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Development of STEM-PjBL Based E-Modules on Reaction Rate to Improve Learning Outcomes

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Abstract

The development of STEM-PjBL based E-Modules reaction rate material is an innovation that combines 21st century approach and learning model. The purpose of this study to analyze the needs of students, feasibility level, practicality level, effectiveness and student responses to STEM-PjBL based E-Modules. The method used is Research and Development with the 4D (Define, Design, Develop, Disseminate) development model. The research sample were students of class XI-1 SMAN 1 Kisaran. Tests, questionnaires and interviews were used to analyze the data. The results showed that 69.7% of the students had difficulty in understanding the response rate and 87.9% needed interactive project-based teaching materials. The e-modules feasibility test showed an average kappa moment of 0.84 (very high), practicality test an average kappa moment of 0.99 (very high), the effectiveness obtained N-gain of 0.78 (high), and the student response test to the STEM-PjBL based E-Modules with average kappa moment of 0.92 (very high).

Keywords: *E-Modules, STEM-PjBL, Reaction Rate, 4D*

INTRODUCTION

Currently, the development of the 21st century requires students to be able to use and manage information properly and correctly by using the Internet in the learning process. In addition, 21st century learning also requires students to have 4C skills (Creativity, Critical Thinking, Communication and Collaboration) so that they can guide students in problem solving and hone their creativity, especially in the field of science such as learning chemistry (Siti Nuraeni et al., 2019).

Chemistry is one of the materials related to everyday life that studies the composition, structure, and properties of substances and materials from microscopic to molecular scales (Wulandari et al., 2018). One of the materials included in chemistry is reaction rate. Reaction rate consists of several sub-subjects such as understanding the reaction rate, collision theory, factors affecting the reaction rate, reaction rate equation, and reaction order. According to (Musya'idah, 2016) that the reaction rate is one of the materials that includes the concept of calculation and contains abstract material so that students find it difficult to learn.

Based on the results of the interviews with the teachers of Class XI Chemistry at SMA Negeri 1 Kisaran, it was found that the teachers still use conventional learning models with discussion and lecture methods. In addition, the teaching materials used for learning only use

textbooks provided by schools, which do not include much project learning and do not integrate STEM (Science, Technology, Engineering and Mathematics). The students' learning results on the reaction rate material were 58.3% who did not pass the KKTP 75. This indicates that students are having difficulty with the reaction rate material. In addition, the information obtained from the student needs analysis in the reaction rate learning process indicates the need for project-based learning to facilitate understanding of the concepts.

One solution to overcome these problems is to apply STEM-PjBL to the E-Modules of reaction rate material. According to (Aulya et al., 2021) that e-modules in learning are packaged in an attractive form because they use the role of technology and are also multiplatform that can be accessed through mobile phones, laptops or computers and are not limited to space and time. STEM-PjBL integrated E-Modules are structured by combining chemistry, experimental science, or PjBL, which combines four STEM components (science, technology, engineering, and mathematics) (Dibyantini et al., 2023). In addition, e-modules are also interactive because they combine visualization and audiovisuals such as images, videos, audio, so they help in understanding learning and are useful for saving paper because they are presented in electronic form (Nisa et al., 2020).

The development of e-modules must be combined with approaches and models that are in accordance with the 21st century. In this case, researchers integrated STEM PjBL in the E-Modules. According to (Agung et al., 2022) STEM-PjBL can improve a more meaningful learning process, and can explore the experience of solving real problems through practicum activities in class. The learning process using STEM-PjBL in learning can also improve student learning outcomes as in research (Riskayanti, 2023) that STEM-PjBL learning can complete student chemistry learning outcomes with an increase in good learning outcomes, namely 94% complete, with an average value of learning outcomes of 87 with a good predicate. As for the research (Silvanny & Yerimadesi, 2023) that chemistry E-Modules based on STEM-PjBL chemistry in phase E can improve students' understanding and learning outcomes on chemical reaction materials. And added by research (Dibyantini et al., 2023) STEM-PjBL teaching materials are stated to increase student learning motivation and literacy in honing knowledge on organic compound material. Thus, appropriate approaches and models such as STEM-PjBL in learning can lead students to explore in an activity through a project and can produce real products based on understanding concepts (science), applying knowledge and skills (technology), designing knowledge (engineering), and finding the right solution based on systematic data analysis (mathematics), thus training students to be active, able to work with teams and think critically.

In the implementation of the interactive e-modules, the researcher used the help of the corporate edition PDF flip application in the application of the STEM-PjBL based E-Modules. According to (Cahyaningtiyas et al., 2024) flip PDF corporate edition includes a digital flipping page publication PDF conversion development application that can create interactive learning content with a variety of output options without requiring additional software to open documents. This application has several advantages such as the ability to add text, links, YouTube videos, audio, quizzes, and several other interesting features. In addition, according to (Kusuma Dewi et al., 2023), E-Modules developed with the help of Flip PDF Corporate Edition can stimulate and motivate students to learn, and they are not easily bored to participate in learning because of their attractive appearance. Thus, the application of e-modules using Flip PDF corporate edition can help develop teaching materials to be more attractive like e-modules because it provides attractive features like a book and can be practically used without space and time limitations.

Based on the above explanation, the researchers were interested in developing a STEM-PjBL based E-Modules to improve the learning outcomes of students' reaction rate material.

METHODS

This research was conducted at State High School 1 Kisaran, Madong Lubis Street No.5, Kisaran Kota, Kec. Kota Kisaran Timur, Asahan Regency, North Sumatra. The research was conducted in the odd semester of the academic year 2024/2025. The population of the study were

all students of class XI of State High School 1 Kisaran. The sampling used purposive sampling technique, namely class XI-1 with 36 students.

The type of research used is research and development (R&D) development using the 4D development model by (Thiagarajan et al., 1974) which includes define, design, develop, and disseminate.

The instruments used are test instruments and non-test instruments. The data analysis techniques used are interviews, questionnaires, and tests. The data analysis in the study is in the form of a test instrument test using SPSS 27, which includes validity, reliability, level of difficulty, and power tests. The non-test instruments consist of material and media feasibility tests, practicality tests, student response tests using the kappa moment (k) formula, and effectiveness tests using the N-gain formula.

According to (Boslaugh, 2008) the kappa moment formula used to tabulate non-test instrument data is as follows.

$$kappa\ moment\ (k) = \frac{p_o - p_e}{1 - p_e}$$

Description:

k = Kappa moment that shows the validity of the product

P_o = Realized proportion, calculated by

$$P_o = \frac{the\ amount\ given\ by\ the\ validator}{maximum\ amount\ value}$$

P_e = Unrealized proportion, calculated by

$$P_e = \frac{maximum\ amount - the\ amount\ given\ by\ the\ validator}{maximum\ amount}$$

The formula for calculating Normalize Gain (N-Gain) is;

$$N\ Gain = \frac{Posttest\ score - Pretest\ Score}{maximum\ score - Pretest\ Score}$$

The following is the research procedure used;

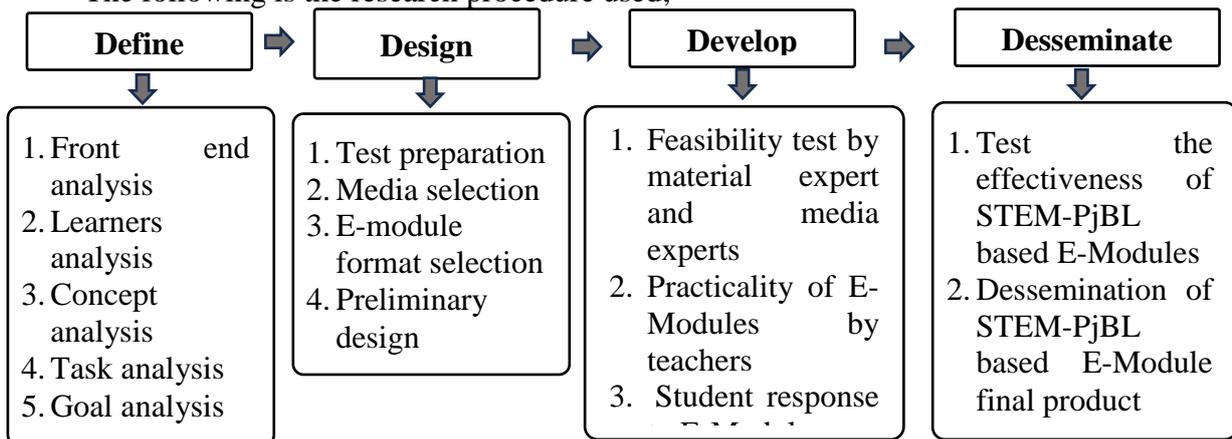| Define	Design	Develop	Desseminate
1. Front end analysis 2. Learners analysis 3. Concept analysis 4. Task analysis 5. Goal analysis	1. Test preparation 2. Media selection 3. E-module format selection 4. Preliminary design	1. Feasibility test by material expert and media experts 2. Practicality of E-Modules by teachers 3. Student response	1. Test the effectiveness of STEM-PjBL based E-Modules 2. Dessemination of STEM-PjBL based E-Module final product

Figure 1. Research procedures

FINDING AND DISCUSSIONS

The STEM-PjBL based E-Modules on reaction rates was developed using the 4D (Four D) development model, which includes the steps of define, design, develop, and disseminate.

1. Define

At this stage, a field analysis is carried out, which is divided into several stages, including (1) Front-end analysis in the form of interviews with teachers regarding the use of learning models, variations in teaching materials and learning media used in learning, and finding out the results of summative assessments of students' reaction rates. (2) Student analysis, it is known that about 69.7% of the students have difficulty in understanding the reaction rate material because they feel bored and the media used is not interesting. Through the completion of the needs

analysis questionnaire, it is known that about 87,9% of students need interactive teaching materials to facilitate the understanding of concepts, and project-based materials such as STEM-PjBL based E-Modules, which are equipped with pictures, videos, quizzes, and supported by the application of practice/project based learning to facilitate the understanding of concepts related to everyday life, as well as evaluation questions to measure students' abilities after studying reaction rates. (3) Conceptual analysis in the form of an explanation of the sub-material that will be elaborated in the e-modules, such as the concept of reaction rate, collision theory, factors that affect the reaction rate, and the reaction rate equation and reaction order. An analysis of important concepts is conducted before the creation of teaching materials, because in the creation of teaching materials, it is necessary to ensure that the material presented in the research process has a systematic structure and facilitates student learning (Harjanto et al., 2023). (4) Analysis of tasks that include learning outcomes according to the expectations to be achieved in the independent curriculum, one of which is that students can perform chemical calculations and can apply chemistry in various areas in everyday life and can strengthen the profile of Pancasila. (5) Analysis of objectives made based on concept and task analysis, in this case the researcher formulates learning objectives that students will achieve after learning using STEM-PjBL based E-Modules for reaction rate. The analysis of objectives has a very important role because at this stage it is hoped that students will become more active in the learning process because the formulated objectives refer to predetermined learning outcomes and are in accordance with the characteristics of students (Harjanto et al., 2023).

2. Design

The design stage is divided into four parts, such as the preparation of the test, the selection of the media, the selection of the format and the initial design. In preparing the benchmark test, the researcher used 40 multiple-choice questions with a cognitive level of C1-C5. After that, the questions were validated and tested on a grade XII class at SMA Negeri 1 Kisaran. Then the results obtained were tabulated using SPSS 27. The results showed that there were 25 valid questions with a Cronbach's Alpha reliability of 0.886 and the test was declared reliable. This is in accordance with the opinion (Sujarweni, V. W., & Utami, 2023) that a test can be said to be reliable if the Cronbach's alpha value is > 0.70. However, only 20 questions were used in the study and they already contained all the learning objectives. In the selection of media, the researcher used several media to assist in the preparation of the developed E-Modules, such as canva, microsoft word, and flip PDF corporate edition. As stated by (Irkhamni et al., 2021) Canva is one of the applications that can create interesting learning media because there are many design options. In addition, microsoft word also helps in creating tables, formulas, and calculations in the e-modules because it is one of the Windows operating systems that provides convenience in word processing (Rachmawaty et al., 2023). And the application used to make the e-modules display more attractive, the researcher used the help of flip PDF corporate edition application, which is a PDF development application that can support the application of digital teaching material animations equipped with images, videos, audios, and texts in the form of a flip with the help of laptops, computers, and handphone (Nisa et al., 2020). The combination of these three applications can produce interesting and interactive learning materials, such as STEM-PjBL based E-Modules. Furthermore, in the choice of format, the researcher used several types of fonts to distinguish between the cover, sub-chapters of the material, and also the content of the material. The cover uses Archivo Black, Shrickland, Garet and Open Sans fonts. The sub-material uses Cooper BT and Canva Sans fonts. Meanwhile, the content uses the Times New Roman font with a size of 12. In addition, the researcher also uses a balanced color composition in the e-modules with several colors, this is intended to make the reader not get bored easily and give an interesting impression to the reader. This is in line with the opinion (Damayanti et al., 2020) that the presence of color in the presentation of material such as teaching materials will encourage students to study the material and make the delivery of information in learning more lively. As for the initial design, the researcher made an e-modules design which is structured as follows;

(1) Opening Section

Figure 2. Front cover

The cover depicts the idea of reaction rate by combining the four STEM fields (Science, Technology, Engineering, and Mathematics).

(2) Content Section

Figure 3. STEM materials and concepts

In the content section, the researcher presents material consisting of several relevant reading sources so that it can be easily understood by the reader and is supplemented by four STEM (Science, Technology, Engineering and Mathematics) subjects that can broaden the students' horizons in deepening the material on each subtopic of reaction rate. In addition, this e-modules is also equipped with accessible images and links, YouTube videos, quizzes, and LKPD links that can be accessed in Engineering in several sub-chapters.

(3) Closing part

Figure 4. Author biography and cover art

The final section of this e-modules consists of a summary of the reaction rate material, a summative assessment, a glossary, a bibliography, the periodic table of elements, and the author's biography.

3. Develop

The development stage is divided into 2, namely expert appraisal and developmental testing. According to (Fayrus & Slamet, 2022) expert appraisal is a method used to validate and assess the feasibility of product design and is carried out by experts in their fields. In this study, it is done by testing the feasibility of the material and media of the developed e-modules. Expert appraisal activities include validation of test and non-test instruments by expert validators. Then a

feasibility test was carried out by 3 UNIMED chemistry lecturers who are subject matter and media experts. The following is the result of the STEM-PjBL based E-Modules feasibility test by subject matter experts using a Likert scale questionnaire (1-5) as in graph 1 below.
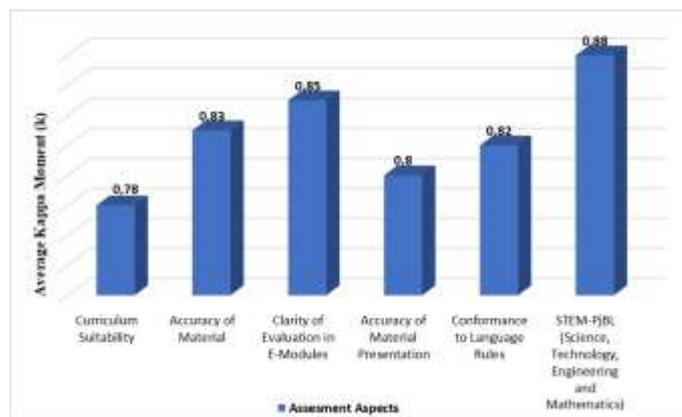
Graph 1. Material expert rating

Based on the results of the material expert assessment of the STEM-PjBL based E-Modules on reaction rate, the average kappa moment (k) value was obtained in several aspects including (1) curriculum suitability; (2) accuracy of material; (3) clarity of valuation in e-modules; (4) accuracy of material presentation; (5) STEM-PjBL (Science, Technology, Engineering and Mathematics) consecutively obtained a kappa moment average (k) of 0,78; 0,83; 0,85; 0,80; 0,82; and 0,88 resulting in a kappa moment average (k) of 0,82 with a very high category.

The media expert's assessment is shown in Graph 2 below:
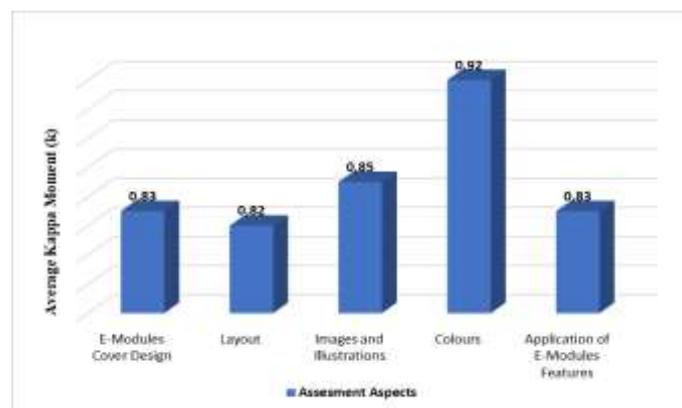
Graph 2. Media expert rating

From the graph above on the results of the media expert's assessment of the STEM-PjBL based E-Modules, the reaction rate obtained an average kappa moment (k) value in several aspects including (1) E-Modules cover design; (2) layout; (3) images and illustrations; (4) color; (5) application of e-modules features successively obtained an average kappa moment (k) of 0,83; 0,82; 0,85; 0,92; and 0,83, resulting in an average kappa moment (k) of 0,85 with a very high category.

Based on the results of the material feasibility test with an average kappa moment (k) value of 0,83 and media feasibility with an average kappa moment (k) value of 0,85. From the two assessments given by the material and media experts, the average kappa moment (k) value obtained was 0,84 with a very high category and the STEM-PjBL Based E-Modules product was considered feasible. According to previous research (Ginting & Amdayani, 2024) the validity test results of the STEM-PjBL based E-Modules on acid-base material have an average kappa moment (k) of 0,82, which is in the very high category.

The next stage is developmental testing in the form of product design trials on actual subjects to see the response data, reactions and feedback from the target users of the developed

product, so that the results of the trials can be used to improve the product (Fayrus & Slamet, 2022). The tests carried out were the practicality test of the e-modules by teachers and the student response test to the STEM-PjBL based E-Modules. The trial given to teachers was in the form of a practicality test, while students were given a response test to the developed e-modules. The following are the results obtained from the practicality test by 3 grade XI chemistry teachers at SMA Negeri 1 Kisaran.
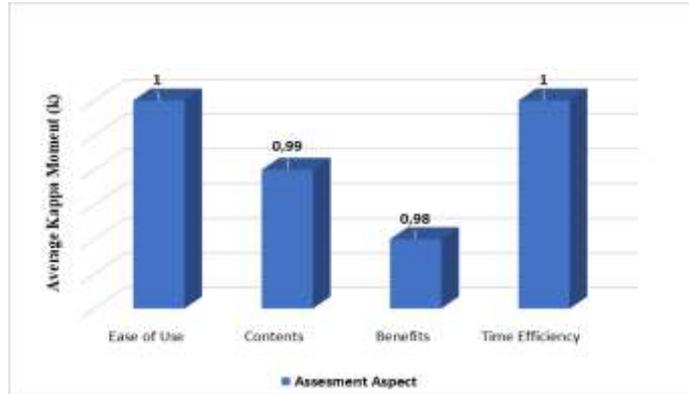
Graph 3. Practicality rating by teachers

Based on the results of the assessment of the practicality questionnaire for the STEM-PjBL based E-Modules, the average kappa moment (k) score was obtained for each aspect, such as (1) ease of use; (2) content; (3) benefits; and (4) time efficiency. In succession, they obtained average kappa moments (k) of 1,00; 0,99; 0,98; 0,98; and 1,00, resulting in an average kappa moment (k) of 0,99 with a very high category and the e-modules being declared practical. According to previous research, such as in the study (Gultom & Amdayani, 2023), the practicality test score obtained by teachers on the STEM-based chemistry E-Modules on the subject of reaction rate was 0,95, with a very high category. Meanwhile, in the research (Agung et al., 2022), the average practicality score obtained by teachers was 94,54 and was declared very practical in the Science E-Modules with the STEM-PjBL model. So it can be said that the e-modules developed by the researcher has a higher level of practicality of use. This is because the STEM-PjBL based E-Modules of reaction rates developed makes several innovations from previous research by paying attention to several important aspects such as ease of use, content, benefits, and time efficiency.

As for the student response test by 36 students of class XI-1 at State High School 1 Kisaran, in this case the data was taken after the students applied the STEM-PjBL based E-Modules on reaction rates in the learning process and the following are the results of the student responses obtained as shown in graph 4.
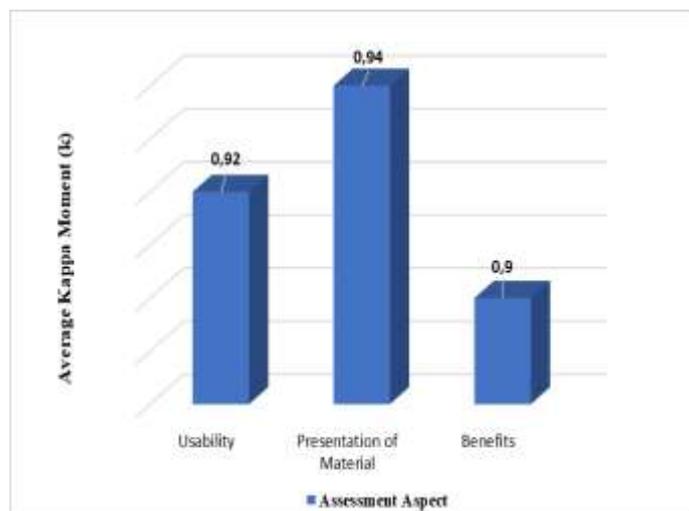
Graph 4. Student response rating

Based on the assessment of student response to the STEM-PjBL Based E-Modules on reaction rate material, the average kappa moment (k) score was obtained for each aspect, including (1) usability; (2) material presentation; and (3) benefits. The average kappa moment (k) was 0,92; 0,94; and 0,90 so that the average kappa moment (k) is 0,92 with a very high category. As for previous research, such as in the study (Aulya et al., 2021) on the development of PjBL-STEM based Chemistry E-Modules on buffer solution material, a student response rating of 87% was obtained. As for the research (Ginting & Amdayani, 2024) on the development of STEM-PjBL based E-Modules for acid-base material, the average student response was 0,82 with a very high category and added by the research (Gultom & Amdayani, 2023) In the development of STEM based Chemistry E-Modules for reaction rate material, the average student response was 0,85 with a very high category. Thus, it can be concluded that the STEM-PjBL based E-Modules for reaction rate developed by the researcher has a higher average student response rating. This is due to the renewal and innovation of the e-modules which was developed by paying attention to the analysis of student needs.

4. Disseminate

At this stage, it consists of three activities such as validation testing, packaging, diffusion, and adoption. In validation testing, a limited trial was conducted on the STEM-PjBL Based E-Modules on reaction rate material given to class XI-1 with a total of 36 students to see the effectiveness of the developed STEM-PjBL Based E-Modules on reaction rate. The implementation of the STEM-PjBL based E-Modules uses a project-based learning model, one of which is on the material of factors that affect the rate of reaction by conducting several projects. In the first meeting, the researcher explained the learning objectives to be achieved in the sub-chapter on the factors that influence the rate of reaction, followed by a pretest to determine the students' initial understanding of the material on reaction rates.

Continued with In syntax 1 (Determining fundamental questions), the researcher asked questions related to examples of the fast and slow rates of reactions in everyday life and then linked them to the factors that influence the rate of these reactions. Then the researcher shared the STEM-PjBL based E-Modules link for students to use in their learning and explained some of the features that can be accessed in the E-Modules. The development of digital e-modules aims to make learning varied and improve students' literacy in understanding learning so as to facilitate the learning process and produce satisfying results (Lastri, 2023). In syntax II (creating a project design), the researcher divides the students into several groups and gives instructions that the project to be carried out consists of 4 projects such as making apple cider vinegar, making infused water, making hydrogen gas and also making tape. In each project process, students can download the LKPD in the link provided for each engineering sub-factor that affects the rate of reaction, supplemented by additional insights into other fields of knowledge such as science, technology, and mathematics. In syntax III (drawing up a schedule), researchers and students discuss the project implementation schedule and the schedule for presenting the results. In syntax IV (monitoring the progress of the project), the researcher gives instructions that during the practicum, cooperation and caution are expected during the project work process. According to (Wiratama & Irfan, 2023), through project activities, students have the opportunity to learn directly to participate in real tasks, enabling them to be actively involved in the learning process and find creative solutions to project problems. This is followed by syntax V (Assessment of results), which is carried out at the next meeting. In this case, the researcher gives each group the opportunity to present the project that has been carried out so that they can broaden their knowledge of factors related to the rate of reaction between groups and discuss the process and results obtained during the project. Through this activity, students will learn how to present their creative ideas in a project presentation (Wiratama & Irfan, 2023). This is followed by syntax VI (evaluation of learning experience), in which the researcher gives appreciation to each group and provides direction and reinforcement for the experiments that have been carried out related to the factors that influence the rate of reaction by relating to the four components of STEM (Science,

Technology, Engineering, and Mathematics). After all the syntaxes are completed, a posttest is given to measure the effectiveness of the STEM-PjBL based E-Modules.

Effectiveness is one of the results of the activities carried out, one of which is the use of e-modules for learning outcomes. An effectiveness test is carried out to measure the level of success in learning. E-Modules can be said to be effective if they have a good impact on students' learning outcomes (Laili et al., 2019). The following are the average results of the pretest and posttest obtained as in graph 5.
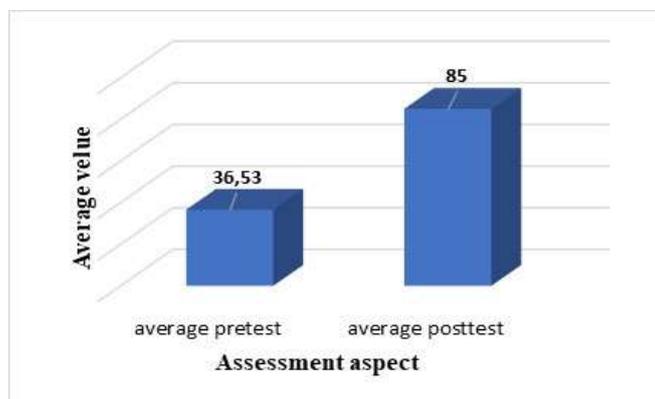
Graph 5. Prestest and posttest results

It is evident from the above graph that employing the STEM-PjBL based E-Modules on reaction rate content increases learning outcomes. And the N-Gain test result obtained a value of 0,78 with a high category and was declared effective in improving learning outcomes. According to previous research, such as in the research by (Ginting & Amdayani, 2024) on the development of STEM-PjBL based E-Modules on acid-base material, an N-Gain value of 0,52 was obtained with a moderate category. Added by research (Agung et al., 2022) the use of STEM-PjBL in the E-Modules of Science is declared effective in improving learning outcomes with an N-Gain score of 0,74. So it can be said that the STEM-PjBL based E-Modules on reaction rate is declared effective and can improve students' learning outcomes in reaction rate material.

In conducting research, there are several obstacles experienced including (1) an unstable internet network, so students have to wait for the E-Modules to appear. The solution is to ask friends who have a stable internet network for a hotspot so that all the features in the e-modules can work properly; (2) students have a little difficulty in understanding the questions so that students often ask questions and the solution that can be provided is for the researcher to provide an explanation again regarding the example questions contained in the e-modules, so that students can understand the questions; (3) lack of literacy in students so that in the application of STEM-PjBL based E-Modules, the researcher has to explain again. However, the researcher tries to ensure that students can relate each concept of learning reaction rate material to everyday life, especially to the four STEM (Science, Technology, Engineering and Mathematics) concepts, so that it will increase students' knowledge of reaction rates.

The advantages of the STEM-PjBL based E-Modules include: (1) the concepts presented in the STEM-PjBL based E-Modules contain concise and clear material; (2) each subchapter of the material contains STEM (Science, Technology, Engineering and Mathematics) concepts and systematic concepts that can broaden students' horizons; (3) there are relevant comprehension questions related to the project that was conducted; (4) there are quizzes and summative assessments to measure students' abilities related to STEM (Science, Technology, Engineering and Mathematics) concepts; (5) there are supplemental videos that can be accessed through barcodes or links in the e-modules; (6) it can be accessed through handphone, laptops or computers without time and space constraints; (7) students feel happy because they can apply theoretical knowledge through practical activities in the classroom; (8) students can explore new experiences related to project making in an easy way; (9) they can explore memorable learning experiences that can motivate high interest in learning. This is in accordance with research (Agung et al., 2022) that the

application of STEM-PjBL can improve a more meaningful learning process, and can explore the experience of solving real problems through practical activities in the classroom. In addition, STEM-PjBL learning can shape students to be active in the learning process, able to communicate and share new knowledge, and can foster character that is easy to recognize and understand concepts (science) by applying knowledge and skills (technology) to be able to form or design (engineering) by analyzing based on data calculations (mathematics) to be able to obtain the right solution. According to (Dibyantini, Amdayani, Siregar, & Syafriani, 2023) STEM-PjBL teaching materials are stated to be able to increase students' learning motivation and literacy in honing knowledge of organic compounds. It was added in the study (Purwaningsih et al., 2020) that the activities carried out in the application of STEM-PjBL can direct students to work in teams and can make it easier for students to connect the information obtained with the knowledge they have in designing projects.

The disadvantage of this STEM-PjBL based E-Modules is that it requires an internet connection for all of its functions to work properly, and it is hoped that future researchers will be able to find innovative ways to create content that can be accessed offline without the need for an internet network.

Packaging, diffusion, and adoption are the subsequent phases of activity. Using the flip PDF corporate edition application, the STEM-PjBL based E-Modules is distributed online as a link so that it can be accessed by many people and become a relevant reference that can help in learning reaction rate material easily using the help of the flip PDF corporate edition application. The Flip PDF Corporate Edition application was chosen because it has the advantage of being available to students through a browser without the need to download additional applications. The device can be a laptop or a smartphone and has easily accessible images, audio, video, and other interesting symbols that can be easily accessed (Kusuma Dewi et al., 2023). Access can be done via the web or browser via cellphone or laptop. The link for the STEM-PjBL based E-Modules for reaction rate is https://online.flipbuilder.com/fbahc/ncte/.

The researcher distributed the STEM-PjBL based E-Modules on reaction rates through 11th grade students and teachers at State High School 1 Kisaran so that it could be used in the learning process. And it is hoped that teachers can disseminate the STEM-PjBL based E-Modules on reaction rates through subject teacher discussion groups so that the E-Modules that has been developed can be useful and broaden the readers knowledge.

CONCLUSION

Based on the research that has been carried out, the results show that in the analysis of students' learning needs, it is known that 69,7% of students find it difficult to understand the material on reaction rates and 87,9% of students need interactive project-based teaching materials that can help in the teaching and learning process such as STEM-PjBL based E-Modules combined with four fields of study such as science, technology, engineering and mathematics, supported by the application of project-based learning related to everyday life. The results of the feasibility test on the STEM-PjBL based E-Modules showed that the reaction rate obtained an average kappa moment (k) score of 0,84 (very high) and was declared feasible based on the assessment of the subject matter expert of 0,83 and the media expert of 0,85. In the practicality test by teachers on the E-Modules, an average kappa moment of 0,99 was obtained (very high) and declared practical. As for the effectiveness of the STEM-PjBL reaction rate E-Modules, it obtained an N-Gain score of 0,78 (high) and was declared effective in improving student learning outcomes. In addition, in the response test, students obtained an average kappa moment (k) score of 0,92 (very high). In this case, the researcher suggests that for future researchers with the STEM-PjBL based E-Modules, this reaction rate can be a relevant reference and can be used as a reference in the creation of interactive teaching materials with diverse chemical materials. It is also hoped that it can develop products that can be accessed offline and are more interactive.

REFERENCES

Agung, I. D. G., Suardana, I. N., & Rapi, N. K. (2022). E-Modul IPA dengan Model STEM-PjBL Berorientasi Pendidikan Karakter untuk Meningkatkan Hasil Belajar Siswa. *Jurnal Imiah Pendidikan Dan Pembelajaran*, *6*(1), 120. https://doi.org/10.23887/jipp.v6i1.42657

Aulya, R. A., Asyhar, R., & Yusnaidar. (2021). Pengembangan E-Modul Kimia Berbasis PjBL-STEM untuk Pembelajaran Daring Siswa SMA pada Materi Larutan Penyangga. *Journal of the Indonesian Society of Integrated Chemistry*, *13*(2), 84–91. https://doi.org/10.22437/jisic.v13i2.14506

Boslaugh, S. (2008). *Statistics in a nutshell*. O'Reily Media.

Cahyaningtiyas, C. A., Miranti, M. G., Bahar, A., & Sulandari, L. (2024). Pengembangan E-Modul Berbasis Flip Pdf Corporate Edition Pada Materi Plain Cake. *Jurnal Ilmiah Profesi Pendidikan*, *9*(3), 1980–1987. https://doi.org/10.29303/jipp.v9i3.2479

Damayanti, E., Alamsyah, N., & Taufiq, A. U. (2020). *Penggunaan Warna terhadap Memori Jangka Pendek: Pendekatan Biopsikologi dalam Pembelajaran*. *2019*, 99–111.

Dibyantini, R. E., Amdayani, S., Siregar, M. I., & Syafriani, D. (2023). Application of STEM-PjBL Based Chemistry Module to Improve Science Literacy and Student Learning Motivation. *Jurnal Penelitian Pendidikan IPA*, *9*(SpecialIssue), 95–102. https://doi.org/10.29303/jppipa.v9ispecialissue.5872

Fayrus, & Slamet, A. (2022). *Model Penelitian Pengembangan (R n D)*.

Ginting, A. M., & Amdayani, S. (2024). Jurnal Teknologi Pendidikan : Development of STEM-PjBL Based E-Modules on Acid-Base Material to Improve Learning Outcomes Jurnal Teknologi Pendidikan : *Jurnal Teknologi Pendidikan*, *9*(2).

Gultom, E. H., & Amdayani, S. (2023). Pengembangan E-Modul Kimia Berbasis STEM Pada Materi Laju Reaksi. *Jurnal Teknologi Pendidikan : Jurnal Penelitian Dan Pengembangan Pembelajaran*, *8*(2), 425. https://doi.org/10.33394/jtp.v8i2.7081

Harjanto, A., Rustandi, A., & Caroline, J. A. (2023). Implementasi Model Pengembangan 4D Dalam Mengembangkan Media Pembelajaran Berbasi Online Pada Mata Pelajaran Pemrograman Web di SMK Negeri 7 Samarinda. *Jurnal SIMADA (Sistem Informasi Dan Manajemen Basis Data)*, *5*(2), 1–12. https://doi.org/10.30873/simada.v5i2.3412

Irkhamni, I., Izza, A. Z., Salsabila, W. T., & Hidayah, N. (2021). Pemanfaatan Canva Sebagai E-Modul Pembelajaran Matematika terhadap Minat Belajar Peserta Didik. *Konferensi Ilmiah Pendidikan Universitas Pekalongan 2021*, 127–134. https://proceeding.unikal.ac.id/index.php/kip/issue/view/12

Kusuma Dewi, D., Tri Pangesthi, L., Handajani, S., & Fatkhur Romadhoni, I. (2023). Pengembangan E-Modul Berbasis Flip PDF Corporate Edition Pada Kompetensi Dasar Puff Pastry Siswa Kelas XII SMK. *Journal of Creative Student Research (JCSR)*, *1*(2), 279–292.

Laili, I., Ganefri, & Usmeldi. (2019). Efektivitas pengembangan e-modul project based learning pada mata pelajaran instalasi motor listrik. *Jurnal Imiah Pendidikan Dan Pembelajaran*, *3*(3), 306–315. https://ejournal.undiksha.ac.id/index.php/JIPP/article/download/21840/13513

Lastri, Y. (2023). Pengembangan Dan Pemanfaatan Bahan Ajar E-Modul Dalam Proses Pembelajaran. *Jurnal Citra Pendidikan*, *3*(3), 1139–1146. https://doi.org/10.38048/jcp.v3i3.1914

Musya'idah, A. S. E. (2016). POGIL, Analogi Model FAR, KBI, dan Laju Reaksi. In *Pros. Semnas Pend. IPA Pascasarjana UM* (pp. 671–680).

Nisa, A. H., Mujib, M., & Putra, R. W. Y. (2020). Efektivitas E-Modul dengan Flip Pdf Professional Berbasis Gamifikasi Terhadap Siswa SMP. *Jurnal Pendidikan Matematika Raflesia*, *05*(02), 14–25. https://ejournal.unib.ac.id/index.php/jpmr

Purwaningsih, E., Sari, S. P., Sari, A. M., & Suryadi, A. (2020). The effect of stem-pjbl and discovery learning on improving students' problem-solving skills of the impulse and momentum topic. *Jurnal Pendidikan IPA Indonesia*, *9*(4), 465–476. https://doi.org/10.15294/jpii.v9i4.26432

Rachmawaty, A., Tubagus Riko Rivanthio, & Nugraha, W. S. (2023). Analisis Penggunaan

Microsoft Word dalam Mengingkatkan Kinerja Karyawan di Politeknik LP3I. *ATRABIS: Jurnal Administrasi Bisnis (e-Journal)*, *9*(1), 10–19. https://doi.org/10.38204/atrabis.v9i1.1318

Riskayanti, Y. (2023). Penerapan pendekatan stem project based learning untuk meningkatkan hasil belajar kimia. *Prosiding Temu Ilmiah Nasional Guru XV*, *15*(1), 466–474.

Silvanny, & Yerimadesi. (2023). Pengembangan E-Modul Kimia Berbasis PjBL-STEM pada Materi Reaksi Kimia untuk Fase E SMA. *Jurnal Pendidikan Tambusai*, *7*(2), 11720–11730.

Siti Nuraeni, Tonih Feronika, & Luki Yunita. (2019). Implementasi Self-Efficacy dan Keterampilan Berpikir Kritis Siswa Pada Pembelajaran Kimia di Abad 21. *Jambura Journal of Educational Chemistry*, *1*(2), 49–56. https://ejurnal.ung.ac.id/index.php/jjec/article/view/2553/1596

Sujarweni, V. W., & Utami, L. . (2023). *The Guide Book of SPSS Cara Mudah dan Cepat Mengelola Data Penelitian dengan SPSS*. Anak Hebat Indonesia.

Thiagarajan, S., Semmel, D. ., & Semmel, M. (1974). *Instructional Development for Trainning Teachers of Exceptional Children*. Indiana University.

Wiratama, L., & Irfan, D. M. (2023). Peran Pembelajaran Berbasis Proyek dalam Meningkatkan Kreativitas Siswa di Tingkat Sekolah Dasar. *Jurnal Pendidikan Merdeka Belajar*, *1*(1), 7–12.

Wulandari, C., Susilaningsih, E., & Kasmui, K. (2018). Estimasi Validitas Dan Respon Siswa Terhadap Bahan Ajar Multi Representasi : Definitif, Makroskopis, Mikroskopis, Simbolik Pada Materi Asam Basa. *Phenomenon : Jurnal Pendidikan MIPA*, *8*(2), 165–174. https://doi.org/10.21580/phen.2018.8.2.2498