POGIL (Process Oriented Guided Inquiry Learning) e-Worksheet to Improve Critical Thinking Skills on Reaction Rate Material

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ABSTRACT

The aims of this research were to obtain the eligibility of the POGIL e-worksheet to improve students' critical thinking skills on reaction rate material in terms of validity, practicality, and effectiveness criteria. The type of research was research and development using the ADDIE development model with three stages, Analyze, Design, and Development. The research was obtain validity from the validation sheet in terms of the eligibility of content, presentation, language, and design getting mode ≥ 3 so it was declared valid. Practicality was obtained from a response questionnaire supported by a student activity observation sheet. Overall practicality of the response questionnaire has 89.09% (very practical), while the learner activity observation sheet getting mode = 1. Effectiveness was obtained from the pretest and posttest of critical thinking skills supported by student learning results. The result of the critical thinking skills test got N-gain, 0.929 Interpretation, 0.722 Analysis, 0.694 Evaluation, 0.556 Inference, and 0.933 Explanation and obtained a significance value of 0 in the paired sample t-test so it was concluded there was an increase in students' critical thinking skills in reaction rate material after using POGIL e-worksheet. The learning outcomes test data were analyzed using the Wilcoxon signed rank test has 0 probability value, then it can be concluded there is an increase in student learning outcomes in reaction rate material after using the POGIL e-worksheet. Based on the results of validity, practicality, and effectiveness, the development of the POGIL e-worksheet is feasible.

Keywords: *POGIL e-worksheet; students' critical thinking skills; reaction rate.*

INTRODUCTION

The four pillars of education are learning to know, learning to do, learning to be, and learning to live together, remain crucial abilities in the 21st century. According to the National Education Association, each person needs to be equipped with 18 different types of 21st-century skills, one of which is learning and innovation skills, which consists of four components: critical thinking abilities, communication, cooperation or teamwork, and creativity (Carneiro & Draxler, 2008).

A person with critical thinking abilities is constantly inquiring about the knowledge that is already available to have a thorough grasp. The six components of critical thinking are interpretation, analysis, inference, assessment, justification, and self-control (Facione, 2013).

According to the interview, SMAN 1 Puri Mojokerto is one of the schools that has employed critical thinking techniques. However, students still have a limited capacity for critical thought. Results from preliminary studies on pupils answering problems requiring critical thinking skills provide proof of this. Results were achieved on five different critical thinking skills, including (1) interpretation (43,33%,), (2) analysis (43,33%,), (3) evaluation (50%), (4) Inference (26,67%), and (5) explanation (22.5%). According to the preliminary research findings, chemistry students' critical thinking abilities need to be strengthened.

Because POGIL learning is a combination of cooperative learning and guided inquiry in learning, it offers opportunities for students to be active in discussion groups to deepen their understanding (Kisworo & Gusman, 2019). As a result, POGIL learning can improve cognitive learning outcomes and critical thinking skills.

The POGIL learning approach also attempts to foster critical thinking, problem-solving, and learning process abilities (Hanson, 2005). The findings of the critical thinking ability test revealed that after applying the POGIL learning model, the average score raised from 75 to 87 (Wijiastuti & Muchlis, 2021).

All topics, including chemistry, need to emphasize the development of critical thinking skills. Chemistry is the study of matter, including its nature and structure, changes and reactions that take place, and the energy that goes along with those changes in the substance itself. The study of chemistry involves a variety of teaching tools in the form of abstract and difficult concepts. Because they cannot be directly witnessed, this makes it challenging for pupils to comprehend these notions (Andriani et al., 2019).

According to the findings of preliminary research, 84% of students said that chemistry is a challenging topic. The reaction rate is one of the most challenging chemistry topics. How quickly the reactants are utilized and the product is created might be referred to as the reaction rate. Temperature, concentration, surface area, and catalyst are just a few of the variables that might affect the reaction rate (Petrucci, 2011).

Because students are allowed to express their ideas and opinions when evaluating the phenomena presented in worksheet, worksheet can successfully educate students' critical thinking skills (Astuji et al., 2017). Student worksheets are is a sheet that students must complete that comprises material, summaries, and assignments. Student worksheets are instructional materials that incorporate a variety of media, including text, photographs, videos, graphics, sound, animation, and interactive elements (Anggraini et al., 2016). According to the findings of interviews with chemistry teachers at SMAN 1 Puri Mojokerto, they occasionally use student worksheets as learning resources but primarily use the chalkboard when imparting knowledge. Only conventional worksheets or soft files that are supplied to pupils are provided by the teacher.

The increased usage of digital technology in the 4.0 era is undoubtedly attractive to pupils. Digital technology can be used to build e-worksheet learning materials that will engage pupils in the subject matter and develop their critical thinking abilities. Liveworksheet is one of the platforms that may be used to create an electronic worksheet. The liveworksheets platform is chosen because it is simple to use and can be accessed from any smartphone or laptop without the need to download an application (Yuliana et al., 2023). This platform not only has a pleasing appearance, but it is also simple for teachers and students to utilize.

TThe researcher is considering doing a study titled "Development POGIL E-Worksheet to Improve Critical Thinking Skills of Students on Reaction Rate Material" in light of the background to the aforementioned issue.

RESEARCH METHODS

Research and development (R&D) is the research methodology employed in this study. The analyze, design, development, and implementation phases of the ADDIE (Analyze, Design, Development, Implementation, and Evaluation) development paradigm are used in this study (Branch, 2009).

Date and Place of the Research

This research is restricted to the development stage, with a few trials run from May 11–25, 2023, at SMAN 1 Puri Mojokerto class XI IPA 7.

Samples from the population and research

20 students from the class XI IPA 7 SMAN 1 Puri Mojokerto made up the sample in the small test.

Data Collecting Methods

1. The use of questionnaires

The instrument review sheet, validation, and student response questionnaires in this study all employed the questionnaire methodology.

2. Test Approach

The newly created learning medium was put to the test both before (pre-test) and after (post-test). The test was administered to determine the student's abilities following their use of the created learning resources. These outcomes are taken into consideration while evaluating the POGIL e-worksheet's effectiveness.

Statistical Analysis Method

The following data analysis methods were employed in this study:

1. Analyzing the Review Sheet

The reviewers' comments and suggestions were taken into consideration while the descriptive and qualitative analysis of the data from the review sheets was amended.

2. Analysis of Validation Sheets

To determine whether the POGIL e-worksheet was feasible, three validators filled out the validation form to acquire validity data. Two validators are chemistry academics from FMIPA and UNESA, and one is a chemistry teacher (Afni & Suyono, 2021). By evaluating each indicator's existence or absence on a Likert scale and presenting the results in the following table, the validity results were examined:

Table 1. Likert Scale Validation Sheet

Scale	Indicator
0	None
1	Very less
2	Less
3	Good
4	Very Good

(Sugiyono, 2013).

The ordinal data that makes up the validation result data can be studied by figuring out the mode for each aspect or indication under the following circumstances:

a. The aspect is recognized as valid if the mode score is less than 3.
b. The aspect is deemed invalid if the mode score falls below 3.

(Lutfi, 2021).

3. Response Questionnaire

Data from the students has been used to improve the POGIL e-worksheet. According to POGIL e-worksheet practice guidelines, the following will be stated:

$$\text{Percentage of Practicality} = \frac{\sum \text{Score Obtained}}{\sum \text{Maximum Score}} \times 100\%$$

The calculation of this score is based on the calculation of the Guttman scale in Table 2.

Table 2. Guttman Scale of Learner Response Questionnaire

Answer	Positive Answer Score	Negative Answer Score
Yes	1	0
No	0	1

The percentage results are used to determine the practicality of the POGIL e-worksheet using the following categories:

Table 3. Practicality of e-worksheet POGIL Category

Number	Category
0-20%	Very Bad
21- 40%	Bad
41-60%	Fair
61-80%	Practical
81-100%	Very Practical

(Sugiyono, 2013)

Based on these categories, the POGIL e-worksheet is said to be practical if the percentage is ≥ 61%.

4. Skill Test Analysis

Learner skill test data obtained from pretest and posttest results are used to calculate normalized Gain (N-Gain) with the following formula.

$$G = \frac{\text{Posttest} - \text{Pretest}}{\text{Maximum Score} - \text{Pretest}}$$

Then the average score obtained will be interpreted into the following Table 5 gain level criteria:

Table 4. Gain Level Criteria

G	Category
Gain > 0,7	High
0,3 ≤ n-gain ≤ 0,7	Medium
n-gain < 0,3	Low

(Hake, 1999)

If the N-Gain value (g>) 0.3, it may be said that students' critical thinking abilities have improved and the learning materials they have been given are considered to be worthwhile.

Additionally, test results from the pretest and posttest were examined using SPSS and the T-test. The steps for performing the T-test are as follows:

a. Normality Test

For paired sample t-test analysis, a normality test is necessary. To ascertain whether or not the population's data is regularly distributed, the normality test is utilized. Due to the limited sample size (30 data), the Shapiro-Wilk approach was utilized for the normality test in this study. Using SPSS, the normality test was performed with the following criteria in mind.

1) The data are considered regularly distributed if the significance value is greater than 0.05.

2) The data are deemed non normally distributed if the significance value is less than 0.05.

(Wahab et al., 2021)

b. Paired Sample T-Test

The paired sample t-test can be used to further analyze the data if it is regularly distributed. If the data are not normally distributed, non-parametric statistical analysis, namely the Wilcoxon test, might be used to continue the investigation.

The parametric statistical analysis includes the paired sample t-test. To determine the significance of the difference between the pre-test and post-test scores, a difference test called the paired sample t-test is utilized (Wahab et al., 2021). The data must be regularly distributed to use the paired sample t-test. The paired sample t-test test does not contain the data variance, which means that it can be either homogenous or inhomogeneous. Using SPSS, the paired sample t-test was performed. This test's hypotheses are as follows:

H0: there is no increase in students' critical thinking skills in reaction rate material after using POGIL e-worksheet

H1: there is an increase in students' critical thinking skills in reaction rate material after using POGIL e-worksheet

This test decision making is based on the significance value. The explanation is as follows:

- If the significance value < 0.05 then H0 is rejected and H1 is accepted.
- If the significance value ≥ 0.05 then H0 is accepted and H1 is rejected

(Wahab et al., 2021)

RESULTS AND DISCUSSION

Analyze

At this stage, a needs analysis is carried out to determine the abilities or competencies that need to be learned by students in improving performance or learning potential. The reaction rate material in the independent curriculum is in phase F with the learning outcome "Students can understand and explain aspects of energy, rate, and equilibrium of chemical reactions".

Design

At this stage, e-worksheets oriented to the POGIL learning model with the help of the liveworksheet platform were designed. The e-worksheet is made into 4 products that contain factors that affect the reaction rate, namely: concentration, surface area, temperature, and catalyst, and train 5 critical thinking skills, namely: interpretation, inference, analysis, explanation, and evaluation. The following is the design of the POGIL e-worksheet to improve critical thinking skills.

- A film is shown in the orientation portion to inspire pupils to engage in learning.
- The critical thinking abilities of inference, interpretation, and analysis are practiced in the exploration part. After watching an experimental movie, students are instructed to write down their hypotheses, variables, experimental design, observational findings, and experimental analysis.
- The critical thinking abilities of explanation and inference are practiced in the concept formation part. Practice problems on response rate factors based on collision theory are presented to students, after which they write conclusions.
- In the application portion, practice questions on reaction rate aspects in daily life are provided to train students' critical thinking abilities.
- The final component includes a self-evaluation.

Development

At this time, POGIL e-worksheet development is being done to enhance critical thinking abilities in the subject matter of reaction rate-affecting elements. The created e-worksheet underwent a review and validation process. The created POGIL e-worksheet's cover design is shown below;

Figure 1. Desain Cover of POGIL e-Worksheet

Following validation, a small experiment involving 20 students from class XI IPA 7

SMAN 1 Puri Mojokerto was done. At this point, the validity, applicability, and effectivity of the POGIL e-worksheet were determined.

Validity

The results of three expert validators' media validation are used to determine validity. Three factors of validity must be examined on the validation sheet, including the viability of the content, presentation, language, and design, which are assessed using the mode. The feasibility of worksheet in terms of validity is determined by four criteria: content, presentation, language, and design (Ulya & Rusmini, 2022). There are three aspects of content validity, namely: (1) the suitability of the material with the curriculum, (2) the accuracy of the material, and (3) the material supporting learning (Asri & Dwiningsih, 2022). The mode acquisition for each component of validity is listed below.

Table 5. Validity Result of POGIL e-Worksheet

Aspect validity	Mode			
	CR	SA	TM	CY
Content eligibility	4	4	3	4
Presentation	3	3	3	3
Language	4	4	4	4
Design	4	4	3	4

Table 5 shows that the concentration, surface area, and catalyst variables received scores of 4 in the content validity assessment, whereas the temperature factor received a score of 3. All reaction rate elements result in a score of 3 for the assessment results on the presenting aspect, and the language component receives a score of 4. While the temperature factor receives a score of 3, the concentration, surface area, and catalyst factors all receive scores of 4. It may be argued that the POGIL e-worksheet is genuine because it has a mode score of at least 3 for each component influencing the reaction rate in terms of the viability of content, presentation, language, and design (Lutfi, 2021). The provisions for analyzing validity data by mode are if the aspects or indicators assessed by the validator obtain mode at a score ≥ 3, then it can be declared valid, while if the aspects or indicators assessed by the validator obtain mode at a score < 3, then it can be declared invalid so that revisions and reassessments must be made until they reach the predetermined criteria, namely each aspect obtaining a score ≥ 3 (Yahya & Lutfi, 2023). The language criteria for the LKPD created according to Putri and Qosyim's research (2021) earned a mode score of 4, indicating that it is very valid (Putri & Qosyim, 2021).

Practicality

Practicality is obtained from the learner response questionnaire which is supported by the learner activity observation sheet. The following is a recapitalization of students' responses.

Table 6. Recapitulation of Learner Response Questionnaire

Aspect	Percentage	Category
Content	95%	Very Practical
Presentation	81,67%	Very Practical
Language	90%	Very Practical
Design	85%	Very Practical

The summary of the student's responses to the POGIL e-worksheet recapitulation findings is shown in Table 6. The POGIL e-worksheet is appropriate for exercising critical thinking abilities, according to the content component, which received a 95% score. The presentation component, which received a percentage of 81.67%, includes the presentation on the POGIL e-worksheet to make it easier to utilize. The use of words or terms on the POGIL e-worksheet, which received a percentage of 90%, is related to the linguistic component. While the 85% usage rate of the POGIL e-worksheet is related to the design element, students are interested in using it.

Previous studies found that the content aspect received a percentage of 92%, indicating that the LKPD's content was in line with its goals. A practicality score of 90% in the presenting area implies that students can use the LKPD's features with ease. A practicality score of 89% in the language area shows that students can easily understand and absorb the content on the LKPD. Students were enthusiastic about using the designed LKPD, as evidenced by the design aspect's 91% practicality (Amalia & Novita, 2022).

According to the examination of the student's responses, 61% of all statements fell into the category of being highly practical. The created POGIL e-worksheet scored an overall practicality of 89.09%. The POGIL e-worksheet

falls under the description of being extremely useful.

Effectivity

The POGIL e-worksheet's effectiveness can be judged by how much students' critical thinking abilities have improved between the pretest and posttest. The five questions in the skills test each contains one of the five critical thinking categories—interpretation, analysis, evaluation, inference, and explanation. Student's performance on the skills test is evaluated using a score between 0 and 3, and the total is then calculated using the formula below.

$$\text{Total Value} = \frac{\sum \text{Obtain Score}}{\text{Total Score}} \times 100$$

The following is the acquisition of pretest and posttest N-gain scores of critical thinking skills on each component.

Table 7. N-gain Critical Thinking Skills

Skills	*N-gain*	Category
Interpretation	0.929	High
Analysis	0.722	High
Evaluation	0.694	Medium
Inferension	0.556	Medium
Eksplanasion	0.933	High

According to Table 7, there is an improvement in each of the critical thinking skill components. The interpretation component has a high category and an n-gain of 0.929. With a high category, the analysis component receives an n-gain of 0.722. With a medium category, the evaluation component has an n-gain of 0.694. With a medium category, the evaluation component has an n-gain of 0.556. While the explanation component has a high category n-gain of 0.933. The N-gain on the evaluation component was 0.62 with a medium category, and the N-gain on inference was 0.51 with a medium category in earlier research (Zulkarnain, 2019).

In addition to using N-gain, the pretest and posttest values of critical thinking skills were also analyzed using the T-test with the help of SPSS.

1. Normality Test

The following are the results of the critical thinking skills normality test using the Shapiro technique.

Table 8. Normality Test Result of Critical Thinking Skills

	Statistic	df	Sig.
Pretest	.957	20	.487
Posttest	.913	20	.072

The data from the pretest and posttest results of students' critical thinking abilities receive a significance value > 0.05 based on the findings of the normality test using Shapiro-Wilk, and the data may be deemed normally distributed since the significance value> 0.05 (Wahab et al., 2021). The paired sample t-test will then be performed.

2. Paired Sample T-Test

The following are the results of the paired sample t-test of critical thinking skills.

Table 9. Paired Sample T-Test Results Of Critical Thinking Skills

t	df	Sig. (2-tailed)
-11.961	19	.000

According to Table 9. H0 is rejected and H1 is approved when the obtained significance value is less than 0.05 (Wahab et al., 2021). The t-test refers to statistical hypothesis provisions in which the null hypothesis (no average difference between pretest and posttest findings) and the alternative hypothesis (an average difference between pretest and posttest results) are compared. Meanwhile, the rule of thumb for making a statistical analysis choice is that Ha is accepted if the significance value (2-tailed) is less than 0.05 and Ha is rejected if the significance value (2-tailed) is more than 0.05 (Cholifah & Novita, 2022). According to Laksono & Novita's research from the year 2022, which obtained a significance value of 0.05, there was a significant difference between the pretest and posttest scores. Thus, it may be inferred that after using the POGIL e-worksheet, students' critical thinking abilities have improved when it comes to reaction rate content (Laksono & Novita, 2022).

CONCLUSIONS

The POGIL e-worksheet to develop students' critical thinking abilities on reaction rate content can be used as a learning tool, according to the research's findings and analysis. This is due to the fact that it satisfies the following eligibility requirements in terms of validity, applicability,

and effectiveness . Validity was determined to be valid based on the validation sheet's mode score of 3, which indicates that the content, presentation, language, and design are all valid. Based on the response questionnaire, the POGIL e-worksheet's overall practicality score was 89.09%. It can be said that the produced POGIL e-worksheet falls under the criterion of being really useful. Effectiveness of teaching critical thinking abilities to pupils is determined by pre- and post-test results. The N-gain value is calculated using the students' results from a test of their critical thinking abilities. It is as follows: (1) Interpretation 0.929, (2) Analysis 0.722, (3) Evaluation 0.694, (4) Inference 0.556, and (5) Explanation 0.933. Additionally, the results of the skill test were examined using the paired sample t-test, which yielded a significant value of 0 (0.05). Thus, after using the POGIL e-worksheet, it can be said that students' critical thinking abilities have improved when it comes to reaction rate content.

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