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DEVELOPMENT OF ELECTRONIC MODULE BASED ON GREEN CHEMISTRY ON REACTION RATE MATERIAL

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ABSTRAK

Tantangan revolusi 4.0 membawa pengaruh pada dunia pendidikan salah satunya mengubah pola pikir peserta didik. Bahan ajar sebagai penunjang pembelajaran harus disesuaikan dengan kebutuhan peserta didik. Kurangnya pemahaman konsep peserta didik terhadap materi laju reaksi dan prinsip green chemistry menjadi salah satu permasalahan dalam proses pembelajaran kimia. Tujuan penelitian ini untuk mengembangkan media pembelajaran berupa elektronik modul berbasis green chemistry pada materi laju reaksi. Metode penelitian yang digunakan yaitu R&D dengan model 4D yaitu Define, Design, Develop dan Dissaminate tetapi hanya dilakukan sampai tahap Develop. Teknik pengumpulan data dilakukan melalui wawancara, angket, dan dokumentasi. Analisis data dilakukan dengan uji validitas ahli dan uji praktikalitas oleh peserta didik. Berdasarkan hasil analisis data diketahui bahwa validasi ahli memperoleh skor rata-rata sebesar 0,82 dengan kategori valid, sedangkan hasil respon peserta didik mendapatkan persentase rata-rata sebesar 88,78% pada tiap aspek yang termasuk dalam kategori sangat baik dan sangat praktis untuk digunakan..

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1. PENDAHULUAN

P21CS Partnership for 21st Century Learning (P21) on framework learning in the 21st century requires students to have expertise in the fields of knowledge and abilities in the fields of technology, media and information, knowledge in the field of learning and innovation as well as life and career skills so that students can be successful in life and work. So this makes it a challenge for teachers to be able to organize appropriate learning for students. One way to maximize the right learning process in the 21st century is to choose the right teaching materials. Teaching materials are materials that are structured in a structured manner and used by teachers and students in the teaching and learning process (Wibowo, 2018). According to Manulang et al., (2020) teaching materials are a set of tools that contain learning materials, learning steps, boundaries, and assessments that are designed systematically and attractively in order to achieve the goals that have been set. So that teaching materials can be interpreted as all forms of materials or materials that are designed in a structured manner and used by students to learn independently in accordance with the applicable curriculum.

Teaching materials as media used to achieve a learning goal can be developed dynamically along with the progress and demands of the times (Asi, 2017). Teaching materials are also one of the success factors in the teaching and learning process (Hasanah et al., 2016). Examples of teaching materials are modules, learning audio, and videos. Based on the results of interviews with teachers and students at one school in Musi Rawas Regency, it is known that the module used in the learning process is the printed module. The printed module used has several weaknesses including: (1) the module only contains a linear material (2) there are no activities that can develop students' thinking skills, (3) the material presented is not related to the principles green chemistry.Based on the shortcomings of the printed module, a simple, complete teaching material is needed, presenting scientific activities that can

develop students' thinking patterns, and presenting material related to the principles ofgreen chemistry. One of the teaching materials that can be developed is E-Modul.

E-Module is a set of electronic learning media that is designed in a structured manner and is used as an independent study material (Utami et al., 2018). E-modules are considered more innovative because they can display complete, interesting, interactive teaching materials (Abdullah et al., 2020). Based on the results of research conducted by Suarsana & Mahayukti (2013) E-modules can improve the mindset of students and get a good response from students. So that E-Modules can be a solution for the existing problems in the print module by utilizing advanced technology. E-Modules are commonly used in the chemistry learning process, one of which is the reaction rate material.

The application of the concept of reaction rate is found in everyday life. Based on this, when studying the material of reaction rates, it is important to be able to include practical activities (Redhana & Merta, 2017). Practical activity is an activity carried out by students to get the opportunity to test and implement chemical theory in actual conditions (Purnamasari et al., 2018). Practical activities can help students better understand and get meaningful learning. According to Redhana & Merta (2017) in carrying out practicum activities, students have not paid attention to the correct practicum activity procedures. This is like the use of hazardous materials in the implementation of practicum activities, the waste generated from chemical practicum activities is not disposed of properly adjust the right type of material, and do not have a special waste treatment system so that the resulting chemical waste will have an impact on the surrounding environment. The practical guide used by students is also not equipped with hazard symbols, there is no information about the properties of chemicals, and is not equipped with how to use laboratory equipment.

This can result in the negligence of students when using materials in practical activities. This problem can be prevented using the principlesgreen chemistry. Principlegreen chemistryis a concept to form a product that can reduce the use of hazardous materials and reduce environmental pollution (Mitarlis et al., 2017). According to Anastas & Eghbali (2010) the principle ofgreen chemistry practicum activities can be designed to be safer because they do not use hazardous chemicals and prioritize work safety principles for students. So that the principlegreen chemistryimportant for students to learn in the learning process, especially in chemistry. Based on the explanation above, researchers are interested in developing a-based E-Module green chemistry as teaching material to study the material reaction rate.

2. RESEARCH METHODS

This research applies development research methods or Research and Development (R&D). The development model used in the research is a 4-D development model adapted from Thiagaraja, Semmel, and Semmel (1974) with 4 stages, namely, define, design, developmentand disseminate. However, the research carried out was only up to the revision stage and product trials on a small scale due to the limitations of the research conducted. The expert validity instrument was determined by a validation questionnaire using a rating scale of 1-5 with information 1 and 5. The results of the expert assessment were calculated with the validity of Aiken's V using the formula:

$$\frac{\sum s}{[n\,(C-1)]}$$

Information:
S: r-lo
lo: the lowest score (1)
c: the highest score (5)
r: the number given by the validator
n: the number of validators

Meanwhile, the results of the student response questionnaires were processed and analyzed to find out the level of quality of the E-Module-based green chemistry. The student response questionnaire instrument was arranged using a rating scale of 1-5 while the questionnaire scale table is presented in Table 1.

Table 1. Assessment guidelines

No	Vulnerable Value	Rating Level
1.	X >80	Very Practical
2.	60< X 80	Practical
3.	40< X 60	Practical enough
4.	20< X 40	Less Practical
5.	X < 20	Not Practical

This research was conducted at SMAN Purwodadi Class XI IPA for the academic year 2022/2023. The product trial was applied on a small scale, taking nine students. The selection of students is done by teacher input and based on the level of understanding with high, medium, and low categories. Data collection techniques used by means of interviews, questionnaires and documentation.

3. RESULTS AND DISCUSSION

The E-Modul design of green chemistry-based reaction rate material consists of the front page, introduction, table of contents, instructions for using the E-Modul, information related to green chemistry, concept maps, description of reaction rate material consisting of three learning activities, student scientific activities based on green chemistry, material summary, sample questions, practice questions, glossary, bibliography and author's history. Product development in this study was carried out with reference to the 4-D development model consisting of several stages, namely define (definition), design (design), develop (development), and disseminate (dissemination). However, the disseminate stage was

not carried out in this study due to time constraints and the product has been tested in a limited manner.

Define stage is used to analyze the problems and needs of students, at this stage it resulted that the chemistry learning process used the 2013 curriculum, but in its implementation it was not optimal due to the limitations of teaching materials used by teachers in the learning process. Students find chemistry very difficult to understand, with green chemistry. The teaching materials used by the teacher are printed books. The weakness of printed books is that the material in printed books is linear, there are no activities that can develop students' thinking skills, and the material presented is not related to principles.green chemistry. The teaching materials used do not present learning activities that are associated with the principles of green chemistry. Even as many as 100% of students do not know the principle green chemistry.

As many as 66.7% of students think that chemistry is a difficult subject. In addition, as many as 77.8% of students also think that the reaction rate material is a difficult material compared to other chemical materials. Next is the task analysis aims to determine the learning in the syllabus. Reaction rate-based material module green chemistryadapted to the results of the questionnaire on the needs of students who consider the reaction rate material as difficult to understand material. The tasks that are arranged must be in accordance with the basic competencies on the reaction rate material including the concept of reaction rate based on collision theory, factors that affect reaction rates, reaction orders and reaction rate equations.

Design Stage is used to design a product in the form of a -based E-Module green chemistry. Some of the activities carried out in product design include: (1) Collecting references used to find data in the form of reaction rate material as the object of the problem that will be raised into an E-Module based on green chemistry. (2) Develop an E-Modul format for green chemistry-based reaction rate material that is adapted to the 2013 curriculum. The format includes, front page, foreword, table of contents, instructions for using the E-Module, information related to green chemistry, concept maps, descriptions of rate materials. Reactions consisting of three learning activities, green chemistry-based student scientific activities, material summaries, sample questions, and practice questions. (3) Selection of supporting applications in the manufacture of E-Module based on green chemistry on the reaction rate material. The layout of the content of the E-Module is done using Microsoft Word 2013, while to produce the E-Module, the reaction rate material based on green chemistry uses the Any Flip application. Any Flip is one of the software for making electronic teaching materials that can convert PDF files into FlipBooks with HTML 5 and Flash files, so that the E-Module of green chemistry-based reaction rate materials can be opened via smartphones, laptops, or computers.

Figure 1. Principle Information Green Chemistry on E-Module

Figure 1. Shows Principle information green chemistrywhich aims to increase the knowledge of students regarding several principlesgreen chemistry.Some principles green chemistrycontained in the E-Module, namely: synthesis of harmless chemicals, designing safe chemicals, using safer solvents, energy efficiency design, design of decomposition processes, safer chemistry to prevent work accidents in practical activities.

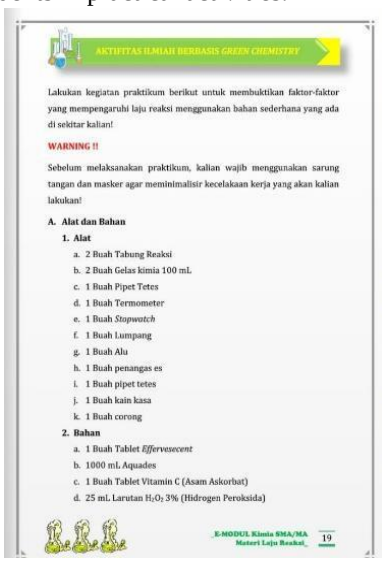

Figure 2. Scientific activities of students based on green chemistry

Figure 2. Shows the scientific activity of students is a practicum activity that students can do to be able to understand the reaction rate material based on the factors that influence it. The practicum activities presented contain practicum materials and tools, step instructions before practicum activities are carried out, student work steps, student observation

columns, and practice questions that have been adjusted based on the principlegreen chemistry. It aims to help students understand the reaction rate material based on the practical activities carried out.

Develop stage is done by making an E-Module of green chemistry-based reaction rate material that is tailored to the learning objectives and need of students. The initial step that can be taken is to produce a draft consisting of a front cover, preface, table of contents, instructions for using the E-Module, information related to green chemistry, and a concept map. The next step is to design the content of the E-Module which consists of a description of the reaction rate material, learning activities associated with the material presented, students scientific activities based on green chemistry, and loading questions as reviews in learning. After the product has been developed, the last step is validation and product testing which can be seen in the following discussion. Product revisions are made based on product improvements according to the suggestions of chemistry experts and teachers. The suggestions given can be seen in Table 2.

Table 2.Validator suggestions

Validator	Suggestions
1.	Fix E-Module front cover color
2.	E-module developed basegreen chemistryit's not so visible, the practical activities are also less revealinggreen chemistry
3.	Add learning objectives in each learning activity
4.	Add pictures and example problems on the factors that affect the rate of reaction
5.	Improve the appearance of the column for the results of practical activities

Furthermore, the validation stage is carried out by experts. The experts gave an assessment of the developed media covering 6 aspects, namely the presentation of the E-Module, the feasibility of the graphic, the feasibility of the content, the language, the presentation technique, and the content.green chemistry. The analysis of the calculation of each aspect by experts can be seen in Figure 3.

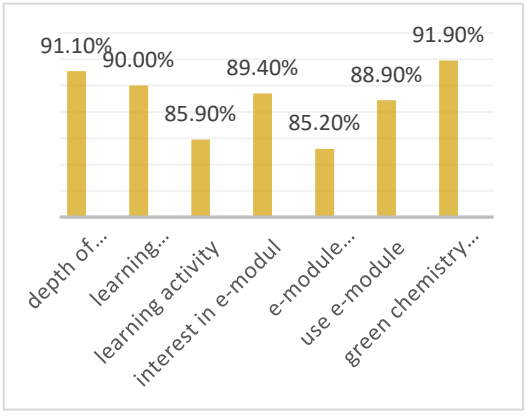

Figure 3. Validation of experts in each aspect

Based on the overall average score of each aspect of the chemistry experts and teachers, a score of 0.82 was obtained with a valid category. So that the results of the assessment and improvements that have been made are based on the validator's suggestions, the E-Module is based on green chemistrycan be tested on students. Valid teaching materials mean that the teaching materials have met the specified criteria standards, so they can be used in the learning process learning. The product trial was conducted on a small scale with 9 students recommended by the chemistry teacher at SMA N Purwodadi. The selected students included 3 students with high learning abilities, 3 students with moderate learning abilities, and 3 students with low learning abilities. Selection with different levels of academic ability is carried out to represent the target population in the -based E-Module green chemistry. The test aims to determine the response of students in using E-Module based on green chemistry in the learning process. This test is carried out by distributing student response questionnaires to the developed E-Module. The analysis of the calculation of the results of the student response questionnaire to the E-Module material based on reaction rategreen chemistry on each indicator can be seen in Figure 4.

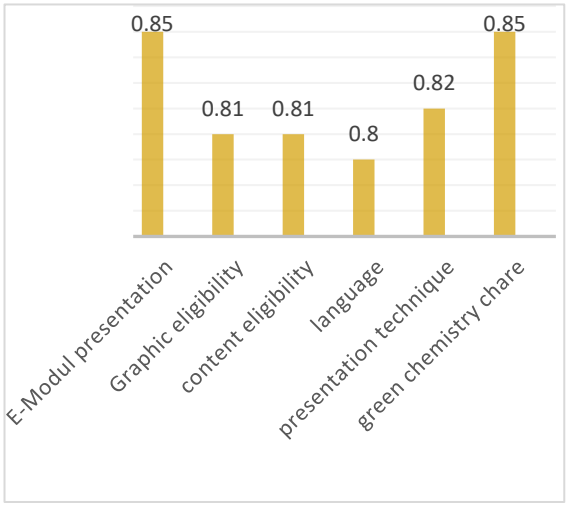

Figure 4. Student Response Results for Each Aspect

Based on the data in Figure 4, it can be seen that the average percentage of students' responses to the E-Module is the based reaction rate materialgreen chemistryof 88.78% which is included in the very good criteria so that it can be used in chemistry learning. Aspects of ease of understanding the material and aspects of learning independence get a percentage of 91.10% and 90.0% so that both have very good categories and are very practical to use. Aspects of learning activity obtained a percentage of 85.9% with a good category and very practical to use. So that the E-Module is based ongreen chemistrycan encourage the enthusiasm of students to learn the material reaction rate. Aspects of interest in learning get a percentage of 89.4% with a very good category and very practical to use. Thus, it can be said that the E-Module reaction rate based material green chemistry increase student interest in learning.

Aspects of the presentation of the E-Modul and the use of the E-Modul each get a percentage of 85.2% and 88.9% with good category and very practical to

use. That is, the presentation of E-Module based on green chemistry is interesting with reading, pictures and simple language used so that it is easy for students to understand. In addition, the charge aspect of green chemistry gets a percentage of 91.9% with a good category and very practical to use. Thus, it can be said that the E-Module material on the reaction rate based on green chemistry is valid and practical to use in the chemistry learning process, especially on the reaction rate material.

4. CONCLUSION

Based on the results of research and product development, it can be concluded that the E-Module is a based reaction rate materialgreen chemistry declared worthy based on the results of a validation questionnaire from chemistry experts and teachers who obtained an average score of 0.82 with a valid category. In addition, the E-Module of reaction rate based material green chemistrydeclared practical in a limited trial with a practicality percentage of 88.78% in the very good category. However, further research is needed to determine the effectiveness of -based E-Modules green chemistryon the rate of reaction.

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