# Multiple Discriminant Analysis to Measure Critical Thinking by Age, Gender, and Self-Confidence in Elementary Students

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| Article Info | ABSTRACT |
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| | This study is motivated by the importance of critical thinking skills in science learning in elementary schools and the need to understand the factors that may affect it, such as age, gender, and self-confidence of students. The purpose of this study is to analyse whether there is a significant influence of age, gender, and self-confidence on students' critical thinking skills. This research design uses a quantitative approach with the method of multiple discriminant analysis. The research sample consisted of 60 fourth grade students from two elementary schools that had been determined purposively. Data collection survey method were carried out through a critical thinking test and a validated self-confidence questionnaire. Data analysis used SPSS software to determine the classification pattern and contribution of each variable. The results showed that there was no significant effect of age, gender, or self-confidence on students' critical thinking ability. This finding confirms that critical thinking ability is more influenced by other factors outside of these three variables. This research contributes to illustrating that teachers should focus more on learning approaches rather than demographic factors. In the future, this result implies that actively designed and contextualised learning can play a greater role in developing critical thinking ability. |

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## 1. INTRODUCTION

Critical thinking ability is an essential skill in 21st century education, as it enables individuals to analyze information in depth, evaluate arguments, and make informed decisions in the face of complex challenges. The development of critical thinking and problem-solving skills is essential to help students navigate an increasingly complex world (Rusmin & Misrahayu, 2024). In addition, emphasized that the development of critical thinking skills requires a change in the mindset of both educators and students, as well as the importance of motivation and willingness to learn in encouraging these skills (Wardani & Fiorintina, 2023). Furthermore, there are 5 aspects of critical thinking skills, namely providing simple explanations, building basic skills, inferring, making further explanations, and strategies and tactics (Sriliani, 2022).

Critical thinking ability assist students in evaluating information critically and objectively to make informed decisions (Ariadila et al., 2023). Facts in the field show that students' critical thinking ability are still low; for example, only 10% of students achieved scores above the minimum completion criteria, with the class average only reaching 50 out of 100 (Purnami et al., 2021). Although there have been many learning approaches such as problem-based learning (Topsakal et al., 2022) and discovery learning (Pratiwi & Doyan, 2024) that have proven capable of developing critical thinking skills, further understanding is still needed regarding individual student factors that may also contribute to these abilities.

Several studies have shown that individual factors such as age, gender, and self-confidence are believed to play a role in the development of critical thinking (Lubis et al., 2019). The cognitive development of children in

elementary school is in the concrete operational phase, characterized by an increase in simple analytical skills and logical thinking (Demirdag, 2019). The capacity for scientific and critical thinking is greatly influenced by the stages of cognitive development (García-Carmona, 2023). However, age is not always a significant predictor, depending on the learning context and other individual characteristics. Therefore, further exploration of the age of elementary school children becomes important to understand the role of age in their critical thinking dynamics.

On the other hand, gender is often associated with differences in learning styles or academic participation that can affect how students analyze information (Marni et al., 2020). Meanwhile, self-confidence is an affective factor that can potentially influence students' active participation in the critical thinking process. Self-confidence is also an important factor because individuals with high self-confidence tend to be more daring in expressing opinions, taking intellectual risks, and completing challenging tasks independently (Pečiuliauskienė & Belakoz, 2019). With sufficient self-confidence, an individual will be able to actualize their potential with certainty and steadiness. The higher the self-confidence, the higher the goals one wants to achieve (Amri et al., 2018).

Nevertheless, empirical studies on the relationship between age, gender, and self-confidence in critical thinking abilities at the elementary school level are still limited. Most previous studies have focused more on secondary or higher education levels (Khavanin et al., 2021). The lack of research at the elementary level is a significant gap that needs to be filled, considering that this phase is the main foundation for shaping students' thinking patterns. This research has urgency from both theoretical and practical perspectives. Theoretically, this study contributes to expanding the understanding of individual determinants that may influence critical thinking abilities from an early age. Practically, the results can serve as a basis for decision-making by teachers and curriculum developers to design more targeted learning interventions based on student characteristics. By comprehensively analyzing the influence of age, gender, and self-confidence on critical thinking, this research is expected to make a tangible contribution to efforts to improve the quality of science education in elementary schools.

## 2. METHOD

This research uses a quantitative approach with a non-experimental design. while the non-experimental design is appropriate because the researcher only observes the variables as they are in the natural environment, without providing any special treatment (Sugiyono, 2017). This approach was chosen because this study does not involve manipulation of variables, but rather focuses on measuring relationships and differences between groups based on certain characteristics, as is common in non-experimental quantitative research (Creswell, 2012). The analysis method used is Multiple Discriminant Analysis (MDA), which is a multivariate technique that falls under the Dependence Method. In discriminant analysis, the criterion or dependent variable is non-metric (categorical), and the predictor or independent variable is metric (interval or factor) (Malhotra, 2020). Independent variables (age, gender, and self-confidence) are measured as follows: age in years (interval scale), gender as a binary categorical variable (1 = female, 2 = male), and self-confidence as a composite score from Likert scale questionnaire responses.

In this study, the dependent variable or category used is critical thinking ability, while the independent variables used are age, gender, and self-confidence. The use of MDA in this research aims to see to what extent these three variables can predict or explain differences in students' critical thinking abilities. The sample in this study consists of fourth-grade students from seven elementary schools. In each school, 10 students were selected as respondents, resulting in a total sample size of 70 students for this study. The sampling technique used purposive sampling method, considering regional representation and data availability at each school. Fourth-grade students were chosen because at this level, their critical thinking skills begin to develop more complexly, and they start to express their self-confidence more clearly in the context of science learning.

Data collection survei method, namely through tests and questionnaires. The survey method allows for data collection in a relatively short time with a wide range of respondents (Haegele & Hodge, 2015). To measure students' critical thinking ability, a 12-item essay test related to 4th-grade science, specifically the topic of energy transformation, was used. Meanwhile, to measure students' self-confidence, a questionnaire instrument consisting of 28 statements based on aspects of self-confidence was used. Data analysis was conducted using two software programs: SmartPLS 4 to test the validity and reliability of the self-confidence instrument constructs and SPSS 25 to perform multiple discriminant analysis (MDA) on the relationships between variables. The construct validity of the self-confidence instrument was tested using Smart PLS 4, with outer loading values > 0.70 for 14 items deemed valid. Reliability was tested with a Cronbach's Alpha value of 0.84, indicating good internal consistency (Anggraini et al., 2022).

Table 1. Participant Demograpics

| Factor | Category | Total | Percentage |
|---|---|---|---|
| Age | 9 | 10 | 14,2% |
| | 10 | 44 | 62,8% |
| | 11 | 16 | 22,8% |
| Gender | Female | 39 | 55,7% |
| | Male | 31 | 44,2% |
| Self-Confidence | Low | 17 | 23,9% |
| | Medium | 38 | 53,5% |
| | High | 16 | 22,5% |

Based on the participant demographics table, it can be concluded that the majority of research participants were at the age of 10, dominated by female participants, and all participants had complete data regarding their level of self-confidence. This composition shows a fairly representative distribution for analysis based on age, gender, and self-confidence. Self-confidence was measured using a 28-item Likert scale questionnaire, with each item rated on a four-point scale. Students' confidence scores ranged from 58.93 to 91.96 out of a maximum of 112, with an average of 75.80 (Standard Deviation = 8.40). This indicates that students generally have a moderate to high level of self-confidence, although there is variation that reflects diverse individual characteristics. The total score is calculated as the sum of item scores, and the average is used for further analysis in the discriminant model.

After the data was obtained, the researcher conducted a test on spss25 software to see the multiple discriminant factor analysis of these factors on students' critical thinking skills. Based on the research objectives and problem formulation that have been previously outlined, the hypothesis in this study is formulated to test the influence of three independent variables, namely age, gender, and self-confidence, on the critical thinking ability of elementary school students. The suggested hypothesis is tested using straightforward multiple discriminsnt analysis once the requirements are satisfied, specifically:

(H1) There is a significant influence of age on the critical thinking ability.
(H2) There is a significant influence of gender on the critical thinking ability.
(H3) There is a significant influence of self confidence in the critical thinking ability.

## 3. RESULT AND DISCUSSION

Based The Dependent Variable (categorical or nominal data) is critical thinking ability (Y). The dependent variable consists of 2 categories, namely if the total critical thinking ability test score < 28 it is said to be (0), where as if the total critical thinking ability test score ≥ 28 it is said to be (1). Independent Variables (interval or ratio data) that influence factors consist of Age (X1), Gender (X2), self-confidence (X3). The age variable is represented in years (9, 10, and 11), gender is coded with the number 1 for females and 2 for males, while self-confidence is recorded based on the average score from the questionnaire that has been tested for validity. This data is used as the basis for conducting relationship analysis and predicting the influence on students' critical thinking ability after completing the previously distributed test instruments.

Table 2. Group Statistic

| Critical Thinking | | Mean | Std. Devation | Valid N (listwise) | |
|---|---|---|---|---|---|
| | | | | Unweighted | Weighted |
| Critical thinking < 28 | Age | 10.1389 | .59295 | 36 | 36.000 |
| | Gender | 1.14167 | .50000 | 36 | 36.000 |
| | Self-Confidence | 2.9636 | .45855 | 36 | 36.000 |
| Critical thinking ≥ 28 | Age | 10.0294 | .62694 | 34 | 34.000 |
| | Gender | 1.4706 | .50664 | 34 | 34.000 |
| | Self-Confidence | 2.9626 | .55212 | 34 | 34.000 |
| Total | Age | 10.0857 | .60775 | 70 | 70.000 |
| | Gender | 1.4429 | .50031 | 70 | 70.000 |
| | Self-Confidence | 2.9631 | .50244 | 70 | 70.000 |

Table 2 shows the mean, standard deviation, and number of valid data for the variables of age, gender, and self-confidence based on two groups of students' critical thinking ability (scores < 28 and ≥ 28). The average age

in both groups is the same, which is 10 years. The average gender score for those with a score < 28 is 1.41 (more females), while for those with a score ≥ 28 it is 1.47 (more males). The average self-confidence in both groups is the same, which is 2.96. The standard deviation describes the data distribution, and the number of valid data points is 36 for the group with scores < 28 and 34 for scores ≥ 28.

Table 3. Tests of Equality of Group Means

| Factor | Wilks' Lambda | F | df1 | df2 | Sig. |
|---|---|---|---|---|---|
| Age | .992 | .564 | 1 | 68 | .455 |
| Gender | .997 | .201 | 1 | 68 | .656 |
| Self-Confidence | 1.000 | .000 | 1 | 68 | .989 |

After determining the mean, standard deviation, and the number of valid data for the variables of age, gender, and self-confidence, the tests of equality of group means were conducted. Table 3 shows to determine whether the difference in the average of a free variable based on the groups of students with critical thinking < 28 and ≥ 28 is statistically significant or not, compare the sig value with the significance level ($\alpha$) used. If the sig value ≥ significance level ($\alpha$), then the difference in means is statistically significant. However, if the sig value < significance level ($\alpha$), then the difference in means is not statistically significant (Di Leo & Sardanelli, 2020). There is a statistically significant difference in the mean of a free variable based on groups of students with critical thinking ability < 28 and critical thinking ability ≥ 28, it indicates that the free variable has an influence in terms of grouping.

Then the analysis results also show that the significance value (Sig.) for the age variable is 0.455. Since this value is greater than the significance level ($\alpha = 0.05$), the average difference in age between students is not statistically significant. Furthermore, the Sig. value for the gender variable is 0.656, which also exceeds $\alpha = 0.05$, so the average difference in gender between students with critical thinking ability is not statistically significant. Similarly, the Sig. value for the self-confidence variable was 0.989, which was much greater than $\alpha = 0.05$. This indicates that the difference in average self-confidence between the two groups of students is not statistically significant. Overall, the three variables-age, gender, and self-confidence-showed no significant effect on the difference in students' critical thinking ability.

Table 4. Pooled Within-Groups Matrices

| | Factor | Age | Gender | Self-Confidence |
|---|---|---|---|---|
| **Correlation** | Age | 1.000 | .069 | .003 |
| | Gender | .069 | 1.000 | -.176 |
| | Self-Confidence | .003 | -.176 | 1.000 |

Table 4 shows the correlation matrix between the independent variables used in the discriminant analysis, namely age, gender, and self-confidence. Based on the results of the analysis, all correlation values between these variables are below 0.3, indicating that the relationship between them is weak or very weak. For example, the correlation value between age and gender is 0.069, indicating that there is no significant relationship between a student's age and gender. Similarly, the correlation between age and self-confidence is only 0.176, so it can be concluded that an increase in student age is not always related to a consistent increase in self-confidence. Meanwhile, the relationship between gender and self-confidence had a negative correlation value of -0.116, indicating a small tendency for certain genders to have different levels of self-confidence, although the difference was not significant. Overall, the low correlation between these three variables indicates that there is no strong multicollinearity, so each variable can be analyzed independently in the discriminant model without significantly affecting each other.

Based on the results of multiple discriminant analysis (MDA) that examined the effect of age, gender, and self-confidence on critical thinking ability, the results of this study indicate that the variables of age, gender, and self-confidence have no significant effect on students' critical thinking skills. This finding is in line with the results of a study which states that there is no significant relationship between age and gender with the critical thinking skills of medical students (Khavanin et al., 2021). Another study also showed that students' critical thinking skills did not differ significantly based on gender or knowledge group (Marni et al., 2020). In addition, critical thinking is described as a process that is influenced more by the learning approach and scientific context than by demographic factors such as age and gender (García-Carmona, 2023).

The insignificant effect of self-confidence on critical thinking skills in this study is also supported by the results of previous studies. Although there are differences in the level of self-confidence between male and female students, it is not directly correlated with critical thinking ability (Kukulu et al., 2013). Another finding states that self-confidence is more influenced by psychosocial factors such as social support and self-care behavior, not by critical thinking skills (Mohebi et al., 2018). In addition, students' self-confidence or self-esteem did not show a significant relationship with their level of critical thinking ability (Khavanin et al., 2021).

## 4. CONCLUSION

This study investigated the influence of age, gender, and self-confidence on elementary school students' critical thinking skills using the Multiple Discriminant Analysis method. Although these three variables were initially hypothesized to contribute to critical thinking, the analysis revealed no statistically significant effects. This outcome aligns with prior research suggesting that critical thinking is more strongly influenced by instructional approaches and learning contexts than by demographic or psychological factors. Accordingly, teachers are recommended to prioritize the implementation of innovative, contextualized teaching strategies to foster students' critical thinking. Future research is suggested to examine additional variables such as instructional models, teacher-student interactions, or classroom climate, and to employ alternative methodological designs such as longitudinal, mixed-method, or quasi-experimental approaches to gain deeper and more generalizable insights

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