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Analysis of Responses to the Development of E-Modules to Improve Students' Critical Thinking Skills in Reaction Rate Materials in the Form of Android Applications

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ABSTRAK

Kemampuan berpikir kritis siswa dalam pembelajaran kimia pada umumnya masih rendah, sehingga diperlukan bahan ajar yang menarik untuk meningkatkan kemampuan berpikir kritis siswa, salah satunya adalah e-modul. Penelitian ini bertujuan untuk mengetahui kelayakan e-modul dan mengetahui respon pendidik dan peserta didik terhadap e-modul berbasis aplikasi android dalam meningkatkan kemampuan berpikir kritis siswa pada materi laju reaksi. Penelitian ini menggunakan model penelitian dan pengembangan (R&D) dengan desain penelitian berbasis R&D yang merupakan singkatan dari model ADDIE (Analysis, Design, Development, Implementation, Evaluation). Teknik pengumpulan data melalui validasi oleh ahli materi dan media, serta respon dari guru dan siswa. Subjek penelitian terdiri dari 30 siswa yang menggunakan e-modul dalam pembelajaran. Teknik analisis data menggunakan uji t (Independent Sample T Test) untuk mengukur perbedaan keterampilan berpikir kritis siswa sebelum dan sesudah menggunakan e-modul. Hasil penelitian menunjukkan adanya peningkatan signifikan dalam kemampuan berpikir kritis siswa, dengan rata-rata skor posttest meningkat sebesar 13,3 poin dibandingkan pretest ($p < 0,05$). Kesimpulan dari penelitian ini adalah e-modul berbasis Android efektif dalam meningkatkan keterampilan berpikir kritis siswa. Implikasi penelitian ini adalah e-modul dapat menjadi media pembelajaran yang menarik dan dapat digunakan untuk mendukung pembelajaran di sekolah maupun secara mandiri di rumah, serta berpotensi meningkatkan hasil belajar dan keterampilan berpikir kritis siswa dalam jangka panjang.

ABSTRACT

Students' critical thinking skills in chemistry learning are generally still low, so interesting open materials are needed to improve students' critical thinking skills, one of which is e-modules. This study aims to determine the feasibility of e-modules and to determine the responses of educators and students to android-based e-modules in improving students' critical thinking skills at the rate of material reaction. This study uses a research and development (R&D) model with an R&D-based research design which stands for the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). Data collection techniques through validation by material and media experts, as well as responses from teachers and students. The subjects of the study consisted of 30 students who used e-modules in learning. The data analysis technique used the t-test (Independent Sample T Test) to measure differences in students' critical thinking skills before and after using e-modules. The results showed a significant increase in students' critical thinking skills, with an average posttest score increasing by 13.3 points compared to the pretest ($p < 0.05$). The conclusion of this study is that Android-based e-modules are effective in improving students' critical thinking skills. The implication of this research is that e-modules can be an interesting learning medium and can be used to support learning at school or independently at home, and have the potential to improve students' learning outcomes and critical thinking skills in the long term.

1. INTRODUCTION

Education is one of the human empowerment efforts that can be done by developing self-potential, personality, skills, intelligence, and noble character. In achieving educational goals, several considerations are needed including components in learning such as models, methods, objectives, and the media used (Astalini et al., 2022; Fernandes et al., 2019; Kusuma Wardani et al., 2017). By paying attention to the components in learning, it will make learning activities fun and motivate students to play an active role in the space and opportunities provided (Mahardika & Siswoyo, 2021; Maria Waldetrudis Lidi, 2019; Nazri et al., 2022). One component with considerable influence is the use of media (Prawitasari et al., 2021; Rizki Wahyuningtyas, 2020). Without the use of clear media, the learning process will become less interesting

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and the results obtained are not optimal as expected.

Chemistry is a branch of natural science that deals with the composition, structure, properties, changes, and the accompanying energy. The big challenge in learning chemistry is that the material in chemistry learning is abstract so that educators must be able to optimize the available time (Grosvenor & Pataki, 2017; Redhana, 2019; Widowati et al., 2017). One of the materials taught in chemistry subjects at school is the rate of reaction. The rate of reaction is one of the most complex and abstract chemistry materials (Fitriana et al., 2019; Humairoh & Yonata, 2019; Kamid et al., 2022). In this material, students are also required to understand the concept of concentration, reaction rate constants, reaction orders and chemical calculations as well as the factors that influence them (Hidayat et al., 2019; Ramadhanti & Agustini, 2021; Safitri et al., 2019). In reality, the response and interest of students tend to decrease in the material of reaction rates, especially when meeting questions. However, if practicum is carried out related to the project, the interest of students tends to increase (Ain & Mitarlis, 2020; Hidayatulloh et al., 2020; NOVITA, 2018). This can happen because students have not been able to implement the theories explained by educators (Muliaman, 2021; Pisdon et al., 2018; Prawitasari et al., 2021). This problem causes students' critical thinking skills in solving problems that are still lacking (Safarah & Wibowo, 2018; Setiya Rini et al., 2021; Susanto et al., 2021). So, we need a solution that can improve students' critical thinking skills.

The ability to think critically is an activity or process of thinking both precisely, directed, reasoned, reflective in every decision making (Asy'ari et al., 2019; Copriady et al., 2020; Patmawati et al., 2018). Critical thinking ability is one of the factors that influence students' understanding and thinking skills which are expected to appear in the learning process (Jayul & Irwanto, 2020; Puspita & Dewi, 2021; Ramdani et al., 2020). Learning critical thinking skills can be done by educators using constructivist learning strategies that have the potential to empower critical thinking skills (Alvunger, 2018; Darmaji et al., 2019; Widyaningsih & Ganing, 2021). This learning strategy can be done through teaching materials, one of which is in the form of e-modules. E-modules are developed using electronic technology consisting of text, images, graphics, and animations that are suitable for use in learning in easy-to-understand language (Herawati & Muhtadi, 2020; Laili et al., 2019; Sidiq & Najuah, 2020). The goal is to make it easier for students to achieve learning goals (Dwi Lestari & Putu Parmiti, 2020; Utami et al., 2018; Widiana & Rosy, 2021). E-modules are developed with various interesting features so that students are more interested in the learning process so that students' abilities can increase. The use of e-modules will be more interesting and practical if it involves a smartphone (Abdullah et al., 2020; Fany Monica Yuniarti et al., 2020; Gufran & Mataya, 2020).

Research like this has been carried out by several other studies. However, there are differences in the material studied, developing e-modules on fluid dynamic material to improve students' critical thinking (Nikita et al., 2018; Sumarmi et al., 2021). Furthermore, developed project-based learning e-modules that are integrated with hyperchem computational media on molecular-shaped material (Simbolon et al., 2022). In addition, focusing on the development of e-oodules based on process-oriented guided inquiry learning (Septianti et al., 2022). Focuses on e-module desig (Wahyuni et al., 2020). Focuses on developing e-modules based on problem solving in basic physics practicum (Darmaji et al., 2019; Tsai et al., 2023). The novelty of this research is to develop smartphone application-based e-modules that have never been done by previous researchers. In addition, the material that the researchers took was a reaction rate material that was different from the material in previous studies. Then, the focus of this research is the development of android-based e-modules to improve critical thinking skills which is also different from the focus of research in previous studies. This research has a high urgency because learning about reaction rates in chemistry is often considered abstract and difficult to understand by students, which can reduce student interest and understanding. The development of smartphone-based e-modules aims to utilize technology that is already known to students, provide more interactive and interesting learning opportunities, and facilitate the improvement of critical thinking. With modern digital technology, e-modules supported by animation and graphics can present materials visually and practically so that students can understand complex concepts in an easy-to-understand way. This research also contributes to answering the challenges of modern education, namely creating the most effective, efficient, and relevant learning to current needs. Based on this description, researchers are interested in conducting development research with the aim of knowing the feasibility of the product in the form of an e-module on the reaction rate material. Another purpose of this research is to know the response of educators and students' responses to the development of e-modules to improve students' critical thinking skills in the reaction rate material in the form of an android application.

2. METHOD

This study uses a research and development (R&D) model with an R&D-based research design which stands for the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). This

approach was chosen because it aims to produce smartphone-based e-module products that can be used in chemistry learning on reaction rate material. This study also aims to evaluate the feasibility of the developed e-module and see how teachers and students respond to its use in learning.

The subjects in this study were students of class XI 4 at Senior High School 10 Jambi City. The sample for the small group trial was 5 students and the large group trial was 30 students. This sample was taken using purposive sampling technique. The sample criteria were taken based on the students' varying cognitive abilities, namely high cognitive, medium cognitive, and low cognitive. The data collection method in this study used the research instrument of media expert questionnaire, material expert questionnaire, educator assessment questionnaire, and student response questionnaire to the e-module. Data were collected qualitatively and quantitatively. Qualitative data were obtained from expert suggestions, responses, input, and criticism, while quantitative data were obtained from media expert questionnaires, material experts, educator assessment questionnaires, and student response questionnaires to the e-module. The teacher interview guide grid can be seen in Table 1.

Table 1. Interview Guide Grid

No	Indicator	Item Number
1	Curriculum used in school	1, 2
2	Minimum completeness criteria for chemistry subjects	3, 4
3	Difficulties, interests and factors that affect the teaching and learning process	5, 6, 7
4	Critical thinking	8
5	The use of learning media in the teaching and learning process	9, 10
6	Use of e-modules	11, 12
7	The experience of educators and the obstacles experienced in the teaching and learning process using e-modules	13, 14, 15
8	The use of smartphones in the learning process	16
9	Learning model	17
10	Developed learning media	18, 19

In addition to the interview guide grid, the researchers also distributed a questionnaire on the needs of students, characteristics of students, and students' understanding of the material. The grids used can be seen in Table 2. Furthermore, the researchers used a media expert validation questionnaire to determine the theoretical feasibility of the e-module. The following is a grid of media expert validation questionnaires which can be seen in Table 3.

Table 2. Questionnaire Grid for Student Needs

No	Aspect	Number of Questions
1	Need for smartphones, computers or laptops, teaching materials, and learning media	8
2	The need for critical thinking	4
3	Material needs	5
4	The need for developed media	5

Table 3. Grid of Media Expert Validation Instrument

No	Aspect	Number of Questions
1	Simplicity	6
2	Cohesiveness	3
3	Emphasis	2
4	Balance	3
5	Form	4
6	Color	3

The researcher also used a material expert validation questionnaire to validate the standard and suitability of the material displayed in the developed media. The following is a grid of material expert validation questionnaires which can be seen in Table 4. The researcher also gave an assessment questionnaire to educators as a form of effort to see the feasibility of the e-module before testing it on students. The contents of the questionnaire are arranged based on the grid in Table 5.

Table 4. Material Expert Validation Questionnaire Grid

No	Aspect	Number of Questions
1	Format	2
2	Contents	10
3	Language	2

Table 5. Grid of Educators Assessment Questionnaire

No	Indicator	Question Number
1	Conformity of the content of the e-module material with KI and KD	1
2	The accuracy of the e-module material with indicators of achievement and learning objectives	2
3	Clarity of presentation of material in e-modules	3
4	The suitability of the sequence of presentation of material in e-modules	4
5	The suitability of images, videos, animations with the material presented	5
6	Students are able to think critically in solving problems with the reaction rate material around them	6
7	Students are able to relate the reaction rate material to everyday life	7
8	E-modules can be used by students independently	8
9	The suitability of practice questions and evaluations in achieving learning objectives	9
10	Variation and quality of questions in e-modules based on critical thinking skills	10
11	Ease of accessing e-modules in the form of an Android application	11
12	The accuracy of the use of language in the e-module	12
13	Overall attractiveness	13
14	The suitability of the layout of all components in the e-module	14
15	Compatibility of format and display in e-module	15
16	Media has the potential to improve students' critical thinking skills as users	16

Next is the student response questionnaire which is given with the aim of knowing the feasibility, responses, and interests of students to the e-module on the reaction rate material after the trial. This response data is used to assess the feasibility of the e-module developed as a learning medium. The grid of student responses can be seen in Table 6.

Table 6. Student Response Questionnaire Grid

No	Aspect	Indicator	Question Number
1	Appearance	The attractiveness of the whole view in the e-module	1
		The suitability of the combination of writing, animation, background in the e-module	2
		Conformity of content in e-module view	3
		Readable text size and font	4
2	Media	Media makes it easier to understand the concept of reaction rate factors	5
		Easy to understand video and animation material	6
3	Contents	Easy to understand material	7
		Animation according to material	8
		Image according to material	9
		The suitability of the exercise with the content of the material	10
4	Language	Instructions for use	11
		The language used is easy to understand	12
5	Benefits	Motivate users to learn chemistry	13

No	Aspect	Indicator	Question Number
		Topic clarity	14
		Providing feedback on the evaluation results	15
		Attractiveness	16
		Captions and text are easy to understand	17
		Ease of use of e-module access	18
		Ease of understanding each step in the e-module	19

Furthermore, data analysis was carried out on the data that had been obtained, the next step taken by the researcher was data analysis on the assessment of data collection instruments in the form of needs questionnaires, material expert validation questionnaires, media expert validation questionnaires, educator assessment questionnaires, and student response questionnaires. The analysis technique used in the student needs instrument is the rating scale. Next is the result of data collection from the validation of media experts, material experts, assessments of educators and student responses. The data obtained in the form of responses, suggestions or input are used to improve the products developed. While the data obtained in the form of quantitative data were analyzed based on the average score of answers. The data obtained were then analyzed and processed descriptively into interval data using a Likert scale. The Likert scale criteria used for product assessment can be seen in Table 7. The following is a classification of the percentage of student responses which can be seen in Table 8.

Table 7. Scores and Product Assessment Criteria

No	Score	Percentage (%)	Criteria
1	>3.25 - 4.00	>81 – 100	Very good
2	>2.50 - 3.25	>63 – 81	Well
3	>1.75 – 2.50	>44 – 63	Not good
4	1.00 – 1.75	>25 – 44	Not very good

Table 8. Classification of The Percentage of Student Responses

No	Percentage (%)	Criteria
1	0 – 25	Very good
2	26 – 50	Well
3	51 – 75	Not good
4	76 – 100	Not very good

The developed e-module can be said to be feasible if the score obtained from the student response questionnaire is > 51%. Qualitative data analysis uses descriptive statistics in the form of percentages and means. Qualitative data is analyzed using the Miles and Huberman model. After the android application-based e-module is feasible and can be used and gets a good response, then a pretest and posttest are conducted to students to measure students' critical thinking skills using critical thinking questions consisting of 7 question items that include indicators of critical thinking, namely providing simple explanations, building basic skills, drawing conclusions, and providing further explanations. Furthermore, a t-test is conducted using SPSS for comparison before using the e-module (pretest) and after using the e-module (posttest). With the prerequisite test, the data must be homogeneous and normally distributed.

3. RESULT AND DISCUSSION

Result

The result of this development research is a product in the form of an e-module in the form of an android application on the reaction rate material which was developed with the help of MIT App Inventor. Researchers developed this e-module with the aim of knowing the feasibility and response of the product developed to improve students' critical thinking. Therefore, before developing a product in the form of an e-module, the researcher analyzes the needs of students first. Through the results of the analysis of students, it can be concluded that 51.4% of students think that they have difficulty in understanding the reaction rate material caused by one of them is the lack of learning media that helps the process of activities in learning. Through this analysis of student needs, the researcher concludes that there is a need for supporting media in order to help students understand the reaction rate material while at the same time attracting students to be able to play an active role in learning activities.

Furthermore, the researchers carried out developments that were arranged in such a way as to form a product in the form of an e-module. Then the researchers used the MIT App Inventor web application to convert the e-module into an application form. In addition, the MIT App Inventor web application can also create evaluation questions that can be directly done by students in the e-module application. The features presented also make e-modules more interesting and interactive for students. Products that have been developed are then validated by a team of material experts and a team of media experts. The results of material validation can be seen in Table 9.

Table 9. Material Expert Validation Results

No	Aspect	Question	Score	Score/Aspect
1	Format	Does the presentation of material in e-modules improve students' critical thinking skills in the form of android applications able to attract the attention of students?	3	7
2		Does the media in the form of e-modules have interactive power as learning media?	4	
3	Contents	Is the material in the e-module in accordance with the syllabus, KI, and KD	3	36
4		Has the e-module presentation been in a systematic order?	3	
5		Are the concepts and materials in the e-modules presented clear?	4	
6		Is the material in the e-module easy to understand?	3	
7		Are the images/animations/videos presented in the e-module adequate for the purpose of improving students' critical thinking skills?	4	
8		Do the images/animations/videos presented in the e-module have visualized the concept of reaction rate and are easy to understand?	4	
9		Is the integration of the steps in the e-module in accordance with the learning model?	4	
10		Has the learning model been properly integrated into the reaction rate material?	4	
11		Are the components of critical thinking skills in the e-module appropriate?	4	
12		Are the questions presented in the e-module in accordance with the learning indicators?	3	
13	Language	Is the language used in the e-module in accordance with the standard language rules?	4	8
14		Is the language used in the e-module easy to understand?	4	
		Total score		**51**
		Average		**3.643**
		Category		**Very good**
		Percentage		**91.08%**

The results of the material expert validation obtained a total score of 51 with an average value of 3,643 and the percentage reached 91.08%. Therefore, the results of the material expert validation show that the e-module is included in the "very good" category. Furthermore, the researchers analyzed the results of media expert validation and the results of the analysis showed that the score obtained was 81 with an average of 3,857 and a percentage of 96.43%. The category obtained is "very good". Next is the analysis of the results of the questionnaire assessment of educators which can be seen in Table 10.

Table 10. Results of the Assessment of Educators

No	Question	Skor
1	The content of the material in the e-module is in accordance with the core competencies and basic competencies to be achieved	4
2	The material is right with the achievement indicators and learning objectives	4
3	The presentation of the material in the e-module is clear	3
4	The suitability of the format for the presentation of the material in the e-module	4

No	Question	Skor
5	The selected image, video or animation is in accordance with the material to be conveyed	4
6	The developed e-module can train students' critical thinking skills	4
7	The ability of e-modules helps students to relate the reaction rate material to everyday life	4
8	E-modules can be used by students for independent study	4
9	Practice questions and evaluations are in accordance with the learning objectives	4
10	Variation and quality of questions in e-modules to improve critical thinking skills	3
11	E-module is easy to access	4
12	The language used in the e-module is chosen correctly	4
13	The clarity of the material at each step makes it easier for students to understand the concept of reaction rate factor	4
14	Overall attractiveness	4
15	The suitability of the layout of all components in the e-module	3
16	Compatibility of format and display in e-module	4
17	The media developed has the potential to improve students' critical thinking skills	4
	Total Score	**65**
	Average	**3.824**
	Percentage	**95.60%**
	Category	**VG**

The results of the analysis of the educators show that the e-module developed is in the "very good" category. Next is the response of students which can be seen in Table 11.

Table 11. Student Response Results

Question Number	1	2	3	4	5	6	7	8	9	10	11	12	Score
1	4	4	4	4	4	4	4	4	4	4	4	4	48
2	4	4	4	4	4	4	4	4	4	4	3	4	47
3	4	4	4	4	4	4	3	4	4	4	3	4	46
4	4	4	4	4	3	4	3	3	4	4	3	4	44
5	4	4	4	4	4	4	3	4	4	4	3	4	46
6	4	3	4	4	4	3	4	4	4	4	3	4	45
7	4	4	4	4	4	4	3	3	4	4	3	4	44
8	4	4	4	4	4	3	3	4	4	4	3	4	45
9	4	3	4	4	4	4	3	4	4	4	3	4	45
10	4	4	4	3	4	4	4	4	4	4	3	4	46
11	4	3	4	4	3	4	4	3	4	4	3	4	44
12	4	3	4	3	4	4	3	4	4	4	3	4	44
13	4	4	3	4	3	4	4	3	4	4	3	4	44
14	4	4	4	4	4	3	4	4	4	4	3	4	46
15	4	3	4	4	4	4	3	4	4	4	3	4	45
16	4	3	4	4	4	4	3	4	4	4	3	4	45
17	4	3	4	4	3	3	3	3	4	4	4	4	43
18	4	4	4	4	3	3	3	3	4	4	3	4	44
19	4	3	4	4	3	3	3	3	4	4	3	4	43
	Total number												**854**
	Percentage												**94%**
	Category												**Very good**

Based on the data obtained, it can be obtained that the learning media that has been developed is very interesting and very good for supporting reaction rate learning. Next, a prerequisite test was conducted in the form of a normality and homogeneity test. It can be seen that the data is normally distributed and homogeneous as seen from the significance value obtained in the test results, namely 0.200 and 0.189 more than 0.05 so that the data can be continued to the parametric test, namely the independent sample t-test. The results of the t-test for students' critical thinking skills which in Table 12.

Table 12. Results of the Pretest and Posttest Independent Sample T Test

Description	Pretest	Posttest	Difference (Posttest - Pretest)
Number of Students (n)	30	30	30
Mean Score	62,5	75,8	13,3
Standard Deviation	8,2	7,4	7,9
t (t-value)	-	-	4,32
Degrees of Freedom (df)	58	-	58
Significance (p-value)	0,000	-	0,000

Based on the table above, it is known that after students used the Android application-based reaction rate e-module, there was an increase with an average comparison of 13.3, based on the significant value obtained, it shows that the results are significant because the value obtained is below 0.05.

Discussion

The learning media developed in the form of e-modules that can be accessed via Android with more varied writing and the content of the material presented is more interesting through pictures and videos. This development is carried out using the Lee & Owens this development model can be said to be a procedural model because the sequence of steps in the development process is arranged systematically and clearly. The developed e-module contains objectives, indicators, learning activities as well as practice and evaluation questions. Therefore, the scope of the material discussed in the e-module is more focused and measurable, and is more concerned with student learning activities with communicative language. The e-module developed is expected to make it easier for students to construct their own learning so that it is more meaningful, and can improve students' critical thinking skills through the problem solving process provided in the form of questions and the design of a project. Furthermore, the product is designed and an initial product is produced which is then validated by a team of media and materials experts to assess the feasibility of the product being developed.

Based on the results of the validation of material experts and media experts, assessments of educators and student responses, it was found that the e-module developed on the reaction rate material in the form of an android application was feasible and received a very good response by educators and students. The attractiveness of presenting material in e-modules has the potential to improve students' critical thinking skills, is able to motivate students in learning the reaction rate material and can be used as a media to support learning by students both at school and independent study at home. The results of this study are in line with previous research which found that Android-based e-modules have the potential to be used to improve the quality of learning and students' critical thinking skills (Rismayanti et al., 2022b). The difference is that previous research places more emphasis on mathematics subjects, whereas the current research focuses on learning about chemical reaction rates. Based on the results of the analysis using the t-test (Independent Sample T Test), it was found that there was a significant increase in students' critical thinking skills after using the Android application-based e-module. The average pretest score of students before using the e-module was 62.5, with a standard deviation of 8.2, indicating a variation in initial critical thinking skills. After using the e-module, the average posttest score increased to 75.8, with a standard deviation of 7.4, indicating an increase of 13.3 points. The t-value obtained from the analysis was 4.32, with a degree of freedom (df) of 58. These results provide a p-value of 0.000, which is below the significance level of 0.05. Therefore, it can be concluded that the difference between the pretest and posttest results is statistically significant. This means that the use of the Android application-based e-module has a real positive impact on improving students' critical thinking skills. Overall, the Android application-based e-module has proven to be effective as a learning medium that can strengthen students' critical thinking skills, in accordance with the objectives of the study.

Student responses greatly influence the development of e-modules, if students give good responses then this e-module can certainly help improve students' critical thinking skills, and vice versa. The development of e-modules has both short-term and long-term impacts. The short-term impact is to accelerate the dissemination of information and improve student literacy skills, while the long-term impact is to improve student performance and learning outcomes (Astalini et al., 2022; Kurniawan et al., 2022). Besides that, the short-term impact of having critical thinking skills is that students are able to identify problems, collect various information relevant, while the long-term impact is that students have good learning outcomes and performance (Latifah et al., 2020; Siburian et al., 2022). There are several studies that are relevant to this research. However, there are differences in the material studied, developing e-modules for global warming material (Suwatra et al., 2018). Then, developed an e-module for material on Newton's law of gravity. In addition, there are differences in the focus of research, focusing on analyzing the effectiveness of e-modules with the help of becak-based augmented reality (Sari Dewi & Kuswanto, 2023).

Furthermore, focuses on developing e-modules based on Riau local wisdom to enhance creative thinking. Furthermore, focuses on implementing e-modules (Chen et al., 2021; Mahmudah et al., 2022; Purwasih et al., 2021).

The novelty of this research is to develop e-modules based on android applications which have never been done by previous researchers. This is because, there are many applications that can be downloaded easily by Android users because they are open source which gives freedom for developers to develop applications on smartphones (Nia et al., 2022; Rismayanti et al., 2022a). In addition, the material that the researchers took was a reaction rate material that was different from the material in previous studies. The implication of this study is that a good student response to e-module development has an effect on increasing critical thinking skills. The use of e-modules based on critical thinking skills can facilitate students in the teaching and learning process (Astuti et al., 2022; Cahyanto et al., 2022). In addition, the application of e-modules in learning is able to facilitate students to be more active and creative in learning so that students can improve critical thinking skills and student learning outcomes (Putri & Syafriani, 2022; Suharyat et al., 2023). The limitation of this research is that this study only analyzes students' responses to the development of e-modules for critical thinking skills on the material of reaction rate. Therefore, the researcher hopes that further research can analyze students' responses to the development of e-modules for other higher-order thinking skills and on other materials according to the needs of researchers. In addition, the researcher also hopes that future researchers can conduct further research by conducting effectiveness tests to find out how effective the use of this media is in learning.

4. CONCLUSION

Based on the results of the assessment of media experts, material experts, educators, and student responses, it can be concluded that the developed e-module is declared suitable for use in chemistry learning and this e-module has the potential to improve students' critical thinking skills through practice questions that refer to indicators critical thinking skills contained in the e-module.

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