



Development of Guided Discovery Learning-Based Reaction Rate Student Worksheets Integrated with Ethnoscience to Support Deep Learning

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Abstract: *Developing Guided Discovery Learning-Based Reaction Rate Worksheet Integrated with Ethnoscience Oriented to Deep Learning Principles.* This study aims to develop a reaction rate student worksheet based on guided discovery learning integrated with ethnoscience, and to determine its validity and practicality in supporting deep learning principles at SMA/MA. This development research applied the 4D model (Define, Design, Develop, Disseminate). The subjects of this study were students of class XI F 2 at SMAN 16 Padang. Data were collected using preliminary study instruments (teacher interviews and student need questionnaires), validity instruments (expert validation sheets), and practicality instruments (teacher and student response questionnaires). The developed worksheet achieved a high validity score of $V = 0,93$ (valid category). The practicality tests by the teacher and students yielded scores of 93% and 84%, respectively, both falling into the highly practical category. Furthermore, the implementation of this worksheet successfully helped students improve their deep learning principles. The guided discovery learning-based reaction rate worksheet integrated with ethnoscience can be successfully developed using the 4D model, meets the valid criteria and is practical for chemistry learning supports the implementation of deep learning principles.

Keywords: Deep learning principles, ethnoscience, guided discovery learning, reaction rate worksheet.

Abstrak: *Pengembangan Lembar Kerja Peserta Didik Laju Reaksi Berbasis Guided Discovery Learning Terintegrasi Etnosains Berorientasi Prinsip Pembelajaran Mendalam.* Penelitian ini bertujuan untuk mengembangkan Lembar Kerja Peserta Didik laju reaksi berbasis guided discovery learning terintegrasi etnosains, serta menentukan kevalidan dan kepraktisannya dalam mendukung prinsip pembelajaran mendalam di SMA/MA. Penelitian pengembangan ini menerapkan model 4D (Define, Design, Develop, Disseminate). Subjek penelitian ini adalah murid kelas XI F 2 SMAN 16 Padang. Data dikumpulkan menggunakan instrumen studi pendahuluan (lembar wawancara guru dan angket kebutuhan murid), instrumen validitas (lembar penilaian ahli), serta instrumen praktikalitas (angket respons guru dan murid). LKPD yang dikembangkan memperoleh nilai validitas sebesar $V = 0,93$ dengan kategori valid. Uji praktikalitas oleh guru dan murid berturut-turut memperoleh persentase sebesar 93% dan 84% dengan kategori sangat praktis. Selain itu, penggunaan LKPD ini terbukti mampu meningkatkan prinsip pembelajaran mendalam pada murid. LKPD laju reaksi berbasis guided discovery learning terintegrasi etnosains dapat dikembangkan menggunakan model 4D, memenuhi kriteria valid dan praktis untuk pembelajaran kimia, serta mendukung penerapan prinsip pembelajaran mendalam.

Kata kunci: LKPD laju reaksi, guided discovery learning, etnosains, prinsip pembelajaran mendalam.

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■ INTRODUCTION

Education in the 21st century requires a shift in learning models to address the challenges of globalization and the Industrial Revolution 4.0. Beyond cognitive mastery, students are now required to think adaptively, critically, and creatively, while developing a mindset for lifelong learning (Asrizal et al., 2024). To meet these goals, instructional focus must pivot from rote memorization toward cultivating meaningful educational experiences. One highly applicable framework is deep learning, which centers on three core principles: meaningful learning, mindful learning, and joyful learning (Hasanah et al., 2025). Recent studies have highlighted that deep learning-oriented instruction enables students to develop deeper conceptual understanding, higher-order thinking skills, and lifelong learning competencies through authentic, student-centered learning experiences (Weng et al., 2023).

Implementing deep learning requires instructional media that actively engage students in knowledge construction. Student worksheets provide structured learning activities that facilitate exploration, inquiry, discussion, and reflection, enabling students to construct conceptual understanding while promoting active engagement in science learning (Jeppsson et al., 2022). When designed using Guided Discovery Learning, worksheets facilitate meaningful learning by enabling students to discover chemistry concepts independently and connect them with prior knowledge. Furthermore, integrating ethnoscience into science learning contextualizes scientific concepts through local culture and everyday phenomena, enabling students to connect scientific knowledge with authentic real-life experiences. Recent studies have demonstrated that this culturally responsive approach enhances scientific literacy, cultural literacy, and meaningful learning (Minarni et al., 2026). This inquiry-based, contextual approach promotes mindful learning by encouraging evidence-based analysis and critical reasoning over rote memorization. Additionally, culturally relevant and interactive activities foster joyful learning by enhancing student motivation, curiosity, and participation. Consequently, integrating GDL and ethnoscience into LKPD provides a strong pedagogical foundation for realizing the three core principles of deep learning in chemistry education.

However, actual classroom practice reveals ongoing challenges in science education, especially within the field of chemistry. The abstract concepts inherent in chemistry frequently hinder students from achieving a comprehensive grasp of the subject. This gap in scientific comprehension is underscored by the 2022 PISA report, which showed that Indonesian students scored 383 in science literacy-significantly trailing the OECD average of 485 (OECD, 2023). This phenomenon serves as a strong indicator that teaching in schools is still dominated by conventional methods that focus on short-term memorisation, and is therefore not yet able to facilitate the development of deep and meaningful conceptual understanding.

Similar problems were clearly identified in the teaching of reaction rate in schools. Based on a preliminary study involving initial observations at SMAN 16 Padang, SMAN 13 Padang and SMA Pertiwi 1 Padang, the majority of pupils experienced serious difficulties in understanding the topic of reaction rate. Data from needs surveys indicate that 64,9 per cent of pupils at SMAN 16 Padang, 67,8 per cent at SMAN 13 Padang, and

57,1 per cent at SMA Pertiwi 1 Padang stated that the material on reaction rates was difficult to understand. These difficulties stem from the abstract nature of the subject matter and the requirement to analyse causal relationships between factors influencing reaction rates at the macroscopic, submicroscopic, and symbolic levels.

Interviews with teachers confirmed that pupils' understanding remains procedural in nature, has not yet reached the level of deep understanding, and that pupils' active engagement in constructing knowledge remains very low. This situation is exacerbated by the limitations of the teaching materials used in schools, which are not yet optimal in facilitating independent learning and are not yet oriented towards the principles of deep learning.

To bridge this gap, it is essential to develop innovative inquiry-oriented instructional materials, particularly Student Worksheets integrating Guided Discovery Learning with an ethnoscience approach. Previous studies have demonstrated that inquiry-based instructional materials effectively promote active learning, strengthen conceptual understanding, and enhance student engagement in science education (Senisum et al., 2022). The Guided Discovery Learning model encourages pupils to construct chemical concepts independently through a series of systematic learning stages in which teachers facilitate students' scientific inquiry and concept discovery (Suwandani et al., 2022). Meanwhile, the integration of ethnoscience acts as a bridge linking abstract modern scientific concepts with cultural contexts, local wisdom, and real-world phenomena familiar to pupils' daily lives, thereby enabling contextual and meaningful learning experiences that have been shown to improve students' scientific literacy and conceptual understanding (Hairida et al., 2026).

Previous research has developed integrated ethnoscience worksheets on the topics of redox reactions, voltaic cells and electrolysis (Wariani et al., 2025), acid base material (Wahyuni et al., 2025) as well as Guided Discovery Learning based student worksheets integrating ethnoscience on the topic of salt hydrolysis, which are both valid and practical (Jelita & Andromeda, 2025). Recent international studies have also demonstrated that ethnoscience-integrated student worksheets promote students' engagement in science learning by connecting scientific concepts with local cultural contexts and supporting the development of scientific literacy (Mulyono et al., 2024). Further research shows that the use of worksheets based on Problem Based Learning integrated with ethnoscience is effective in developing scientific literacy and creative thinking (Hidayah et al., 2025) and effectively improve pupils' critical thinking skills in relation to the subject of chemical bonding (Rahmawati & Muchlis, 2025). These findings are consistent with previous studies showing that ethnoscience-integrated instructional materials provide contextual learning experiences by connecting scientific concepts with local cultural knowledge, thereby supporting students' understanding of chemistry concepts (Sinaga & Damanik, 2025). However, despite these promising findings, studies integrating Guided Discovery Learning, ethnoscience, and deep learning principles within a single student worksheet for reaction rate learning remain limited, particularly at the senior high school level. Therefore, this study aims to develop a Guided Discovery Learning-based student worksheet integrated with ethnoscience to support the implementation of deep learning principles in reaction rate learning for senior high school students.

■ **METHOD**

This research employed a modified Four-D (4D) development model adapted from Thiagarajan et al. (1974). The original 4D model consists of four stages: Define, Design,

Develop, and Disseminate. However, this study was limited to the Develop stage due to time and resource constraints. The modification did not affect the achievement of the research objectives, as the study primarily focused on developing and evaluating the validity and practicality of the reaction rate Student Worksheet integrated with Guided Discovery Learning, ethnoscience, and deep learning principles. This study was conducted from January to June 2026 at SMA Negeri 16 Padang

Define stage

This stage is carried out to identify learning needs through an initial analysis, an analysis of the learners, a task analysis, a conceptual analysis, and the formulation of learning objectives. During this stage, interviews were conducted with chemistry teachers and a needs questionnaire was distributed to Year 11 students in Phase F at SMA Negeri 16 Padang. The results of this analysis were used as the basis for determining the characteristics and requirements of the worksheets to be developed.

Design stage

This stage involves drafting an initial version of the LKPD based on the results of the analysis carried out during the 'define' stage. The LKPD is designed to integrate the Guided Discovery Learning approach, an ethnoscience context, and the principles of deep learning. The components of the LKPD developed include the cover page, instructions for use, learning outcomes, learning objectives, material on reaction rates, guided discovery-based learning activities, practice questions, and a bibliography.

Development stage

The Develop stage aimed to produce a valid and practical Student Worksheet through expert validation and limited practicality testing. Product validation was conducted by five validators consisting of three lecturers from the Department of Chemistry, Faculty of Mathematics and Natural Sciences, Universitas Negeri Padang, and two senior high school chemistry teachers from SMA Negeri 16 Padang. Suggestions and comments provided by the validators were used to revise and improve the worksheet before it was implemented in the practicality test. Following the validation process, a limited practicality test was conducted involving two chemistry teachers and 35 Grade XI (Phase F) students at SMA Negeri 16 Padang as the prospective users of the developed worksheet. The practicality test was intended to evaluate the usability and effectiveness of the worksheet in supporting the learning process

Research Instruments

The instruments used in this study consisted of a validation questionnaire and practicality questionnaires for teachers and students. The validation questionnaire comprised 25 items distributed into four assessment aspects: content feasibility (8 items), presentation feasibility (7 items), language feasibility (5 items), and graphical feasibility (5 items). The teacher practicality questionnaire consisted of 12 items, whereas the student practicality questionnaire consisted of 15 items. Both practicality questionnaires evaluated three aspects, namely ease of use, time efficiency, and the benefits of the developed worksheet. The validation and practicality instruments were adapted from previous Student Worksheet development studies and modified to accommodate the characteristics of the Guided Discovery Learning-based worksheet integrated with ethnoscience and deep learning principles (Fadlililah & Nasrudin, 2023). All questionnaire

items were rated using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). All questionnaire items were rated using a five-point Likert scale, as presented in Table 1.

Table 1. Likert scale table

Likert Scale	Practicality
1	Strongly disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

Data Analysis

The data collected in this study consisted of qualitative and quantitative data. Qualitative data included comments and suggestions provided by the validators, teachers, and students to improve the developed worksheet. Quantitative data were obtained from the scores assigned through the validation and practicality questionnaires.

The content validity of the developed worksheet was determined using Aiken's V coefficient based on the ratings provided by the validators. The Aiken's V index was calculated using the following formula

$$V = \frac{\sum s}{[n(c - 1)]}$$

$$s = r - I_0$$

The validity level was interpreted according to the criteria presented in Table 2.

Table 2. Decision based on indeks Aiken's V (V)

Range	Category
< 0.8	Invalid
>0.8	Valid

Source: (Retnawati, 2016)

After the worksheet met the validity criteria, its practicality was evaluated based on the responses provided by teachers and students. The practicality percentage was calculated by comparing the total score obtained with the maximum possible score using the following formula.

$$NP = \frac{R}{SM} \times 100$$

The practicality level was interpreted according to the criteria presented in Table 3.

Table 3. Level of practicality

Nilai	Practicality
86% - 100%	Very Practical
76% - 85%	Practical
60% - 75%	Quite Practical
55% - 59%	Less Practical
≤54%	Impractical

Source: (Purwanto, 2010)

■ RESULT AND DISCUSSION

Result

The procedure for developing a reaction rate-based Student Worksheet using Guided Discovery Learning (GDL) integrated with ethoscience was designed through the Define, Design and Develop stages.

Definition Stage

Front-end analysis

An initial analysis revealed that 64,9% of pupils found the material on reaction rates quite difficult, whilst 13,5% found it difficult due to the abstract nature of the concepts and the demands of mathematical calculations. Chemistry teaching in schools is still dominated by conventional group discussion (46,5%) and lectures (20,9%), and has never integrated local wisdom (ethnoscience) due to teachers' limited ideas. However, 75 per cent of pupils stated that they found it easier to understand the subject matter if they could discover the concepts independently, and 91,8 per cent of pupils were more interested when chemistry was linked to their local culture.

Analysis of pupils

A student characteristic analysis was performed on Phase F (Year 11) high school students. The needs questionnaire revealed that 73,7% of students prefer an instructional approach that starts with a problem and encourages independent concept discovery. Additionally, 75% of students report that forming concepts helps them understand the material better than simply memorizing formulas. Consequently, these results serve as the foundation for designing worksheets based on Guided Discovery Learning, featuring structured problems and guiding questions.

Task Analysis

At this stage, the results were obtained that based on the CP in the reaction rate material, namely "analyzing the factors that influence the reaction rate", there are several abilities that must be achieved by students through the ATP that has been determined. These abilities include (1) explaining the concept and theory of collisions on reaction rates, (2) analyzing factors that influence reaction rates, (3) analyzing experimental results related to factors that influence reaction rates, and (4) determining rate laws, reaction orders, and reaction rate constants based on experimental data.

Concept analysis

Based on the concept analysis carried out, it was found that the material on reaction rates contains abstract concepts. A concept analysis table was then drawn up, covering concept labels, types, definitions, attributes, the hierarchy within the material, as well as examples and non-examples. This table was used as the basis for drawing up the concept map.

Formulation of learning objectives

The formulation of TP and ATP is based on the CP in BSKAP No. 046/H/KR/2025, namely: (1) Pupils are able to explain the concept of reaction rate, (2) Pupils are able to explain the theory of particle collisions, (3) Pupils are able to explain the factors affecting reaction rate, (4) Pupils are able to write reaction rate equations based on experimental results, and (5) Pupils are able to determine the order of a reaction and the rate constant from experimental data. The following are the results of the ATP formulation: (1) Pupils are able to explain the concept of reaction rate accurately, (2) Pupils are able to explain the theory of particle collisions accurately, (3) Pupils are able to explain the factors affecting reaction rate, (4) Pupils are able to analyse experimental results to explain the influence of factors on reaction rate, (5) Pupils are able to write the equation for the law of reaction rate from experimental data, and (6) Pupils are able to accurately determine the order of reaction, the rate constant, and the reaction rate constant based on experimental data.

Planning Stage

The design phase is carried out to establish the basic framework for the development of the LKPD; the stages are as follows:

Choice of media

Based on an analysis of the task, concepts and learners, the material on reaction rates emphasises conceptual understanding and the analysis of experimental data to determine the order and laws of reaction rates. Taking into account time constraints, classroom conditions and learner characteristics, the chosen teaching resource is a print-based worksheet, as it is practical, structured and facilitates discussion. These worksheets have been developed using the Guided Discovery Learning approach, incorporating phenomena as stimuli and guiding questions to enable pupils to discover concepts independently and think critically.

Selecting a format

These worksheets, developed on the basis of Guided Discovery Learning, were created using Microsoft Word and Canva. The fonts used are Baloo Thambi (45 pt) for headings, Alice (15 pt) for subheadings, and Times New Roman (12 pt) for the body text, to ensure the material remains clearly legible.

Initial plan

Once the CP, TP, ATP, content and format of the worksheets have been finalised, the next step is to draw up a preliminary draft of the worksheets. This draft is drawn up in accordance with the guidelines (Kemendikdasmen, 2026 : 11). Which consists of a cover page, an introduction, Guided Discovery Learning based syntax centred learning activities (motivation and problem presentation, data collection, data processing, verification, and drawing conclusions), and is supplemented by an assessment, an answer key, and a bibliography. The integration of ethoscience is found in the ethoscience review section, as well as in the stages of motivation, problem presentation, and data processing.



Figure 1. Cover LKPD

Development stages

At this stage, a valid and practical LKPD was produced. Based on a validity test of the four main components of feasibility namely, content, presentation, language, and graphics conducted by five validators, a V score was obtained, as shown in Table 4 below:

Table 4. Results of the validity test conducted by experts

NO	Aspects Evaluated	V	Category
1.	Content Suitability Components	0,94	Valid
2.	Components of a dish's suitability	0,94	Valid
3.	Language feasibility components	0,94	Valid
4.	Graphical feasibility components	0,92	Valid
Overall Average		0,93	Valid

As shown in Table 4, the validity assessment conducted by five validators showed that the developed worksheet obtained validity indices of 0,94 for content feasibility, 0,94 for presentation feasibility, 0,94 for language feasibility, and 0,92 for graphical feasibility, with an overall average V value of 0,93. The validity scores for individual indicators ranged from 0,80 to 1,00, indicating that all indicators met the validity criteria and the developed worksheet was categorized as valid. Following the validity assessment, a practicality test was conducted to evaluate the usability of the developed worksheets. This level of practicality was measured using questionnaires completed by chemistry teachers and students at SMA N 16 Padang, with the corresponding data summarized in Table 5.

Table 5. Results of the Practicality Test for Teachers and Students

Assessment components	Teachers' Practicality		Student Practicality	
	Percentage Value	Category	Percentage Value	Category
Ease of Use	93%	Very Practical	83%	Practical
Attractions	97%	Very Practical	84%	Practical
clarity			84%	Practical
Learning suitability	90%	Very Practical		
Benefits	93%	Very Practical	85%	Practical

Figure 2 below illustrates the comparison of practicality test results between teachers and students:

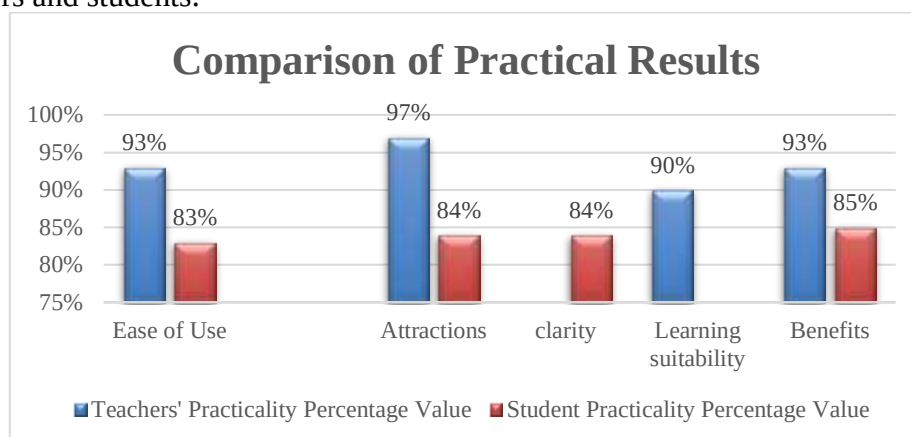


Figure 2. Comparison Chart of Practicality Test Results

Analysis of Learning Principles in Student Worksheets

The analysis of learning principles in the worksheets was conducted based on students' group work on the worksheets. This analysis aimed to assess student engagement at each stage of Guided Discovery Learning, which reflects the learning principles of mindful learning, meaningful learning, and joyful learning. The analysis data are presented in Table 6.

Table 6. Analysis of Student Activities Based on the Syntax of Guided Discovery Learning

GDL Syntax	Student Activities	Principles of Learning	Groups showing activity
Motivation & Problem Statement	Observing the phenomenon of ethnoscience related to reaction rates	Meaningful	9 Groups (1, 2, 3, 4, 5, 6, 7, 8, 9)
Data collection	Conducting activities to discover concepts	Mindful, Joyful	9 Groups (1, 2, 3, 4, 5, 6, 7, 8, 9)
Data processing	Analyzing the results of the observations	Mindful	8 Groups (1, 2, 4, 5, 6, 7, 8, 9)
Verification	Group discussions and observations	Mindful, Joyful	6 Groups (1, 4, 5, 6, 8, 9)
Conclusion	Deriving concepts based on the results of activities	Mindful	6 Groups (1, 2, 4, 5, 6, 9)

Discussion

Validity of the LKPD

Validity testing was conducted using a structured validation questionnaire to determine the suitability of the designed worksheets. The evaluation involved five validators: three chemistry lecturers from the Faculty of Mathematics and Natural Sciences (FMIPA) at UNP and two chemistry teachers from SMAN 16 Padang. These evaluators assessed the developed LKPD across four core dimensions: content, presentation, language, and graphics. The high validity score indicates that the developed

worksheet has fulfilled the essential criteria of a good instructional material in terms of content, presentation, language, and graphical design. This result suggests that the worksheet is appropriate for supporting chemistry learning because each component was designed according to the principles of Guided Discovery Learning, integrated with ethnoscience, and aligned with the current curriculum.

The content feasibility aspect obtained a validity index of 0,94 indicating that the worksheet content is appropriate for achieving the intended learning objectives. This high score was achieved because the worksheet was systematically designed based on the CP, TP, ATP, and the syntax of Guided Discovery Learning integrated with ethnoscience. The worksheet also includes complete standard components, namely the cover, foreword, table of contents, CP, TP, ATP, concept map, introduction, ethnoscience review, and Guided Discovery Learning activities (Yerimadesi et al., 2020: 36-49). This systematic organization supports the implementation of deep learning principles by providing clear learning stages that help students construct concepts independently. These findings are consistent with Fajrin et al. (2026), who reported that systematically structured worksheets provide clear instructional guidance and encourage active student engagement in learning activities.

The language feasibility aspect obtained a validity index of 0,94 indicating that the worksheet uses clear, concise, and communicative language that is appropriate for senior high school students. The language was carefully designed to follow standard Indonesian grammar, use scientific terminology consistently, and present instructions that are easy to understand. This helps students focus on discovering reaction rate concepts independently without being hindered by ambiguous wording. These findings are consistent with (Prastowo, 2011 : 205-206), who emphasized that worksheets should facilitate learning through clear and communicative language, and with Murti & Puspitawati (2023), who stated that effective worksheets should employ language that is understandable and appropriate for learners' characteristics.

The presentation feasibility aspect obtained a validity index of 0.94, indicating that the worksheet presents learning materials in a logical and systematic sequence. The worksheet was designed based on the Guided Discovery Learning syntax proposed by (Yerimadesi et al., 2020 : 36-49), consisting of motivation and problem presentation, data collection, data processing, verification, and conclusion. In addition, the worksheet includes complete components such as the cover, preface, table of contents, CP, ATP, concept map, introduction, ethnoscience overview, learning activities, assessment, answer key, and references. This systematic presentation enables students to follow the learning process step by step, supports the implementation of deep learning principles, and facilitates meaningful concept construction. These findings are consistent with Novita et al. (2023), who reported that systematically organized worksheets with clear learning sequences facilitate students' engagement and participation in learning activities.

The graphical feasibility aspect obtained a validity index of 0,92, indicating that the worksheet has an attractive and well-organized visual design. The selection of fonts, color combinations, illustrations, and page layout was carefully adjusted to improve readability and maintain students' attention throughout the learning process. In addition, the integration of ethnoscience through contextual images and cultural examples makes the learning materials more relevant and engaging for students. An appropriate visual design can increase students' learning motivation and facilitate understanding of scientific concepts (Nurliyana et al., 2025). Furthermore, the integration of ethnoscience into

learning materials has been reported to enhance students' interest and learning achievement (Okwara & Upu, 2017).

The high validity of the developed worksheet can also be attributed to the integration of Guided Discovery Learning, ethnoscience, and deep learning principles within a single instructional material. Guided Discovery Learning provides structured learning stages that encourage students to actively construct scientific concepts through observation, investigation, and verification. The integration of ethnoscience connects reaction rate concepts with students' local cultural experiences, making learning more meaningful and contextual. Furthermore, the worksheet was designed to support deep learning principles by promoting mindful learning through critical analysis, meaningful learning through contextual ethnoscience phenomena, and joyful learning through collaborative and interactive learning activities. The combination of these three approaches represents the main novelty of the developed worksheet and contributes to its high validity.

Although the developed LKPD were found to have a very high level of validity, there are several sections that require revisions in accordance with the validators' recommendations. Therefore, before the LKPD are pilot tested with students, revisions will be made to them first, as shown in Figure 3 below.

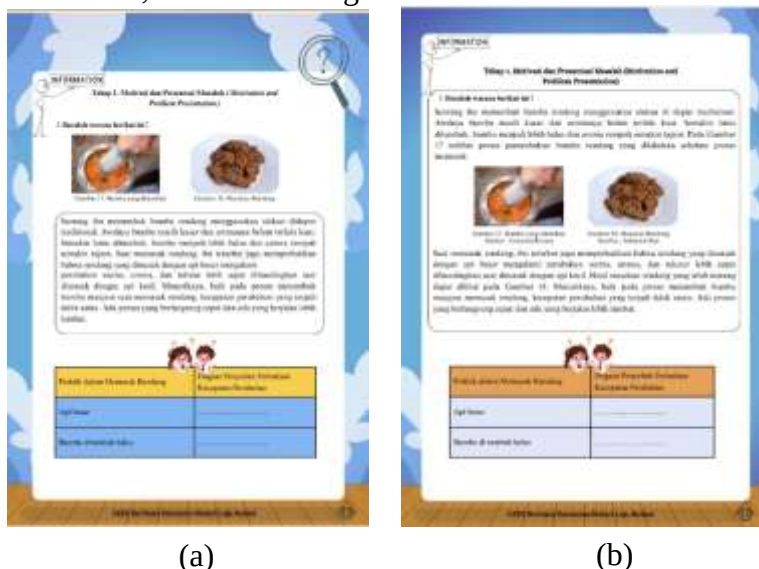


Figure 3. (a) Stage 1 syntax before revision (b) Stage 1 syntax after revision

Practicality

After the validity test and the product were deemed acceptable, a field trial was conducted at Padang State High School 16 during the odd semester of the 2025/2026 academic year. Data on practicality was obtained from questionnaires completed by two chemistry teachers and all students in Class XI F 2, with evaluation criteria including appeal, ease of use, suitability for learning, and benefits; the data was then analyzed using percentages (Purwanto, 2010). The practicality test indicated that the developed worksheet was considered very practical by teachers (93.13%) and practical by students (84%). These results suggest that the worksheet is easy to implement in classroom learning, supports teachers in facilitating Guided Discovery Learning activities, and enables students to participate actively in the learning process. The integration of ethnoscience and structured learning activities also contributes to the practicality of the worksheet by making learning more contextual and easier to follow.

In terms of ease of use, the worksheets received a score of 93% from teachers and 83% from students. The high score on the ease-of-use aspect indicates that the worksheet instructions, learning activities, and guiding questions were presented clearly and systematically, enabling both teachers and students to use the worksheet without difficulty. The Guided Discovery Learning syntax provides step-by-step guidance that helps students construct concepts independently, while the ethnoscience context makes the learning activities more familiar and easier to understand. These findings are consistent with Krisnawati & Cintamulya (2025) and Yusni & Supriatno (2023) who reported that clear and well-structured worksheets can enhance students' understanding, scientific process skills, and independent learning.

In terms of clarity, the worksheets received a score of 84% from students, indicating that the learning materials, illustrations, and instructions were presented clearly and were easy to understand. This result suggests that the worksheet successfully minimized students' confusion by providing systematic explanations, relevant examples, and guiding questions that facilitated concept construction throughout the learning process. Meanwhile, the learning suitability aspect obtained a score of 97% from teachers, indicating that the worksheet was well aligned with the CP, ATP, reaction rate content, and students' characteristics. This alignment ensures that the worksheet effectively supports the achievement of the intended learning objectives. These findings are consistent with Prastowo (2011), who emphasized that worksheets should be clear and communicative, and with Dezola et al. (2023) who highlighted the importance of aligning instructional materials with the curriculum and learners' characteristics.

In terms of attractiveness, the worksheets received a score of 90% from teachers and 84% from students. These results indicate that the visual appearance and learning design of the worksheets successfully attracted students' attention and increased their motivation to participate in learning activities. The use of attractive layouts, appropriate color combinations, relevant illustrations, and ethnoscience-based contexts created a more engaging learning experience and encouraged students to actively explore reaction rate concepts. These findings are consistent with Widodo et al. (2023) who reported that an engaging worksheet design can increase students' motivation and improve learning outcomes. Similarly, Wahyuni & Yerimadesi (2021) emphasized that effective visual presentation enhances students' interest and participation in learning.

In terms of usefulness, the worksheets received a score of 93% from teachers and 85% from students, indicating that they effectively support both teaching and learning activities. The worksheet assists teachers in facilitating the Guided Discovery Learning while helping students actively construct reaction rate concepts through structured guiding questions and contextual ethnoscience activities. As a result, students become more engaged in the learning process and develop greater independence in understanding scientific concepts. These findings are supported by (Nurfitriani et al., 2025) who reported that Guided Discovery Learning-based instructional materials can improve students' engagement, learning independence, and conceptual understanding.

Analysis of the Achievement of Learning Principles

In Table 6, the principle of meaningful learning is strongly evident in the motivation and problem-presentation stages, where all groups (9 groups) successfully linked the chemistry concept of reaction rate to the local phenomenon of cooking traditional Minangkabau rendang. Students were encouraged to observe why the physical changes in finely ground spices, pounded with a traditional mortar and pestle, produced a sharper

spice aroma compared to coarsely ground spices (representing the effect of surface area), and why using a high stove flame accelerated the cooking of the rendang meat compared to a low flame (representing the effect of temperature on reaction rate). This contextual ethnoscience approach shifts students' perception of chemistry from a subject involving the memorization of abstract formulas to a living science embedded within their own culture. This finding indicates that integrating ethnoscience into Guided Discovery Learning enables students to connect scientific concepts with their everyday experiences. Such contextual learning supports the principle of meaningful learning because students construct new knowledge by relating abstract chemical concepts to familiar cultural practices, resulting in deeper conceptual understanding.

The principles of mindful learning and joyful learning are closely reflected in students' active collaboration during the data collection, processing, and verification stages. The use of technology specifically, scanning barcodes to access video recordings of experiments facilitates joyful learning because students can visually observe microscopic phenomena together with their group members. The process of answering guiding questions and engaging in comprehensive discussions fosters students' critical thinking mindful as they independently build a foundation for the laws of reaction rate and order. This is consistent with the findings Yani & Yerimadesi (2023) which confirms that the implementation of the guided discovery model has proven effective in positioning students as active participants in constructing their own understanding through structured learning activities. These learning activities demonstrate that the developed worksheet not only promotes conceptual understanding but also encourages students to think critically, collaborate actively, and participate enthusiastically throughout the learning process. Therefore, the worksheet successfully supports the implementation of mindful learning, meaningful learning, and joyful learning as the core principles of deep learning.

Collaborative activities involving the exchange of ideas during group presentations also foster a supportive learning environment and help students develop social skills (Nainggolan & Purwaningsih, 2024). Thus, the implementation of LKPD has proven effective in creating a chemistry learning ecosystem that is interactive, contextual, enjoyable, and focused on deep conceptual understanding.

Overall, the findings indicate that the developed Guided Discovery Learning-based worksheet integrated with ethnoscience is not only valid and practical but also capable of supporting the implementation of deep learning principles in chemistry learning. The integration of Guided Discovery Learning, ethnoscience, and deep learning within a single worksheet represents the novelty of this study, providing students with structured, contextual, and meaningful learning experiences that encourage active knowledge construction and deeper conceptual understanding.

Despite the positive findings, this study has several limitations. First, the field trial involved students from only one class in a single senior high school, which may limit the generalizability of the findings. Second, this study focused only on evaluating the validity and practicality of the developed worksheet. Therefore, the effectiveness of the worksheet in improving students' learning outcomes, critical thinking skills, or deep learning achievement has not yet been examined. Future research is recommended to conduct large-scale implementation and effectiveness testing to further evaluate the impact of the developed worksheet on students' learning.

■ CONCLUSION

Based on the findings of this study, the Guided Discovery Learning-based reaction rate student worksheet integrated with ethnoscience was successfully developed through the Define, Design, and Develop stages of the 4D model. The developed worksheet demonstrated high validity and practicality, indicating that it is feasible for use as a supplementary learning material in senior high school chemistry learning. The integration of Guided Discovery Learning, ethnoscience, and deep learning principles provides students with contextual and structured learning experiences that have the potential to support meaningful, mindful, and joyful learning. Therefore, the developed worksheet may serve as an alternative instructional material to facilitate more contextual and student-centered chemistry learning. Future studies are recommended to examine its effectiveness in improving students' learning outcomes and deep learning achievement through wider implementation.

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