2.

Table 1. Distribution of the ideal category of chemical literacy

Category	Control	Experiment
Excellent	0%	0%
Good	86.67%	100%
Fair	13.33%	0%
Poor	0%	0%
Very Bad	0%	0%

Based on Figure 5 and Table 2 shows that most of the students in the experimental class can answer all chemical literacy questions in every aspect better than most of the students in the control class. The chemical literacy ability of the experimental class students showed better results than the control class.

The difference in students' chemical literacy skills between the control and experimental classes is influenced by illustrations of problems in daily life which are presented through videos on electronic modules used in learning in the experimental class. Students formulate the problems in the video, formulate hypotheses, collect information based on the theory described in the electronic module (shown in Figure 6) submitted by the teacher, verify findings, and draw conclusions.

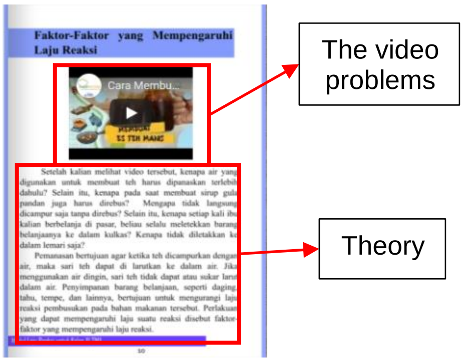

Figure 6. The video problems and theory-related page

On this page (Figure 6), students must explain the relationship between the theories and the video's content. The questions are an effort to improve students' chemical literacy skills. Students are not only able to understand chemical content but are also able to use it in daily contexts. In every process of collecting information that students have done, the teacher will guide students in making decisions and verifying the results of the decisions that have been created. At this stage, it will positively and significantly impact learning activities, investigations, successful performance, and student learning outcomes [45].

Guided inquiry learning modules and models can improve conceptual understanding and chemical literacy skills. [31-32]. An electronic module positively influences learning achievement [46-48]. The use of an e-module improves critical thinking skills. It makes students more interested and happier because e-module contain animated videos, pictures, and content summaries to make students more enthusiastic about participating in learning [49]. Students should have involvement in learning so that students understanding of concepts can increase and learning becomes more meaningful [50].

The electronic module is practical because it has features not shared by print modules or textbooks, such as video features with moving images and sound, which attract students' attention rather than static images. Electronic modules are installed in smartphones so it can be used anytime and anywhere. In the classroom, students will be more interested in opening their smartphones than opening textbooks, so they are worthy of use for learning.

The magnitude of the effect of implementing learning using an electronic module on the rate of reaction based on guided inquiry on students' chemical literacy skills can be seen from the statistical effect size test using the Cohen's d equation [51]. The effect size measurement results obtained are 0.74 in the medium category. The learning process using the guided inquiry-based electronic reaction rate module can affect students' literacy skills compared to learning that does not use the guided inquiry-based reaction rate electronic module in learning.

CONCLUSION

The guided inquiry-based electronic module is feasible, practical, and effective to be used in learning. The feasibility of the validation results from expert judgment shows that the product is proper to use in learning, and the practicality is categorized as an excellent category. The product proved effective because the percentage of the experimental class's test exceeded the control class's, which were 66.5727 and 63.0557, respectively. Learning using a guided inquiry-based electronic module effectively contributes 0.74 with a medium strength category. The product can be used as a new reference to support the teaching and learning process. In addition, it is recommended to make more exciting media, especially for learning chemistry.

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