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Development of E-Worksheet Problem-Based Learning Model with Ethnoscience Content to Improve Critical Thinking Skills

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ABSTRAK

Penelitian ini didesain E-LKPD model *Problem-Based Learning* bermuatan etnosains. Penelitian ini bertujuan untuk menghasilkan produk, menganalisis kelayakan, dan keefektifan E-LKPD untuk meningkatkan keterampilan berpikir kritis peserta didik. Penilitian termasuk penelitian pengembangan (R&D) dengan desain 3D (*Three-D*) terdiri dari tahap *Define, Design,* dan *Develop*. Model penelitian *quasi-experiment* menggunakan *posttest-only control group design.* Subjek uji coba sejumlah 71 peserta didik kelas XI-11 dan XI-12. Metode pengumpulan data melalui instrumen tes dan non tes. Instrumen pengumpulan data meliputi lembar wawancara, kuesioner, angket, dan asesmen. Analisis olah data hasil pengembangan terdiri atas uji kelayakan, keefektifan, dan respon peserta didik terhadap produk E-LKPD. Hasil penelitian menunjukkan validasi ahli materi, media, dan uji keterbacaan dinyatakan bahwa produk E-LKPD layak digunakan yang diperoleh koefisien Aiken's V sebesar 0,95 dan 0,89 kriteria sangat tinggi; serta persentase skor sebesar 87,06% kriteria sangat baik. Hasil uji coba skala besar menunjukkan E-LKPD efektif meningkatkan keterampilan berpikir kritis berdasarkan hasil uji *Mann Whitney* sebesar 0,002 < 0,05 yang menyatakan bahwa adanya perbedaan signifikan keterampilan berpikir kritis kelas eksperimen dan kelas kontrol. Produk E-LKPD memperoleh respon peserta didik dengan skor 90,48% kategori sangat baik. E-LKPD model PBL bermuatan etnosains yang dikembangkan layak dan efektif meningkatkan keterampilan berpikir kritis, serta memperoleh respon peserta didik sangat baik.

ABSTRACT

This study was designed as an E-worksheet model of Problem-Based Learning with ethnoscience content. The study aimed to produce a product, analyze its feasibility and effectiveness in improving students' critical thinking skills. The study included research and development (R&D) with a 3D (Three-D) design consisting of the Define, Design, and Develop stages. The research model is a quasi-experimental design using a posttest-only control group design. The study subjects consisted of 71 students from grades XI-11 and XI-12. Data collection methods included both test and non-test instruments. Data collection instruments included interview sheets, questionnaires, surveys, and assessments. Data analysis of the developed product included feasibility tests, effectiveness tests, and student responses to the E-worksheet product. The research results showed that the expert validation of the material, media, and readability test indicated that the E-worksheet product was feasible for use, with Aiken's V coefficients of 0.95 and 0.89, which are very high criteria, and a score percentage of 87.06%, which is a very good criterion. The results of the large-scale trial showed that the E-worksheet was effective in improving critical thinking skills based on the Mann Whitney test result of 0.002 < 0.05, which indicated a significant difference in critical thinking skills between the experimental class and the control class. The E-worksheet product received a very good response from students with a score of 90.48%. The E-worksheet PBL model with ethnoscience content developed is feasible and effective in improving critical thinking skills and receives a very good response from students.

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INTRODUCTION

Improvements in the quality of education in Indonesia are being made to keep pace with developments in the 21st century, which demands 4C skills (Rahayu *et al.*, 2023; Miller *et al.*, 2023; Haryani *et al.*, 2021; Mardhiyah *et al.*, 2021). The Merdeka Curriculum encourages the use of the Problem-Based Learning (PBL) model to foster effective student engagement, thereby improving problem-solving skills in real-world contexts (Alwi *et al.*, 2022). The results of the 2022 PISA survey show Indonesia's low literacy skills, so it is necessary to develop learning media to improve students' critical thinking skills.

Chemistry learning is abstract and lacks context, causing students to have difficulty understanding concepts, especially reaction rate material, which requires the ability to explain, calculate, and analyze critically (Minarni *et al.*, 2022; Harahap & Novita, 2021; Sari & Harahap, 2021). The low level of critical thinking skills among students is caused by the dominance of questions in the Lower Order Thinking Skills (LOTS) domain, both in textbooks and in conventional learning processes (Khaeruddin *et al.*, 2023). Mastering higher-order thinking skills (HOTS) is essential for solving real-life problems in everyday life (Nugrahnastiti & Kamaludin, 2024; Auliyani *et al.*, 2022; Wikanta & Susilo, 2022).

Advances in educational technology are driving the integration of digital devices such as Electronic Student Worksheets to improve students' understanding of concepts, learning outcomes, and critical thinking skills (Alexon & Handayani, 2024; Dewitasari & Rusmini, 2023; Indriani *et al.*, 2023; Rizkayanti *et al.*, 2023; Erna *et al.*, 2021). The Google Sites platform is considered practical and effective for designing interactive and flexible website-based E-worksheet, supporting the integration of interactive media to increase learning motivation.

An innovative PBL model approach to 21st century learning that emphasizes problem solving and active student engagement, reinforced with ethnoscience content as a form of contextualization of local culture in science. Ethnoscience-based learning connects cultural and natural phenomena to strengthen understanding of chemistry concepts (Zidny & Eilks, 2022). One potential example of local wisdom is ecoprinting, in which each process is closely related to the concept of reaction rate, such as the effects of concentration, temperature, and surface area.

Based on the analysis of the problems described above, it is evident that alternative teaching materials are needed to better support students' learning processes and strengthen their critical thinking skills, particularly in the topic of reaction rates. Previous studies have developed PBL-based worksheets and ethnoscience-based learning separately; however, the integration of both approaches—especially in digital form—remains limited. This gap highlights the need for innovative teaching materials that not only facilitate problem-based learning but also contextualize chemical concepts through local cultural knowledge. Therefore, this study aims to develop a PBL-based E-worksheet enriched with ethnoscience

content on reaction rate topics as an effort to improve students' critical thinking skills and provide culturally relevant, engaging, and accessible instructional resources.

METHODS

This study uses the Research and Development (R&D) method. The R&D method is used to test the feasibility and effectiveness of product development. The development model used is a modification of the 3D (Three-D Models) model, namely definition (define), design (design), and development (develop). The research model was conducted using a quasi-experiment with a posttest-only control group design. The subjects of this study were class XI-12 (35 students) as the experimental class and class XI-11 (36 students) as the control class at SMAN 5 Semarang. Data collection techniques using test and non-test instruments consist of assessments, questionnaires, and observation sheets. The assessments used are essay tests with critical thinking skill indicators, and the questionnaires used consist of readability questionnaires and student responses. Validation of E- worksheet by subject material experts and media experts, as well as readability tests to determine the suitability of E- worksheet products. Assessments were analyzed using difference tests to determine the effectiveness of E- worksheet products. Student response questionnaires were used to determine how effective E- worksheet is in increasing interest and ease of understanding in chemistry learning.

RESULT AND DISCUSSION

Result

This study produced interactive teaching materials in the form of PBL-based E- worksheet containing ethnoscience content. The purpose of the study was to determine the feasibility, effectiveness, and student response to the developed E- worksheet. The research stages used the 3D (Three-D) development model, consisting of Define, Design, Develop.

The define stage consists of six stages, namely initial analysis, student analysis, task analysis, concept analysis, formulation of learning objectives, and formulation of research instruments. The results of interviews with chemistry teachers revealed that PBL-based E-worksheet containing ethnoscience content on reaction rates have not been developed, and the available E- worksheet do not train students' critical thinking skills. The results of the student needs survey revealed that students only study chemistry during chemistry class, leading to low understanding of certain topics. The analysis results indicate the need to develop an E- worksheet PBL model incorporating ethnoscience to enhance students' critical thinking skills.

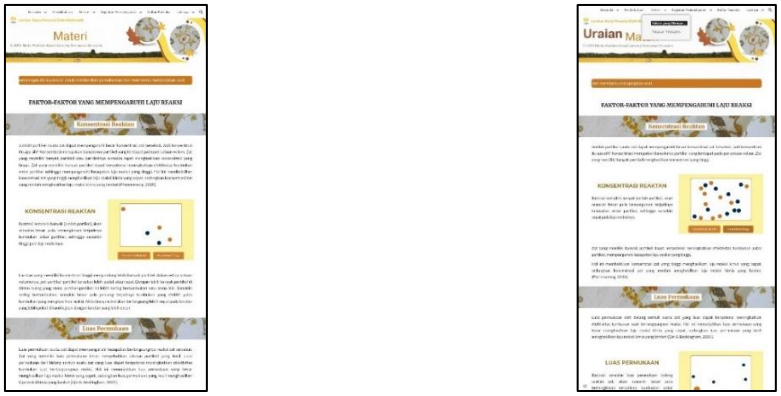
The design stage consists of two stages, namely the design of the main draft of the E- worksheet and supporting research tools. The design of the main draft consists of the initial draft and the final

product of the E- worksheet after expert validation in accordance with the suggestions and input provided. The following is an explanation:

1) PBL Syntax

Figure 1. PBL Syntax

2) Reaction Rate Material



(a) Initial Draft of E-LKPD (b) Final Product of E-LKPD

Figure 2. Reaction Rate Material

3) Ethnoscience Review

Figure 3. Ethnoscience Review (Ecoprint)

Based on the integration of local wisdom, an example of reaction rate that focuses on factors affecting reaction rate in real life is the creation of ecoprint. Ecoprint can be explained through the factors of concentration, surface area, and temperature during the manufacturing process. The materials used

can be linked to the concept of reaction rate. Natural materials, such as various types of leaves and flowers, as well as chemical materials, such as sodium carbonate (soda ash), aluminum sulfate (alum), iron powder (Fe), and calcium carbonate (lime), are used in the required quantities.

The development stage consists of two phases: validation testing and pilot testing of the E-worksheet to assess its feasibility, effectiveness, and student response. The validation of the E- worksheet was conducted by subject matter experts and media experts, including chemistry lecturers from Semarang State University and chemistry teachers from SMAN 5 Semarang. The feasibility test yielded expert validation results and readability tests, indicating that the developed E-worksheet is suitable for use, as evidenced by the analysis of material expert validation data in Table 1 and media expert validation data in Table 2.

Table 1. E-LKPD Material Validation Results

No.	Aspect	Aiken's V	Criteria
1.	Content suitability	0,93	Very High
2.	Presentation suitability	0,96	Very High
	Validity of E-LKPD	0,95	Very High

Table 2. E-LKPD Media Validation Results

No.	Aspect	Aiken's V	Criteria
1.	Graphic feasibility	0,90	Very High
2.	Linguistic feasibility	0,88	Very High
3.	Feasibility	0,94	Very High
	Validity of E-LKPD	0,89	Very High

The initial draft of the E-LKPD received suggestions and input from the three validators. After revision, the final E-LKPD product was produced and then tested on a small scale with 20 respondents from class XII-4 of SMAN 5 Semarang, using the assessment criteria based on Sudjana (2005, p. 47). The readability test results are shown in Table 3.

Table 3. E-LKPD Readability Test Results

No.	Assessment Aspect	Score (%)	Criteria
1.	Construction	84,25	Very Good
2.	Content	88,75	Very Good
3.	Language	87,75	Very Good
4.	Utility and Usefulness	87,50	Very Good
	Readability of E-LKPD	87,06	Very Good

The results of validation by subject matter experts and media experts obtained Aiken's V coefficients of 0.95 and 0.89, respectively, with very high criteria. The E-LKPD readability test results obtained a score of 87.06 with very good criteria. Based on the results of the validity and readability analysis of the E-LKPD, it was concluded that the developed E-LKPD is suitable for use in chemistry learning.

The next objective of the study was to determine the effectiveness of E-LKPD, which was measured by comparing the post-test results of students in the experimental class and the control class.

The test consists of 12 essay questions designed to assess critical thinking skills, with the control class achieving an average score of 72.10 and the experimental class achieving an average score of 80.95. The results show a difference in the average posttest scores for critical thinking skills between the experimental class and the control class, as shown in Figure 4.

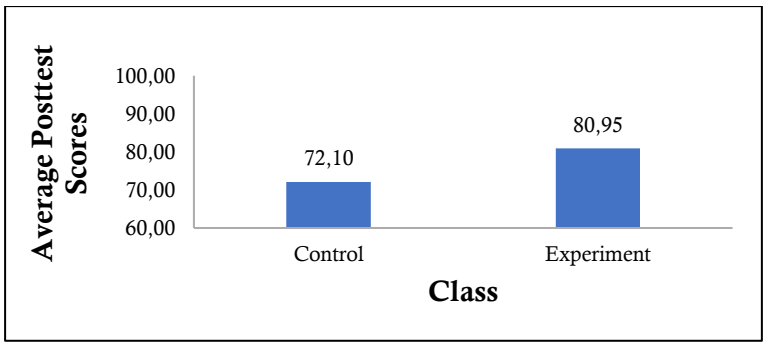


Figure 4. Average Posttest Scores for Critical Thinking Skills

A comparison of the average posttest scores of the two classes shows that the critical thinking skills of the experimental class are higher than those of the control class, concluding that the PBL-based E-LKPD model with ethnoscience content can improve students' critical thinking skills. The analysis continued by identifying the significance of the difference in posttest scores between the two groups using the Mann Whitney test. The results of the difference test analysis are presented in Table 4.

Table 4. Mann Whitney Test Results

Test Statistics	***Sig. Levene Test* Score**
Asymp. Sig. (2 tailed)	0,002

The results of the critical thinking skills test for both groups in the posttest were 0.002 < 0.05, indicating a significant difference in critical thinking skills between the experimental class and the control class. Further analysis was conducted to identify indicators of critical thinking skills among students in the experimental class and control class. The results of the identification are presented in Figure 5 and Figure 6.

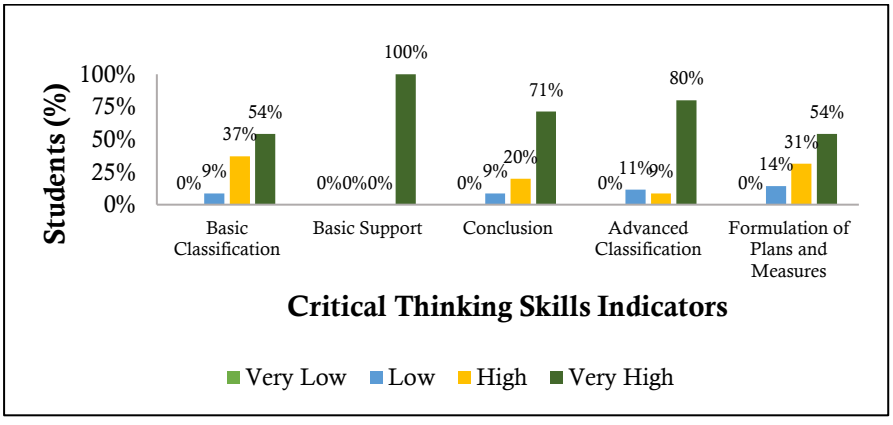


Figure 5. Identification of Experimental Classes

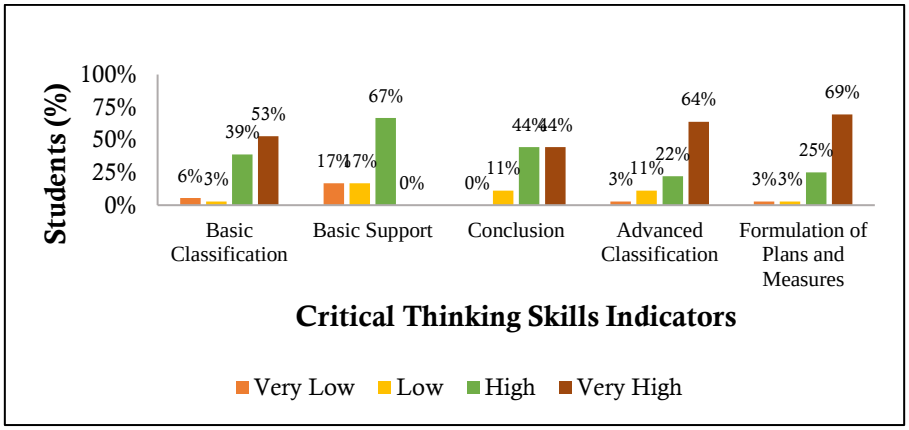


Figure 6. Identification of Control Classes

The results of the identification are shown in Figure 5 and Figure 6. The number of students with high and very high criteria was more dominant in the experimental class than in the control class, indicating that the use of PBL-based E-LKPD containing ethnoscience content can influence the improvement of students' critical thinking skills.

After learning, students were asked to respond to the PBL-based E-LKPD containing ethnoscience, which obtained a score of 90.48%, consisting of an interest aspect of 93.48% and an easy-to-understand aspect of 87.46% with a very good criterion. The results of student responses to the E-LKPD product are shown in Table 5.

Table 5. Student Responses to E-LKPD Products

No.	Assessment Aspect	Score (%)	Criteria
1.	Interest	93,48	Very Good
2.	Ease of understanding	87,46	Very Good
	Rata-Rata	90,48%	Very Good

Based on the students' responses in Table 5, the PBL-based E-LKPD incorporating ethnoscience received a very positive response, which can increase students' interest and facilitate their understanding of reaction rate material integrated with local wisdom on ecoprinting.

The PBL-based E-LKPD containing ethnoscience content is feasible, effective, and has received very positive feedback from students in terms of increasing their interest in the content and facilitating their understanding of reaction rate material. However, there are still limitations in the E-LKPD display, which can only be accessed in desktop mode, and the ethnoscience context is limited to ecoprinting. This serves as a suggestion for further research to systematically design E-LKPD.

Discussion

The feasibility of E-LKPD consists of expert validation and readability testing. E-LKPD validation is carried out by expert validators to determine the validity of the product by obtaining suggestions that are used as guidelines for revision (Hamidah *et al.*, 2024). Validators are experienced

and proven experts in the field of instrument evaluation for assessing developed products (Sugiyono, 2020). The subject matter expert validators consisted of two chemistry lecturers and one chemistry teacher, as well as 20 grade XII-4 students as readability test respondents. The analysis of Aiken's V coefficient for the validity of the subject matter expert E-LKPD was 0.95 and for the media expert was 0.89, with a very high criterion. The readability test yielded an average score of 87.06%, meeting the criteria for very good. The validation results and readability test indicate that the E-LKPD product using the PBL model with ethnoscience content on reaction rates is suitable for use. The suitability results show that the E-LKPD product is suitable for use, consistent with the research by Devi & Haryani (2025), Suyanto *et al.* (2024), and Syarani *et al.* (2025).

The initial assessment of students in grade XI showed that classes XI-11 and XI-12 were homogeneous and normally distributed. The implementation of the PBL-based E-LKPD model with an ethnoscience component was carried out in the experimental class. After the learning process, a posttest was conducted in both classes to measure students' critical thinking skills. The post-test results were analyzed using the Mann Whitney test, yielding a value of $0.002 < 0.05$, indicating a significant difference between the experimental class and the control class. The identification of critical thinking skill indicators for both groups showed that the basic classification indicator can gradually train students' critical thinking through the habit of formulating problems and answering questions (Ananda & Martini, 2025; Annisa *et al*., 2021). Supporting indicators can basically encourage students to collect and analyze information properly, observe, and consider the results of their observations (Marlina & Ramadhani, 2023; Purwanti, 2023). The indicators conclude that an ethnoscience approach involving community science can encourage students to analyze and improve their curiosity and ability to explore knowledge in depth (Mahdian *et al*., 2024; Wardani & Fiorintina, 2023). Indicators that classify further enable learners to define terms, consider definitions, and identify assumptions, which are important skills for in-depth analysis and complex classification (Djafar *et al.*, 2024 ; ‘Aisy & Ardhana, 2023). Indicators formulating plans and steps show that the problem-based approach applied is able to help students understand concepts, analyze problems, and determine the right solutions in solving problems.

The students' response to the E-LKPD developed based on the aspects of interest (93.48%) and ease of understanding (87.46%) concluded that the E-LKPD received a very good response from students in increasing their interest and facilitating their understanding in chemistry learning. The results of student responses indicate that the E-LKPD product can enhance students' interest in learning chemistry and facilitate their understanding of the material through the integration of local wisdom.

The results of the analysis show that the PBL-based E-LKPD model with ethnoscience content that has been developed is effective in improving students' critical thinking skills. This is in line with the research by Rahmawati & Muchlis (2025), Puspita & Nasrudin (2025), Pratiwi & Nasrudin (2025), Sudirman & Yusnaeni (2025), Azizah & Dwiningsih (2025), and Nilawati *et al*. (2025) that critical

thinking skills improved after using the E-LKPD developed during the learning process. The success of the E-LKPD in improving students' critical thinking skills was also influenced by the implementation of a problem-based learning model. Muda *et al*. (2024), Mutiara *et al*. (2024), and As-Syauqi *et al*. (2024) stated that the PBL model is the only form of learning that is most effective in developing critical thinking skills. Noviati & Widowati (2025) and Verawati *et al*. (2025) explains that the integration of ethnoscience and PBL can prepare students to solve real-world problems through a combination of cultural content and technology. This is in line with the research conducted by Atmojo *et al*. (2025), Verawati *et al*. (2025), Dewi *et al*. (2025), and Isvida *et al*. (2024) that ethnoscience content is effective in improving students' critical thinking skills.

CONCLUSION

This development research produced an E-LKPD product based on the PBL model with ethnoscience content on the subject of reaction rates, which is suitable and effective for improving students' critical thinking skills. The suitability of the E-LKPD, based on the results of material validation, media, and readability tests, meets very high and very good criteria. The effectiveness of the E-LKPD was proven to enhance students' critical thinking skills, as evidenced by higher post-test scores in the experimental class compared to the control class. The PBL-based E-LKPD incorporating ethnoscience received very positive feedback from students, as it increased their interest and made it easier for them to understand the reaction rate material in chemistry lessons.

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