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The Analytical Thinking Ability of Prospective Science Teachers: An Overview of Study Programs and Gender

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Abstract: The study aimed to describe the analytical thinking skills of science teacher candidates based on the study program and gender. This research is a descriptive quantitative study with a sample of 80 students, 20 boys and 60 girls from the Biology Education Study Program (38 students), Physics Education (13 students), and Chemistry Education (29 students). The instrument used is descriptive subjective test questions adapted to three indicators of analytical thinking skills, namely differentiating, organizing, and attributing. Analyzed descriptively and statistically. The instrument used has been declared valid with Cronbach's Alpha reliability of 0.77. The results of the study show that overall, students' analytical thinking skills are quite analytical. However, there are differences in the ability to think analytically based on the study program. In addition, there is also a difference in the ability to think analytically between female and male students, although the difference is not too significant, namely only 4.63%. Based on these findings, it is necessary to make efforts to improve the analytical thinking skills of prospective science teacher students through the development of learning programs that focus more on developing analytical thinking skills.

Keywords: Analytical Thinking Skills; Gender; Science Teacher

Introduction

Analytical thinking skills play a crucial role in the learning process of students in tertiary institutions, particularly in comprehending complex concepts and enhancing their problem-solving abilities (Fitriani et al., 2021; Nurdiana et al., 2023). These skills are especially important in 21st-century education, where students are required to develop higher-order cognitive abilities (Hunaepi et al., 2020; Nurcahyani et al., 2020; Sundari et al., 2020), particularly in disciplines like basic biology. Basic biology courses offer an excellent platform for nurturing analytical thinking skills as they involve understanding and interpreting various biological phenomena (Dafrita, 2017; Kitchen et al., 2003). These courses typically focus on essential biology concepts and processes, fostering skills like critical thinking and hands-on problem-solving (Agnafia, 2021; Astriani et al., 2017).

Skills are the ability to operate jobs easily and quickly, usually tending to psychomotor activities (Sulistyowati, 2019). Thinking is an activity involving the working system of the brain involving conscious feelings and will to understand and find solutions to a problem. Analytical thinking is a series of activities carried out to solve or describe one subject into more detailed parts or components to solve problems (Ahmad, 2021; Waskita et al., 2019). Analytical thinking skills involve the ability to categorize information, identify connections, and integrate related components to comprehend real-life phenomena (Aktoprak & Hursen, 2022; Fitriani et al., 2021; Zakaria & Lim, 2022). According to Bloom's taxonomy, analytical thinking skills belong to the fourth level, analyzing (Hasyim,

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2018; Muhsin & Laksono, 2023). These skills are generally categorized into three indicators: differentiating, organizing, and attributing (Astriani et al., 2017).

In the learning process, the importance of analytical thinking skills is to encourage students to formulate and ask questions, not just to answer questions. Thus, educators should properly encourage students to ask basic questions about what they are learning and assist students in making informed decisions (Rosadi et al., 2018). Analytical thinking skills are needed when a difficult decision requires a solution to be identified or creates a problem to be solved. Higher-order thinking skills are an important aspect of the learning process (Winarti, 2015). Analytical skills are an important part of problem-solving so that students can make the right decisions related to phenomena in everyday life. Analytical skills are abilities that are active when students are faced with unusual problems and uncertainty. One important aspect of work is knowing how to think analytically and use it to solve problems (Taleb et al., 2016).

Analytical thinking skills are an important aspect of identifying and solving problems, especially in the context of learning biology. However, the results of previous research indicate that students experience difficulties in applying analytical thinking skills, and the percentage of their analytical thinking skill level is still low. The cause of low analytical thinking skills can come from a lack of stimulation in the learning process to develop these abilities. One of the contributing factors is the helplessness of students in developing their thinking skills. Learning tends to lead to practice answering questions by focusing on memorization, without providing opportunities for students to actively think and use higher-order thinking skills (Lestari, 2020).

In overcoming this problem, the learning environment needs to apply methods that encourage students to think more analytically. Lecturers can provide challenging challenges, encourage students to think critically, analyze information, and formulate problem solutions independently. Learning should also avoid learning patterns that only rely on memorization but rather emphasize understanding concepts and applying knowledge in real situations.

Several previous studies regarding analytical thinking skills in the learning process show that the level of analytical thinking skills is still very low. Based on previous research by Nilah & Roza (2020) states that students still have difficulties in achieving indicators of analytical thinking skills, on the distinguishing indicator students have not been able to answer the questions given due to a lack of understanding of concepts, on the organizing indicators students answer not coherently and not structured so that it causes some of the steps to answer correctly and some wrongly, while the indicators connect students who are less trained in answering analytical questions making it difficult to understand the purpose and intent of the questions.

In line with Winarti (2015) also states that students' analytical abilities are still at a low level, this is caused by the lack of student's ability to understand concepts and theories, where which also affects students' analytical abilities. Besides that, Astriani et al. (2017) states that students' analytical thinking skills on the distinguishing and organizing indicators are in a good category, but the linking indicator needs to get more attention because the category is not good. This is because students are still not able to connect data and theory, so they are not able to provide an overview of the interrelationships of the concepts being studied.

Based on the description above, it can be concluded that analytical thinking skills are important to develop, because analytical skills are an important part of problem solving, both in solving biological problems, and in their application in everyday life. Therefore, it is important to conduct this research to find out the profile of the analytical thinking skills of class 2022 students who are taking basic biology courses at the Faculty of Engineering and Applied Science, Mandalika University of Education. After knowing the profile of students' analytical thinking abilities on the three indicators (differentiating, organizing, and connecting), it is hoped that this can be a reference as a solution in improving the quality and quality of learning in general biology courses, so the purpose of conducting this research is to describe the analytical thinking skills of prospective science teachers based on study program and gender.

Method

This research is descriptive quantitative research using a survey method to identify the analytical thinking skills of 80 prospective science teachers. The nine items describing the Cytologist sub-matter are used to collect data on the analytical thinking skills of the prospective teacher, which includes components such as: Differentiate, Organizing, and Attribution.

The test instrument has been empirically validated on 80 students of biology, chemistry, and physics study programs who have taken basic biology courses. The purpose of this validation is to assess the validity and reliability of the test instrument. The instrument test results were then analyzed by comparing the Pearson correlation value with the r_{table} value N = 80, which was 0.396 at a significance level of 0.05. The results of testing the validity and reliability of the test instruments are presented in Table 1 and Table 2.

Table 1. Instrument Validity Test Results

Items	Pearson Correlation	Remarks
Number 1	0.65	Valid
Number 2	0.83	Valid
Number 3	0.84	Valid
Number 4	0.70	Valid
Number 5	0.65	Valid
Number 6	0.83	Valid
Number 7	0.45	Valid
Number 8	0.68	Valid
Number 9	0.67	Valid

Table 2. Instrument Reliability

Cronbach's Alpha	N of Items
0.77	9

Descriptive statistical analysis is used to see how analytical thinking skills are acquired. Where is the test result data to measure students' analytical thinking abilities seen from the scores obtained in working on analytical thinking skills test questions? The scores obtained by students are then calculated to measure their ability to think analytically. The results of the analytical thinking skills test that have been obtained are analyzed based on each scoring guideline indicator. The score that has been obtained will be made in the form of a percentage, then the percentage of each aspect will be qualified in calculating analytical thinking skills with the formula below (Mahyastuti, 2017).

$$NP = \frac{R}{SM} \times 100\% \quad (1)$$

Information:
NP = Percentage of students' analytical thinking skills
R = Score obtained
BC = Maximum score

To get a clear picture of student's analytical thinking skills, grouping is done. The grouping is done into 5 categories: very analytical, analytical, quite analytical, less analytical, not analytical. The guideline for categorizing student analytical thinking skills used in this study is an analysis using descriptive statistics: The system the grouping used is adjusted to previous research (Astuti, 2016).

$$P = \frac{f}{N} \times 100\% \quad (2)$$

Information:
P = Percentage number
f = Frequency sought percentage
N = The number of samples of respondents

Table 3. Criteria for Analytical Thinking Ability

Percentage	Analytical Category
80% ≤ NP ≤ 100%	Very Analytical
60% ≤ N.P. € 80%	Analytical
40% ≤ NP € 60%	Simply Analytical
20% ≤ N.P. € 40%	Less Analytical
N.P. € 20%	Not Analytical

Result and Discussion

Test Results Skills Think Analytic
Average Every grain Test Results Questions Skills Think Analytical kindly Whole

Measurement level Skills think analytical student done with use instrument test written form question description that consists of 9 questions with each three question for every indicator Skills think analytical, indicator differentiating, organizing, and attributing. Test Results Skills Think Analytical kindly Whole done with a spread question to 80 Students, consisting of 29 students in Chemistry Education, 13 students in physics, and 38 students education FSTT Biology. As for the average, each grain question results in test Skills to think analytically in a manner whole can see in Figure 1.

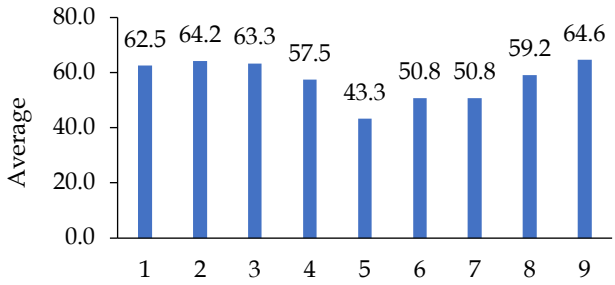


Figure 1. Average of Each Item on the Overall Analytical Thinking Skills Test Results

The average of each item on the overall analytical thinking skills test is in the range of 40-65 with the quite analytical category below the 60 percentage, namely questions number 4, 5, 6, 7 and 8, and with the analytical category because the percentage is above 60, namely questions number 1, 2, 3, and 9. The Average of Each Item on the Results of the Analytical Thinking Skills Test Based on the Study Program The average results of the analytical thinking skills test based on the study program were carried out by distributing questions to 29 chemistry education students, 13 physics students, and 38 FSTT biology education students. The average for each item on the results of the analytical thinking skills test based on the study program can be seen in Figure 2.

	1	2	3	4	5	6	7	8	9
Chemistry	44.8	72.4	69.0	48.3	37.9	48.3	70.1	70.1	69.0
physics	94.9	89.7	97.4	84.6	61.5	76.9	38.5	82.1	97.4
- Biology	66.7	50.5	48.6	56.8	42.3	45.0	41.4	44.1	51.4

Figure 2. The average of each item on the results of the Analytical Thinking Skills Test by Study Program

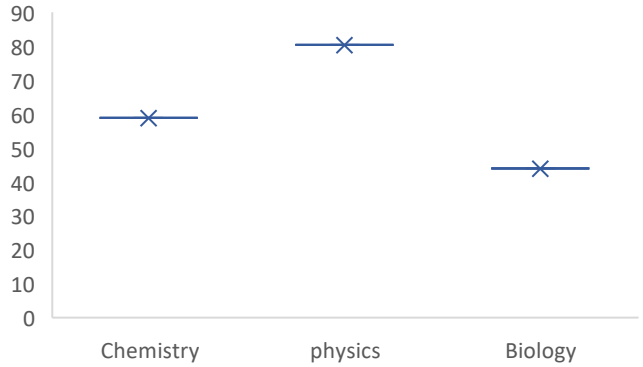
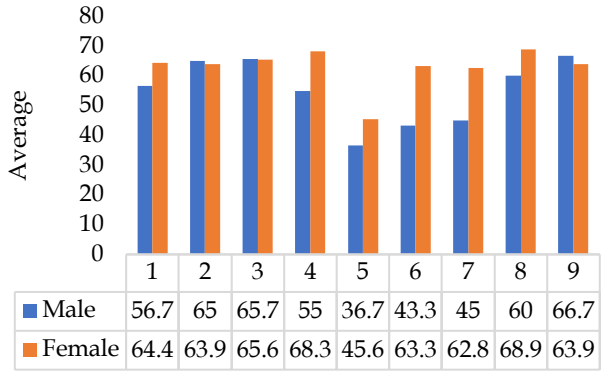


Figure 3. Average Level of Analytical Thinking Skills by Study Program

Based on the data in Figure 3 above, it shows that the average level of students' analytical thinking skills in terms of study programs has different percentages, for the Chemistry Education study program the percentage is 58.87, for the Physics Education study program the percentage is 80.33, for the Biology Education study program the percentage is 43.94.

Average of Each Item Results of Analytical Thinking Skills Test Based on Gender

The average results of the analytical thinking skills test based on gender were carried out by distributing questions to 80 students, with details of 20 consisting of male students and 60 female students.



	1	2	3	4	5	6	7	8	9
Male	56.7	65	65.7	55	36.7	43.3	45	60	66.7
Female	64.4	63.9	65.6	68.3	45.6	63.3	62.8	68.9	63.9

Figure 4. The average of each item on the Analytical Thinking Skills Test Based on Gender

Based on the data presented in Figure 4 and Figure 5, it can be concluded that there is not a significant difference in the percentage of analytical thinking skills between male and female students. The percentage of female students with analytical thinking skills is 58.51, while male students scored 53.88, both falling under the category of "Enough" analytical. The measurement of analytical thinking skills was conducted using a written test consisting of 9 questions, with each question assessing three indicators of analytical thinking: differentiation, organization, and attribution. The study sample included 80 students, comprising 29 Chemistry Education students, 13 Physics Education students, and 38 Biology Education students.

The analytical thinking skills were assessed from three different perspectives: overall skills, skills based on the study program (Chemistry Education, Physics Education, and Biology Education in their first semester), and skills based on gender. The differentiation indicator has been identified as a strong performer in assessments of students' analytical thinking skills, with average scores between 60% and 80%. This performance level is classified as "Good" in terms of analytical ability. Such findings are not isolated, as they align with earlier research conducted by Astriani et al. (2017) and Nilah & Roza (2020), both of which reported similar outcomes, highlighting percentages above 60% for the "differentiation" indicator. This consistency across studies suggests a significant and positive correlation between the differentiation skill and analytical thinking ability among students. It underscores the importance of nurturing this particular aspect of analytical skills in educational practices and curriculum development to enhance critical thinking capabilities.

The statement about students demonstrating analytical skills below 60% for the "organization" indicator, categorizing their analytical level as "Enough," suggests a concerning trend in education regarding the development of analytical thinking skills. This observation aligns with findings from Taleb et al. (2016), which pointed to a deficiency in analytical thinking skills among students, attributing this shortfall to a lack of understanding of fundamental concepts and theories. Such deficiencies can significantly impact students' ability to analyze, synthesize, and evaluate information effectively, which are crucial skills in both academic and real-world settings.

This issue underscores the importance of instructional strategies that not only convey information but also actively engage students in critical thinking and the application of concepts in various contexts. Enhancing students' understanding of underlying theories and concepts could foster better analytical skills, suggesting a need for educational approaches that prioritize depth of understanding and the development of critical thinking capabilities. Addressing this challenge may involve incorporating more problem-based learning, where students tackle real-world problems, and integrating analytical skills training across the curriculum. Teachers and educators might also benefit from professional development opportunities focused on effective strategies for teaching analytical skills and concept mastery.

Furthermore, the findings from Taleb et al. (2016) and the observed performance indicators can serve as a

basis for further research into educational methods and interventions that can enhance analytical thinking skills. Investigating the specific barriers to understanding concepts and theories, as well as testing different pedagogical approaches, could provide valuable insights into improving educational outcomes in this area. Similarly, for the indicator "attribution," the test results revealed that some students fell under the category of "Enough" analytical, while others were in the "analytical" category. Previous research by Taleb et al. (2016) also emphasized the need for special attention to the "attribution" indicator, as some students struggled to associate data with theories adequately, resulting in an incomplete formation of conceptual linkages on the analytical thinking test.

The low analytical thinking ability in both indicators can be attributed to a lack of stimulation in the learning process, where students are often trained to provide rote answers, hindering the development of higher-level thinking skills (Lestari, 2020). Therefore, it is crucial for educators to foster analytical thinking skills in students by encouraging them to formulate and propose questions, rather than merely answering them. This approach can enhance students' understanding and ability to relate learned concepts and improve their analytical thinking skills (Rosadi et al., 2018).

From the data analysis results, it is evident that the level of analytical thinking skills differs among the study programs. Chemistry Education students have a percentage of 58.87% in analytical thinking skills, falling under the category of "Enough" analytical. Physics Education students scored 80.33%, categorized as "analytical," while Biology Education students obtained 43.94% in analytical thinking skills, also classified as "Enough" analytical. These findings highlight the variations in analytical thinking skills among the study programs.

The average scores for analytical thinking skills by gender indicate that male respondents scored 53.88% in analytical ability, whereas female respondents scored 58.51%. Although there is a difference of 4.63% between female and male students, it is not considered significant. Several other research studies on different objects have reported similar findings, where females tend to have higher analytical thinking percentages compared to males. The study by Simanjuntak et al. (2020) on creative thinking and its relation to gender differences provides insight into how educational approaches can be adapted to leverage the strengths and address the challenges unique to each gender. Similarly Cahyono (2017) research on critical thinking underlines the necessity of understanding gender-based differences in thinking methods and abilities to enhance educational practices.

The conclusion drawn from these studies, along with the references to Taleb et al. (2016) and Winarti (2015), highlights the crucial role of analytical thinking in education. Analytical thinking is not just about solving problems in academic settings; it's about empowering students to navigate complex decisions and challenges in everyday life. By developing these skills, educators can prepare students to approach uncertain situations with confidence and creativity, making informed decisions that reflect a deep understanding of the issues at hand.

These insights advocate for a more nuanced approach to education, where the development of thinking skills is prioritized. Educators and curriculum developers are encouraged to consider gender differences and other individual factors when designing and implementing teaching strategies. This personalized approach can help ensure that all students have the opportunity to develop their analytical, creative, and critical thinking abilities to their fullest potential.

Conclusion

The study revealed descriptive measurements of analytical thinking skills across three dimensions: overall, by academic program, and by gender. In general, students exhibited analytical aptitude, with some items falling into the analytical category and others into moderately analytical. Analytical skills varied by academic program, with Chemistry Education scoring 58.87% (reasonably analytical), Physics Education scoring 80.33% (analytical), and Biology Education scoring 43.94% (moderately analytical). Moreover, there were slight discrepancies in analytical thinking skills between male and female respondents, with a 4.63% difference. The research underscores the importance of enhancing the analytical thinking abilities of prospective science educators by designing tailored learning programs that prioritize the development of these skills. It also emphasizes the need to identify factors influencing students' analytical thinking levels, such as the learning environment, teaching methodologies, instructional models, and student motivation

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Author Contributions

Each writer has a contribution based on his field of expertise both in the preparation of background, methods, analysis and discussion. Lukman Nasution focuses on reviewing and improving manuscripts, Baiq Nurhidayati Kartiwi Putri Rinjani focuses on data collection, Hunaepi, Taufik Samsuri, focuses on compiling manuscripts and adjusting them to journal templates, and focuses on analyzing research results.

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Conflicts of Interests
Declare conflicts of interest.

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