



Development of Problem-Based E-Worksheet to Train Problem-Solving Skills in Reaction Rate Material

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Abstract: This research aims to develop a PBL-based E-Worksheet to train problem-solving skills in reaction rate materials. The research method employed is the ADDIE model R&D, excluding the implementation stage. Data were obtained from study sheets, validation, activity observations, response questionnaires, as well as pretest and post-test skills. Validity analysis uses a median based on the Likert Scale. The practicality analysis utilizes percentages based on the Guttman Scale, whereas activity observation employs percentages at each meeting. Effectiveness analysis used the interpretation criteria of skill completeness and the N-Gain test. The results of the study showed that the E-Worksheet met the valid criteria, with a median score of 4 in content and construct validation across four categories, practicality as indicated by questionnaire results and activity observation at 95.56%, and effectiveness in practicing problem-solving skills, with an average N-Gain value of 0.87 in the high category. The implications of this study suggest that PBL-based E-Worksheets can serve as an alternative teaching material that supports the development of 21st-century skills, particularly in problem-solving related to reaction rate materials.

Abstrak: Penelitian ini bertujuan untuk mengembangkan E-Worksheet berbasis PBL guna melatih keterampilan *problem solving* pada materi laju reaksi. Metode penelitian yakni R&D model ADDIE tanpa tahap implementasi. Data diperoleh dari lembar telaah, validasi, observasi aktivitas, angket respon, serta *pretest* dan *posttest* keterampilan. Analisis validitas menggunakan median berdasarkan Skala Likert. Analisis kepraktisan menggunakan persentase berdasarkan Skala Guttman, sedangkan observasi aktivitas menggunakan persentase pada tiap pertemuan. Analisis keefektifan menggunakan kriteria interpretasi ketuntasan keterampilan dan uji N-Gain. Hasil penelitian menunjukkan bahwa E-Worksheet memenuhi kriteria valid dengan skor median validasi isi dan konstruk sebesar 4 kategori baik, praktis dengan hasil angket dan observasi aktivitas sebesar 95,56%, serta efektif melatih keterampilan *problem solving* dengan rata-rata nilai N-Gain sebesar 0,87 kategori tinggi. Implikasi dari penelitian ini menunjukkan bahwa E-Worksheet berbasis PBL dapat menjadi alternatif bahan ajar yang mampu mendukung pengembangan keterampilan abad 21 khususnya *problem solving* pada materi laju reaksi.

A. Introduction

The primary issue underlying this study is the limited problem-solving skills of students in chemistry materials, particularly in the context of reaction rates. Based on the results of the pre-research conducted at SMAN 13 Surabaya in April 2024, the average achievement of problem-solving skills was only 23.4% with details: understanding (12.1%), analysis (34.1%), planning (28.3%), implementation (15.9%), and evaluation (15.9%). These results suggest that students have not received sufficient training in solving chemical problems related to everyday life. The teacher also admitted that he had never practiced this skill in the context of a real phenomenon. In addition, the learning model used in the classroom tends to be conventional, focusing on lectures and algorithmic problem-solving, rather than on understanding concepts or applications in real-world situations. This condition underscores the need for more contextual learning innovations and fosters 21st-century skills.

The solution to this problem is the development of Problem-Based Learning (PBL)-based Student Activity E-Worksheet using the liveworksheet platform. The PBL model was chosen because it encourages students to think critically and actively find solutions to contextual problems, while live worksheet media supports interactive and flexible digital learning (Mentari et al., 2025). The collaboration between PBL and Liveworksheet provides a meaningful and enjoyable learning experience. The developed e-Worksheet will explicitly train problem-solving skills through systematic indicator stages, including understanding, analysis, planning, implementation, and evaluation. This solution is also relevant to the Independent Curriculum policy, which emphasizes the development of student competencies that are character-driven and ready to face future challenges.

This study identifies a clear gap compared to previous research, which has primarily focused on the influence of the PBL model on problem-solving skills without developing specific digital-based learning media. Several other studies have developed electronic media, but they have not been systematically designed to train the five indicators of problem-solving skills in the context of reaction rate material. Therefore, the development of PBL-based E-Workbooks in live-worksheet format is unique because it integrates problem-based learning approaches, digital technology, and problem-solving skill indicators in a structured and comprehensive manner.

The novelty of this research lies in the integration of PBL learning models and digital live-worksheet media in the development of E-Worksheets, which are specifically designed to improve students' problem-solving skills on the topic of reaction rate. This e-worksheet is intended not only as a learning aid but also as a cognitive training tool that guides students through the process of solving problems scientifically and systematically. This research represents an innovation in the practice of chemistry learning, as it combines aspects of technology and 21st-century skills into a development product that can be used directly by teachers and students.

The research is also based on the latest relevant theories and literature. Megawati et al (2023) stated that 4C skills are essential in today's world of work, while Yuriev et al (2017)

emphasized the importance of five indicators in problem solving. Ayunda et al (2023) emphasized that PBL is suitable for contextual materials, such as reaction rates. Meanwhile, Lindayani (2021) and Nirmayani (2022) support the use of live worksheets as an interesting and practical digital learning medium. These literatures, which date back to the last five years, reinforce the theoretical basis and relevance of this research in the context of modern learning.

The purpose of this study is to develop a PBL-based E-Worksheet using a live worksheet platform to train students' problem-solving skills on reaction rate material. This research makes a significant contribution to the development of chemistry education by presenting innovative digital learning products that are responsive to current needs. In addition, the results of this research can serve as a model for implementing the Independent Curriculum, which is designed to strengthen students' competencies and character. Thus, this research is expected to enrich meaningful and contextual chemistry learning strategies and answer the challenges of 21st-century learning.

B. Method

The research was conducted in April 2025 at SMAN 13 Surabaya in the 2024/2025 Academic Year. The method used is Research and Development with the ADDIE model. This research includes the development of media aimed at assessing the feasibility of the E-Worksheet, so the research is carried out without an implementation stage. The media trial was conducted using the One-Group Pretest-Posttest Design. The research flow is listed in Figure 1.

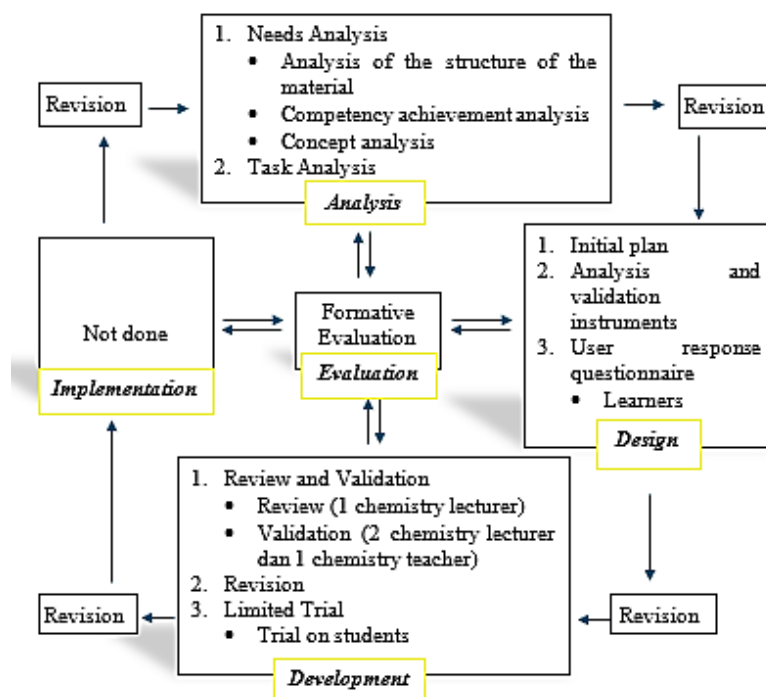


Figure 1. Research Flow

Validity Test Data Analysis

The validity test is obtained from the validation sheet. Two lecturers and one chemistry teacher conducted the validation process. Validation data is used to determine the validity of the E-Worksheet developed. The validation sheet utilizes a Likert Scale that encompasses the validity criteria of content and construct. The Likert scale is categorized as an ordinal scale, where responses are ranked in order. The value on the ordinal scale does not represent the actual number (David et al., 2018). Therefore, mathematical operations cannot be applied (Nuryadi et al., 2017). One way of analysis that can be applied is to use the median value. An E-Worksheet is declared valid if the median is ≥ 3 and there is no value of < 3 . The Likert Scale criteria are listed in Table 1.

Table 1. Likert Scale Criteria

Criteria	Scale Value
Very Not Good	1
Not Good	2
Enough	3
Good	4
Very Good	5

Practicality Test Data Analysis

The practicality test was obtained from the response questionnaire sheet and the observation sheet of student activities. The collection of response questionnaire data was carried out after a limited trial. The response questionnaire sheet is made according to the Guttman Scale. The response questionnaire data were analyzed quantitatively, with percentages used to represent the results. An E-Worksheet is declared practical if the percentage is $\geq 61\%$. The criteria of the Guttman Scale are listed in Table 2.

Table 2. Guttman Scale Criteria

Answer	Negative Question Score	Positive Question Score
Yes	0	1
Not	1	0

Observation data collection was conducted during the trial's initial phase. The observation sheet records both relevant and irrelevant student activities according to the PBL syntax, divided into 3-minute intervals over 90 minutes. Observation data was analyzed quantitatively by percentage. An E-Worksheet is declared practical if the percentage is $\geq 61\%$. Observation data uses the following percentage formula :

$$\% \text{ of student activity} = \frac{\Sigma \text{frequency of activity that appears}}{\Sigma \text{frequency of overall activity}} \times 100\%$$

Effectiveness Test Data Analysis

The effectiveness test was obtained from the problem-solving skills pre- and post-test sheets. The data collection was conducted following a preliminary trial, which included a skill pretest-posttest sheet consisting of six essay questions. The data sheet was analyzed quantitatively using the criteria of skill interpretation and the N-Gain test. The criteria for interpreting skill completeness are presented in Table 3.

Table 3. Criteria for Interpretation of Skill Completeness

Percentage (%)	Interpretation Criteria
0-20	Verry Low
21-40	Low
41-60	Enough
61-80	High
81-100	Very High

Adaptation of (Riduwan, 2013)

An E-Worksheet is considered successful if a percentage of $\geq 61\%$ is achieved with high criteria. E-Worksheet is declared effective if the N-Gain ≥ 0.3 with moderate criteria (Hake, 1998).

C. Result

This research utilizes the ADDIE model, which comprises four stages: Analysis, Design, Development, and Evaluation. However, since this research is a development of learning media aimed solely at determining the feasibility of the E-Worksheet, the research was conducted without an implementation stage.

1. Analysis Stage

The analysis stage is the first step that aims to identify learning needs and conditions. This research was conducted at SMAN 13 Surabaya using problem-solving skills tests, questionnaires, and teacher interviews. The results showed that students had difficulty solving contextual problems related to the factors that affected the reaction rate, with an average skill level of only 23.4%. Therefore, Problem-Based Learning learning media is needed to practice these skills. The analysis was conducted in four aspects: material structure, competency achievement, concepts, and tasks. The structure of the material and concepts is adjusted to the independent curriculum and reaction rate theory. The flow of learning objectives is systematically designed from problem identification to solution analysis. Assignments are organized according to PBL syntax and indicators of problem-solving skills. The results of this analysis served as the basis for developing the E-Worksheet, which aims to enhance students' critical thinking skills in response to the demands of the 21st century.

2. Design Stage

The design stage aims to compile the initial design of the E-Worksheet. The initial draft involves determining the subject matter, creating a concept, preparing a needs map, selecting a title, and determining the format of the E-Worksheet. This media was developed using the independent curriculum phase F with reference to learning outcomes and objectives. The structure of the E-Worksheet comprises several components, ranging from the cover page to the content of learning activities that follow the five phases of PBL, including problem-solving skills indicators. The content of the E-Worksheet aligns with the syntax of the PBL model and the problem-solving skills indicator. In Phase 1 of problem orientation, the E-Worksheet presents two types of phenomena: contextual phenomena and routine phenomena. Contextual phenomena are those commonly encountered by students in their daily lives, whereas routine phenomena are typically encountered in laboratories. In the E-Worksheet concentration factor, the contextual phenomenon involves washing coffee stains with bleach of different concentrations, and the routine phenomenon involves the reaction of an HCl solution with Mg bands. In the area factor, the contextual phenomenon involves burning wood with varying surface areas, and routine phenomena include HCl reactions with CaCO_3 of different surface areas. In the catalytic factor, the contextual phenomenon is represented by the ripening of bananas with and without carbide, and the routine phenomenon is represented by the reaction of H_2O_2 with MnO_2 . Each phase 1 of the E-Worksheet contains fundamental questions related to the problem of this phenomenon. (Indicators of problem-solving skills: understanding and analysis). The E-Worksheet's phase 1 citation is listed in Figure 2.



Figure 2. Phase 1 E-Worksheet (a) Phenomenon 1 (b) Phenomenon 2

In Phase 2 of organizing students to learn, students discuss in groups when answering the problem of the phenomenon (Indicator of problem-solving skills: analysis). The E-Worksheet's phase 2 view is shown in Figure 3.



Figure 3. Phase 2 E-Worksheet (a) Phenomenon 1, (b) Phenomenon 2

In Phase 3, guiding individual and group investigations, students determine variables, formulate problems, find relevant reading sources, design and conduct experiments, record observations, create graphs, and analyze and answer questions in that phase (Indicators of problem-solving skills: understanding, analysis, planning, implementation, and evaluation). An excerpt of the E-Worksheet's phase 3 display is presented in Figure 4.

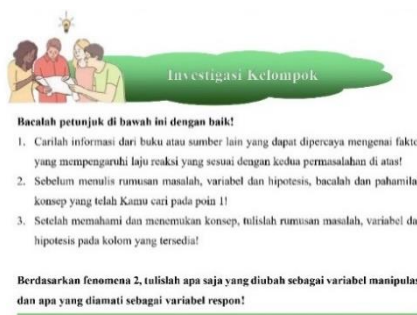


Figure 4. Phase 3 E-Worksheet

In Phase 4 of developing and presenting the results, students are instructed to create and present a simple practicum report in front of the class as a group (Indicator of problem-solving skills: implementation and evaluation). A phase 4 view of the E-Worksheet is presented in Figure 5.

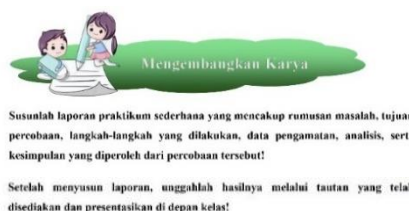


Figure 5. Phase 4 E-Worksheet

In Phase 5 of analyzing and evaluating the problem-solving process, students assess the process by associating it with theories and phenomena (Indicators of problem-solving skills: analysis, planning, implementation, and evaluation). An excerpt from the E-Worksheet's Phase 5 display is shown in Figure 6.



Figure 6. Phase 5 E-Worksheet

The design stage evaluation aims to assess the suitability of the E-Worksheet design before proceeding to the next stage in the ADDIE model. The design is based on PBL syntax and Yuriev's problem-solving components, utilizing the LiveWorksheets platform for the material on factors influencing reaction rates. Four E-Worksheets are designed according to the learning objectives, are relevant to real life, and practice problem-solving. The review, validation, and user questionnaire instruments are designed in accordance with Nieveen's criteria.

3. Develop Stage

The development stage presents the results of the review, validation results, and findings from practicality and effectiveness tests of the media following limited trials.

Review and Revision Results

The review and revision results are listed in Table 4.

Table 4. Review and Revision Results

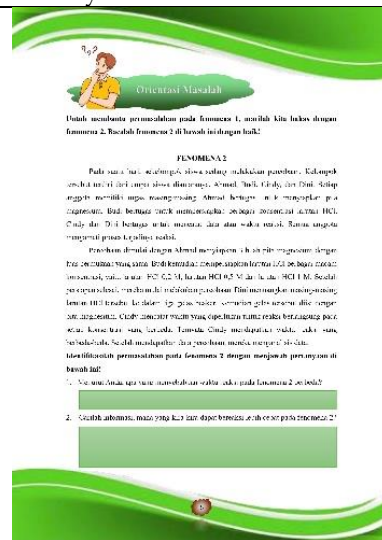
Before Revision (Draft I)	After Revision (Draft II)
<p>Identifikasi permasalahan pada fenomena 1 dengan menjawab pertanyaan di bawah ini!</p> <p>1. Mengapa pengapuran pemutih baju pada cara kedua lebih cepat dalam menghilangkan noda kopi dibandingkan dengan cara pertama?</p> <p>Mari Belajar</p> <p>Identifikasi permasalahan-permasalahan yang ada di fenomena 1 dengan menjawab pertanyaan di bawah ini!</p> <p>1. Dari kedua cara pengapuran pada fenomena 1, manakah yang memiliki konsentrasi pemutih baju lebih tinggi?</p> <p>2. Faktor apa yang mempengaruhi laju penghapusan noda kopi?</p>	<p>Identifikasi permasalahan pada fenomena 1 dengan menjawab pertanyaan di bawah ini!</p> <p>1. Dari kedua cara pemutih pada fenomena 1, manakah yang memiliki konsentrasi pemutih baju lebih tinggi?</p> <p>Mari Belajar</p> <p>Identifikasi permasalahan-permasalahan yang ada di fenomena 1 dengan menjawab pertanyaan di bawah ini!</p> <p>1. Mengapa pengapuran pemutih baju pada cara kedua lebih cepat dalam menghilangkan noda kopi dibandingkan dengan cara pertama?</p> <p>2. ...faktor apa yang mempengaruhi laju penghapusan noda kopi?</p>

Before Revision (Draft I)

After Revision (Draft II)

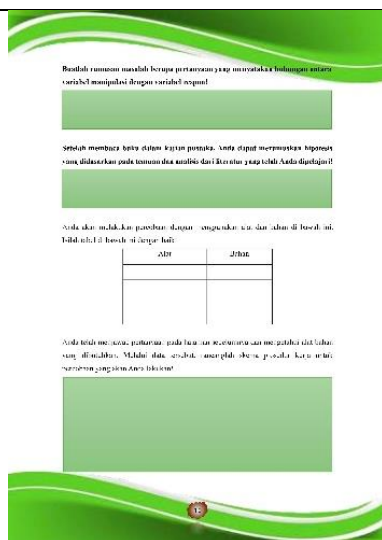
In E-Worksheet 1, the question contained in phase 1 of phenomenon 1, namely "Why is the use of clothes bleach in the second way faster in removing coffee stains compared to the first way?" is confused with question number 1 in phase 2, namely "Of the two washing methods in phenomenon 1, which one has a higher concentration of clothes bleach?"

Both questions have been corrected according to the suggestions for improvement. Phase 1 of phenomenon 1 question becomes "Of the two washing methods in phenomenon 1, which one has a higher concentration of shirt bleach?". In contrast, question number 1 of phase 2 becomes "Why is the use of clothes bleach in the second way faster in removing coffee stains compared to the first way?"



In E-Worksheet 1, part of phenomenon 2, the molarity of the HCl solution is too large, namely 0.5 M, 1 M, and 1.5 M, and there is no information related to the reaction time obtained that is different.

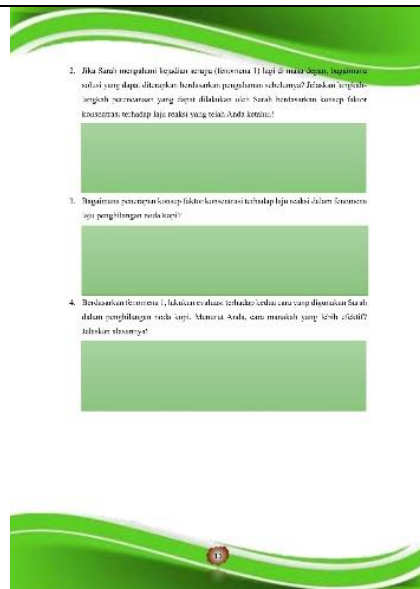
The molarity of the HCl solution in E-Worksheet 1 phenomenon two was changed to 0.2 M, 0.5 M, and 1 M, and information related to the reaction time obtained was added.



In all E-Worksheet phase 3 sections, more precisely, before the submission of the

Worksheet phase 3 sections, commands and

Before Revision (Draft I)



After Revision (Draft II)



In Phase 5 of the E-Worksheet, an additional question related to the learning process has been added.

One question related to the learning process has been added to all E-Worksheet phase 5 sections, namely in question number 5.

Validity Test Results

The validation results are listed in Table 5.

Table 5. Results of E-Worksheet Content and Construct Validation

No	Rated components	Median and Criteria			
		E-Worksheet 1	E-Worksheet 2	E-Worksheet 3	E-Worksheet 4
1.	Content Validity	4 (G)	4 (G)	4 (G)	4 (G)
2.	Construct Validity				
	a. Language Criteria	4 (G)	4 (G)	4 (G)	4 (G)
	b. Presentation Criteria	4 (G)	4 (G)	4 (G)	4 (G)
	c. Graphic Criteria	4 (G)	4 (G)	4 (G)	4 (G)

Remarks: The letter G is an abbreviation for the "Good" assessment criterion from the Likert Scale, with a score of 4.

The e-Worksheet, developed based on the validity of content and constructs, obtained a median score of 4, meeting good criteria. This demonstrates that the content of the E-Worksheet material aligns with the Learning Outcomes, Learning Objectives, PBL model, and components of problem-solving skills. On the construction criteria, the language used is clear and precise. Additionally, the E-Worksheet media is interesting in terms of its presentation and graphics. According to the results of the content and construct validation data, the E-Worksheet media is deemed valid and worthy of trial.

Practicality Test Results

The results of the response questionnaire are listed in Table 6.

Table 6. Response Questionnaire Results

No	Question	Result	Description
1.	Is the phenomenon in the E-Worksheet a problem in everyday life?	88%	Practical
2.	Can you understand the phenomenon presented in the E-Worksheet?	96%	Practical
3.	Do the phenomena in the E-Worksheet help you to plan for problem-solving?	100%	Practical
4.	Do the questions in the E-Worksheet help you relate the phenomenon to the material about the reaction rate?	96%	Practical
5.	Can you troubleshoot after using the E-Worksheet?	72%	Practical
6.	Does the PBL model on the E-Worksheet help you in solving problems?	88%	Practical
7.	Can you apply the concept of reaction rate to solve problems?	64%	Practical
8.	Are your problem-solving skills improving?	76%	Practical
9.	Is the use of language in the E-Worksheet difficult to understand?*	76%	Practical
10.	Does the design of the E-Worksheet used have an attractive appearance?	88%	Practical
11.	Is the layout of the text presented in the E-Worksheet systematic?*	64%	Practical
12.	Do the illustrations in the E-Worksheet help you in understanding the material?	88%	Practical
13.	Is the E-Worksheet difficult to access?*	88%	Practical
	Average	83,38%	Praktis

The average overall response rate among students was 83.38%. It can be concluded that the E-Worksheet developed is declared practical.

The results of the observation of activities are used to support the practicality of the E-Worksheet. The results of the observation of activities are listed in Table 7.

Table 7. Activity Observation Results

Meeting	Observation Results (%)	
	Relevant	Irrelevant
Meeting 1 (E-Worksheet 1 and 2)	93,33	6,67
Meeting 2 (E-Worksheet 3 and 4)	97,78	2,22
% Average	95,56	4,44

The results show that E-Worksheet was able to increase students' active involvement with an average of 95.56% of relevant activities and only 4.44% of irrelevant activities during the two meetings.

Effectiveness Test Results

The data on the results of the pretest-posttest for problem-solving skills, by indicator, are contained in Table 8.

Table 8. Pretest and Post-test Results of Problem-Solving Skills for Each Indicator

Indicator	Pretest Result (%)	Post-test Result (%)
<i>Understanding</i>	48,00	98,00
<i>Analysis</i>	35,00	97,00
<i>Planning</i>	25,33	88,00
<i>Implementation</i>	16,00	80,00
<i>Evaluation</i>	6,00	80,00

The criteria for completeness of problem-solving skills are classified as high and very high. This is because the percentage obtained in the post-test is 80% to 98%. Meanwhile, the data on the N-Gain pretest-posttest results are listed in Table 9.

Table 9. N-Gain Pretest-Posttest Results: Problem-solving skills

Indicator	N-Gain	Category
<i>Understanding</i>	0,98	High
<i>Analysis</i>	0,94	High
<i>Planning</i>	0,86	High
<i>Implementation</i>	0,77	High
<i>Evaluation</i>	0,78	High
Average	0,87	High

The overall pretest and post-test results yielded an N-Gain range of 0.77 to 0.98, falling within the high category. This is in accordance with Hake (1998), who states that the E-Worksheet developed is considered adequate if the N-Gain value is above 0.3.

The development evaluation phase aimed to assess the suitability of the E-Worksheet through review, validation, and limited trials. The evaluation results indicated that the E-Worksheet was valid in terms of content and construct. Input from reviewers, validators, and students was used to revise the product, improving its quality, meeting learning needs, and ensuring validity, effectiveness, and practicality.

4. Evaluation Stage

The evaluation conducted was a formative evaluation using a student response questionnaire – this questionnaire aimed to determine students' responses to the developed E-Worksheet. The questionnaire was structured in the form of a Guttman Scale with several questions. The results of the student response questionnaire are presented in Table 6.

D. Discussion

The validity of the developed E-Worksheet is determined based on the validity criteria of content and constructs. An e-worksheet is considered feasible or valid if it obtains a median score of greater than 3 from all three validators, as interpreted on the Likert Scale. The validity of the content aims to determine the extent to which the content of the E-Worksheet aligns with the established criteria, including the suitability of indicators, materials, and learning objectives (Ramadhana et al., 2022). The aspect of material suitability, in relation to the Learning Outcomes, obtained a median of 4, which was deemed valid. E-Worksheet material aligns with the learning outcomes of the Independent Curriculum, as its planning is based on an analysis of the material structure and learning outcomes applicable in schools. An e-worksheet that assesses the appropriateness of learning outcomes will clearly support an effective learning process (Febriningtyas & Dwiningsih, 2024). The aspect of conformity of the material with the Learning Objectives achieved a median of 4, indicating validity. E-Worksheet materials align with learning objectives because their development is based on an analysis of competency achievement. The preparation of clear learning objectives aims to determine that students can undergo the teaching and learning process with a clear structure and a deep understanding of the material being taught (Luthfiyyah & Puspitawati, 2024).

The aspect of material suitability with the PBL model yielded a median of 4, indicating feasibility. The E-Worksheet material has been developed in accordance with the PBL model. The E-Worksheet presents contextual phenomena related to factors that affect the rate of reaction, encouraging learners to build knowledge through assignments and collaborative investigations in groups to solve problems. This is reinforced by Mahendra et al (2023), who states that the PBL model is effectively used to train problem-solving. The aspect of material suitability, as measured by the Problem Solving Skills Component, obtained a median of 4, indicating validity. These skill components include understanding, analysis, planning, implementation, and evaluation. Based on Piaget's theory of cognitive development, high school students are in the formal operational stage of cognitive development. At this stage, students think logically and systematically, enabling them to understand problems around them.

Construct validity is a test of the feasibility of the E-Worksheet by linking test results to the underlying theory (Puspitasari & Febrinita, 2021). The validity of the construct was reviewed in terms of language, presentation, and graphics. According to Prastowo (2015), language standards in the media include the use of Indonesian in accordance with the rules, the application of terms that follow the Improved Spelling, and ensuring that the language used is clear and easy to understand by readers. The use of language in the E-Worksheet was deemed valid, with a median assessment of 4 in terms of clarity and conformity to Indonesian rules, indicating that the language was clear and in accordance with the rules. The three aspects of presentation are the representation of the cover, the consistency of the presentation system, and the place where the answer was obtained, with a median of 4, indicating validity, which demonstrates that the E-Worksheet was prepared with attention

to presentation criteria and user comfort. The condition for a good presentation of an E-Worksheet is to use standard font sizes and types; therefore, the E-Worksheet must pay attention to the type, size, and color of the letters so that users are comfortable and the text is easy to read (Fitriyah & Yulita, 2024). According to BNSP (2012), the standard of graphic criteria in the media includes the typography of the letters used, the design of the appearance, color, size, and layout, as well as the illustrations used in the E-Worksheet. The aspect of E-Worksheet presentation was assessed based on seven assessments, which obtained a median of 4 feasible categories, indicating conformity with BNSP graphic standards.

A limited trial was implemented using the E-Worksheet with the PBL model, which integrated problem-solving skills. Problem-solving skills training, especially understanding indicators, is introduced in Phase 1, where students are oriented to problems. In this phase, a non-routine and routine phenomenon related to the reaction rate factor being studied is presented, along with an illustration. Students are then asked to respond to the phenomenon. Furthermore, in Phase 3, guiding individual investigations or groups in problem-solving skills related to the understanding indicator is also trained. Students are trained by identifying manipulation, control, and response variables based on information in Phenomenon 2. Next, they read and gather information from relevant sources to understand the effect of concentration on the reaction rate, as well as explain the phenomenon based on impact theory. Additionally, this is achieved by associating the results of the experiment's observations with relevant concepts or theories, allowing students to understand the relationship between empirically obtained data and the underlying scientific explanation. Mubarokah (2017) research states that students' ability to design experiments, which includes the formulation of problems, tools, and materials, the preparation of experimental steps, and the presentation of observational data, is part of the application of scientific methods as well as an important benchmark in developing problem-solving skills and independence through a scientific approach.

Problem-solving skills training, especially Analysis indicators, is in phase 2 of organizing students to learn. In Phenomenon 1, Phase 2, a question was asked about the effect of bleach concentration on the reaction speed. Students were asked to analyze the effect of bleach concentration on the speed of coffee stain removal using two different methods. Meanwhile, in 2 phase 2, questions were asked about the concentration of the HCl solution and its effect on the number of particles and the reaction rate. Students were asked to analyze the HCl solution concentration data and determine which solution had the highest number of particles, as well as identify the factors that affect the reaction rate based on the phenomenon. Not only that, students are also trained by identifying problem formulations and hypotheses based on information in phenomenon 2. Next, it is by analyzing the graphs and data obtained.

Additionally, it involves analyzing the problem-solving process in phase 5. Analysis is the ability of learners to identify and connect various statements with relevant concepts

in order to find solutions to a problem. Analysis trains students to better understand concepts by identifying similarities relevant to the problem (Sarip et al., 2022).

Problem-solving skills training, especially in Planning indicators, is in phase 3 to guide individual and group investigations. In this phase, a space is provided to fill in the answers. Students are asked to plan the experimental procedure to be carried out. Furthermore, in phase 5, analyzing and evaluating problem-solving skills, especially planning indicators, were also trained. Students are trained by planning solutions based on previous experience and applying the concept of concentration factors to the reaction rate in solving phenomenon 1. The application of a problem-based practicum, or allowing students to design their own practicum procedures, can hone problem-solving skills (Sutarno et al., 2017).

Problem-solving skills training, especially Implementation indicators, is found in phase 3 to guide individual or group investigations. In this phase, students are asked to conduct experiments by following pre-designed work procedures. In Phase 4 of developing and presenting results, problem-solving skills related to implementation indicators are also trained by asking students to create a simple practicum report. In addition, it is also contained in phase 5, which analyzes and evaluates problem-solving by implementing the theory of concentration factors on the reaction rate in phenomena.

Problem-solving skills training, especially Evaluation indicators, is found in phase 3 to guide individual or group investigations. Students are asked to evaluate the results of the experiments obtained. In Phase 4 of developing and presenting results, problem-solving skills in the Evaluation indicator were also developed and refined through the presentation of practicum reports. In addition, phase 5 also analyzes and evaluates problem-solving by clearly identifying problems, collecting relevant information, comparing various alternative solutions, and evaluating the effectiveness of the correctly chosen solution. This is supported by Jayadinigrat & Ati (2018), who argue that the PBL model, by evaluating experimental results, presenting practicum reports, and comparing alternative solutions, can improve problem-solving skills.

The results of the response questionnaire gave a positive response to the E-Worksheet. As shown in the results, the percentage of average student responses obtained was 83.38% in the practical category, indicating that this media can be used effectively. The data from observing student activities also support the practicality of the E-Worksheet developed. The relevant activities of the students at the first meeting, as indicated by E-Worksheet 1, showed a concentration factor of 93.33% and two temperature factors of 93.33%. This suggests that students utilized 93.33% of the 90 minutes for relevant activities. Likewise, in the second meeting, the activities of relevant students, as indicated by E-Worksheet 3, which covered the factors of surface area and four catalyst factors, showed that students utilized 97.78% of the 90 minutes for relevant activities. These results suggest that E-Worksheet can actively increase participation as learning progresses. Additionally, it has proven effective in fostering a conducive atmosphere that encourages students to actively participate in learning activities.

The achievement of the Understanding indicator in the pretest, at 48%, indicates that the number of pretest scores obtained from all students is divided by the maximum number of scores for the Understanding indicator. The criteria for completeness of each indicator of problem-solving skills are classified as high and very high. This is because the percentage obtained in the post-test is 80% to 98%. This is in accordance with Riduwan (2013), who states that the E-Worksheet developed is considered high if the percentage of skill completeness interpretation criteria is higher than 61% and is considered very high if the percentage is higher than 81%.

The highest N-Gain value of 0.98 was obtained on the Understanding indicator, indicating that students have developed a better understanding of problems. The N-Gain value of 0.94 on the Analysis indicator indicates that students can significantly improve their analytical thinking skills. The N-Gain value of 0.86 on the Planning indicator indicates that students' ability to formulate a solution plan for a problem has increased. In the Implementation indicator, an N-Gain value of 0.77 was obtained, indicating an increase in the ability to implement the plan into tangible actions. However, this value was lower than that of other indicators. The Evaluation Indicator has an N-Gain value of 0.78, indicating that students' skills in evaluating the process have also improved. The overall N-Gain results showed that all indicators of problem-solving skills improved, with a high category in all aspects. This demonstrates that the E-Worksheet developed is effective in practicing problem-solving skills.

E. Implication

The E-Worksheet, based on the Problem-Based Learning (PBL) model, has been declared feasible in practicing students' problem-solving skills on reaction rate materials. Therefore, this medium can be used as an alternative learning tool, especially in training problem-solving skills.

F. Limitation and Suggestion for Further Research

There is a limitation to the research that E-Worksheet does not present video or other electronic media that can be accessed directly through E-Worksheet. This is because when students conduct experiments using tools and chemicals during the learning process.

It is recommended for the development of PBL-based E-Worksheet in practicing problem-solving skills, not only in the subchapter of factors that affect the reaction rate, but also in other chapters or subchapters that support the training of problem-solving skills. Development needs to be carried out so that the scope of media use becomes wider and helps train students' 21st-century skills that are urgently needed in facing challenges in the digital era.

G. Conclusion

This research has successfully developed an E-Worksheet based on Problem-Based Learning, suitable for practicing problem-solving skills in reaction rate materials. The e-Worksheet developed met the valid criteria based on the results of the content and construct assessment, was deemed practical based on positive responses from students and student activities, and proved effective in improving problem-solving skills, as shown by the N-Gain value in the high category. Thus, this PBL-based E-Worksheet can serve as an alternative teaching material that supports the development of 21st-century skills at the secondary education level.

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