JURNAL EDUSCIENCE (JES)
p-ISSN : 2303 - 355X | e-ISSN : 2685 - 2217
PUBLISHED BY : LPPM of UNIVERSITAS LABUHANBATU

E-LAPD Based on Problem Based Learning to Improve Students' Critical Thinking Skills

Siti Andini Ajeng Pramesti[1], Bertha Yonata[2*]

[1,2]Department of Chemistry Education, Faculty of Mathematics and Science, Universitas Negeri Surabaya, Surabaya, Indonesia
*Email: berthayonata@unesa.ac.id

ARTICLE INFO

Keywords:
Student Worksheet Activity
Electronic
Critical Thinking Skills
Problem Based Learning
Reaction Rate

ABSTRACT

Purpose – Development of E-LAPD based on Problem-Based Learning to improve students' critical thinking skills on reaction rate material, where E-LAPD (Electronic-Learning Activity Problem Discussion) is a digital learning tool designed to guide students through problem-based activities and discussion, which is said to be valid, practical, and effective.

Methodology – This research is quantitative research using the ADDIE research development model. Data were collected from validation data, student questionnaire sheets, observation sheets, and pretest and posttest question sheets. Then the validation data was analyzed with a Likert scale to test validity, student questionnaire sheets and observation sheets to test practicality, and pretest and posttest question sheets were analyzed using N-Gain to test effectiveness.

Findings – The results of the research in the form of E-LAPD based on problem-based learning to improve students' critical thinking skills on reaction rate material in class XI SMA are feasible to use because they meet the valid criteria with an average score of content and construct validation of 4 with a good category. The developed E-LAPD is declared practical in terms of the results of student response questionnaires and observation sheets, with a percentage of 97.81%. The E-LAPD developed can be declared effective in training students' critical thinking skills based on the analysis of the N-Gain test results with a result of 0.90 in the high category, so it can be said that there is an increase in scores between before and after the use of E-LAPD.

Contribution – Innovation in developing learning media, namely electronic student activity sheets based on problem-based learning, to improve students' critical thinking skills in class XI high school reaction rate material.

Received 29 January 2025; Received in revised form 10 February 2025; Accepted 12 June 2025
Jurnal Eduscience (JES) Volume 12 No. 3 (2025)
Available online xx June 2025

INTRODUCTION

Chemistry learning is part of natural science education, characterized by applying the scientific method. In this process, students are expected to develop experiences from formulating problems, making hypotheses, designing experiments, testing hypotheses, collecting and processing data, and communicating results. One of the chemistry topics closely related to the application of the scientific method is reaction rate, where students are invited to observe natural phenomena occurring in daily life (Roestiyah N.K., 1985). To successfully carry out these processes, students must have critical thinking skills (Eva Ervia et al., 2024)s. However, in reality, the results of a preliminary study conducted in April 2024 at a high school in Sidoarjo showed that students' critical thinking skills were still relatively low, particularly in the indicators of interpretation (57%), evaluation (59%), inference (53%), explanation (42%), and self-regulation (55%).

This is in line with the research by Ma'rufah and Wisanti (Ma'rufah Siti & Wisanti, 2023), which found that among 56 students, the percentage of critical thinking skills in the indicators of analysis, explanation, and interpretation was still in the very low category. Other studies by Rusmansyah (Rusmansyah, Leny Yuanita, Muslimin Ibrahim, and Isnawati, 2019) and Mardiyanti (Haryani Sri Mardiyanti, 2020) also reported similar results. This finding is supported by Şendağ and Odabaşı (Şendağ, Serkan; Odabaşı, 2009), who stated that students' critical thinking skills tend to remain low when the learning process does not involve meaningful problem-solving activities in real and contextual situations.

Based on these findings, a learning model that can stimulate students' critical thinking skills is needed. One of the appropriate models is Problem-Based Learning (PBL). This student-centered model emphasizes the integration of theory and practice while facilitating students to solve real-world problems relevant to everyday life (Meilasari et al., 2020). PBL has been proven to improve students' critical thinking skills by encouraging them to actively engage, reflect critically, and work collaboratively in problem-solving activities (Loyens, S. M. M.; Kirschner, P. A.; Paas, 2012). Through this approach, students are expected to analyze, design, conduct, and conclude experimental results independently with guidance from teachers. Several studies (Mustika, R., 2014) have also demonstrated that applying PBL can enhance students' critical thinking skills, especially in reaction rate material.

In addition to learning models, learning media also play an essential role in supporting the teaching and learning process. One promising learning medium is the Electronic-Learning Activity Problem Discussion (E-LAPD), a digitally based student activity sheet designed to facilitate students in problem-based learning activities. The E-LAPD contains discussions, problem-solving tasks, and virtual or real experiments arranged according to the PBL syntax. Research by Saputra and Sunu (Setiawan Aji Saputra, 2019) showed that the development of PBL-based LAPD effectively improved students' critical thinking skills, achieving 90.63% on learning indicators and 87.5% in learning outcomes. Combining PBL and digital media like E-LAPD enables students to think more actively, engage in discussions, and collaborate in solving real-life problems. Therefore, developing E-LAPD based on PBL is a relevant and potential solution for implementing reaction rate material.

This study is motivated by the need for instructional media to enhance students' critical thinking skills in reaction rate topics, which are often perceived as abstract and complex. By developing the E-LAPD (Electronic Learning Activity Problem Discussion) based on *Problem-Based Learning* (PBL), this research aims to produce an interactive and feasible digital learning tool that effectively engages students in critical thinking through contextual problem-solving. The novelty of this study lies in integrating the PBL approach into a digital platform designed explicitly for reaction rate material, supporting active, independent, and collaborative learning while addressing the limitations of existing learning media. Based on the background presented, the research question can be formulated as follows: "How does developing E-LAPD based on Problem-Based Learning (PBL) improve students' critical thinking skills in reaction rate material for high school students?"

METHODOLOGY

Research Design

This research uses the ADDIE development model, which consists of five systematic stages: Analyze, Design, Development, Implementation, and Evaluation. All stages in this model are carried out step-by-step and structured to produce a valid, practical, and effective electronic learning media in the form of an E-LAPD based on Problem-Based Learning (PBL). In the analysis stage, the researcher conducts a literature review to examine relevant theories and previous research related to learning media development. A field study is also conducted to identify students' learning needs and the challenges faced in the classroom. The results of this analysis are used as the basis for designing learning media that align with these needs.

The next stage is the design stage, where the initial design of the E-LAPD based on PBL is created, including steps such as determining the content, organizing the sequence of the material, designing student activities based on the PBL syntax, and structuring the layout and interface of the E-LAPD media. The initial design is then reviewed by an expert (chemistry lecturer) to ensure it aligns with the learning objectives and the needs of the students. In the development stage, the researcher creates the initial product of the E-LAPD based on the refined design. This product then undergoes validation by three evaluators, including two chemistry lecturers and one chemistry teacher, who assess the appropriateness of the content, language, presentation, and graphics. Revisions are made based on the feedback from the evaluators.

Once the product is validated and revised, the implementation stage takes place, involving a limited trial in high school students to assess the practicality and effectiveness of the media. The implementation involves students directly in the learning process using the PBL-based E-LAPD. Practicality is assessed based on teacher and student feedback regarding the use of the media. At the same time, effectiveness is measured by improving students' critical thinking skills before and after the lesson. Finally, in the evaluation stage, an analysis is conducted on the implementation results to determine how well the developed E-LAPD media achieved the learning objectives and improved students' critical thinking skills. This evaluation is both formative and summative, serving as the basis for refining the media and as evidence of the effectiveness of using E-LAPD in the learning process.

Participants

The participants in this study were 33 11th-grade students from a public high school in Sidoarjo, selected using purposive sampling. The selection was based on criteria such as interest in chemistry, academic performance, and willingness to participate. The school is a well-established public institution with a diverse student body. The students represented a range of characteristics: some were highly interested in chemistry, while others showed less interest. This diversity is important for evaluating the effectiveness of the E-LAPD media across different levels of student engagement. Purposive sampling was chosen to ensure a mix of students with varying interests and abilities in chemistry, allowing for a comprehensive assessment of the media's impact. The diversity of the participants enhances the transferability of the findings to similar educational contexts.

Data Collection

Interviews

Interviews were conducted before pre-research activities were carried out to analyze needs and collect data and information that could be used to identify the actual situation that occurred in the field. Interviews were conducted with one chemistry teacher who teaches at the school so that we could know what needs and problems students face when learning activities are carried out. From the interview activities, we will learn about students' needs and problems. From the interview data, we can develop E-LAPD according to the needs.

E-LAPD Validation

E-LAPD validation was used to collect validity data from the E-LAPD, which was developed based on the assessment by two chemistry lecturers and one chemistry teacher. E-LAPD validation was carried out before the trial activities were carried out. E-LAPD validation was used to determine the feasibility of the

development of E-LAPD. The assessment was carried out based on content and construct validity criteria. The content validation assessment criteria include content feasibility components, namely material coverage, material accuracy, and skill dimensions in E-LAPD. Construct validity assessment criteria, which include presentation components and language components. The presentation component includes presentation techniques, supporting material presentation, learning presentation, and presentation completeness. The linguistic component includes the suitability of language with the development of students, readability, motivational ability, and the sequence of thought flow.

Student Response Questionnaire

The learner response questionnaire was used to determine students' opinions after using the developed E-LAPD. The student response questionnaire sheet was given after the trial was conducted. The student response questionnaire consists of 11 statements that students must answer with "Yes" or "No." Learners can provide answers based on their experiences after participating in learning activities using E-LAPD. The learner response questionnaire data is used to determine the practicality of E-LAPD.

Observation of Learner Activity

Student activity is observed to determine students' activity through field observations. Three observers carried out the observations, recording student activity data with student activity observation sheets. This is done to support data on the practicality of E-LAPD. The student activity observation sheet was filled out during learning activities or a limited trial.

Critical Thinking Skills Tests

Critical thinking skills tests are used to obtain quantitative data in the form of test scores as student learning outcomes. In this test method, pretests and posttests are used to measure students' knowledge and critical thinking skills. The pretest is conducted before learning activities using the developed E-LAPD, while the posttest is conducted after learning activities using the developed E-LAPD. The pretest and posttest results will then be calculated using the n-gain score to see the improvement rate between before and after treatment. To assess students' critical thinking skills, a test instrument was developed based on critical thinking skill indicators proposed by Facione (Peter A. Facione, 2013), which include interpretation, analysis, evaluation, inference, explanation, and self-regulation. The instrument consists of multiple-choice and short essay items to measure students' abilities in these areas.

Table 1. Grid of Test Questions

Critical Thinking Indicator	Description of Skill Measured	Items	Item Type
Interpretation	Identifying and understanding information accurately	1, 2, 3, 4	Essay
Analysis	Breaking down relation between ideas or concepts	5	Essay
Explanation	Explain the relation between the manipulation variable and the response variable in the experiment	6	Essay
Evaluation	Evaluate the relation between the concept and the experiment	7	Essay
Inference	Find conclusions from the experiments that have been carried out	8	Essay
Self-Regulation	Reflecting on and revising one’s own thinking process	9	Statement

Data Analysis

Data from validating E-LAPD based on problem-based learning to improve students' critical thinking skills on reaction rate material were analyzed descriptively and quantitatively. The validity assessment consists of content and construct validation based on calculating the assessment score criteria using a Likert scale, as in the following table.

Table 2. Likert Scale

Statement	Score
Very Good	5
Good	4
Enough	3
Not Good	2
Very Not Good	1

Adapted (Riduwan, 2018)

The research data were analyzed on each indicator using the median because the validation score data is included in the ordinal scale, so mathematical operations cannot be performed on the data. Therefore, the validation score is analyzed quantitatively on each indicator to avoid chaotic data distribution (Thomas M. Haladyna & Michael C. Rodriguez, 2013). Median is the middle value of a data set, or can also be referred to as the middle value. Therefore, if the E-LAPD developed is valid, if the score is more than equal to 3, if the score obtained is less than 3 (for example, getting a score of 1 or 2), then the media will be revised. The results of this validation analysis are used to determine the validity of E-LAPD's feasibility.

The practicality assessment of E-LAPD was obtained through the results of the learner response questionnaire related to its ease of use. The percentage of learner response questionnaire data was analyzed based on the Guttman scale. The Guttman scale measures the firmness of an answer with a "Yes" or "No" statement. The highest score is one, and the lowest score is zero. The calculation of the Guttman scale can be seen in the following table.

Table 3. Guttman Scale

Answer	Negative statement score	Positive statement score
Yes	0	1
No	1	0

(Riduwan, 2018)

Calculation of the percentage of data obtained with the formula:

$$\text{Practicality } (\%) = \frac{Score\ Number}{Maximum\ Score} \text{ x } 100\%$$

If the percentage of research results ≥ 61% is obtained, then the developed e-LAPD is said to be practical. Data analysis of student activity observation results is used to support the results of the student response questionnaire. This analysis is based on observations made by 3 observers. Each observer observed 1 group containing 5 students per group. Then the observer fills in the results of his observations on the observation sheet of the activities of the students observed with an interval of 3 minutes. The data from the observation of students' activities are processed into a percentage of students' activities which are calculated using the following formula:

$$\%\ \text{Learning Activity} = \frac{\sum The\ frequency\ of\ protege\ activity\ is\ emerging}{\sum Overall\ frequency\ of\ activity} \times 100$$

The results of the observation percentage are used to determine the practicality of PBL-based E-LAPD. This is done to support data on the results of media practicality. If the percentage of relevant activities ≥ 61% is obtained, then the e-LAPD developed has practical criteria. Analysis of test data from pretest and posttest test sheets. The pretest is given before learning activities using E-LAPD to determine the initial knowledge of

students while the posttest is given after learning activities using E-LAPD to determine the level of understanding of students and measure the effectiveness of the use of E-LAPD developed. Data criteria analysis of knowledge learning outcomes before and after applying the PBL learning model to improve critical thinking skills is by calculating the difference in the average score of pretest and posttest scores. The data of students' test results were analyzed descriptively quantitatively using N-Gain analysis.

$$n - gain\ score = \frac{posttest\ score - pretest\ score}{maximum\ score - pretest\ score}$$

Furthermore, the results of the calculation of the n - gain score are interpreted in the criteria which can be seen in the following table.

Table 4. N-Gain Score Criteria

Value Range	Category
$G \geq 0,7$	High
$0,3 \leq G < 0,7$	Medium
$G < 0,3$	Low

(Richard R. Hake, 1999)

Based on these criteria, E-LAPD can be declared effective if an increase in the N-Gain score of more than 0.3 is obtained so that it falls into the medium or high category.

Table 5. Score Interpretation

Presentation (%)	Criteria
0-20	Very not good
21-40	Not good
41-60	Enough good
61-80	Good
81-100	Very good

Based on Table 5, interactive videos are said to be practical to very practical if the practicality percentage is ≥61%.

Product effectiveness, namely in reality (operation) providing results according to expectations. The expected results in the form of impacts due to the product being developed can be learning results, motivation, activities during use, interest, and other special skill (Lutfi, 2021). Data Analysis of the PBL-based E-LAPD Effectiveness using SPSS and interpretation of N-gain scores to measure the improvement of learning results. The initial stage of the effectiveness test with SPSS is to to test data normality that must be carried out before carrying out data analysis which aimed at determining whether the distribution of the data produced is normal or not.

To find out the truth of the hypothesis, the Wilcoxon Test can be interpreted as follows. The results seen in the SPSS output are Asymp. Sig. (2-tailed):

- If p(sig) < 0.05 → H_0 is rejected → There is a significant difference between pretest and posttest.
- If p(sig) > 0.05 → H_0 is can't be rejected → There is no significant difference between pretest and posttest

The PBL-based E-LAPD Effectiveness Data Analysis uses N-gain score interpretation to measure the improvement of learning outcomes which can also be used as data in the E-LAPD effectiveness test. The improvement of students' learning outcomes can be calculated using the following formula:

$$(g) = \frac{(Sposttest - Spretest)}{(Smaks - Spretest)}$$

FINDINGS

This research is a type of quantitative research with the ADDIE development model, with the following steps:

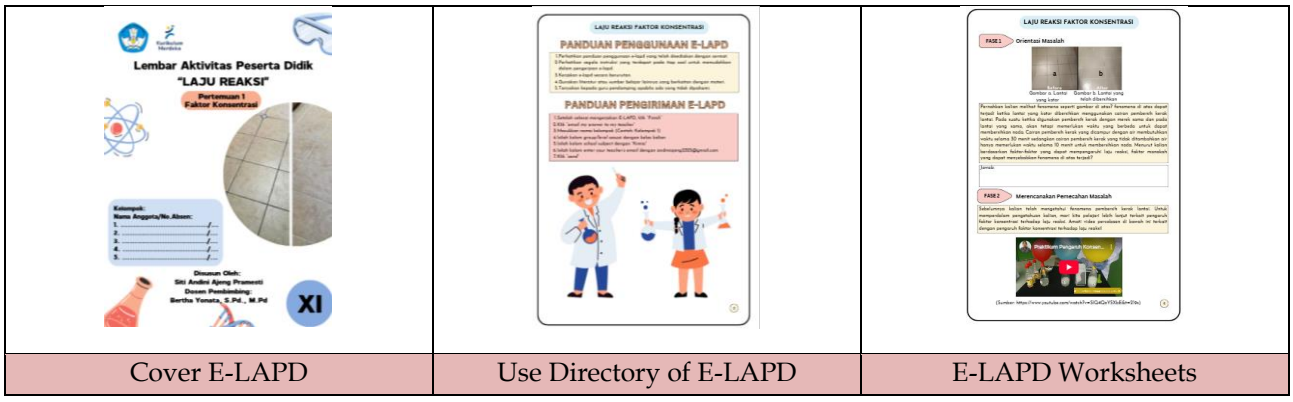
Analyze

The analysis stage was carried out to identify existing problems. All relevant information regarding the product to be developed was gathered through field studies and literature reviews. The researchers conducted an evaluation following the pre-research phase based on the analysis results. A test of students' critical thinking skills was administered before the research. The results showed that students scored 57% on the interpretation indicator, 89% on analysis, 59% on evaluation, 53% on inference, 42% on explanation, and 55% on self-regulation. These scores were obtained from students' critical thinking tests and teacher interview questionnaires. The results indicate that students' critical thinking skills are still not optimal across several indicators.

Qualitative findings revealed several classroom challenges. In one of the high schools in Sidoarjo, teachers reported that many students were unresponsive when attempting to train critical thinking skills and needed continuous direction in group activities involving five students, most preferred to remain silent and rely on peers perceived as more capable. Regarding specific skills, the interpretation indicator was only reflected in limited activities, such as formulating problems, hypotheses, and presenting data tables. Concepts like experimental variables were rarely addressed. For evaluation and inference, many students struggled to understand without paying close attention during practical sessions. Meanwhile, analysis, explanation, and self-regulation skills were also not sufficiently taught. Based on these pre-research findings, it is evident that all indicators of critical thinking skills need improvement, especially in the context of the "factors affecting the reaction rate" sub-topic in chemistry.

Design

The learning media design stage begins with choosing a platform to upload the E-LAPD that will be developed. The platform chosen is Liveworksheet because it can be accessed by anyone easily. Teachers can add answer places, images, and YouTube video links to the uploaded E-LAPD. After editing, the teacher can save changes to the E-LAPD media and get a link that can later be used to work on the E-LAPD. The PBL-based E-LAPD to improve students' critical thinking skills on reaction rate material consists of 14 pages, where on the cover page as attached in Figure 1. there is an E-LAPD title, factors that affect the reaction rate (concentration, temperature, surface area, and catalyst), group, student name, attendance number, and class. Here are some views of the developed E-LAPD. There is a page that contains guidelines for using E-LAPD, there is a page that contains the contents of the E-LAPD in the form of phenomena, videos, and also questions that have been presented.



Cover E-LAPD	Use Directory of E-LAPD	E-LAPD Worksheets

Figure 1. The E-LAPD Platform

Development

This stage is the process of developing the design or design that has been made in the previous stage into an E-LAPD product that is ready for use in limited trials, at this stage E-LAPD is developed based on the revised results of the design evaluation stage.

Implementation

From the pretest and posttest data, students will use it as a test of the effectiveness of interactive videos. Effectiveness is reviewed from the SPSS Test and N-gain score. The results of the SPSS Test using the Kolmogorov-Smirnov Test to test normality in the table 4.

Table 4. Notmality Test (Kolmogorov-Smirnov)

	Kolmogorov-Smirnov			Shapiro-Wilk		
	statistic	df	sig	statistic	df	sig
Pretest	.111	33	.200	.968	33	.427
Posttest	.128	33	.189	.917	33	.015

From the table 4, it was found that the data was not distributed Result because it obtained a P-value(sig) $<\alpha = 0.05$ so that it was included in non-parametric statistics. Therefore, the effectiveness test was continued with the Wilcoxon Test.

Table 5. Wilcoxon Test Result

		N	Mean Rank	Sum of Ranks
Posttest-Pretest	Negative Ranks	0[a]	.00	.00
	Positive Ranks	33[b]	17.00	.561.00
	Ties	0[c]		
	Total	33		

From Table 5, it was found that the negative ranks of the pretest and posttest were 0.000, which stated that no students experienced a decrease in value from the pretest to the posttest. From the Wilcoxon Signed Ranks Test, $p < 0.05$ was obtained, so that H0 was rejected, which states that there is a difference between students' pretest and posttest scores. Therefore, the E-LAPD is effective.

In the limited trial at the implementation stage, students were also given a response questionnaire to determine the practicality of this E-LAPD. Practicality can be measured using a student questionnaire. The following are the data results obtained from the student response questionnaire.

The trial involved 33 students who had previously studied the topic of reaction rates. This limited trial utilized both effectiveness and practicality instruments. Student response questionnaires were administered and supported by observation sheets of student activities to measure effectiveness. Practicality was assessed using pretest and posttest instruments to evaluate students' critical thinking performance. The student response questionnaire aimed to gather feedback on using the E-LAPD within a problem-based learning (PBL) approach. Observations of student engagement during learning activities also served as supporting data. The recapitulation of questionnaire results is presented in Table 4. This trial provided initial insights into how students interact with the E-LAPD and how it supports their engagement and cognitive development in learning about reaction rates.

Table 4. Recapitulation of Learner's Response

No	Purpose	∑ Positive Response	Percentage Average
1	To get the matches to the E-LAPD guidelines	33	100%
2	To see if the protege was easy using the E-LAPD	33	100%
3	To find out if the E-LAPD look is interesting	32	93,33%

No	Purpose	∑ Positive Response	Percentage Average
4	To find out if using the E-LAPD study is boring	33	100%
5	To find out if the E-LAPD that was used can train trainees in passing the initial understanding that has already been had	33	100%
6	To see if the E-LAPD used can train learners in determining the variables of the experiment, the formula of problems, hypotheses, the tools and materials used, and the steps in the experimental activity	33	100%
7	To see if the E-LAPD used can train learners in analyzing experimental activities, explain experimental relationships with concepts, conclude experiment results, and evaluate the experiment results with phenomena that have been presented	33	100%
8	To find out if the E-LAPD that used can train trainees in developing and presenting properly crafted work	33	100%
9	To find out whether the E-LAPD used can train learners in doing analysis and evaluations on the problem-solving process of the prepared phenomena	33	100%
10	To find out if the words or terms used on the E-LAPD are clear and not ambiguous	33	100%
11	To find out if the kind of letter-size letters used on the E-LAPD are appropriate and easy to read	32	93,33%
Average			98,79%

Based on Table 5, the practicality of the E-LAPD reached a score of 98.79%, falling into the "very practical" category. This result was further supported by student activity observations conducted by three independent observers. Meanwhile, the effectiveness of the E-LAPD was evaluated through students' pretest and posttest scores on a critical thinking skills assessment. The test consisted of eight essay questions, including items that targeted self-regulation. The analysis of the pretest and posttest results showed a clear improvement in students' critical thinking abilities following the implementation of the PBL-based E-LAPD. This suggests that the learning tool had a positive impact on students' engagement and cognitive development within the topic of reaction rates. A detailed summary of the results according to each critical thinking aspect is presented in Table 6.

Table 6. Pretest and posttest results come in line with critical thinking skills

No	Skill Aspect	Pretest (%)	Posttest (%)
1	Interpretation	57,50	94,58
2	Analysis	21,67	93,33
3	Explanation	15,00	90,00
4	Evaluation	23,33	88,33
5	Inference	23,33	96,67
6	Self-Regulation	55,83	96,67

In addition, the data from the pretest and posttest results were analyzed by the n-gain test to determine the improvement of students' critical thinking skills. The following is the n-gain test data from the critical thinking skills test of students on reaction rate material which can be seen in the diagram below.

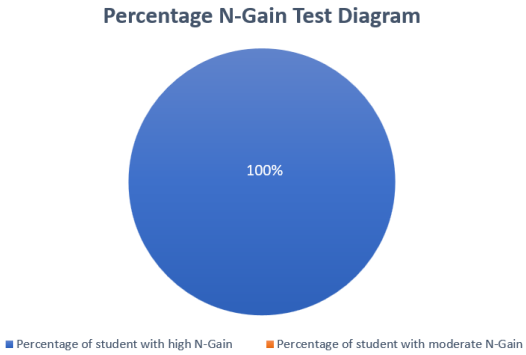


Figure 4. Percentage N-Gain Test Diagram

Based on the table of pretest and posttest scores, as well as the n-gain score obtained by students, it can be seen that 33 students get an n-gain score of 0.7 ≤ (<g>) with a high category as in Figure 4.

Evaluation

The evaluation stage is carried out to collect data at each stage which is used as revision material so that the results of media development are better. The evaluation stage is carried out periodically at the end of each stage of analysis, design, development, and implementation.

DISCUSSION

Based on the results of the research that has been described, the next step will be to describe the research discussion. This study has a goal of producing PBL-based E-LAPD, which is feasible to use to improve the critical thinking skills of grade XI students on reaction rate material, in terms of validity, practicality, and effectiveness, by Nieveen (Nienke M. Nieveen, 1999). The discussion of the validity, practicality, and effectiveness aspects of PBL-based E-LAPD will be described as follows:

The Validity

Three validators—two chemical professors and one chemical teacher—review the worthiness criteria for the LAPD's validity aspect. Validity is determined by content and constructive criteria. E-LAPD is declared valid for a median >3 of the validators based on an interpretation of the Likert scale score. The following is a feasibility description of the validity aspects based on the content and construction of e-lapd development.

The Validity of The Content

The validity of the content is a viable assessment procedure of a developed medium. The validity of content measures whether the developed media meets the assigned criteria. According to Rubio (Doris McGartland Rubio, Marla Berg-Weger, Susan S. Tebb, E. Suzanne Lee, 2003), the validity of content is found in assessments about how well content is in a medium. Regarding the validity of the contents, the validator will pass judgment on all the contents of the developed e-lapd. Validation results on the validity of the content of e-LAPD based PBL to increase learners' critical thinking ability on reaction rate materials, at the median of 5 with very valid criteria.

The Validity of The Construction

The validity of the construction shows the extent to which the instrument developed may reveal a theoretical construction to be measured. Suryabrata (Suryabrata, 2000) states that the validity of the construction score exposes the theoretical construction underlying the instrument. On the validity of the construction, the validator will render an assessment of the PBL drafting structure that will be developed. Validation results on the validity of e-LAPD construction-based PBL are used to increase learners' critical thinking ability on reaction rate materials, with a median of 4 with valid criteria.

Practicality

Practicality is the quality of the learning device reviewed from media ease when used by learners in material study (Edi & Rosnawati, 2021). Nieveen's (Nienke M. Nieveen, 1999) criteria of practicality, according to Nieveen et al (2010), are that the e-lapd developed should be useful in real-world settings and easy to use and understand in the process of learning and teaching (Rizki et al., 2020). An e-lapd with a PBL-based ability to increase learners' critical thinking ability on reaction rate materials is reviewed based on student responses and is supported by observing learners' activities. The protégé response determines participants' responses to the e-lapd developed.

Student Response Questionnaire

Based on the results of the protégé response on the chart, 98.79% of the participants responded positively to the developed e-lapd. Thus, the e-lapd that was developed can be said to be practical in developing learners' critical thinking skills.

Observation on The Activities of Learners

Based on data observation on learners' activities, found at a limited trial of the first meeting, the percentage of relevant participants' activities was 95.24%, and in the second meeting, 98.41%. This considerable percentage of learners' activities is also supported by student responses that learners have filled out according to their personal opinion.

The Effectiveness

The effectiveness of the e-LAPD was reviewed from pretest and posttest scores using research instruments and a critical thought skill test sheet. Before learning was conducted using e-lapd-based to improve learners' critical thinking ability at reaction rate materials, learners were asked to work on pretest sheets already prepared to identify the early abilities of learners. The protégé is then asked to group 5 people into one group to work on an e-lapd-based to increase learners' critical thinking ability on matter rates of concentration, temperature, surface area, and catalyst. The trainees are subsequently asked to work on the completed posttest sheet to learn the final ability of learners after working on an e-LAPD with a bl to increase learners' critical thinking ability at reaction rate materials.

The pretest and posttest results were then tested using quantitative descriptive analysis. Further results of the n-gain score are interpreted based on the criteria seen in Table 3. Based on these criteria, the e-lapd can effectively raise the n-gain score over 0.3 to a moderate or high category. After reviewing data results from pretests and posttests, it has been found that 33 learners gained a gain score of 0.7 in the high categories. Then, an e-lapd PBL based on improving learners' critical thinking ability through reaction materials is said to be effective in developing learners' critical thought skills. The following is a stretch of the e-LAPD effectiveness reviewed from each critical thinking skill indicator:

Interpretation

The indicator of critical interpretation thinking skills consists of 4 problems; the total percentage of pretest was 57.50%, and the posttest was 94.58%. Interpretation is the ability of learners to understand and express the intent of a data, situation, research, rule, procedure, or variable criteria (Peter A. Facione, 2013). This coincides with pretesting given; learners are given phenomena, then interpreted in formulas for problems, hypotheses, test variables, and observation tables.

Pretest results are used to measure the initial capabilities of critical learners' thinking skills before applying an advanced model of CBI learning. The learners' pretest results on the interpretation indicator still get a minimum score because the answers given have not yet met the indicators in the assessment column.

Then, after completing the pretest, the learner trained his critical thinking skills through study using e-lapd-based PBL on four factors that affected the reaction rate: the concentration, temperature, surface area,

and catalyst. On the e-lapd-based PBL developed, learners have critical thought skills and interpretive indicators in phase 1: orifying the problem. The learner's critical thinking skills on the interpretation indicator are trained at phase 1 problem orientation by giving opinions and solutions to the phenomena presented. The learner is presented with a phenomenon linked to the discussed reaction rate factor, along with a supportive image. Then the learner is asked to determine a solution for the phenomenon.

There is also phase 2 of planning problems that can also train learners' critical thinking skills in the interpretation indicator. The learner's critical thinking skills are trained by determining problem formulas, variables of experiments, hypotheses, tools, experiment materials, and experimental measures. In phase 2, the learner is presented with a video that must be observed. Then the learner is asked to formulate the problem, determine the experiment's variables, formulate hypotheses, determine tools and materials, and determine the experimental measures according to the studied video.

Then, after following the study using the e-lapd developed, the trainee completed the posttest. The student posttest scores were 4 for answering correctly and meeting all the indicators in the assessment series, as questions related to phenomena, and containing responses and manipulation variables.

There has been an improvement in the interpretation indicator for pretest and posttest subjects. This is because at the time the experiment is limited to using the e-lapd developed learners are trained to formulate problems, form hypotheses, define test variables in which the activity is included in phase 1 and 2 model PBL, which is problem orientation and planning problem solving. According to Abdullah (2016), students' skills in preparing experimental designs are included in scientific methods that are indicators of critical thinking. Critical thinking is an activity conducted using a series of scientific methods involving understanding, formulating problems, formulating and testing hypotheses, and determining solutions that can be done.

Increased results of pretest and educational postings on interpretation indicators are also supported by validation of e-lapd, educational participants' Numbers, and the observation of educational activities at which the median four validation comes, so e-lapd is worthy to be used to assess effectiveness, Then at the meeting, the student's response is found to be a positive response from the learner and is supported by observing the activities of the learner with an average percentage of the relevant activities of the participants at the meeting of 1 and 98.41% at the meeting of 2.

Analysis

The indicator of critical thinking skills analysis consists of 1 problem, and it gets an overall percentage of pretest by 21.67% and a posttest by 93,33%. Analysis is the ability of learners to clarify conclusions based on the relationship between information and concepts, with questions present in problems (Peter A. Facione, 2013). This corresponds with the question: learners were asked to describe the relationship chart between the surface area and the reaction rate from the observation table.

Pretest results are used to measure the initial capabilities of critical learners' thinking skills before applying an advanced model of CBI learning. The learners' pretest results on the interpretation indicator still get a minimum score because the answers given have not yet met the indicators in the assessment column.

Then, after completing the pretest, the learner developed his critical thinking skills using the developed e-LAPD based PBL. On the developed e-lapd-based PBL, learners are equipped with critical analytical indicator skills at phase 3 of conducting experiments. The learner's critical thinking skills at the analysis indicator were dilated at phase 3 by completing the observation table of the attempts that had already been made. In addition to completing the observation chart in phase 3 to develop the analysis indicator, learners are also asked to write their reactions. Then, after following the study using the e-lapd developed, the trainee completed the posttest. The result of the protégé posttest scores 4 for answering correctly and meeting all the indicators in the assessment series. Charts are made according to data and have the needed information on them.

There has been an increase in the pretest and posttest of learners in the analysis indicator. This is because at the time the testing was limited, using the e-lapd, developed learners were trained to make charts and make

test observation tables on which the activity belongs to phase 3 model cbi, which is to experiment. According to the study by Arini & Juliadi (Arini, W., & Juliadi, 2018), learners' critical thinking skills on analysis indicators can also be trained by getting students to look for similarities in their understanding of integrated concepts.

Increased results of pretest and educational postings on analysis indicators are also supported by validation of e-lapd, educational participants' Numbers, and the observation of educational activities at which the median four validation is gained. Then, at the meeting, the development minister's response is found to be a positive response from learners, which is supported by observing the activities of learners with an average percentage with the statement of relevant activities of the participants at the meeting of 1 and 98.41%.

Explanation

The indicator of critical thinking skills explanation consists of 1 problem, and it gets a percentage of pretest of 15.00% and a posttest of 90.00%. Exposition is the ability of learners to express their reasoning when giving reasons for justification of a concept, evidence, methodology, and logical criteria based on information or data available, in which this reasoning is presented as an argument (Peter A. Facione, 2013). This is consistent with the given problem, in which students are asked to explain the relationship between variable manipulation and response based on the chart of observation and graph.

Then, after completing the pretest, the learner developed his critical thinking skills using the developed e-lapd based PBL. On the e-LAPD-based PBL developed, learners developed the critical thinking skills of their exhibitions at phase 3 of conducting experiments. The critical thinking skills of the learner at the analysis indicator are dilated at phase 3, experimenting with several questions presented, at numbers 3 and 4, learners are asked to explain the relationship between response variables and manipulation based on the observation and chart, and explain the experimental relationship with the collision theory. Through several questions raised on the e-lapd developed, the learners' critical thinking skills can be expanded for menus.

There has been an increase in the results of pretest and educational postings of explanation indicators. This is because at the time the experiment is limited to using the e-lapd developed learners are trained to explain the relationship between variable manipulation and response variables based on the observation and graph tables, and explain the experimental relationship with the crash theory, where the activity belongs to phase 3 model bl, which is to experiment.

Increased results of pretest and educational postings on analysis indicators are also supported by validation of e-lapd, educational participants' Numbers, and the observation of educational activities at which the median four validation is gained. Then at the meeting, the student's response is found to be a positive response from the learner and is supported by observing the activities of the learner with an average percentage of the relevant activities of the participants at the meeting of 1 and 98.41% at the meeting of 2.

Evaluation

At the critical thinking skill indicator, the evaluation consists of 1 problem, with an overall percentage of pretest of 23.33% and a posttest of 83,33%. An evaluation is the ability of learners to assess the credibility of a source of information and to evaluate the validity of a conclusion based on the available evidence (Peter A. Facione, 2013). This was in accordance with the question given, in which the protégé was asked to determine the catalyst's relation with the reaction's speed according to his experience after conducting a simple experiment and answering some of the previous questions.

Then, after completing the pretest, the learner developed his critical thinking skills using the developed e-lapd based PBL. On the developed e-lapd-based PBL, the learner's critical thought skill indicator evaluation is completed at phase 3 of the experiment. Learners' critical thinking skills at the evaluation indicator were trained at phase 3 by determining solutions consistent with the phenomenon presented according to the experience after a trial. At phase 4 of developing and presenting work, the critical thinking skills of the learner's evaluation indicators are developed by developing simple experimental reports. Then, after following the study using the e-lapd developed, the trainee completed the posttest, with the results of the posttest entry.

There has been an increase in the pretest and protégé posttest in the evaluation indicator. This is because when the experiment is limited to using the e-lapd developed, the learners are trained to determine the appropriate solutions to the phenomena presented according to their experience after a simple experiment that includes phase 3 model cbi, which is to experiment. According to the study by Arini & Juliadi (Arini, W., & Juliadi, 2018), learners' critical thinking skills at the evaluation indicator can also be trained by making it a habit to work on problems by varying degrees of completion. This is because critical thinking is one of the highest-level thinking skills. Critical thinking skills cannot be acquired briefly but must be developed (Haryandi et al., 2019).

Increase in the pretest and educational posttest results on the evaluation indicator is also supported by the validation of e-lapd, educational participants' Numbers, and the observation of educational activities at which the median four validation comes, so e-lapd is worthy to be used to assess effectiveness, Then at the meeting, the student's response is found to be a positive response from the learner and is supported by observing the activities of the learner with an average percentage of the relevant activities of the participants at the meeting of 1 and 98.41% at the meeting of 2.

Inpreference

The indicator of critical thinking skills in preference consists of 1 problem, with an overall percentage of pretest by 23.33% and a posttest by 96.67%. Inference is the ability of learners to identify elements needed in making rational conclusions, considering relevant information with a problem and consequences based on existing data (Peter A. Facione, 2013). This is due to the issues given, which learners are asked to draw conclusions based on experiments based on their understanding.

Then, after completing the pretest, the learner developed his critical thinking skills using the developed e-lapd based PBL. On the developed e-lapd-based PBL, learners are trained with their infertile critical thinking skills at phase 3 of conducting experiments. The learners' critical thinking skills at the inference indicator are trained at phase 3 to conduct an experiment based on the experiment's results according to their understanding.

Then, after following the study using the e-lapd developed, the trainee completed the posttest. The student's posttest results scored 4 for answering correctly and meeting all the indicators in the assessment series, new sentences according to phenomena, and containing response and manipulation variables (Hildani & Safitri, 2021; Safitri, 2024; Safitri et al., 2019, 2022).

There has been an increase in the pretest and educational posttest results at the inference indicator. This is because when the experiment is limited, using the e-LAPD developed, the protégé is trained to draw conclusions based on the experiment's results according to its understanding, where the activity is included in phase 3 model cbi, which is to experiment. According to the study by Arini & Juliadi (Arini, W., & Juliadi, 2018), learners' critical thinking skills at inference indicators can also be trained by training students on the material that occurs frequently in everyday life.

The validation of e-LAPD also supports the increase in the pretest and educational postings of the inference indicator, the educational participants' Numbers. The observation of educational activities at which the median four validation is made available so that e-LAPD is worthy to be used to assess effectiveness, then at the meeting, the student's response is found to be a positive response from the learner and is supported by observing the activities of the learner with an average percentage of the relevant activities of the participants at the meeting of 1 and 98.41% at the meeting of 2.

Self-Regulation

Regarding self-regulation, critical thinking skills consist of 4 statements, with an overall pretest percentage of 55.83% and a posttest percentage of 96.67%. Self-regulation is the ability of learners to review their thoughts, identify errors, and adjust their understanding based on Facline's evaluation (Peter A. Facione, 2013). The protégé was asked to reflect on his experience after using the e-lapd.

Then, after completing the pretest, the learner developed his critical thinking skills using the developed e-lapd based PBL. On the developed e-LAPD-based PBL, the learner developed his self-regulation critical thought skill on page 11 of the e-lapd, which reflects upon the learning activities using the e-lapd. The learner's critical thinking skills were tested by being asked to reflect on themselves after carrying out the learning activities using the e-lapd developed. The cook prepared a chart consisting of several statements related to the experience of using the e-lapd. Learners can pick in the "yes" and "no" columns based on their experiences using the e-lapd. Then, after following the study using the e-lapd developed, the trainee completed the posttest. Results of the posttest entry. There has been an increase in the pretest results and protégé posttests on the regulation indicator. This is because at the time of the limited trial using the e-lapd, the protégé was trained to reflect on his experience after using the e-lapd.

An increase in the pretest and educational postings of the self-regulation indicator is also supported by the validation of e-lapd, which is the number of educational participants. The observation of educational activities at which the median four validation is made available so that e-lapd is worthy to be used to measure effectiveness, Then at the meeting, the student's response is found to be a positive response from the learner and is supported by observing the activities of the learner with an average percentage of the relevant activities of the participants at the meeting of 1 and 98.41% at the meeting of 2. Overall, the research results may indicate that e-lapd, based on problem-based learning, is valid, practical, and effective in boosting critical learners' thinking ability in their high school Xi class action rates.

CONCLUSION

The conclusion of this study is that e-lapd based on problems based learning to increase learners' critical thinking ability on their xi high school class reaction materials is worth using because e-lapd is based on PBL to increase learners' critical thinking capability on reaction rate materials is valid from scores of validation sheets of three validator with a median assessment of four valid categories, E-lAPD based on PBL to increase the critical thinking ability of learners at the rate of reactions is practically based on the growing response rate at 98.79% and is supported by the advanced observation sheet of educational activities getting a 96.83% percentage of the meeting, so e-LAPD is based on PBL to increase the critical thought capability of the student at the reaction rate is highly practical, And e-lapd based on PBL to improve the critical thinking ability of learners at the rate of reactions is effectively developing critical thought skills of learners from a scoring test results of 0.90 high levels, and thus, it can be said that there has been an increase in the score between before and after the use of e-LAPD. In all e-LAPD, based on problem-based learning, higher-level reaction materials can be a valid, practical, and effective learning medium to increase learners' critical thinking ability.

REFERENCES

Abdullah, I. H. (2013). Intuisi Siswa Madrasah Ibtidaiyah (Mi) Dalam Pemecahan Masalah Matematika Divergen. Delta-Pi: Jurnal Matematika Dan Pendidikan Matematika, 2(1), 66–75

Arianti, A. (2019). Peranan Guru dalam meningkatkan motivasi belajar siswa. Didaktika: Jurnal Kependidikan, 12(2), 117-134.

Arini, W., & Juliadi, F. (2018). Analisis kemampuan berpikir kritis pada mata pelajaran fisika untuk pokok bahasan Vektor siswa kelas X SMA Negeri 4 Lubuklinggau, Sumatera Selatan. Berkala Fisika Indonesia, 10(1), 1-11.

Bandura, Albert. 1997. Self Efficacy. The Exercise of Control. New York: W.H Freeman and Company

Edi, S., & Rosnawati, R. (2021). Kemampuan Berpikir Kritis Siswa Dalam Pembelajaran Matematika Model Discovery Learning. Jnpm (Jurnal Nasional Pendidikan Matematika), 5(2), 234-246.

Ennis, R.H. 1995. Critical Thinking. University of Illinois

Eva Ervia, Risma Delima Harahap, & Ika Chastanti. (2024). Analisis Perkembangan Kurikulum Biologi dari kurikulum 1984 Sampai dengan Kurikulum Merdeka. *Didaktika: Jurnal Kependidikan*, *13*(1), 927–936. https://doi.org/10.58230/27454312.491

Hildani, T., & Safitri, I. (2021). Implementation of JSIT Curriculum-Based Mathematics Learning in Forming Students Character. *Daya Matematis: Jurnal Inovasi Pendidikan Matematika*, *9*(1), 66–70. https://doi.org/https://doi.org/10.26858/jdm.v9i1.19374

Lutfi, A. (2021). *Research and Development (R&D): Implikasi dalam pendidikan kimia*.

Richard R. Hake. (1999). *Analyzing Change/Gain Scores*. milis AERA Division D (Measurement and Research Methodology).

Facione, P. A. (2013). Critical thinking: What it is and why it counts (2013 ed.). Millbrae, CA: Insight Assessment.

Hake, R, R. (1999).Analyzing Change/Gain Scores.AREA-D American Education Research Association's Devision.D, Measurement and Reasearch Methodology.

Haladyna, T. M., & Rodriguez, M. C. (2013). Developing and validating test items. New York: Taylor & Francis

Haryandi, S., Misbah, M., Mastuang, M., Dewantara, D., & Mahtari, S. (2019). Analysis of Students' Critical Thinking Skills on Solid Material Elasticity. Kasuari: Physics Education Journal (KPEJ), 2(2), 89-94.

Lidinillah, D. A. M. (2007). Perkembangan metakognitif dan pengaruhnya pada kemampuan belajar anak. Skripsi tidak dipublikasikan, Universitas Pendidikan Indonesia, BandungMeilasari, S., M, D., & Yelianti, U. (2020). Kajian Model Pembelajaran Problem Based Learning (PBL) dalam Pembelajaran di Sekolah. Jurnal Pendidikan Biologi Dan Sains, 3(2), 195–207.

Meilasari, S., M, D., & Yelianti, U. (2020). Kajian Model Pembelajaran Problem Based Learning (PBL) dalam Pembelajaran di Sekolah. Jurnal Pendidikan Biologi Dan Sains, 3(2), 195–207.

Ma'rufah, S., dan Wisanti. 2023. Pengembangan Lembar Kerja Peserta Didik-Elektronik (E-LAPD) Lumut Berbasis Pendekatan Saintifik Untuk Melatih Kemampuan Berpikir Kritis Siswa. BioEdu, 12(1): 001-015

Mardiyanti, H.S. 2020. Penerapan Model Pembelajaran Problem Based Learning untuk Meningkatkan Kemampuan Berpikir Kritis Siswa Kelas X MIPA-2. Journal of Classroom Action Research, 2(1): 1-8.

Nieveen, N. 1999. Prototyping to Reach Product Quality. Jan Van den Akker, Robert Maribe Braneh, Ken Gustafson, and Tjeerd Plomp (Ed), London: Kluwer Academic Publishers

Nurjanah, N., dan Guntur, T. 2022. Pengembangan ELKPD Berbasis Problem Based Learning untuk Melatihkan Keterampilan Berpikir Kritis pada Materi Hereditas Manusia. BioEdu, 11(3): 765-774.

Mustika, R. et al. (2014). Pengaruh Model Pembelajaran Berbasis Masalah Terhadap Kemampuan Berpikir Kritis. Jurnal Bioterdidik, Vol 2, No. 8 Tahun 2014.

Ramalisa, Y. (2013). Proses Berpikir Kritis Siswa SMA Tipe Kepribadian Thinking dalam Memecahkan Masalah Matematika. Edumatica, 3(1), 42–47

Rendhana, I Wayan dan Liliasari. 2008. Program Pembelajaran Keterampilan Berpikir Kritis pada Topik Laju Reaksi untuk Siswa SMA. Forum Kependidikan. Vol. 27, No. 2

Riduwan. (2015). Dasar-Dasar Statistika. Bandung: Alfabeta.

Rizki, H.T.N., Wijaya, A., dan Frentika, D. (2020). Pengembangan perangkat pembelajaran dengan pendekatan Knisley berorientasi pada level berpikie Van Hiele dan kemampuan penalaran adaptif. Axiom: Jurnal Pendidikan dan Matematika. 9(1): 64-79. DOI:http://dx.doi.org/10.30821/axiom.v9i1.7237

Roestiyah N.K. (1985). Strategi belajar mengajar. Jakarta: Bina Aksara.

Rubio, D. M., Berg-Weger, M., Tebb, S. S., Lee, E. S., &, & Rauch, S. (2003). Objectifying content validity: Conducting a content validity study in social work research. Social Work Research, 27(2), 94–104. https://doi.org/https://doi.org/10.1093/swr/27.2.94

Rusmansyah, Yuanita, L., Ibrahim, M., Isnawati, dan Prahani, B.K. 2019. Innovative chemistry learning model: Improving the critical thinking skill and self effecacy of pre-service chemistry teachers. Journal of Technology and Science Education, 9(1): 59-76.

Riduwan. (2018). *Dasar-Dasar Statistika*. Alfabeta.

Safitri, I. (2024). Transformation of Student Science Achievement Through Project-Based Learning (PjBL): A Meta Analysis Study. *Scientiae Educatia: Jurnal Pendidikan Sains*, *13*(2). https://doi.org/DOI: 10.24235/sc.educatia.v13i2.18694

Safitri, I., Harahap, A., Hrp, N. A., Simanullang, D. ., & Nuraisyah. (2022). Pengaruh Model Pembelajaran Problem Based Learning Terhadap Kemampuan Pemecahan Masalah Matematika Siswa. *Jurnal Pembelajaran Dan Matematika Sigma (JPMS)*, *8*(1), 72–86.

Safitri, I., Pasaribu, R., Simamora, S. S., & Lubis, K. (2019). The effectiveness of android application as a student aid tool in understanding physics project assignments. *Jurnal Pendidikan IPA Indonesia*. https://doi.org/10.15294/jpii.v8i4.19433

Saputra, A. S., dan Sunu K. 2019. Keefektifan Lembar Kegiatan Peserta Didik Berbasis Problem Based Learning pada Materi Perubahan Lingkungan untuk Melatihkan Keterampilan Berpikir Kritis. BioEdu, 8(2). ISSN 2302-9528.

Suryabrata, S. (2000). Pengembangan Alat Ukur Psikologis. Yogyakarta: Andi.