
The Effect of Problem Based Learning Worksheet on Critical Thinking Skills of Eight Grade Students: A Perspective from Gender Difference

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Abstract. Critical thinking skills (CTS) are essential in the 4.0 era. However, the attempts to enhance these skills during learning are still suboptimal, particularly in science education at the junior high school. Gender is believed as one affecting factor on students critical thinking. The research investigated the effects of problem based learning (PBL) student worksheets on students critical thinking from the perspective of gender differences. This quasy experimental research applied pretest-posttest nonequivalent multiple group design. The samples were chosen through purposive sampling, resulting in one male class having 24 students and one female class having 24 students. The research instruments included a lesson plan, a PBL-based student worksheet, and pretest-posttest questions that had been validated. Data analysis uses statistical tests in the form of paired and independent sample t-tests, and N-gain. The analysis indicated that using PBL-based student worksheets increases CTS more effectively in female students than in male students. These are proven by paired and independent sample t-tests showing a significant difference (Sig. 2-tailed = 0.000 < 0.050) with N-gain signifies a moderate increase of 0.6 for male students and a high increase of 0.7 for female students. These findings may serve as recommendations to enhance students critical thinking and as a reference for gender-segregated schools in designing learning programs that optimize the role of each gender.

Keywords: student worksheet, PBL, critical thinking, gender

Introduction

Critical thinking skills (CTS) are considered among the central 4C skills in the 4.0 era or 21st century era and are crucial to support the educational process (Ariyati et al., 2021). These skills also serves as a significant determinant factor in individual learning success, including learning activities and outcomes (Pratiwi & Octavia, 2021). Critical thinking stimulates students' cognitive reasoning, enabling them to acquire knowledge and solve problems (Diharjo et al., 2017). In solving a problem, an individual with strong CTS can analyze, evaluate, and draw conclusions to formulate the best decision (Ariyati et al., 2021). Besides, CTS also enables adaptation to changing environments and advancements in science and technology (Prayogi et al., 2018).

However, available evidence suggests relatively low CTS, particularly among students in science courses (Purwanto et al., 2019). Meanwhile, the progression of these skills among Indonesian students has not yielded significant results (Billah et al., 2021). The results of the PISA 2018 signified that Indonesian students placed 70th position among 78 countries in science with an average score of 396 and placed 72nd position among 78 countries in literacy with an average score of 371. These scores are lower than the average scores of the OECD countries, which are 489 and 487 in science and literacy, respectively (Schleicher, 2019). Additionally, the results of the TIMSS survey suggest that Indonesia is placed 36th position among 49 countries (Bajung et al., 2021). In this survey, the science aspect assesses students' ability to identify accurate explanations of scientific phenomena, use knowledge to identify simple cases and determine the validity of a conclusion. Meanwhile, the literacy aspect evaluates their ability to build knowledge, think critically, and formulate reasoned judgments (Schleicher, 2019). These data indicated that level of CTS of Indonesian students is still relatively low compared to other countries. Further, the data suggests that Indonesia's education quality, particularly in the fields of science and literacy, lags significantly behind the other nations.

One of the science course materials with low cognitive learning outcomes is the additives material. A study reported the percentage of correct answers on additive material in the national exam results from 2015-2019 was 31.47%, which falls into the low category (Kartina et al., 2019). Saparuddin et al. (2021) asserted a significant positive correlation between outcomes of learning and skills of critical thinking. Accordingly, the low cognitive learning outcomes in additive material may be attributed to limited CTS.

To enhance students' critical thinking, they must train them during the learning process by integrating problems into learning activities (Sulaeman, 2020). PBL is a method that presents real-life problems as a basis for acquiring knowledge through problem-solving (Fakhriyah, 2014). Activities in PBL that involve students in the process of solving problems are deemed to enhance CTS (Suhirman et al., 2021). As stated by Apriyani et al. (2017), students' critical thinking can be enhanced with PBL. Similarly, Dharma et al. (2019) also describe students' greater critical thinking after attending PBL learning. Another research also discovered that compared to conventional learning, PBL is more effectively in enhancing students' critical thinking (Al-Fikry et al. 2018).

This study presents the integration of problems in PBL to students through the students' worksheets, focusing on problems related to additive materials. The worksheet was chosen as a medium for integrating problems in learning because it contains tasks to be completed by students (Gabriella & Mitarlis, 2021). The use of students' worksheets during the learning processes has been stated to enhance students' processes skills and thinking (Astuti et al., 2018). The integration of real-world problems into students' worksheets is expected to train and enhance students' critical thinking (Aini et al., 2021).

Apart from learning activities, gender has also been reported as an indirect effect on students' critical thinking (Wardani et al., 2018). Male and female students exhibit different characteristics, including learning interests, perseverance, and rigor (Hante et al., 2020). Additionally, they also differ in their analytical abilities in cognitive processes, such as in distinguishing, organizing, and attributing (Kuncoro et al., 2022). Research conducted by Ardiansyah et al. (2023) described that male and female students exhibit varying academic abilities. Their difference in academic abilities is influenced by CTS because both factors have a significant relationship (Hayati, 2019).

Following the aforementioned discussion, a method is needed that can train to increase students' critical thinking through the learning activity, particularly in science aspect, while considering gender differences. Accordingly, the learning facilitated by PBL-based students' worksheets is expected to present positive effects on students' critical thinking. As stated by Khovivah et al. (2022), student worksheet can assist students in constructing knowledge and improving their problem-solving abilities. Further, the

integration of problems into the PBL concept through student worksheets can provide students with valuable experience in conceptualization, thereby, fostering students' critical thinking (Khovivah et al., 2022).

The study on the efficiency of PBL-based students' worksheets to enhance students' critical thinking has been conducted extensively. First, Khovivah et al. (2022) study on the application of PBL-based student worksheets on students' critical thinking of eighth graders and concludes an increase in students' critical thinking. Similarly, Khaldun et al. (2017) also study on the application of PBL-based student worksheets to increase students critical thinking of eighth graders and reported similar findings to Khovivah et al. (2022). However, different from those studies, this research also examines the impact of gender variables on the application of PBL-based student worksheets during learning. Investigation into this aspect is crucial as it can enhance the comprehension of the learning methods employed for accelerating CTS based on gender differences. This knowledge can serve as a reference to promote gender equality, particularly in the education sector. Besides, the study's outcomes are expected to be beneficial, especially in schools that segregate classes by gender.

The research investigated the effects of PBL-based students worksheets on students critical thinking in eighth grade from the perspective of gender differences. This study also provides an alternative approach to training students critical thinking by considering their gender differences.

Methods

This quasy experimental research applied pretest-posttest nonequivalent multiple group design (Table 1). The sampling technique using purposive sampling (Sundayana, 2018).

Table 1. Pretest-posttest nonequivalent multiple group research design

Class	Pretest	Treatment	Posttest
A ₁	O ₁	Treatment with PBL-based student worksheet in male class	O ₂
A ₂	O ₃	Treatment with PBL-based student worksheet in female class	O ₄

(Source: Saprudin et al., 2019)

This research was carried out at Islamic Junior High School Flagship, Amanatul Ummah Surabaya, Indonesia, with a sample of 48 eighth-grade students divided into two class, namely one male class having 24 students and one female class having 24 students. The research instruments included lesson plans, PBL-based student worksheets, and pretest-posttest questions that had been validated by expert lecturers and empirically tested, namely validity and reliability tests.

Data analysis used the Shapiro-Wilk data normality test to assess distribution data, paired sample t-tests to compare pretest-posttest scores within each class, and N-gain analysis to measure learning gains. Meanwhile, independent sample t-tests to compare N-gain between classes. The SPSS software was utilized for data analysis.

The alternative hypothesis (H_A) for interpreting the paired sample t-test is as follows: A significant differences was found in students' critical thinking after learning with a PBL-based student worksheet. In addition, the alternative hypothesis (H_A) adopted for a decision on the independent sample t-test is described in the following: A significant

differences in increasing students' critical thinking between male class and female class when using PBL-based student worksheet.

The calculated N-gain score uses the formula of normalized gain (g), below:

$$g = \frac{\text{posttest score} - \text{pretest score}}{\text{ideal score} - \text{pretest score}} \quad (1)$$

The N-gain score is then categorized into five normalized gain (g) categories that have been modified in such a way, namely:

Table 2. Interpretation N-gain score

N-gain score	Interpretation
$-1.0 \leq g < 0.0$	There is a decrease
$g = 0.0$	Remain
$0.0 < g < 0.3$	Low
$0.3 \leq g < 0.7$	Moderate
$0.7 \leq g \leq 1.0$	High

(Source: Sundayana, 2018)

Results and Discussion

The results of validity on the research instrument suggest that PBL-based student worksheet and the pretest and posttest instrument were feasible to be applied as the research instruments, as presented in Tables 3 and 4.

Table 3. Summary of validation results for PBL-based worksheet instruments

Aspect	%	Criteria
- Media	86.25	Highly feasible
- Content and material	89.40	Highly feasible
Average	87.83	Highly feasible

Table 4. Summary of validation results for the pretest-posttest instrument

Aspect	%	Criteria
- Material and content of assessment item	93.60	Highly feasible
- Language and writing of assessment item	88.00	Highly feasible
Average	90.80	Highly feasible

Table 2 presents the validity results from the PBL-based student worksheet, with an average of 87.83%, classified as highly feasible. Meanwhile, Table 3 shows the validity results on the pretest-posttest question, indicating the average of 90.80% categorized as highly feasible. So it can be concluded that the research instrument is highly feasible for implementation. Besides, the empirical test on the five pretest-posttest questions also suggests valid, as indicated in Table 5.

Table 5. Results of validity test on pretest-posttest question items

No. Item	Koef. Correlation (r)	T _{count}	t _{table}	Description
1	0.723	7.701	2.005	Valid
2	0.649	6.274	2.005	Valid
3	0.729	7.817	2.005	Valid
4	0.722	7.666	2.005	Valid
5	0.666	6.569	2.005	Valid

The reliability of the pretest-posttest question was also obtained a Cronbach's Alpha of 0.730. This indicates that the questions are considered reliable or highly reliable according to Guildford's criteria (Sundayana, 2018). From the validity and reliability of test results, it is evident that all five pretest-posttest questions assessing CTS are valid and reliable. So it can be used as effective research instruments to obtain accurate and consistent results.

In addition, the adoption of PBL-based student worksheet suggests an increase in students' critical thinking, both in male and female students, as illustrated in Figure 1.

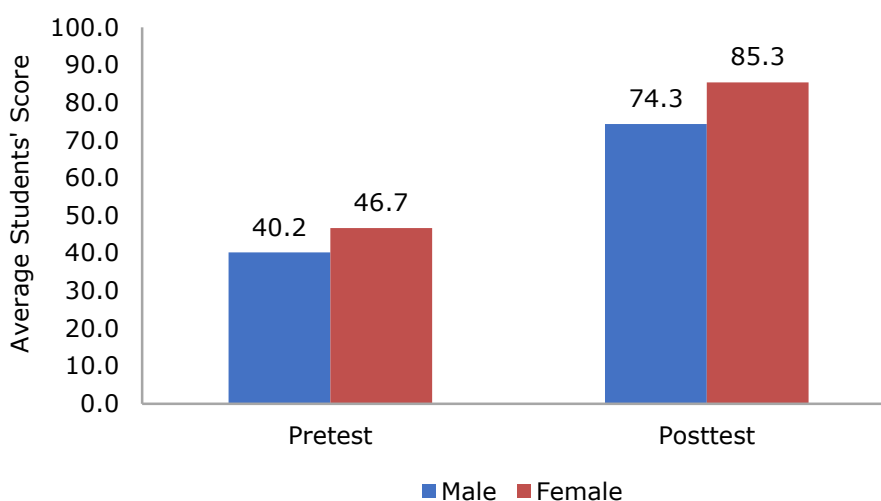


Figure 1. Average pretest and posttest scores on critical thinking skills

To determine the possible significant difference after learning with a PBL-based student worksheet, a t-test was conducted. Before the t-test, a Shapiro-Wilk data normality test was conducted to ascertain the distribution data. Table 6 presents the Shapiro-Wilk test.

Table 6. Results of normality test on pretest-posttest

	<i>Shapiro-Wilk</i>			Description
	Statistic	df	Sig.	
Pretest score of male students	0.923	24	0.067	Normal
Posttest score of male students	0.940	24	0.167	Normal
Pretest score of female students	0.938	24	0.145	Normal
Posttest score of female students	0.933	24	0.116	Normal

The Shapiro-Wilk data normality test results show that all data has a Sig value. > 0.050, thereby, they have a normal distribution, and then data was tested further using a paired sample t-test to evaluate the possible significant difference after learning with a PBL-based student worksheet.

Table 7. Results of paired sample t-test on pretest-posttest

Types of data	df	Sig. (2-tailed)
Pair 1 <i>pretest-posttest</i> male students	23	0.000
Pair 2 <i>pretest-posttest</i> female students	23	0.000

Table. 7 presents the paired sample t-test results on the pretest-posttest for male and female students. The obtained Sig. (2-tailed) value of 0.000 indicates a Sig. (2-tailed) < α , specifically $0.000 < 0.050$. Therefore H_1 is accepted, demonstrating A significant differences was found in students' critical thinking after learning with a PBL-based student worksheet. Based on the findings, it was revealed that using of PBL-based student worksheet affects increasing students' critical thinking. This reason is the integration of PBL in students' worksheet makes students think more critically in acquiring knowledge which in turn supports improving students' critical thinking (Ayunda & Alberida, 2023). Wenno et al. (2021) described that PBL learning model implementation enhances students' critical thinking. Linearly, Ayunda & Alberida (2023) reported that the PBL combined with student worksheets effectively increases students' critical thinking. Khovivah et al. (2022) reported an increase in students' critical thinking of eighth graders after application of PBL-based student worksheet in the material excretory system. Meanwhile, Khaldun et al. (2017) also describe an increase in students' critical thinking of eighth grader students after implementation of PBL-based student worksheet on the topic of light.

In addition, the N-gain test was performed to analyze the enhancement of students' critical thinking who attended the learning using a PBL-based student worksheet. Figure 2 displayed the N-gain test of students' critical thinking from the perspective of gender differences, while Figure 3 displayed the N-gain test on the critical thinking indicators from the perspective of gender differences.

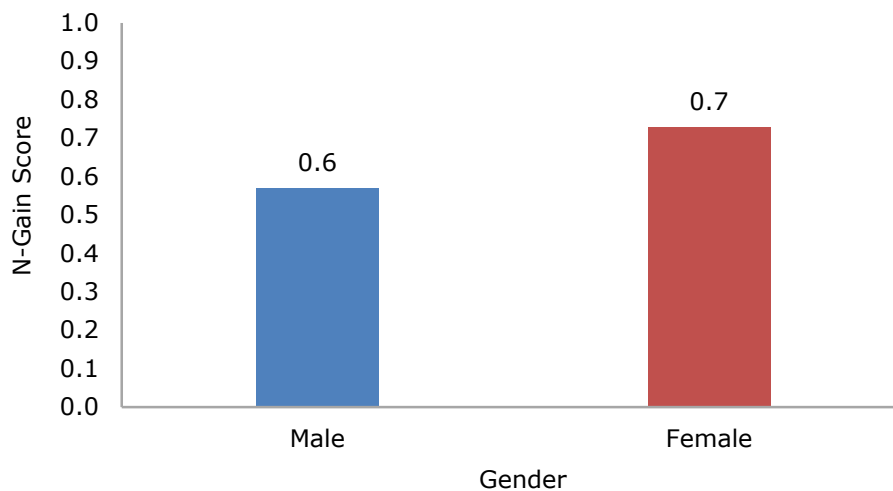


Figure 2. Average N-gain score on critical thinking skills from the perspective of gender differences

Figure 2 shows that the average N-gain score for CTS between male and female students is different. Male students obtained an average score of 0.6 in the moderate category, while female students obtained an average score of 0.7 in the high category.

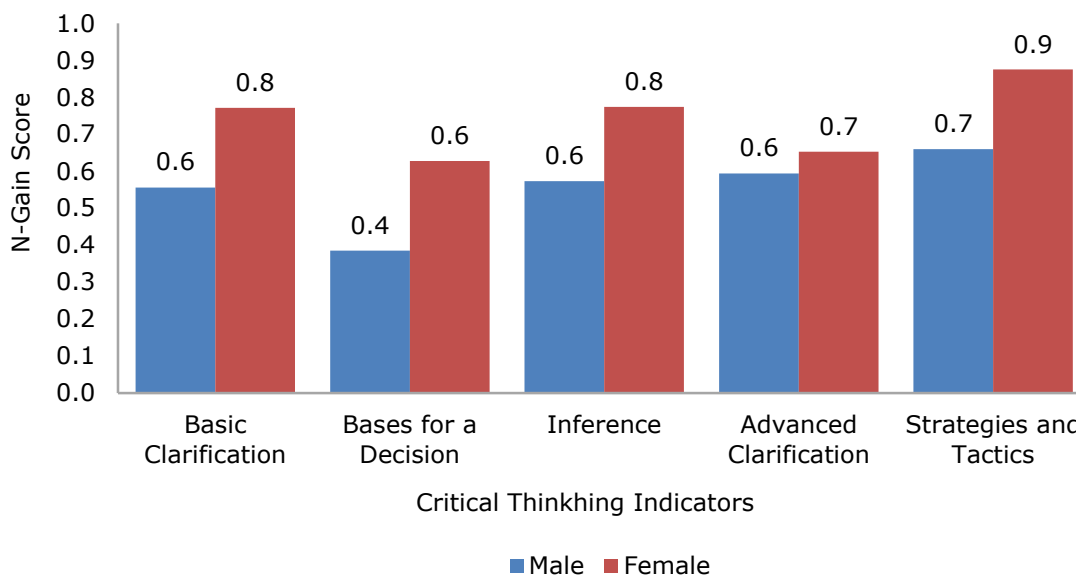


Figure 3. Average N-gain score on critical thinking indicator from the perspective of gender differences

Based on Figure. 3, female students' critical thinking are higher (in the high category) than male students (in the moderate category) on three indicators of CTS. These three indicators are basic clarification, inference, and advanced clarification. As well as strategies and tactics. In the other two indicators of CTS, male and female students are in the same category. These two indicators are the basic for a decision in the moderate category and strategies and tactics in the high category.

The N-gain test results on students' critical thinking were then followed by a t-test to evaluate the difference in improvement of students' critical thinking after application PBL-

based student worksheet from the perspective of gender differences. The study first conducted a normality test using the Shapiro-Wilk test as a prerequisite for the t-test. Table 8 presents the Shapiro-Wilk data normality test.

Table 8. Results of normality test on N-gain

	<i>Shapiro-Wilk</i>			Description
	Statistic	df	Sig.	
<i>N-gain</i> of the male student	0.917	24	0.051	Normal
<i>N-gain</i> of the female student	0.971	24	0.687	Normal

The results of the Shapiro-Wilk data normality test (Table 8) show that all data has a Sig. value > 0.050 . These results show that all data has a normal distribution. By referring to these results, the next stage is to carry out an independent sample t-test to evaluate the significance of differences in the increase in CTS between male and female students after implementing the PBL-based worksheets.

The independent sample t-test results on the N-gain of students' critical thinking from the perspective of gender differences, implying the Asymp. Sig. (2-tailed) = 0.000, which means the value of Asymp. Sig. (2-tailed) $< \alpha$, namely $0.000 < 0.050$. Therefore, H_a is accepted. The analysis results suggest a significant difference in increasing students' critical thinking between male class and female class when using PBL-based student worksheet. This is also supported by the N-gain test results on students critical thinking indicating differences in the average scores, male students have a score of 0.6 (moderate category), while female students have a score of 0.7 (high category). Following the findings, there is a significant difference in increases in students' critical thinking between male and female, namely female students exhibiting higher increases. The study's findings align with previous research conducted by Azizah & Rosdiana (2022), indicating male and female students have differences in terms of critical thinking. Specifically, female students are better than their male counterparts. Similar findings have also been reported by Harso & Gago (2018), indicating in terms of critical thinking, female students possess higher their male counterparts in science. Meanwhile, Wardani et al. (2018) also found that in terms of critical thinking, female students are superior to their male counterparts.

Improving CTS occurs better in female students because they are superior in the areas of explanation, conclusion, and evaluation, as suggested by the N-gain test on critical thinking indicators are evident. The critical thinking indicators for N-gain analysis were adopted from (Ennis, 2015) as illustrated in Figure 3. Male students showed an increase in the high category in only one indicator, namely strategies and tactics indicators. While the other four indicators, namely basic clarification, bases for a decision, inference, and advanced clarification showed an increase in the moderate category. However, female students showed an increase in the high category in four indicators, namely basic clarification, inference, advanced clarification, and strategies and tactics. While the other indicator, namely bases for a decision showed an increase in the moderate category. This finding is linear with the study from Putri et al. (2020) describing that female junior high school students have advantages in analyzing, interpreting, evaluating, concluding, and explaining. Meanwhile, Riadi et al. (2019) identified that female junior high school students have advantages in thinking skills namely, analysis, interpretation, evaluation, conclusion, and explanation.

The dissimilarity in CTS between genders is attributed to distinct brain structures in each gender, which generates their different perspectives (Utami & Yonanda, 2020).

Specifically, female tend to have a thicker corpus callosum compared to male, corpus callosum itself is a brain structure in the form of white matter that resembles a ribbon consisting of nerve fibers and connects the right and left hemispheres of the brain (Amin, 2018). These differences may allow female to perform multiple tasks simultaneously, while male may quickly focus on a single task but experience a decrease in their hearing abilities (Amin, 2018). Accordingly, each gender tends to have differences in learning styles. Male tend to prioritize hands-on activities such as practicum, design, and assembling tools, while female prefer communication-related methods such as lectures, writing, discussions, and presentations (Amin, 2018). Male and female also present distinct verbal abilities, with women having greater verbal skills than male (Izzaty & Setiawati, 2019). Additionally, female students are more enthusiastic, diligent and have a higher learning spirit than male students (Azizah & Rosdiana, 2022). This can also be seen during learning using PBL-based student worksheet. Where female students are more enthusiastic, diligent and have a higher learning spirit than male students. Therefore, gender influences thinking skills, particularly in critical thinking. Research studies by Azizah & Rosdiana (2022) described that gender affects students' critical thinking, particularly in science. Shubina & Kulakli (2019) asserted that gender significantly affects creative and CTS.

The research's findings demonstrate the significance of comprehending gender roles in selecting the relevant learning approach for gender-segregated schools. In this case, educators must recognize that the learning approach must be tailored to the gender-based needs and characteristics for promoting gender equality. Consequently, teachers can make efforts to promote gender equality in education by using a gender-differentiated learning approach, facilitating collaborative activities and projects, encouraging open discussions, as well as conducting education on gender equality.

Conclusion

Based on the results of this research, it can be concluded that implementing PBL-based worksheets is effective in improving students' critical thinking. Learning activities in PBL syntax that are integrated into worksheets have proven to be very helpful in training students' critical thinking. The findings of this research also provide information regarding the differences in the improvement of CTS between male and female students, with better improvements occurring in female students. The explanation related to this finding is that female students have better skills in explaining, concluding, and evaluating. Apart from that, female students are also more enthusiastic and more diligent than male students. The findings of this research strengthen the concept that gender is one of the factors that influence CTS. The author's suggestion as a follow-up to the findings of this research is that PBL-based worksheets can be implemented as an alternative solution in an effort to improve student's critical thinking. However, further studies need to be carried out regarding the development of activity designs in PBL syntax, which can help strengthen the CTS of male students, who, in the results of this study, showed lower results than female students.

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