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Feasibility of Discovery Learning Based Student Worksheets on Acid-Base Materials to Practice Critical Thinking Skills

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Abstract
This study aims to evaluate the feasibility of using discovery learning-based student worksheets (LKPD) to foster CTS in the context of acid-base topics. The feasibility of the LKPD is assessed through three key criteria: validity, practicality, and effectiveness. The worksheets incorporate critical thinking skills (CTS) such as interpretation, evaluation, analysis, and inference, applied to understanding acid-base properties and strength. A one-group pretest-posttest design was used, involving 22 students from class XI-4 at SMAN 1 Kedamean, Gresik. Research instruments included response questionnaires, student activity observation sheets, and pretest-posttest assessments for CTS and cognitive learning outcomes. The results revealed the following: (1) Practicality was supported by student activity observations, with a higher proportion of relevant activities and 93.33% of students giving positive feedback, categorizing the LKPD as very practical. (2) The LKPD received a validity score of 4. (3) Effectiveness was demonstrated through pretest-posttest results, with 90.9% of students achieving classical completeness and an n-gain of 0.7 for critical thinking skills, rated as high. Based on these results, the discovery learning-based LKPD is considered feasible.

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INTRODUCTION

Chemistry is a field that uses scientific methods and experiments to explain various natural events about the composition, structure, properties, transformations, dynamics, and energy of substances. This discipline is used to solve various problems, both numerical and theoretical, as well as to develop rules, facts, descriptions, and terminology in this field (Yunitasari., et al, 2022. Chemistry is a science that is often considered difficult by students, thus negatively affecting their understanding and causing low learning outcomes (Lamalat et al., 2018).

Because chemical reactions are involved in nearly every material change, chemistry is always relevant to daily life. Acid base is one of the chemical substances that is frequently regarded as challenging and is present in daily life. A small example of the application of acids and bases in everyday life is gastric acid disease which can be treated with alkaline stomach medicine. Students will struggle to understand later content if they don't have a solid comprehension of this idea. Thus, it is imperative to have a thorough understanding of acid-base (Setiadi et al., 2019). Learning chemistry, particularly acid-base topics, can be achieved by linking the concepts students have mastered with the phenomena being explored (Fatmawati et al., 2023). Skills like collaboration, critical thinking, creative problem-solving, communication, community involvement, and character building are crucial for the 21st century (Mardhiyah et al., 2021). As stated in Regulation No. 21 of 2016 by the Indonesian Minister of Education and

Culture, students are required to develop skills in thinking and acting, beyond just memorizing facts.

To enhance 21st-century education, learning media that support student engagement in the learning process are essential. One commonly used tool to guide and assist students in their learning activities is the Learner Worksheet (LKPD). Student worksheets are essential in supporting the learning process, helping learners grasp the material being taught especially experimental content. Therefore, media guidelines are necessary to direct the flow of the practicum (Muna & Rusmini, 2021). The development of LKPD is based on the criteria proposed by Nieveen (1999), which include validity, effectiveness, and practicality.

According to Darmodjo and Kaligis explained that LKPD is said to be of good quality if it meets the didactic requirements which means that LKPD must follow the principles of effective teaching and learning, constructional requirements relating to language use, sentence structure, vocabulary, and clarity must be appropriate such as examples of using language that is appropriate for students, simple sentences, clear sentence structure and technical requirements relating to the appearance of LKPD content such as examples of using appropriate writing or fonts, images can convey the content of LKPD, and attractive LKPD appearance (Sanjaya, et al. 2017).

Interviews conducted by researchers at SMAN 1 Kedamean, Gresik, East Java, on February 5, 2024, with a chemistry teacher revealed that the current LKPD only contains material summaries and practice questions, without addressing students' CTS. One of the experts who studied Critical Thinking Skills (CTS) is Facione. According to Facione (2015), it consists of six skills: interpretation, analysis, inference, explanation, evaluation, and self-regulation. Examining, connecting, and assessing every aspect of a problem can improve CTS. Critical thinking involves reflection and analytics (Destini et al., 2022). Critical thinking skills involve a structured and intentional approach that helps learners cultivate mental processes, such as evaluating assumptions, asking relevant questions, identifying implications, and reflecting on or debating various issues (Fisher, 2011)

According to the findings of pre-research observations made on February 5, 2024 at SMAN 1 Kedamean, Gresik, East Java, with 33 students serving as respondents, there is still a deficiency in the students' CTS abilities in the areas of interpretation, analysis, evaluation, and inference. Based on the results of the initial CTS pre-research test, the percentage of CTS in the interpretation indicator was 24%, in the analysis indicator was 24%, in the evaluation indicator was 63%, and in the inference indicator was 34%. Meanwhile, based on interviews, chemistry teachers said that students' CTS were still lacking, in addition to the teaching method being centered on the teacher, it was also because many students did not understand the basic concept of acid-base material.

To improve students' CTS, appropriate LKPD is needed, namely LKPD that refers to the Discovery Learning model. Pristiyono (2021) suggests that the discovery learning model is one approach that actively engages students in the learning process. This model offers opportunities for students to discover concepts independently during learning. Moreover, an effective learning model should always create opportunities for students to engage meaningfully in the learning experience (Februanti et al., 2023)

For teachers to act as facilitators in the learning process, the Discovery Learning model encourages students to be critical, creative, and independent in their pursuit of knowledge (Sunarto and Amalia, 2022). The Discovery Learning model is very helpful for improving CTS because the learning model can help students find concepts through experiments and their own learning outcomes that are in accordance with Jerome Brunner's theory.

Therefore, this study aims to obtain an LKPD that is suitable for use in learning that focuses on improving critical thinking skills in accordance with 21st century expectations which emphasize that students have several skills, while through discovery learning, students typically develop analytical thinking skills and learn to address the challenges they encounter on their own.

METHOD

This research aims to develop a Discovery Learning-based LKPD designed to improve the critical thinking skills (CTS) of 11th-grade students on acid-base material, with the goal of producing a viable and effective LKPD. This research uses the 4D model introduced by Thiagarajan and Semmel in 1974, which includes four main stages. The stages of the 4D model are described as follows: The definition stage has five steps, the design stage has four steps, the development stage has three steps. This study was limited to the development stage of the research process.The following is a chart that illustrates the research procedure for developing discovery learning-based student worksheets

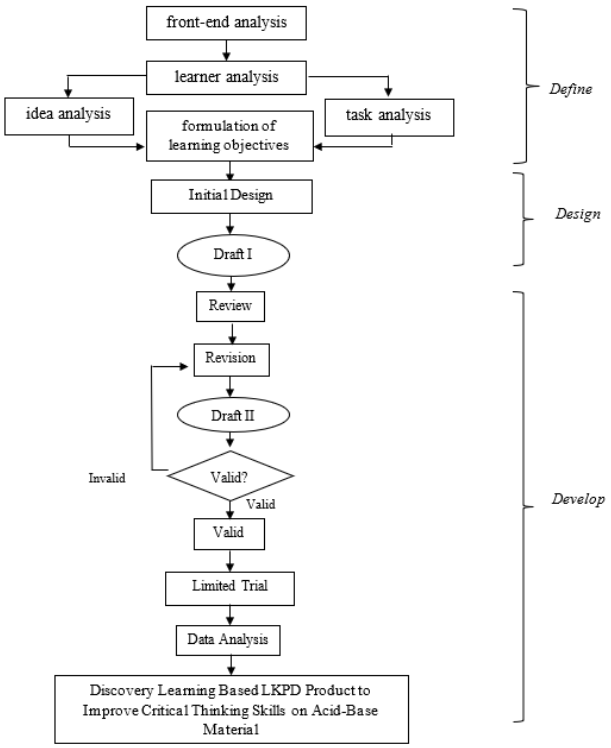

Figure 1. 4D Development Flowchart
Based on the 4D Development Model as outlined by Thiagarajan (Ibrahim, 2014)

This study employed a trial design using a one-group pretest-posttest method (Sugiyono, 2012)

O_1 x O_2

Figure 2. One Group Pretest Posttest Design.

Identifying:

X : The treatment of using Discovery-based LKPD Learning.
O_1 : Pretest
O_2 : Posttest

The instruments used were (1) review sheet, (2) validation sheet, (3) student response questionnaire, (4) student activity observation sheet, (5) cognitive learning outcomes pretest-posttest sheet, (6) CTS pretest-posttest sheet. There are 3 methods used, namely questionnaire, test and observation methods. The questionnaire method given is a review questionnaire, validation and student response. The LKPD validation sheet consisting of content and construct validity sheets was given to 3 validators. The review questionnaire was given to chemistry lecturers to get suggestions and improvements. The assessment used is a test of cognitive learning outcomes and pretest and posttest of CTS. The observation method was utilized to collect data on student participation and activities during the learning process, using an observation sheet completed by three observers. There were 22 students who took part in the series of trials conducted.

The validity of LKPD is assessed based on content validity and construct validity such as the design used in LKPD, the suitability of the material with learning objectives, the suitability of LKPD with CTS indicators (interpretation, analysis, evaluation and inference), the suitability of LKPD with the learning model used.

Validation

The purpose of validation is to gather expert evaluations, which serve as the foundation for revisions if any errors are identified in the initial design of the developed LKPD. The validation focuses on assessing content and construct validity.The validation data obtained will be analyzed using the Likert Scale.

The validation sheet besides being used for LKPD is also used to assess other supporting instruments including response questionnaire sheet instruments, observation of student activities, pretest posttest sheets of learning outcomes and pretest posttest sheets of critical thinking skills

Table 1. Likert Scale Validity

Evaluation	Scale Value
Invalid	1
Less Valid	2
Quite Valid	3
Valid	4
Very Valid	5

Validation data generated by the validator will be analyzed with median statistics. The developed LKPD can be said to be valid if the median ≥ 4 with valid criteria or assessment.

Practicality

Practicality analysis data is taken from activity observation sheets and student response questionnaires. Questionnaire data analysis is calculated using the formula

$$\text{Positive response (\%)} = \frac{\sum positive\ response\ to\ each\ item\ obtained}{\sum positive\ response\ to\ items} \text{ x } 100\%$$

To evaluate the practicality of the developed LKPD, data from the student response questionnaire is supported by the study of practical data from observation outcomes of activities. The analysis of observation data is calculated using the formula

$$\text{Student Activity (\%)} = \frac{\sum activities\ carried\ out}{\sum overall\ activity} \text{ x } 100\%$$

The analysis of student activity observations and questionnaire responses yielded percentages that will be translated into scores as follows.:

Table 2. Interpretation of Scores

Percentage (%)	Category
0-20	Impractical
21-40	Less practical
41-60	Quite Practical
61-80	Practical
81-100	Very Practical

Student activities are considered effective if the percentage of relevant activities is ≥61%. Similarly, the LKPD is deemed practical if the questionnaire responses show a result of ≥61%.

Effectiveness

Learning outcome data analysis is used to see the mastery of the material by students. The learning outcome completion value must be ≥75 and obtain classical completion of ≥75%. The analysis is conducted by examining the pretest and posttest result sheets. The data for individual student learning achievement and overall class completion are calculated using the following formula:

$$\text{Learning outcomes} = \frac{score\ obtained}{score\ max} \times 100$$

N-Gain was used to analyze students' CTS based on the pre- and post-test results. N-gain reflects the score improvement achieved during the test in comparison to the maximum possible score. The results are then analyzed using the N-Gain score, as outlined by Hake (1999). The LKPD is considered feasible if the n-gain value is ≥ 0.3, indicating either moderate or high improvement (Hake, 1999). The classification of n-gain is presented in Table 3.

Table 3. n-Gain Score Improvement Categories

Gain Score	Category
≥0.7	Tall
0.7 > g ≥ 0.3	Currently
<0.3	Low

RESULTS AND DISCUSSION

Thiagarajan's 4D design methodology, which has four stages was used to perform the research. This study solely looks at the testing or development phase. The following are the results and discussion.

Define

The define stage is a key phase consisting of five steps. This stage was carried out during preliminary research at SMAN 1 Kedamean. Front-end analysis step identifies the problems that need to be addressed for developing the LKPD. Learner analysis step focuses on understanding student characteristics, such as their critical thinking skills (CTS) and cognitive abilities, which are still relatively low.

Concept analysis step identifies the core concepts of the acid-base material used in the LKPD development. Task analysis step examines the tasks assigned during learning, emphasizing interpretation, analysis, evaluation, and inference questions. Finally, the analysis of learning objectives step determines the goals that serve as the foundation for designing the LKPD..

Design

The design phase is the second step, focused on creating Discovery Learning-based LKPD aimed at enhancing critical thinking skills. This phase involves four main steps: preparing tests, choosing appropriate media, selecting the format, and drafting the initial LKPD design.. In this study, the LKPD developed consists of two types, namely acid-base properties LKPD and acid-base strength. The developed LKPD is divided into three sections: introduction, content, and conclusion. The introduction includes the cover, learning outcomes, learning objectives, and usage instructions. The content section features learning activities, questions, and experimental procedures. The conclusion contains the bibliography..

(a) (b)

Figure 3. (a) acid-base properties LKPD; (b) acid-base strength.LKPD

Discovery learning-based LKPD is used to improve students' skills by discovering concepts independently. the activities on this LKPD begin with students observing and understanding phenomena that are in accordance with the first syntax of discovery learning (stimulation), students identify problems and formulate problems that are in accordance with the second syntax of discovery learning (problem statement), students collect data through literature sources, the internet and practicums that have been adapted to the third syntax of discovery learning (data collection), students collect data through literature sources, the internet and practicum that have been adapted to the third syntax of discovery learning. Students analyze and fill in the observation table after carrying out the practicum which in the LKPD has been adjusted to the fourth syntax of discovery learning (data processing), students answer questions as proof of the concept found in the fifth syntax of discovery learning (verification) and students make conclusions in the sixth syntax of discovery learning (generalization)

Develop

The develop stage is the third phase of the 4D model, focused on creating LKPD learning materials. This phase includes (1) review and revision by chemistry lecturers to gather feedback and suggestions, (2) validation by three validators to evaluate the developed LKPD, and (3) limited trials involving students.

On the research conducted, the feasibility of the LKPD was assessed through three key aspects: validity, effectiveness, and practicality.

Validity

The eligibility criteria of the developed LKPD are assessed based on the content and construct criteria using median analysis. LKPD is said to be valid if the median value is ≥4 with valid or very valid criteria.

The validity results data can be seen in Table 4 below.

Table 4. LKPD Validity Results

Rated aspect	LKPD 1	LKPD 2
Validity of Content	4	4
Validity of Presentation Construct	4	4
Validity of Linguistic Constructs	4	4
Validity of Graphical Constructs	4	4

According to Table 4, LKPD 1 and 2 received a median score of 4, indicating they fall within the valid category for both content and construct validity. If the median score of the LKPD is below 4, revisions and revalidation are made until the required standard is reached. The validation process was conducted by three validators, they are lectures and a teacher from SMAN 1 Kedamean Gresik, with a focus on assessing content and construct validity. The development criteria for the LKPD were based on Nieveen's (1999) framework, which includes: 1) validity, where the LKPD is deemed appropriate for use, evaluated through content and construct validity; 2) effectiveness, measured by critical thinking skills (CTS) and learning outcomes; and 3) practicality, determined by students' feedback through questionnaires and observation sheets of student activities. This aligns with the Ministry of National Education's (2008) requirement that LKPD must meet the criteria for achieving essential skills that students need to understand.

Practicality

The practicality of the LKPD is determined through the results of questionnaires and observations of student activities. Student activities are considered to be conducted effectively if relevant activities is ≥61%. Likewise, the LKPD is regarded as practical if the questionnaire response results show a percentage of ≥61%.

Observation of Student Activities

The student observation sheet was handed out to three observers during the learning process, and the questionnaire was administered to students after they had used the developed LKPD. The data gathered from observing student activities are shown in Table 5 below.

Table 5. Results of Observations of Student Activities

Observed activities	Meeting 1	Meeting 2
Relevant Activities	83.89%	84.46%
Irrelevant Activities	16.11%	15.56%

As shown in Table 5, the observation results reveal that the percentage of relevant student activities was 83.89% and 84.46%, indicating that relevant activities were more frequent than irrelevant ones. The overall practicality percentage obtained from the observation results was 84.17% of the total time during the two meetings using the Acid Base Properties LKPD and the Acid Base Strength LKPD. Observation activities of student activities were carried out during two meetings using the Acid-Base Properties LKPD at meeting 1 and the Acid-Base Strength LKPD at meeting 2. The learning carried out used the learning model *Discovery Learning.* This means that student activities can be carried out well with a relevant activities ≥61% than irrelevant activities. In accordance with research according to Mukmainah &

Yonata (2020) that student activities can be said to be carried out well in improving CTS if the results of the percentage of relevant activities obtained are greater than irrelevant activities.

Student Response Questionnaire

The practicality of LKPD is also known from the results of the response questionnaire sheet given after students do learning by using LKPD which aims to determine the practicality of LKPD through student responses. Table 6 below contains the information gathered from the student answer questionnaire sheets.

Table 6. Results of Student Response Questionnaire Sheet

Observed Aspects	Percentage
The Attraction of LKPD	93.93%
Ease of Learning Activities	92.92%

The types of questions used in the response questionnaire are negative and positive questions. Based on the data that has been obtained, it can be seen that the developed LKPD is said to be feasible when viewed in terms of practicality with an average percentage of ≥ 61%. As shown in Table 6, the response questionnaire results indicate that the LKPD's attractiveness received a percentage of 93.93%, while the ease of learning activities aspect scored 92.92%. The overall practicality percentage of positive student responses obtained was 93.33%. Based on the practicality percentage results in Table 6, the response questionnaire results can be said to be practical.

Effective

If there is a rise in the CTS test findings and cognitive learning outcomes, the produced LKPD is considered effective. The pretest and posttest findings, which will be examined using n-Gain and classical completeness, provide information about the increase in test results. Before implementing LKPD based on Discovery Learning, the pretest is utilized to ascertain the students' starting skill levels. The posttest, which is based on Discovery Learning and uses LKPD, is used to assess students' final competencies.

Critical Thinking Skills (CTS)

The elements of CTS that applied are analysis, evaluation, inference, and interpretation. The only purpose of interpretation is to precisely record what is understood or being requested in order to comprehend the problem. Analytical abilities include figuring out the right interpretation and the relationships between concepts and questions. Evaluation indicators support students in making sense-based judgments about the connections among concepts, descriptions, and claims. The ability to recognize and extract the components required to draw reliable inferences is referred to as inference. The pretest and posttest findings, which will be examined using n-Gain, show how the CTS test results have improved. Table 7 below lists the outcomes of the pretest and posttest data.

Table 7. Results of Pretest and Posttest of Students' CTS

Name	Score		*n-Gain*	Category
	Pretest	*Posttest*		
PD 1	46	100	1	Tall
PD 2	60	86	0.6	Currently
PD 3	20	100	1	Tall
PD 4	26	80	0.7	Tall
PD 5	40	86	0.7	Tall
PD 6	53	93	0.8	Tall
PD 7	33	80	0.7	Tall
PD 8	53	93	0.8	Tall

Name	Score		*n-Gain*	Category
	Pretest	***Posttest***		
PD 9	46	100	1	Tall
PD 10	53	80	0.5	Currently
PD 11	46	100	1	Tall
PD 12	33	73	0.6	Currently
PD 13	53	100	1	Tall
PD 14	13	66	0.6	Currently
PD 15	6	86	0.8	Tall
PD 16	46	80	0.6	Currently
PD 17	40	86	0.7	Tall
PD 18	53	100	0.7	Tall
PD 19	13	80	0.7	Tall
PD 20	53	86	0.7	Tall
PD 21	53	100	1	Tall
PD 22	33	66	0.5	Currently
	***n-Gain*Score**		0.7	Tall

Six students had n-gain scores in the moderate group, while sixteen students received n-gain scores in the high category, according to the results of the above table. If the n-gain score is interpreted as ng ≥ 0.7 in the high group or as 0.7 > g ≥ 0.3, then LKPD is considered effective (Hake, 1999). With an n-gain score in the range of 0.5-1 and a medium to high category, the created LKPD can be deemed practical based on the pretest and posttest findings shown in Table 7.

Working through the questions provided both before and after utilizing the LKPD based on Discovery Learning allowed researchers to compile information on the CTS results of the students. The assessment criteria used to assess the LKPD use assessment indicator criteria made by the developer. LKPD assessment gets maximum results if the scores obtained in one experimental group match all the assessment indicator criteria made.

The LKPD was developed using the following CTS indicators: interpretation, analysis, evaluation, and inference. LKPD was utilized to educate critical thinking skills (CTS). The LKPD designed syntax has been modified to align with the critical thinking skills (CTS) indicators that are being taught. Students do better in the medium to high group, according to the n-Gain values of each indicator. According to Zakiyah and Yonata's research from 2021, the LKPD produced a method that yielded an n-Gain score with a medium to high description, indicating its effectiveness. Sucipto (2018) claims that because the Discovery Learning learning model encourages students to enhance their learning process through critical thinking, it can enhance critical thinking abilities and learning results.

Classical Completion

Cognitive learning results are measured using classical completeness for both the pretest and posttest. SMAN 1 Kedamean, Gresik sets a value of ≥75, and a value of that kind indicates that learning outcomes are complete. These are the outcomes. Table 8 lists the Pretest and Posttest of Cognitive Learning Outcomes.

Table 8. Results of the Pretest and Posttest of Cognitive Learning Outcomes

Name	Score			
	Pretest	**Completeness**	**Posttest**	**Completeness**
PD 1	70	Not Completed	100	Completed
PD 2	60	Not Completed	90	Completed
PD 3	50	Not Completed	80	Completed

PD 4	50	Not Completed	80	Completed
PD 5	80	Completed	80	Completed
PD 6	60	Not Completed	80	Completed
PD 7	70	Not Completed	90	Completed
PD 8	60	Not Completed	80	Completed
PD 9	80	Completed	100	Completed
PD 10	70	Not Completed	70	Not Completed
PD 11	80	Completed	80	Completed
PD 12	40	Not Completed	80	Completed
PD 13	60	Not Completed	90	Completed
PD 14	60	Not Completed	100	Completed
PD 15	50	Not Completed	90	Completed
PD 16	80	Completed	80	Completed
PD 17	50	Not Completed	90	Completed
PD 18	70	Not Completed	80	Completed
PD 19	30	Not Completed	80	Completed
PD 20	70	Not Completed	90	Completed
PD 21	50	Not Completed	80	Completed
PD 22	60	Not Completed	70	Not Completed

The results of the cognitive learning test, when analyzed using classical completeness, produced the following results.

$$\text{(\%) classical completeness = KB = x 100\%}\frac{number\ of\ students\ completed}{number\ of\ student}$$

$$= \frac{20}{22}\text{x 100\% = 90.9\%}$$

From the calculation above, it is known that classical completeness gets a percentage of 90.9%. These results indicate that LKPD media is said to be effective in training students' CTS.

Learning media developed based on discovery learning has an important role in improving learning outcomes, critical thinking skills and can motivate students to learn based on response questionnaire data. This is in accordance with relevant previous studies where the feasibility of the LKPD obtained shows that the LKPD is effective in improving students' critical thinking skills. Therefore, based on the results of the analysis obtained, the discovery learning-based LKPD developed by researchers can be said to be practical, valid and effective.

CONCLUSION

Based on the analysis and discussion of the research, the LKPD based on Discovery Learning to develop CTS in acid-base material is considered feasible. In terms of validity, it achieved a median value of 4. Its practicality was demonstrated by a 93.33% positive response from the questionnaire and 84.17% from student activity observations. The effectiveness was shown through an n-gain of 0.7 for CTS and a 90.9% success rate in the classical completeness test of cognitive learning outcomes.

RECOMMENDATIONS

There is a need to expand the research with more research subjects because the creation of LKPD based on Discovery Learning on acid-base material was done with a small number of research subjects.

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