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# The Roles of Academic Ability, Gender, and Grade Level in Pre-Service Teachers' Critical Thinking Skills at Ecology Course

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**Abstract**

Pre-service teachers (PSTs) are expected to have the ability to engage in mitigating various ecological difficulties in the future thanks to their abilities in critical analysis. Critical thinking (CT) is influenced by various factors. However, not much in-depth research has been conducted on CT skills in previous studies. This study evaluated PSTs' CT abilities based on GPA, gender, and grade level. In this quantitative descriptive research, 265 PSTs from various institutions in Java, Indonesia participated. An ecological essay test was used to collect data, and descriptive statistics and the Kruskal Wallis test were used to analyze the data. The results showed that PSTs' CT skills were in the medium category ($\bar{x}$ = 45.12), with the interpretation component getting the highest score ($\bar{x}$ = 51.64) and the inference aspect getting the lowest score ($\bar{x}$ = 33.96). The findings of this study also showed statistically significant differences in CT skills based on GPA, gender, and grade level. Better CT skills are found in PSTs who have a high GPA, are female, and are in 5$^{th}$ grade. This finding may have an impact on improving lecture programs so that PSTs' CT skills improve more effectively.

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## 1. INTRODUCTION

Trends related to critical thinking (CT) skills in the world have continued to increase within a decade (Saphira et al., 2022). In another study, over the past two decades, a substantial body of literature consisting of several publications has consistently highlighted the ongoing significance of CT skills as a central area of concern requiring attention and resolution (Dong et al., 2023). Educators in various countries, such as Thailand, Vietnam (Asia), the UK (Europe), and Canada (North America), are still working on developing their students' CT skills (Seki et al., 2023). Seki et al., (2023) also reported that 86% of educators from these countries still experience challenges in empowering CT skills. Demir et al., (2023) have supported the notion that enhancing CT abilities remains a primary objective in the educational systems of Korea, Turkey, and the United States of America. CT is regarded as an essential educational objective, but it has not yet been optimally trained and developed (Eren & Akinoglu, 2013). There is still relatively little evidence concerning the results of developing CT skills in various educational contexts (Cui & Teo, 2023). Various studies in Indonesia also show that PSTs do not yet have optimal CT skills (Amin et al., 2017; Iwan et al., 2023; Supratman et al., 2021).

CT skills are a logical and rational reflective process to produce appropriate and accountable decisions (Ennis, 1993). CT skills can be seen as reasoning skills in understanding a problem and, at the same time, formulating a solution logically (Sosu, 2012). CT are also associated with the skills to reflect on the thinking

process and its outcomes (Ho et al., 2023; Wang & Zheng, 2016). Reflection is a key element of metacognitive skills manifested in evaluation skills (Cui & Teo, 2023). CT is a cognitive process that encompasses problem-solving, formulation of conclusions, assessment of probabilities, and the act of decision-making (Wang & Zheng, 2016). CT skills include aspects of analysis, interpretation, inference, evaluation, explanation (Fikriyati et al., 2022; Marni et al., 2019), problem identification and formulation (Purnami et al., 2021), self-regulation (Wale & Bishaw, 2020), conceptualization and application (Changwong et al., 2018). CT skills are objectively analyzing and evaluating problems to make judgments (D'Alessio et al., 2019). CT skills are measured from interpretation, analysis, evaluation, inference, and explanation skills. These five types of skills are considered to underlie the maturity of students' thinking in responding to contextual problems around them (Marni et al., 2019), especially those related to environmental problems (Purnami et al., 2021).

CT abilities are crucial in a variety of professions, including for teachers and pre-service teachers (PSTs). Teachers must possess CT competencies in the 21st century (Gümüs, 2022; Wang & Jia, 2023). CT skills are a predictor of a PST's professional identity, both in terms of content mastery, didactics and pedagogy (Sheybani & Miri, 2019). PSTs who are critical will be able to organize dynamic learning and, at the same time, be relevant to the needs and characteristics of students. PSTs require CT skills to monitor scientific developments and analyze real-world problems (Hujjatusnaini et al., 2022). Acquiring proficient CT abilities empowers educators and prospective instructors to establish an educational setting that fosters the development of their students' necessary thinking skills (Ayçiçek, 2021; Wang & Jia, 2023). Cultivating CT abilities is essential for comprehending the complex structure of biological systems while also serving as a fundamental component of the evaluation process within the natural sciences (Saenab et al., 2021).

Acquiring and refining CT abilities are subject to various influences, including academic ability (Alkharusi, 2019; Permana et al., 2019; Suciati et al., 2022). Academic abilities are generally reflected in learning outcomes (Fong et al., 2017) and students' learning performance (D'Alessio et al., 2019). Individu with high academic abilities tend to have good initial knowledge, which has implications for high CT skills (Mahanal et al., 2019). Technically, the academic abilities of student in higher education are generally described through their grade point average (GPA) score. Apart from academic abilities, a possible factor that influences CT skills is gender. According to Erdoğan (2020), Tamam et al., (2021), and Suciati et al., (2022), male PSTs have different CT abilities than female PSTs. In contrast, (2013) reported that the CT skills of male PSTs did not differ significantly from those of female students. The next factor that plays a role in influencing CT skills is the level of education. Gedik (2013) reported that upper-level PSTs had better or superior thinking skills than lower-level PSTs. The learning experiences received in the learning process within a certain time can impact the empowerment of CT skills in PSTs (Bustami et al., 2016; Saputri et al., 2020). Several studies related to CT skills only focus on gender (Tamam et al., 2021) gender and class level (Gedik, 2013), gender and GPA score (Suciati et al., 2022), and academic ability (Zubaidah et al., 2018). One study was found to examine CT skills from the perspectives of gender, academic achievement, and grade level (Erdoğan, 2020). However, this research only discusses CT skills in general, without touching on every aspect of CT skills.

The enhancement of CT skills is also crucial in the context of ecological learning. Professionals in various fields must master key ecological concepts and their applications to identify the causes and impacts of an environmental issue and simultaneously be actively involved in implementing solutions (Lewinsohn et al., 2015). Ecological learning is oriented towards developing students' CT skills in analyzing various phenomena and solving environmental problems based on mastery of ecological concepts (Mayarni & Nopiyanti, 2021). Critical reflection and creative imagination on everyday environmental issues in certain socio-cultural contexts can encourage higher education students' competence and motivation in implementing pro-environmental behaviour (Cheng, 2019). CT skills about the environment are an important form of cognitive skill in the 21st century that can be used to identify, interpret, conclude, explain, analyze and evaluate material or problems related to the environment (Purnami et al., 2021). CT skills help researchers and conservationists make good decisions, solve problems, and manage resources in adaptive ways (Porzecanski et al., 2021).

This urgency is also very relevant to the people in Java, who still face various environmental problems such as industrial activities, population growth (Pujiati et al., 2023), and waste management (Darus et al., 2020). Deforestation and deforestation on the islands of Java and Bali have occurred since 1950 as an implication of significant population growth (Santoro et al., 2023). Existing environmental problems are also accompanied by the issue of moving the national capital from Jakarta to East Kalimantan in 2024, which is full of various environmental issues. Several environmental factors that generally encourage capital city relocation include environmental pressure due to population, air pollution, the Urban Heat Island (UHI) phenomenon, decreased quality and environmental resources due to the development of settlements and urban areas, the potential to be affected by disasters, and geographic centrality (Rachmawati et al., 2021). The need for environmental conservation faced by the Indonesian Javanese community then represents increasingly threatening global environmental problems and challenges. The rapid pace of industrialization and urbanization has increased

deforestation significantly, increasing average temperature, climate change, the intensity of natural disasters (Ali et al., 2014), wood supply, imbalance in the hydrological cycle, threats to biodiversity, global cycles of important elements, as well as massive carbon emissions (Indarto & Mutaqin, 2016). Forest existence is related to the dynamics of temperature, rainfall, hydrological cycle (Xu et al., 2022), and carbon regulation (Lawrence et al., 2022). On the other hand, deforestation, pollutions, and climate change are bad for global mental health (Wigand et al., 2022).

Research that examines critical thinking skills has been conducted by involving certain variables, such as gender (Tamam et al., 2021), gender and semester level (Gedik, 2013), gender and GPA (Suciati et al., 2022), as well as academic ability (Zubaidah et al., 2018). Erdoğan (2020) has also studied critical thinking skills based on gender, academic achievement, and semester level, but has not analyzed each aspect of critical thinking specifically in a specific learning context. This result shows that most of the previous research is still partial and has not studied critical thinking skills comprehensively by integrating various factors that affect it, especially in the context of ecological learning. Therefore, empirical evidence that simultaneously examines the relationship between GPA, gender, semester level, and the five main aspects of critical thinking (interpretation, analysis, evaluation, inference, and explanation) in biology teacher candidates in Indonesia is still relatively limited.

Based on these conditions, this research contributes by presenting a comprehensive analysis of the critical thinking skills profile of prospective biology teacher students based on aspects of critical thinking as well as examining the role of GPA, gender, and semester level in an integrated way in ecological learning. The findings of this research are expected to be an empirical basis in the development of more effective learning design in biology teacher education programs.

## 2. RESEARCH METHOD

### 2.1. Research Design and Procedure

This study employed a quantitative non-experimental design with descriptive and inferential approaches. The descriptive approach was used to describe the profile of pre-service teachers' critical thinking skills in ecology courses, while the inferential approach was applied to examine differences based on GPA, gender, and grade level. Data on CT skills is obtained by filling out essay test related to ecosystem material and its problems which are taught in Ecology courses using google form.

### 2.2. Participants

The participants in this research included of 265 pre-service teachers (PSTs) who were enrolled in Ecology courses at different universities in Java, Indonesia. The participants were selected using purposive sampling based on their enrollment in ecology courses. Table 1 displays the demographic characteristics of the participants.

**Table 1.** Demographic data of participants

| Characteristic | | Amount | Percentage |
|---|---|---|---|
| GPA scores | < 3.00 (Low) | 14 | 5.28% |
| | 3.00 – 3.49 (Medium) | 60 | 22.64% |
| | >3.50 (High) | 191 | 72.08% |
| Gender | Male | 30 | 11.32% |
| | Female | 235 | 88.68% |
| Grade Levels | 3rd grade | 90 | 33.96% |
| | 5th grade | 175 | 66.04% |

### 2.3. Research Instruments

Data were collected using an essay test consisting of seven items with a rating scale of 0-3. Aspects of CT skills that are measured include aspects of interpretation, analysis, evaluation, inference, and explanation (Facione, 1990; Fikriyati et al., 2022; Plummer et al., 2022; Sutama et al., 2022). This essay test has gone through an expert validation and empirical validation process. Five experts from the fields of biology education and ecology and environmental science carried out the validation process. The results of the analysis using Aiken's formula show that the questions are very valid, with a validity index > 0.8. Empirical validation was conducted by administering a set of questions to a sample of 100 PSTs studying biology education. The obtained data was thereafter subjected to Confirmatory Factor Analysis (CFA) for the purpose of analysis (See Table 2).

**Table 2.** Empirical question validation results

| Item | SLF | Error | $SLF^2$ | AVE | CR |
|---|---|---|---|---|---|
| A1 | 0.876 | 0.232 | 0.768 | 0.810 | 0.895 |
| A3 | 0.923 | 0.148 | 0.852 | | |
| B4 | 0.900 | 0.190 | 0.810 | 0.859 | 0.924 |
| B6 | 0.953 | 0.092 | 0.908 | | |
| C7 | 0.961 | 0.076 | 0.924 | 0.924 | 0.924 |
| D9 | 0.961 | 0.076 | 0.924 | 0.924 | 0.924 |
| E11 | 0.962 | 0.074 | 0.926 | 0.926 | 0.926 |

The results in Table 2 show that the questions are valid with an SLF (Standardized Loading Factor) value ≥ 0.5 and reliable with an AVE value (Average Variance Extracted) ≥ 0.5 and CR (Construct Reliability) ≥ 0.7 (Hair Jr et al., 2019). There were 5 question items that were eliminated during the validation process from an initial total of 12 items.

## 2.4. Data Analysis

The data were analyzed using descriptive and inferential statistics. Descriptive statistics were used to summarize students' critical thinking profiles and categorize their achievement levels. Inferential analysis using the Kruskal-Wallis test was conducted to examine differences in critical thinking skills based on GPA, gender, and grade level, as the data did not meet the assumptions of normality and homogeneity, with each significance value < 0.05 (See Table 3 & Table 4). The criteria for categorizing students' CT skills were adopted from Verawati et al., (2022) (See Table 5).

**Tabel 3.** Normality test results

| Aspect | Kolmogorov-Smirnov[a] | | |
|---|---|---|---|
| | Statistic | df | Sig. |
| Interpretation | .204 | 265 | .000 |
| Analysis | .212 | 265 | .000 |
| Evaluation | .302 | 265 | .000 |
| Inference | .386 | 265 | .000 |
| Explanation | .284 | 265 | .000 |

**Table 4.** Homogeneity test results

| | Levene Statistic | df1 | df2 | Sig. |
|---|---|---|---|---|
| Based on Mean | 35.794 | 4 | 1320 | .000 |

**Tabel 5.** Criteria for CT skills

| | Percentage | Criteria |
|---|---|---|
| CT > Xi + 1.8 Sdi | CT > 80 | Very high |
| Xi + 0.6 Sdi < CT ≤ Xi + 1.8 Sdi | 60 < CT ≤ 80 | High |
| Xi - 0.6 Sdi < CT ≤ Xi + 0.6 Sdi | 40 < CT ≤ 60 | Moderate |
| Xi - 1.8 Sdi < CT ≤ Xi - 0.6 Sdi | 20 < CT ≤ 40 | Low |
| CT ≤ Xi - 1.8 Sdi | CT ≤ 20 | Very low |

Note:

$Xi = \frac{1}{6}$ (maximum score + minimun score)

$Sdi = \frac{1}{6}$ (maximum score - minimum score)

## 3. RESULT AND DISCUSSION

### 3.1. Results

#### 3.1.1. Profil of PSTs' CT skills

The findings pertaining to the examination of CT skills of PSTs are displayed in Table 6, Table 7, and Table 8. The analysis results in Table 6 show that more than 50% of PSTs have achieved CT skills in the moderate category. Interestingly, the total percentage of PSTs with low and very low CT skills (total: 27.54) is greater than that of PSTs with high CT skills (total: 19.62).

**Table 6.** CT skills achievements

| | Very Low | Low | Moderate | High | Very High |
|---|---|---|---|---|---|
| Person (%) | 9,43 | 18,11 | 52.83 | 19,62 | - |

**Table 7.** Kruskal-Wallis test results for aspects of CT skills

| Aspect | Means Rank | Kruskal-Wallis H Score | Df | Asymp. Sig. |
|---|---|---|---|---|
| Interpretation | 790,22 | 136,88 | 4 | 0,000 |
| Analysis | 742,46 | | | |
| Evaluation | 606,50 | | | |
| Inference | 463,40 | | | |
| Explanation | 712,42 | | | |

**Table 8.** Summary of descriptions of aspects and profiles of CT skills

| Aspect | Average Score | Category |
|---|---|---|
| Interpretation | 51.64 | Moderate |
| Analysis | 48.43 | Moderate |
| Evaluation | 42.01 | Moderate |
| Inference | 33.96 | Low |
| Explanation | 49.43 | Moderate |
| Total Average | 45,12 | Moderate |

Next, analysis with the Kruskal Wallis test in Table 7 produces a Sig. value 0.000 ≤ 0.05. These results show a difference in the mean significant rank in all five aspects of CT skills. The analysis results in Table 8 also show that the highest achievement is in the interpretation aspect, with a mean score of 51.64 (moderate category). On the other hand, the lowest achievement was in the inference aspect, with an average score of 33.96 (low category). However, the results of this study poin out that the average achievement of the CT skills of PSTs as a whole is in the moderate range.

#### 3.1.2. CT skills of PSTs based on Academic Ability

The findings pertaining to the evaluation of CT abilities in relation to the academic ability (GPA score) are displayed in Table 9 and Table 10. According to the findings presented in Table 9, a statistically significant distinction was observed in the CT skills of PSTs with high, medium, and low grade point average (GPA) values (Sig. < 0.05).

**Table 9.** Kruskal-Wallis test results of CT skills based on GPA score

| Level of GPA Score | N | Means Rank | Chi-Square | Df | Sig. |
|---|---|---|---|---|---|
| < 3.00 (Low) | 14 | 50.79 | 42,613 | 2 | .000 |
| 3.00 – 3.49 (Medium) | 69 | 98.21 | | | |
| >3.50 ( High ) | 182 | 152.51 | | | |

The analysis results in Table 10 clearly show that only PSTs with high GPA scores have moderate category CT skills. Meanwhile, CT skills in the other two groups was in the low category. However, PSTs with a medium GPA score have CT skills 27.60% higher than those with a low GPA score. Based on Table 10, the achievement of all aspects of PSTs' CT skills with low GPA scores is in the low category. In addition, only the interpretation and explanation aspects of PSTs with medium GPA scores were in the moderate category, and only the inference aspects of PSTs with high GPA scores were in the low category. The analysis results in Table 10 show an interesting trend that PSTs' achievements in CT skills tend to align with their academic ability.

**Table 10.** Average achievement of CT skills based on GPA score

| Level of GPA Score | CT skills | | | | |
|---|---|---|---|---|---|
| | Total Average | Categories | Aspect | Average Per Aspect | Category per Aspect |
| < 3.00 | 29.92 | Low | Interpretation | 36.90 | Low |
| | | | Analysis | 23.81 | Low |
| | | | Evaluation | 23.81 | Low |
| | | | Inference | 23.81 | Low |
| | | | Explanation | 30.95 | Low |
| 3.00 – 3.49 | 38.18 | Low | Interpretation | 43.33 | Moderate |
| | | | Analysis | 39.44 | Low |
| | | | Evaluation | 33.33 | Low |
| | | | Inference | 26.11 | Low |
| | | | Explanation | 41.67 | Moderate |
| >3.50 | 54.02 | Moderate | Interpretation | 55.15 | Moderate |
| | | | Analysis | 53.05 | Moderate |
| | | | Evaluation | 45.90 | Moderate |
| | | | Inference | 37.00 | Low |
| | | | Explanation | 53.40 | Moderate |

### 3.1.3. CT skilss of PSTs based on Gender

The findings related to the attainment of CT skills among PSTs based on gender are given in Table 11 and Table 12. Table 11 shows that male PSTs' CT skills significantly differ from female PSTs (Sig. 0.020 < 0.050).

**Table 11.** Kruskal-Wallis test results of CT skills according to gender

| Gender | N | Means Rank | Chi-Square | Df | Asymp. Sig. |
|---|---|---|---|---|---|
| Male | 30 | 102.48 | 5,426 | 1 | .020 |
| Female | 235 | 136.90 | | | |

The analysis results in Table 12 show that the achievements of male and female PSTs' CT skills are in the moderate category. Even so, the CT skills in female PSTs was 29.62% higher than in male PSTs. The analysis results in Table 12 also show three aspects of CT skills in male PSTs already in the moderate category, namely aspects of interpretation, evaluation, and explanation. Meanwhile, for female PSTs, the achievements for all aspects of CT skills were already in the moderate level, except inference aspect.

**Table 12.** CT skills achievement according to gender

| Gender | CT skills | | | | |
|---|---|---|---|---|---|
| | Total Average | Overall Categories | Aspect | Average Score | Categories Per Aspect |
| Male | 40.37 | Moderate | Interpretation | 48.33 | Moderate |
| | | | Analysis | 38,33 | Low |
| | | | Evaluation | 41.11 | Moderate |
| | | | Inference | 32.22 | Low |
| | | | Explanation | 41.11 | Moderate |

| | | | | | |
|---|---|---|---|---|---|
| Female | 52.33 | Moderate | Interpretation | 55.18 | Moderate |
| | | | Analysis | 51.64 | Moderate |
| | | | Evaluation | 46.72 | Moderate |
| | | | Inference | 35.61 | Low |
| | | | Explanation | 51.26 | Moderate |

### 3.1.4. CT skills of PSTs based on grade levels

The analysis results regarding PSTs' CT skills achievements based on grade levels are shown in Tables 13 and 14. Based on the data shown in Table 13, there is a significant disparity in the CT abilities of 3rd grade PSTs and 5th grade PSTs (Sig. 0.000 < 0.050).

The findings presented in Table 14 poin out that the CT skills of 3rd grade and 5th grade PSTs fall within the moderate range. However, the CT skills achievement of 5th grade PSTs was 26.76% higher than that of 3rd grade PSTs. Interestingly, the inference aspect was the only lowest achievement, both in the 3rd grade and 5th grade PSTs.

**Table 13.** Kruskal-Wallis test results of CT skills by grade levels

| Grade Levels | Means Rank | Chi-Square | Df | Asymp. Sig. |
|---|---|---|---|---|
| 3rd Grade | 98.97 | 27,187 | 1 | 0.000 |
| 5th grade | 150.50 | | | |

**Table 14.** CT skills aspects achievement by grade levels

| Grade Levels | CT skills | | | | |
|---|---|---|---|---|---|
| | Total Average | Overall Category | Aspect | Average Score | Categories Per Aspect |
| 3rd grade | 41.81 | Moderate | Interpretation | 52.47 | Moderate |
| | | | Analysis | 47.07 | Moderate |
| | | | Evaluation | 40.84 | Moderate |
| | | | Inference | 33.33 | Low |
| | | | Explanation | 48.35 | Moderate |
| 5th grade | 53.30 | Moderate | Interpretation | 49.80 | Moderate |
| | | | Analysis | 51,41 | Moderate |
| | | | Evaluation | 44,58 | Moderate |
| | | | Inference | 35,34 | Low |
| | | | Explanation | 51.81 | Moderate |

## 3.2. Discussions

Mastery of CT skills supports the success of PSTs in the academic field and everyday life. However, CT skills are not passed down from birth but require a proper trigger to develop properly (Suciati et al., 2022). The findings of this study indicate that the CT abilities of Indonesian PSTs in the ecology course remain at a moderate level. This result suggests that higher-order thinking abilities have not yet been optimally developed in the learning process. Similar conditions have also been reported in previous studies, which show that developing critical thinking in higher education is still a major challenge (Saefi et al., 2016; Seki et al., 2023; Suciati et al., 2022). Higher education institutions must provide a learning environment that can support PSTs activities in operating CT skills (Bustami et al., 2016; Puig et al., 2019), especially by applying appropriate learning methods and strategies (Saefi et al., 2016). The urgency of cultivating CT skills must be explicitly integrated into learning objectives, learning activities, and assessments so that they can be properly developed in higher education students (Puig et al., 2019).

Among the assessed components of CT skills, interpretation showed relatively better performance compared to other aspects, while inference was identified as the weakest component. Interpretation skills encompass the ability to comprehend and articulate the significance of diverse experiences, circumstances, or representations (Facione, 2015). Interpretation skills are also related to abilities in learning, classifying problems or phenomena based on initial concepts or ideas so that they have clear meaning (Nugraheni et al., 2022). Good performance in interpretation indicates that most PSTs are able to understand, classify, and explain ecological problems based on their prior knowledge and learning experiences. However, the low achievement in inference suggests that many students still experience difficulties in synthesizing evidence, evaluating alternative explanations, and drawing well-supported conclusions. Similar patterns have been reported in previous studies, which consistently identify inference as one of the most challenging aspects of

critical thinking (Raslan, 2023; Saefi et al., 2016). Suciati et al., (2022) reported that PSTs need help making conclusions and related outcomes. Students cannot make decisions appropriately, so they tend to present less relevant solutions to the problem (Langgi et al., 2022).

Limited inference ability may reflect insufficient exposure to learning activities that require students to test hypotheses, interpret data, and construct scientific arguments. In ecology learning, students are expected to analyze complex systems involving multiple interacting variables. Without adequate training in scientific reasoning, students may rely on surface-level understanding and produce simplified conclusions. According to learning theory, higher-order thinking skills develop through continuous engagement in problem-solving and evaluative tasks (Dong, 2014; Sutama et al., 2022). Therefore, the low performance in inference observed in this study indicates a need for more structured opportunities for students to practice analytical and reflective inquiry.

The findings of this research show that the development of students' critical thinking skills is not determined by one factor alone, but the result of the interaction between cognitive readiness, learning design, and learning experience. Although students have a good understanding of concepts, but if they are not trained to think critically, then it is likely that students' interpretation skills tend to be better than inference skills. In constructivist learning theory, high-level thinking skills develop through student involvement in analyzing evidence, doing reflection, and problem-solving activities (Lorencová et al., 2019; Plummer et al., 2022). This condition reflects the inequality of the two abilities more related to learning practices than the limitations of individual student abilities.

Furthermore, the difference in critical thinking skills of prospective teacher students based on academic ability, gender, and semester level shows that academic factors and learning experience play a role together in developing students' cognitive ability. Students with high GPA scores generally have better involvement in reflection and problem solving activities, thus supporting the development of analytical and evaluative skills. This is in line with (Gedik, 2013) who reported that the GPA score indicates the level of CT skills. Marfu'i & Sriyono (2019) added that CT skills are one component of intellectual ability, influenced by the GPA score. Academic abilities can be influenced by application of learning methods (Suciati et al., 2022).

The difference in critical thinking skills based on gender found in this study is in line with several studies that report that female students often have a higher level of cognitive reflection and study persistence than male students (Liu & Pásztor, 2023; Tamam et al., 2021). The influence of gender on an individual's cognitive style is significant, particularly in relation to key aspects of CT, including analysis, assessment, self-regulation, argumentation, and decision-making abilities (Sukarma, 2019). Women have a CT tendency or disposition lower in instant judgment but stronger in self-efficacy and the habit of exploring hypotheses. Thus, women tend to be more dedicated and careful in making various decisions than men (Liu & Pásztor, 2023). Furthermore, Minasyan & Tovmasyan (2020) stated that women seem more sensitive and tend to make decisions in groups, while men are often too confident and like to make their own decisions quickly.

In addition to GPA and gender, the present study suggests that the development of CT skills among pre-service teachers (PSTs) is also influenced by their grade level. According to (Gedik, 2013), the higher the grade level, the more learning experiences can influence CT skills. The research results of Nguyen & Nguyen (2020) also show a jump in CT skills scores among first-year students, sophomores, juniors and seniors at university. Organized learning activities are the factors that encourage the spikes and differences in the achievements of these CT skills. Investigation and exploration of phenomena stimulate the development of CT skills in a better direction (Issa & Khataibeh, 2021). The cultivation of CT skills requires students to explore and implement concepts in a disciplined manner (Sutama et al., 2022). Prior knowledge and use of learning techniques have the potential to impact academic proficiency and the development of CT skills among PSTs (Saputri et al., 2020). These combined findings indicate that academic achievement, gender-related learning characteristics, and cumulative learning experiences interact in shaping students' critical thinking profiles. Rather than functioning independently, these factors mutually reinforce students' engagement in reflective learning and scientific reasoning processes.

These findings highlight the importance of designing learning environments that systematically promote higher-order thinking in ecology education. Inquiry-based learning, collaborative problem solving, and scientific investigation have been shown to effectively improve students' analytical and inferential abilities (Razak et al., 2022; Ristanto et al., 2022). Through these approaches, students are encouraged to interpret data, evaluate alternative solutions, justify conclusions, and communicate evidence-based arguments. Integrating such strategies into teacher education programs may help address weaknesses in inference and evaluation skills.

Furthermore, developing critical thinking skills among PSTs is essential not only for academic success but also for their future professional roles as teachers. Educators with strong critical thinking abilities are more likely to design meaningful learning experiences and foster similar skills among their students (Ismail et al., 2019; Lorencová et al., 2019). Therefore, teacher education curricula should emphasize continuous training in reasoning, reflection, and scientific inquiry, particularly in environmentally oriented courses.

Overall, this study demonstrates that the development of critical thinking skills among pre-service teachers is influenced by an integrated system involving instructional practices, learner characteristics, and academic progression. The moderate overall performance combined with relatively weak inferential ability suggests that current ecology instruction has not yet fully supported higher-order reasoning. By integrating inquiry-oriented pedagogy, collaborative learning, and structured reflection, teacher education programs may more effectively bridge the gap between conceptual understanding and analytical reasoning. These findings highlight the need for systemic instructional improvement rather than isolated pedagogical interventions. Nevertheless, further studies involving broader samples and diverse educational contexts are required to strengthen the generalizability of these results.

## 4. CONCLUSION

CT skills are predictors of learning success as PSTs. Mastery of CT skills can support the academic performance of PSTs and the professionalism of their work in the future. CT skills are influenced by several factors. The results of this study suggest that the mean level of CT skills among PSTs on Ecology course remains at a moderate level. The highest score is in the interpretation aspect, while the lowest is in the inference aspect. Other findings show that factors such as academic ability (GPA score), gender differences, and grade level also influence PSTs' CT skills. PSTs with high GPA scores have better CT skills than PSTs with medium and low GPA scores. On the other hand, there is evidence to suggest that female pre-service teachers (PSTs) exhibit higher levels of CT skills in comparison to their male counterparts. Furthermore, it has been shown that PSTs in their 5th grade have a greater proficiency in CT compared to PSTs in their 3rd grade. Even though the results are not significantly different from those of previous studies, the PST is generally quite critical when evaluating ecological problems. Critical thinking skills are not inherited genetically, but rather require space to develop and improve. Enhancing critical thinking skills can be achieved by employing learning models or tactics that enable pre-service teachers to engage in inquiry and foster collaborative practices. The anticipated outcomes of this research are poised to serve as a significant factor for the Teacher Education Program, particularly for instructors, in adopting and implementing diverse instructional approaches that enhance CT abilities in PSTs. Finally, the interpretation of the results of this research needs to be done carefully and carefully, especially considering the limited number of respondents, the grade levels of the respondents, and the specifications of the scientific fields used as a reference in the data collection process. The generalization of research results still requires further testing with more respondents and, simultaneously, in a wider study area

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