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Paul-Elder Based Student Worksheet as an Evaluation Tool and Development of Critical Thinking Skills: an Experimental Study in High School

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Keywords

Critical Thinking Skills, Paul-Elder Framework, Student Worksheet

Abstract

Critical thinking skills are essential for addressing 21st-century challenges. In the field of education, learning systems are designed to enhance students' abilities to analyze information, evaluate arguments, and make well-reasoned decisions based on rational and logical thinking. This study aims to examine the differences in the application of Paul-Elder-based student worksheets (LKPD) in improving students' critical thinking skills. This research employed an experimental method, using a control group that received Problem-Based Learning (PBL) worksheets and an experimental group that received Paul-Elder-based worksheets as a special treatment. Critical thinking skills data were collected through pre-tests, post-tests, and student worksheets (LKPD). The results showed that the experimental group experienced a more significant improvement in critical thinking skills compared to the control group. The improvement pattern in the experimental group was more systematic, particularly in problem identification, information gathering, and concept comprehension. However, a decline was observed in the conclusion-drawing stage, indicating that students still struggled to formulate accurate conclusions. Meanwhile, in the control group, critical thinking skills developed but followed a less consistent pattern.

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INTRODUCTION

The 21st century presents various challenges that society must face. Every individual needs to possess high levels of skills and competence to adapt to these changes. The ability to select, analyze, and evaluate rapidly evolving information is also highly required. With these skills, individuals can better keep up with the times (Rawung *et al*., 2021). Education plays a crucial role in addressing the challenges of the 21st century. The goal of 21st-century education is to create a high-quality society by developing human resources with the ability and willingness to contribute to national aspirations.

Developing a relevant curriculum is one way to address 21st-century challenges, ensuring that education reflects and anticipates the changes occurring in today's world (Aprilia, 2020). A curriculum that focuses solely on memorization and exams does not help students grasp the material in depth. Memorization-based learning encourages students to retain information without truly understanding it, resulting in less meaningful and irrelevant learning experiences. Additionally, students' critical thinking and creativity skills may decline. Increased stress levels may arise due to excessive pressure and anxiety (Isma *et al*., 2023). The Merdeka Curriculum was developed to be more flexible, focusing on essential materials and the development of students' character and competencies as part of Indonesia's vision to meet 21st-century educational challenges. The 21st-century skills emphasized in education will prepare students to become independent, creative, collaborative individuals capable of adapting to complex societal changes (Lubis *et al*., 2023).

Critical thinking skills are one of the essential competencies required to navigate the challenges of the 21st century. In education, learning systems are designed to enhance students' ability to analyze information, evaluate arguments, and make well-reasoned decisions based on rational and logical thought. Education plays a key role in fostering critical and analytical thinking skills in students (Nantara, 2021). Previous research on critical thinking levels conducted in a high school in Bandung found that the average critical thinking level of 10th-grade students was low (Wayudi *et al*., 2020). The lack of familiarity with learning models that encourage critical thinking contributes to students' low performance in this area. Therefore, choosing an appropriate teaching method is crucial for educators. Learning should focus on both learning skills and cognitive processes, including critical thinking skills. Educators must first assess students' critical thinking abilities before selecting an appropriate teaching method. This initial assessment is essential to preparing students for the 21st-century workforce and society (Setianingsih *et al*., 2022).

Student Worksheets (LKPD) are instructional materials designed to support both independent and group learning. LKPD plays a vital role in facilitating students' understanding of materials, increasing student engagement, fostering independent learning, accommodating diverse learning styles, optimizing classroom time, and instilling a sense of responsibility (Handika, Sobri & Fauzi, 2024). LKPD consists of a series of tasks or activities that guide students in building conceptual understanding, developing thinking skills, and fostering a scientific attitude in learning. Additionally, LKPD serves as a source of information and a tool for practice exercises (Sapitri, Ardana, & Gunamantha, 2022). LKPD can also be developed in electronic formats rather than being limited to paper-based formats (Yuzan & Jahro, 2022).

An effective student worksheet (LKPD) should assist students in understanding subject matter, such as chemistry (Monica, Nurhamidah, & Elvinawati, 2023)). LKPD may include a title, learning objectives, usage instructions, sample illustrations, and exercises that guide students in independent or group learning (Putri & Wisanti, 2023). Moreover, the integration of worksheets into lessons can help teachers improve students' critical thinking skills (Suryati *et al*., 2024). The development of critical thinking skills depends on the structure and content of the worksheet, which should include various indicators of critical thinking (Wahyuni, Zaini, & Rezeki, 2022).

Paul and Elder introduced a framework for critical thinking competency that aims to assess students' critical thinking abilities. This framework is expected to help teachers determine the extent of students' critical reasoning skills in a particular subject (Paul & Elder, 2005). Students need to be proficient in critical thinking, especially in academic learning (Mataniari *et al*., 2020). These skills are crucial for students to succeed in facing global challenges in the 21st century (Darwati & Purana, 2021).

Paul & Elder (2014) define critical thinking as the process of improving one's quality of thought and developing skills to process reasoning effectively using intellectual standards related to a specific subject, content, or problem. Paul and Elder introduced a critical thinking model that consists of three essential components: intellectual standards, elements of thought, and intellectual traits. A critical thinker applies intellectual standards to various elements of reasoning, thereby developing intellectual traits (Nurjaman, 2020). The key components of critical thinking that serve as indicators of reasoning ability include purpose, questions, point of view, information, inferences (conclusions), concepts, implications, and assumptions. These eight elements are necessary for individuals to develop critical thinking skills. The application of these elements is based on fundamental reasoning principles. If an individual possesses all eight elements, they can be considered a proficient critical thinker.

In the field of education, critical thinking skills are a fundamental aspect that must be developed to prepare students for modern challenges. A learning process focused solely on memorization, without allowing students to analyze, evaluate, and draw logical conclusions, can hinder the development of deeper thinking patterns (Aisyah *et al*., 2024). Therefore, a learning strategy is needed that not only delivers subject matter but also encourages students to question, examine, and connect various concepts systematically. One way to achieve this is through the development of Student Worksheets (LKPD) designed based on the Paul-Elder critical thinking framework. By integrating critical thinking elements such as goal analysis, information evaluation, and reflection on multiple perspectives, students become better trained in solving problems rationally and independently. The use of this type of LKPD is expected to help students develop more structured thinking patterns, ensuring they do not merely understand concepts theoretically but can also apply them in broader and more complex contexts.

METHODS

This study employs a quasi-experimental research design. By providing special treatment to the experimental group while maintaining a control group for comparison, experimental research aims to determine whether a causal relationship exists and how strong that relationship (Payadnya & Jayantika, 2018). The treatment applied in this study is the implementation of student worksheets (LKPD) based on the Paul-Elder framework, which was given to the experimental group. Meanwhile, the control group received Problem-Based Learning (PBL)-based LKPD. The quasi-experimental design used in this study is the nonequivalent pre-test-post-test control group design. This design involves administering a pre-test before treatment and a post-test after treatment for both the experimental and control groups.

Table 1. Research Design

Subject	Before Treatment	Treatment	After Treatment
Eksperimental Group	O_1	X	O_2
Control Group	O_3	Y	O_4

(Source: Sugiyono (2012))

Explanation:
O_1 = Pre-test for the Experimental Group
O_2 = Post-test for the Experimental Group
O_3 = Pre-test for the Control Group
O_4 = Post-test for the Control Group
X = Implementation of Paul-Elder-Based LKPD
Y = Implementation of PBL-Based LKPD

This research was conducted at SMA Negeri 2 Semarang, a public high school located in Semarang City. The population in this study consisted of all 10th-grade students at SMA Negeri 2 Semarang. The sampling technique used was random sampling, where classes were randomly selected as samples. After selecting the sample classes, another random draw was conducted to determine which class would be assigned to the experimental group and which to the control group. The selected sample consisted of two groups, with class XI-3 as the control group and class XI-7 as the experimental group. The data sources used in this study included readability test questionnaires, pre-tests, post-tests, and student worksheets (LKPD). The data collection techniques included questionnaires, pre-tests, post-tests, and LKPD analysis. For data analysis, the study employed descriptive analysis, normality tests, homogeneity tests, and hypothesis testing using the Mann-Whitney test and the coefficient of determination test.

RESULTS AND DISCUSSION

Results

Descriptive statistical analysis is a method used to describe and summarize data in a way that is easily understood. The purpose of this method is to provide an overview of the data. It helps in understanding the basic characteristics of the observed dataset without making complex inferences or drawing conclusions about the overall population. The results of the descriptive statistical analysis can be seen in Table 2 below.

Table 2. Descriptive Statistics of the Control Group

Measure	***Pre-test* Control**	**LKPD-1 Control**	**LKPD-2 Control**	***Post-test* Control**
Mean	73.75	82.00	65.28	75.08
Median	75.00	83.00	70.00	76.00
Mode	75	87	70	83
Variance	106.250	89.429	125.635	123.393
Range	40	40	45	53
Minimum	55	57	43	37
Maximum	95	97	88	90

The results of the LKPD (Student Worksheet) from the first session in the control group, as shown in Table 2, indicate an increase in the group's average score compared to the students' pre-test scores. However, the results from the second session in the control group show a decline in the average score compared to the first session. Additionally, the average score obtained in the second session was lower than the pre-test score of the control group. Nevertheless, there was an increase in the average score in the second session. The average post-test score was higher than the average pre-test score in the control group. Based on the average LKPD scores from the first session, the experimental group experienced an improvement compared to the pre-test average score (Table 3).

Table 3. Descriptive Statistics of the Eksperimental Group

Measure	***Pre-test* Eksperimental**	**LKPD-1 Eksperimental**	**LKPD-2 Eksperimental**	***Post-test* Eksperimental**
Mean	76.25	87.22	77.83	85.58
Median	75.00	87.00	81.00	87.00
Mode	65	87	80	97
Variance	151.964	129.263	218.657	123.907
Range	40	50	50	55
Minimum	60	50	48	45
Maximum	100	100	98	100

Based on the average LKPD scores from the first session, the experimental group experienced an improvement compared to the pre-test average score (Table 3).

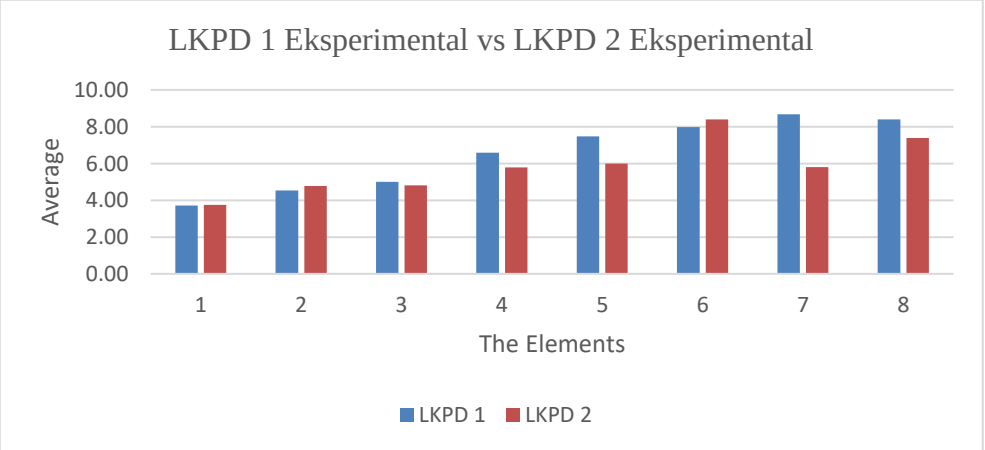

Figure 1. LKPD 1 Eksperimen vs LKPD 2 Eksperimen
Legend for the Figure:
1 = Goals, 2 = Questions, 3 = Assumptions, 4 = Perspectives, 5 = Information, 6 = Concepts, 7 = Conclusion, 8 = Implications

The average LKPD score for the first session in the experimental group is shown in Figure 1. The diagram illustrates that students' lowest critical thinking skills were at Stage 1 (Goals) with an average score of 3.72. Meanwhile, the highest skill level was at Stage 7 (Conclusion), with an average score of 8.39. The critical thinking process of the students can be observed in Figure 1. The graph demonstrates fluctuations in critical thinking skills, showing both increases and decreases. Overall, students' critical thinking skills tended to improve, although there was a decline at Stage 8 (Implications). Based on the average LKPD scores from the second session, the experimental group showed an increase compared to the pre-test average score. However, there was a decrease when compared to the average LKPD score from the first session.

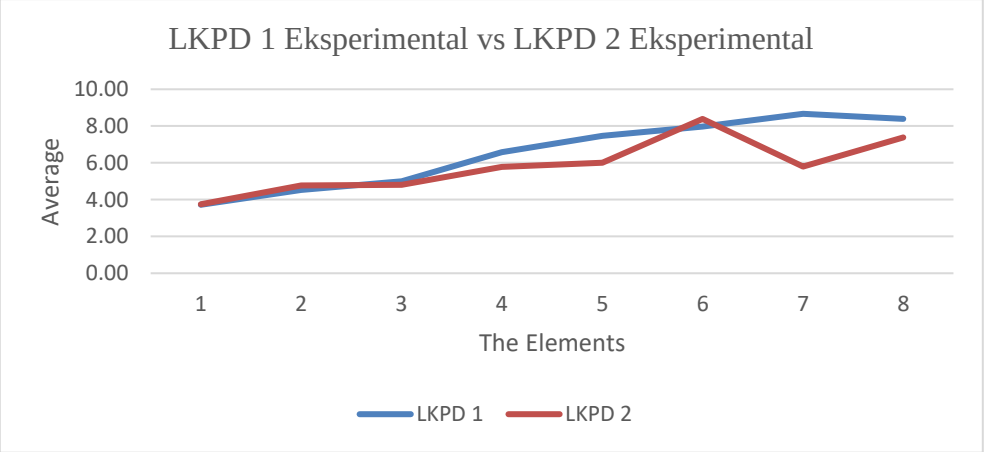

Figure 2. Critical Thinking Process: LKPD 1 (Experimental) vs. LKPD 2 (Experimental)

Legend for the Figure:
1 = Goals, 2 = Questions, 3 = Assumptions, 4 = Perspectives, 5 = Information, 6 = Concepts, 7 = Conclusion, 8 = Implications

The average LKPD (Student Worksheet) score from the second session in the experimental group is shown in Figure 2. The diagram indicates that students' lowest critical thinking skill level was at Stage 1 (Goals), with a score of 3.75. The highest skill level was at Stage 6 (Concepts), with an average score of 3.89. On average, students experienced a decline in critical thinking skills when completing the LKPD in the second session compared to the first session. The critical thinking process in the second LKPD session is illustrated in Figure 2. Based on the graph, there was a significant decline in students' critical thinking skills at Stage 7 (Conclusion). Based on the post-test average scores, there was an improvement compared to the pre-test average scores. However, when compared to the average LKPD score from the first session in the experimental group, the post-test score remained lower. Meanwhile, when compared to the average LKPD score from the second session, there was an increase.

Table 3. Mann-Whitney Test Ranking Results

Groups	N	Mean Rank
Control	36	26.42
Eksperimental	36	46.58

The next stage of analysis involved using the Mann-Whitney test. This test was applied to

determine whether there was a significant difference between the implementation of the learning approach and students' critical thinking skills. The criterion for the Mann-Whitney test is that if the Asymp. Significance (2-tailed) value is less than 0.05, then Ho is rejected, and Ha is accepted. Based on the descriptive test results or the ranking results in Table 3, it can be observed that the Mean Rank of the experimental group was significantly higher than that of the control group. This indicates that the percentage score in the experimental group was higher than in the control group.

Based on the output in Table 4, the Asymp. Sig (2-tailed) value obtained was 0.000, which is less than 0.05. Therefore, it can be concluded that Ha is accepted. This confirms that there is a difference in students' critical thinking skills between the experimental group and the control group. Since a significant difference was found, it can be stated that "there is a significant difference in students' critical thinking skills between those who implemented the LKPD based on Paul Elder's framework and those who did not."

Table 4. Mann-Whitney Test Results

Test	Asymp. Sig. (2-tailed)
Critical Thinking Skills	0.000

Discussion

The control group did not receive any special treatment during the learning process. This group was taught using Problem-Based Learning (PBL). PBL is a learning approach that helps teachers create a learning environment that begins with significant and relevant problems for students, allowing them to gain a more realistic learning experience (Wardani, 2023). Choosing the right learning model impacts student engagement during the learning process and their learning outcomes (Djonomiarjo, 2020). One of the learning models that can enhance student learning outcomes is PBL (Yusita *et al*., 2021). An initial knowledge assessment was conducted before the learning activity began through a pre-test. The learning stages in the control group included the teacher explaining the learning objectives, followed by distributing Student Worksheets (LKPD) to students. The LKPD contained problem identification, information gathering, problem-solving, presentation of findings, and reflection. The next stage involved students presenting their completed LKPD results. However, only a few students were selected to present due to time constraints. A post-test was given to students after the learning process, assessing their understanding with questions aligned with the material taught (Magdalena *et al*., 2021).

The experimental group received special treatment during the learning process. In this group, the LKPD was designed based on the Paul-Elder framework. The learning stages in the experimental group were similar to those in the control group, where students were required to identify problems, gather information, solve problems, present their findings, and reflect on their learning outcomes. However, the key difference between the experimental and control groups was the application of the Paul-Elder framework. Problem-solving in the experimental group incorporated elements of thinking according to Paul-Elder. By applying these elements, it was expected that the development of students' critical thinking skills could be observed progressively from one stage to another.

Students' critical thinking skills in completing LKPD-1 can be observed in Figure 1. The diagram shows that the lowest level of critical thinking occurred at Stage 1 (Goals). The low critical thinking skills at this stage may be due to students rarely encountering questions structured similarly to those in the provided LKPD. This aligns with the post-test results in the control group, where most students demonstrated low critical thinking skills at the "Goals" stage. Meanwhile, the highest level of critical thinking was observed at Stage 7 (Conclusion). Students are required to draw conclusions about a given problem (Susilowati & Sumaji, 2021). The critical thinking process that students followed while

working on the LKPD (Figure 2) indicates a general increase in their critical thinking abilities. This improvement begins at Stage 1 (Goals), then progresses through Stage 2 (Questions), Stage 3 (Assumptions), Stage 4 (Perspectives), Stage 5 (Information), Stage 6 (Concepts), and Stage 7 (Conclusion). However, there was a decline at Stage 8 (Implications), which is consistent with the post-test results in the control group, where a decrease was also observed at this stage.

Students' critical thinking levels in the experimental group while working on LKPD-2 can also be seen in Figure 2. The highest level of critical thinking occurred at Stage 6 (Concepts), which aligns with the post-test results in the control group. Critical thinking ability significantly influences students' conceptual understanding. If a student has strong critical thinking skills, their conceptual understanding will also be strong (Prajono, Gunarti & Anggo, 2022). On the other hand, students' critical thinking skills were lowest at Stage 1 (Goals), which is consistent with the low critical thinking levels observed in LKPD-1. This finding also aligns with the results from LKPD-1 in the experimental group and the post-test in the control group.

The critical thinking process followed by students in the experimental group while working on LKPD-2 (Figure 2) showed an increasing trend at Stage 1 (Goals), Stage 2 (Questions), Stage 3 (Assumptions), Stage 4 (Perspectives), Stage 5 (Information), and Stage 6 (Concepts). However, there was a decline at Stage 7 (Conclusion). This finding is supported by research conducted by Agus & Purnama (2022), which states that students often struggle with drawing conclusions. According to Paul-Elder, a critical thinker needs **accuracy** the ability to evaluate the truth and validity of received information. Additionally, precision is essential in the conclusion stage to avoid ambiguous language. Finally, at Stage 8 (Implications), an increase in critical thinking skills was observed.

The next stage is presenting the results of the LKPD completed by the students. However, only a few students were selected to present due to limited time. The quality of the presentations also depended on the students' presentation skills (Ramadhani & Aristiawan, 2023). Afterward, a reflection session was conducted collaboratively between the teacher and students. This reflection could be done together through peer discussions or with someone considered more knowledgeable (Saputri *et al*., 2023).

A post-test was conducted after two sessions. The post-test was given at the end of the learning process with questions aligned with the material that had been taught (Magdalena *et al*., 2021). The results of the LKPD completed by students in the experimental group, as shown in Figure 1, indicate that LKPD-2 generally had lower scores compared to LKPD-1. The most noticeable difference was in the seventh thinking element, which is conclusion. A study by Sumargono *et al* (2022) found that students' ability to analyze and conclude fell into the low category. Similarly, research conducted by Rahma & Kurniawan (2021) showed that students often struggled to interpret graphs. The ability to draw conclusions is a fundamental skill necessary for students to understand subject matter effectively (Ngilmaya *et al*., 2021).

In Stage 1 of both LKPD-1 and LKPD-2, students' critical thinking skills in goal formulation were almost the same. However, in Stage 2, where students formulated questions, the average score in LKPD-2 was higher than in LKPD-1. In contrast, in Stage 3 (assumptions), the average score for LKPD-2 was lower than for LKPD-1, as was the case for Stage 4 (perspectives) and Stage 5 (information). On the other hand, in Stage 6 (concepts), the average score for LKPD-2 was higher than for LKPD-1. However, in Stage 7 (conclusion) and Stage 8 (implications), LKPD-1 had higher average scores compared to LKPD-2. The height of the diagram reflects students' level of critical thinking. Figure 2 shows that the critical thinking flow in LKPD-1 tended to increase steadily, whereas in LKPD-2, the flow fluctuated, showing ups and downs in students' critical thinking processes. The more stable improvement in LKPD-1 compared to LKPD-2 may be due to differences in the material presented and varying levels of difficulty in the learning content.

The hypothesis test used is the man-whitney test. The Man-Whitney test is used to determine whether there is a significant difference between the application of learning and critical thinking skills.

Based on the output results in table 14, it is known that the Asymp. Sig (2-tailed) result is 0.000 less than 0.05. So it can be concluded that Ha is accepted, thus it can be said that there is a difference in Students' Critical Thinking Skills between the experimental group and the control group. Because there is a significant difference, it can be said that "there is a significant difference between the critical thinking skills of students who apply LKPD based on the Paul Elder framework to students' critical thinking skills" or in other words Ha is accepted and Ho is rejected.

CONCLUSION

This study demonstrates that the application of the Paul-Elder framework can influence students' critical thinking skills. The analysis results indicate that students in the experimental group, who used LKPD based on the Paul-Elder framework, experienced a more significant improvement in critical thinking skills compared to the control group, although there were differences in achievement across different thinking elements. Comparison Between the Control and Experimental Groups:

A. The control group, which received PBL without applying the Paul-Elder framework, still showed an improvement in critical thinking skills, but with a less systematic pattern compared to the experimental group.
B. The experimental group exhibited a more consistent improvement pattern in critical thinking, particularly in stages such as problem identification, information gathering, and concept comprehension.

Overall, the application of the Paul-Elder framework in PBL has been proven to enhance students' critical thinking skills, although certain stages, such as drawing conclusions and setting objectives, still require further attention.

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