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Application of STEM-Based Learner Worksheet on Reaction Rate Material to Improve Students' Critical Thinking Ability

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Abstract: *The STEM approach in learning can improve students' critical thinking skills. This study aims to 1) measure the validity of the developed LKPD; 2) determine the response of students to the developed LKPD; 3) determine the improvement of students' critical thinking skills; 4) determine the critical thinking skills of students using the developed STEM-based LKPD compared to using school LKPD. Data were collected through BSNP questionnaire, N-gain and right side t-test. The results were 94.34% of material experts and 87.50% of media experts of the developed LKPD had a very high interpretation and the level of validity was "Very valid". 87.27% of students' responses were rated "Very good" to be used in learning the topic of reaction rate. The N-Gain test results showed the gain of the experimental class taught using STEM-based LKPD was 0.81 while the gain of the control class that did not use STEM-based LKPD was 0.71. The t-test results show the value of $t_{value} = 3.276 > t_{table} = 1.667$. It is concluded that the use of STEM-based LKPD is very good to use in lectures on the topic of reaction rate.*

Keywords: *Learner Worksheet, STEM, Reaction Rate, Critical Thinking*

INTRODUCTION

The widespread use of information and communication technology in daily activities demonstrates the globalization of today's world. This technology can connect many regions around the world, giving us the ability to explore the world without borders. In addition, this development will have an impact on every aspect of human life, especially in the field of education. Based on the evaluation, the Government completed the revision of the Indonesian education curriculum. The goal of national education is to ensure that all learners have access to knowledge; however, it also requires them to practice critical thinking, problem-solving, and learning skills so that they can apply their knowledge in their daily lives, especially in chemistry (Sugiharti & Kurnia, 2021).

Many chemistry lessons in high school include calculations, chemical reactions, and abstract concepts that are difficult for students to understand. There are no teaching materials that support critical thinking available for students, according to literature research. The available teaching materials are not interesting for students to relate to the environment or real life. In addition, the design of teaching materials does not use a learning approach, lacks visual effects, is monotonous, and does not relate to the real world. As a result, learning activities become unpleasant for students. Sugiharti's study (2021) found that students do not have

sufficient ability in learning chemistry, as shown by the average learning outcomes of students at SMA Negeri 10 Medan, which still do not meet the minimum completion criteria (KKM). As a result, students will face difficulties when working on HOTS practice questions.

The results of interviews with chemistry teachers at MAN 2 Medan showed that learning reaction rates faced many challenges, especially in the subchapter of factors affecting the reaction rate, which was difficult to understand because the concept was still abstract. In addition, STEM is not used and varied lecture methods are used. The availability of learning resources in the form of LKPD used has not used the learning model approach and has not utilized the environmental conditions of students.

According to 21st century learning principles, teachers and lecturers act as facilitators in a student-centered learning environment. To get students actively involved in learning activities, teachers and lecturers must be able to develop appropriate learning strategies, models and media (Panggabean et al., 2023). According to (Bararah, 2022), one of the most important things that a teacher must understand during the teaching process is teaching strategies. To achieve optimal learner competence, in designing learning programs and learning activities for learners, educators must pay attention to the attitudinal characteristics of learners (Lubis, 2021). Based on some research previous research, developing learning media learning media development is needed to be able to overcome problems in the learning process learning process (Silaban & Panggabean, 2022).

In this 4.0 revolution, it has a huge impact on the world of education, especially chemistry education, where the implementation of chemistry learning is carried out by applying the STEM (Science, Technology, Engineering, and Mathematics) learning approach which can help students develop the skills needed to make product designs related to the environment through technology. STEM requires students to improve their critical and analytical thinking skills.

In this STEM approach, these "hands-on-hands" activities increase learner engagement and improve their understanding of the material. STEM will involve direct teaching. Direct teaching is a teacher-centered learning model, which has 5 steps in its implementation, namely preparing students to receive lessons, demonstration, guided training, feedback, and further training (Marpaung & Sutiani, 2020).

Lestari et al., (2018) found that the STEM method can improve students' ability to think critically. It is expected that STEM-based learner worksheets (LKPD) can help students understand chemistry concepts more easily and improve their ability to think critically. It is expected that the combination with the STEM approach applied in the LKPD will enable good LKPD results. In addition, this approach can be used as teaching materials that can be used by teachers to deliver learning materials.

LITERATURE REVIEW

Critical Thinking

Critical thinking is a way of thinking logically and thoughtfully with a focus on making decisions about what is done or considered right. Reasonable means thinking based on facts to make the best decision; reflective means consciously seeking the best possible solution (Norris & Ennis, 1989).

The definition of "critical thinking" is a person's attempt to evaluate the truth of evidence, logic, and their own conscious biases. A critical thinking ability experiment was conducted to measure aspects of students' critical thinking ability. Indicators of thinking ability are the basis of the test. Analyzing, synthesizing, recognizing and solving problems, inferring, and evaluating or judging are five important thinking indicators that can be developed through activities (Jahro et al., 2021).

The five indicators can be explained as follows: 1) Analyzing skills are the skills of decomposing a structure into its components to find out the organization of the structure; 2) Synthesizing skills are different from analyzing skills. Synthesizing skills are the skills of combining parts into a new structure or arrangement; 3) Problem solving skills are skills that allow readers to apply concepts to new problems or contexts; 4) Inferring skill is the activity of the human mind based on the understanding/knowledge (truth) it has that can move on to reach another new understanding/knowledge (truth); 5) The ability to evaluate, which requires deep thinking to determine the value of something based on various criteria.

Learner Worksheets

LKPD are printed teaching materials that help students learn independently and unaccompanied. One way to support and assist students in teaching and learning is LKPD. It allows students to interact well and improve their cognitive achievement through the activities they do (Agustina et al., 2020). LKPD is a teaching material that can reduce the role of the teacher while increasing the involvement of students. This is because this teaching material is easy to understand and has many questions that can be used to practice doing problems, which makes learning easier for students (Indriani & Lazulva, 2020). Learner worksheets help learners in investigation and problem solving. Worksheets can also help them in their learning.

STEM (Science, Technology, Engineering and Mathematics) Approach

STEM is one of the learning approaches that can encourage students to design, develop and utilize technology, and hone their affective, cognitive and manipulative skills. This approach can also be used in the field of science. The focus of STEM-oriented learning is generally on applying the concepts of science, technology, engineering and math (Nadelson & Seifert, 2017).

It is expected that students will be able to participate actively and kinetically in the thinking process because the STEM approach prioritizes hands-on and minds-on learning in real-world situations. This means that the STEM approach prioritizes the practical application of science and technology and practical learning. In addition, systematic thinking about science exploration and math analysis during the STEM learning process will encourage students to integrate STEM knowledge and skills, find connections between knowledge and problems, and improve their critical thinking ability. In other words, STEM upholds the application and connection of all knowledge disciplines, as well as problem solving, troubleshooting, and helps students acquire abstract conceptual knowledge (Tsai et al., 2018).

METHODS

This research is designed with RnD research using the ADDIE development model which consists of five stages namely analysis, define, development, implementation, and evaluation. This research was conducted at MAN 2 Model Medan which is located at Jl. Williem Iskandar No. 7A, Bantan Tim, Kec. Medan Tembung, Medan City, North Sumatra. This research examines STEM-based LKPD. The reaction rate material is the subject of this research. The developed LKPD will be validated by media experts and material experts, after which student responses are collected using a questionnaire. after obtaining student response data, collected and processed by the formula:

$$P = \frac{f}{n} \times 100\%$$

Description:
P = Frequency
f = Frequency of Answers
n = Number of Respondents

To find out the increase in critical thinking will be done with the gain test and right one-sided t test to see if students' critical

thinking skills are higher if they use STEM-based LKPD than those who do not use. After the data is processed into a score, the next step is the calculation of normalized gain. The purpose of this calculation is to determine the quality of the increase in mastery of critical thinking skills that occur before and after learning. The formula developed by Meltzer (2002) is as follows:

$$\text{N-Gain} = \frac{posttest\ score - pretest\ score}{maximum\ score - pretest\ score}$$

The N-Gain (g) obtained shows the category of critical thinking skills improvement. According to Hake (1998) the interpretation of the average score of N-Gain (normalized gain).

Table 1. Interpretation of Normalized Gain Mean Score

Interval	Interpretation
0.70<g<1.00	High
0.30<g<0.70	Medium
0.00<g<0.30	Low

RESULT AND DISCUSSION

Material Validation

Material expert validators evaluate the feasibility of material presentation, STEM components and language use. The following are the results of the evaluation of STEM-based LKPD on reaction rate material in accordance with BSNP validity requirements.
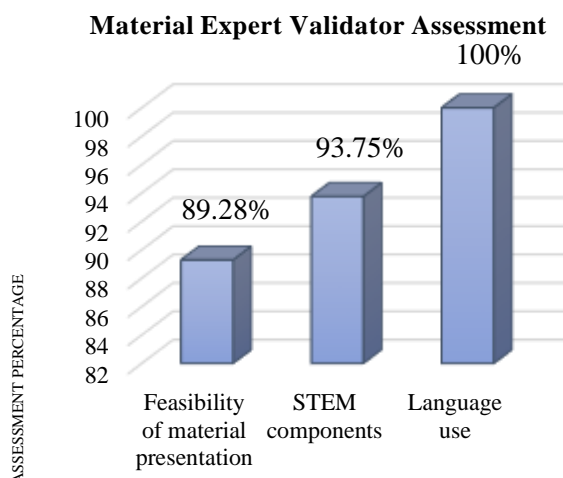
Material Expert Validator Assessment

Figure 1. Material validation assessment results

Based on the assessment of the validation of STEM-based LKPD material on the reaction rate material obtained an average of 94.34%. This shows that the average score of the STEM-based LKPD content on the reaction rate material is "Very high" with a validity level of "Very valid". That means that the STEM-based LKPD developed can be used in learning reaction rate material.

Media Validation

The aspects that will be assessed by media expert validators are aspects of component presentation, STEM components and graphical aspects. The following are the results of the evaluation of STEM-based LKPD on reaction rate material in accordance with BSNP validity requirements.

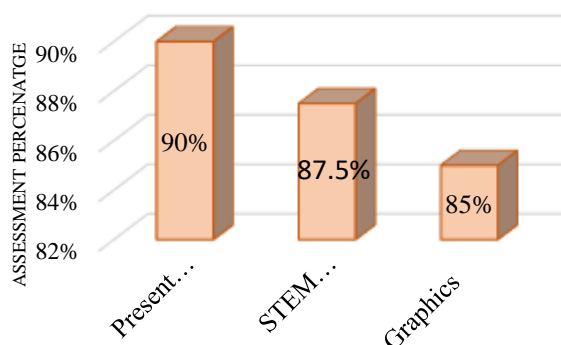**Media Expert Validation Assessment**

Figure 2. Media validation assessment results

Based on the assessment of the validation of STEM-based LKPD material on reaction rate material obtained an average of 87.50%. This shows that the average score of STEM-based LKPD content on reaction rate material is "Very high" with a validity level of "Very valid". Thus, it shows that the media contained in the STEM-based LKPD can be used as a complement to the reaction rate material so as to make students more involved in the learning process.

Gain Test

Before treatment in the experimental and control classes, pretests were given to measure students' initial abilities using

instruments that had been declared valid. In summary, the results of the pretest and posttest of students in the experimental class and control class can be seen in table 2 below.

Table 2. Average critical thinking scores of experimental and control class students

Class	Average value	Mean
Experiment	Pretest	25.52
	Posttest	86.15
Control	Pretest	24.30
	Posttest	78.47

From table 2, it can be seen that the average pretest score in the experimental class was 25.52 with a posttest score of 86.15. While in the control class the average pretest was 24.30 with a posttest value of 78.47.

The results of the experimental class and control class gain test calculations are as follows:

Table 3. Gain test of experimental and control classes

Class	Mean	%Gain	Description
Experiment	0.81	81%	High
Control	0.71	71%	High

Table 3 shows the average normalized gain value of the experimental class of 0.81 with a high category and the N-gain in the control class of 0.71 is in the high category. It can be seen that there is a significant difference between the N-gain of the experimental class and the control class. It can be concluded that there are differences in the increase in critical thinking of students taught using STEM-based LKPD and students taught without using STEM-based LKPD.

Research conducted by (Fithri et al., 2021) shows that the implementation of STEM-based LKPD can improve students' critical thinking skills by 94%. Meanwhile, (Prasadi et al., 2020) said that the implementation of STEM-based LKPD and local wisdom can be implemented in teaching and learning activities, as well as improving critical thinking.

Hypothesis Test

To find out H_0 is accepted or rejected, hypothesis testing is carried out. The results of the hypothesis test can be seen in the following table:

Table 4. Hypothesis testing (right side t_{test})

Class	Mean	Standard deviation	T_{test}	T_{table}	Result
Experiment	86.15	8.448	3.276	1.667	Ha accepted
Control	78.47	11.187			

Based on the data analysis conducted, the results of the hypothesis test, namely the right-sided t test, obtained t_{test} and t_{table}, with $t_{test} = 3.276 > t_{table}$ 1.667 which means that the alternative hypothesis (H_a) is accepted and the null hypothesis (H_0) is rejected. This shows that the critical thinking skills of students taught by using STEM-based LKPD on reaction rate material developed are higher than the critical thinking of students taught without using STEM-based LKPD. This is related to research conducted by (Yulianti et al., 2020) STEM-based LKPD can improve critical and creative thinking skills with high average criteria. STEM learning can develop skills to analyze and solve problems that occur in real. Rissanen, 2014 shows that STEM-based learning is able to improve students' creative thinking skills in a relatively short time and is able to make it easier for students to understand a learning material.

Student Response

Data on student responses to the use of STEM-based LKPD were collected using a questionnaire. Of the 40 student respondents who studied the topic of reaction rate, the analysis results obtained were 85.83% of students liked the appearance of STEM-based LKPD, 87.63% of students liked the material in STEM-based LKPD, 89.17% of students stated that the language used in STEM-based LKPD was easy to understand and 86.46% stated that students had more enthusiasm for learning and encouraged them to practice critical thinking skills. Overall, the response questionnaire obtained

a score of 87.27% with the category "Very good".

Research by (Furqoniyah et al., 2022) showed response results with an average percentage of 85%, the results of this percentage indicate that students respond positively to the use of STEM-based LKPD. Yuliani et al., (2023) also obtained the same results where the average results of student response sheets scored 87% and were in the 80%-89% interval.

CONCLUSION

This study concluded that material validation obtained a score of 94.34% with the category "very valid" and media validation obtained a score of 87.5% with the criteria "very valid". The use of STEM-based LKPD is proven to improve students' critical thinking skills on reaction rate material, namely 81% for experimental classes using STEM-based LKPD and 71% for classes without using STEM-based LKPD. Students' critical thinking skills using STEM-based LKPD are better than without using STEM-based LKPD, student responses to STEM-based LKPD on reaction rate material obtained very good criteria with a value of 87.27%. Thus it can be said that the use of STEM-based LKPD on reaction rate material is very good and can be used in learning chemistry on reaction rate material.

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