Pre-Service Elementary Teachers' Perceptions of Advanced Basic Science Courses in Supporting Teaching Competencies

Nofamataro Zebua[a*] | Ester Novi Kurnia Zebua[a] | Muhammad Andi Tanri Prasetyo[b] | Sherly Hariyanti[b]

[a] Department of Biology Education, Faculty of Teacher and Training Education, Universitas Nias, Gunungsitoli, Indonesia
[b] Department of Chemistry, Faculty of Mathematics and Natural Science, Universitas Negeri Malang, Malang, Indonesia

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Corresponding Author:
Author Name: Nofamataro Zebua
Email: zebuanofa99@gmail.com

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Abstract: The low level of scientific reasoning skills and conceptual understanding among pre-service elementary school teachers remains a significant challenge in science education at the higher education level. This condition reflects a gap between students' mastery of scientific theories and their ability to connect scientific concepts with instructional practices in primary education. This study aims to examine the perceptions of pre-service primary school teachers toward the Advanced Fundamental Science Concepts course in supporting their professional teaching competencies. The study employed a descriptive quantitative approach supported by qualitative data obtained through interviews. Data were collected using a questionnaire consisting of 20 validated and reliable statements, which was voluntarily administered to 36 students enrolled in the Primary Teacher Education Program. Data analysis was conducted using descriptive statistics in the form of percentages, while interview data were analyzed qualitatively to strengthen and enrich the research findings. The results indicate that students demonstrated positive perceptions toward the Advanced Fundamental Science Concepts course, particularly in terms of understanding fundamental science concepts (84%) and the relevance and application of science concepts (81%). The findings further reveal that students have recognized science as a scientific reasoning process; however, they continue to encounter difficulties in data analysis and scientific inference skills. Therefore, science education in teacher preparation programs should place greater emphasis on strengthening scientific reasoning competencies through inquiry-based and practice-oriented learning approaches.

Keywords: Student perceptions, fundamental science concepts, teaching competencies, scientific reasoning

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Introduction

Science education in elementary schools plays an essential role in developing students' critical thinking, problem-solving skills, and scientific literacy from an early age. In the context of 21st-century education, elementary school teachers are expected not only to understand scientific concepts theoretically, but also to be able to teach them through contextual and meaningful approaches (Kennedy & Sundberg, 2020; Okan, 2024). Primary Teacher Education Programs serve as one of the main pathways for preparing prospective teachers with pedagogical and professional competencies in elementary science education. However, various reports indicate that the mastery of scientific concepts among pre-service elementary school teachers remains suboptimal, particularly in courses that are conceptual and analytical in nature (Darling-Hammond et al., 2020; OECD, 2019).

The Advanced Fundamental Science Concepts course is one of the important components of the Elementary Education curriculum because it is designed to strengthen students' understanding of scientific principles that form the foundation of science instruction in elementary schools (van Werven et al., 2023). This course emphasizes not only content mastery but also the ability to connect scientific concepts with everyday life phenomena (Krajcik & Czerniak, 2025). Ideally, learning in this course should improve students' readiness to design and implement effective science instruction. Nevertheless, in practice, some students still experience difficulties in understanding abstract concepts, lack confidence in teaching science, and have limited laboratory and practicum experiences during their coursework (Setiawan & Suwandi, 2022).

Students' perceptions of a course constitute an important aspect because they can influence learning motivation, academic engagement, and the achievement of learning competencies. Positive student perceptions are generally associated with increased learning interest and greater professional readiness as future educators (Rokhma & Surjanti, 2025). In contrast, negative perceptions may lead to low participation in learning activities and insufficient mastery of the concepts being studied. In the context of teacher education, students' perceptions of science courses serve as an

important indicator for evaluating the effectiveness of the learning process that has been implemented (Putri et al., 2024).

Several previous studies have examined students' perceptions of science learning in higher education; however, most have focused on learning motivation, the use of instructional media, or the implementation of specific learning models (Škugor et al., 2024; Yılmaz & Malone, 2020). A study conducted by Fitriani et al. (2025) highlighted the influence of instructional media on Elementary Education students' interest in learning science, while research by Masykuroh et al. (2024) emphasized the implementation of project-based learning in improving science process skills. These studies have contributed significantly to the development of science education in higher education. Nevertheless, research specifically examining Elementary Education students' perceptions of the Advanced Fundamental Science Concepts course in relation to teaching competencies remains relatively limited.

In addition to limitations in research focus, a gap is also evident in the methodological approaches used in previous studies. Most prior research employed simple descriptive approaches that merely described students' perception levels without relating them to the competency dimensions of prospective teachers (Fidalgo et al., 2020; Haatainen et al., 2021). Several studies also tended to focus on general science learning contexts and did not specifically address the Advanced Fundamental Science Concepts course as a strategic component in developing the professional competencies of elementary school teachers (Amerstorfer & Münster-Kistner, 2021; Havik & Westergård, 2020). This condition indicates the need for more comprehensive research to understand how students' perceptions of the course may support their readiness as prospective science teachers in elementary schools.

On the other hand, the challenges of science learning in higher education are becoming increasingly complex due to technological advancements, curriculum changes, and the demands of 21st-century skills-based learning (A. J. Rahmawati et al., 2023; Yanxia et al., 2025; Zebua & Ziraluo, 2026). Elementary Education students are expected not only to understand scientific theories but also to apply scientific approaches, think critically, and integrate technology into learning activities. This ideal condition has not yet been fully achieved, as there remains a gap between conceptual mastery and the ability to implement science instruction effectively in practice. Therefore, evaluating students' perceptions of the Advanced Fundamental Science Concepts course is important for identifying both the strengths and weaknesses of the learning process that has been implemented.

Based on the description above, this study was conducted to analyze Elementary Education students' perceptions of the Advanced Fundamental Science Concepts course in supporting the teaching competencies of prospective elementary school teachers. This study is expected to provide empirical insights into how students perceive the relevance, effectiveness, and contribution of the course to their professional readiness. An important question that arises is whether the Advanced Fundamental Science Concepts course has optimally supported the development of pedagogical and professional competencies among Elementary Education students. The findings of this study are expected to serve as a basis for evaluating and improving science education in Elementary Education study programs so that it better aligns with the needs of prospective teachers in the modern educational era (Ziraluo et al., 2025).

Methods

Research design

This study employed a quantitative approach using a descriptive method supported by qualitative data obtained through interviews. The quantitative approach was used to obtain an overview of Elementary Education students' perceptions of the Advanced Fundamental Science Concepts course in supporting teaching competencies, while interviews were conducted to verify and strengthen the findings obtained from the questionnaire (Creswell & Creswell, 2017). The study was conducted during the even semester of the 2025/2026 academic year in the Primary Teacher Education Program, with data collection carried out from March to April 2026. All stages of the research were conducted systematically, starting from instrument development, instrument testing, data collection, and data analysis, while adhering to research ethics principles, in which all respondents participated voluntarily without any coercion.

Population and research sample

The population of this study consisted of all Elementary Education students who had completed the Advanced Fundamental Science Concepts course. The research sample was determined using purposive sampling techniques, namely students who had completed the course and were willing to participate as research respondents because they were considered to have learning experiences relevant to the objectives of the study. Before data collection was conducted, respondents were provided with explanations regarding the purpose of the study and the procedures for completing the instruments so that participation was carried out consciously and voluntarily. The confidentiality of

respondents' identities was maintained throughout the study to ensure that the collected data objectively and honestly reflected students' perceptions.

Research instrument

The primary instrument used in this study was a student perception questionnaire consisting of 20 statements measured using a five-point Likert scale ranging from strongly disagree to strongly agree. The questionnaire items were developed based on indicators related to perceptions of material relevance, learning effectiveness, learning experiences, and the contribution of the course to the teaching competencies of Elementary Education students. Prior to its use in the study, the instrument was tested for validity and reliability using statistical software. Validity testing was conducted using the Pearson Product-Moment correlation with the criterion that the calculated r-value must exceed the r-table value at a 5% significance level, while reliability testing was conducted using Cronbach's Alpha coefficient with the requirement that the alpha value exceed 0.70. Therefore, all questionnaire items were declared valid and reliable for data collection purposes.

Data collection techniques

Research data were collected through questionnaire distribution and semi-structured interviews. The questionnaires were distributed both directly and through online media to Elementary Education students who met the respondent criteria, and respondents completed them independently without intervention from the researchers. All respondents were given full freedom to decide their willingness to participate in the study without any pressure from any party. In addition, interviews were conducted with several students selected based on variations in questionnaire responses to verify and clarify the quantitative findings so that the resulting data would be more in-depth and comprehensive.

Data analysis techniques

Questionnaire data were analyzed using descriptive statistical techniques by calculating mean scores, percentages, and categories of students' perceptions toward the Advanced Fundamental Science Concepts course. The analysis results were then presented in the form of tables and descriptive explanations to facilitate interpretation and understanding. Meanwhile, interview data were analyzed using descriptive qualitative analysis techniques through stages of data transcription, data reduction, theme categorization, and conclusion drawing. The interview findings were used to support and verify the quantitative data so that the research results would possess stronger validity and greater depth of information.

Result

Instrument validity and reliability testing

Instrument validity and reliability testing were conducted before the questionnaire was used in the research data collection process. These tests aimed to determine the accuracy and consistency of the instrument in measuring Elementary Education students' perceptions of the Advanced Fundamental Science Concepts course. Validity testing was conducted using the Pearson Product-Moment correlation with the assistance of IBM SPSS Statistics 23, while reliability testing was performed using Cronbach's Alpha coefficient (Mellinger & Hanson, 2021). The number of respondents involved in the instrument testing was 36 students with a significance level of 5%, resulting in an r_{table} value of 0.329.

The validity test results indicated that all questionnaire items had calculated r-values greater than the r-table value. The highest correlation value was obtained for item P13 at 0.810, while the lowest correlation value was found for item P19 at 0.455. Nevertheless, all items met the validity criteria because they had calculated r-values greater than 0.329 and significance values lower than 0.05. Therefore, all statement items were declared valid and appropriate for use as research instruments. The results of the instrument validity test are presented in Table 1.

Table 1. Instrument Validity Test Results

Item	Calculated r-value	r-table	Sig.	Description
P1	0.480	0.329	0.003	Valid
P2	0.667	0.329	0.000	Valid
P3	0.520	0.329	0.001	Valid
P4	0.662	0.329	0.000	Valid

P5	0.701	0.329	0.000	Valid
P6	0.554	0.329	0.000	Valid
P7	0.693	0.329	0.000	Valid
P8	0.522	0.329	0.001	Valid
P9	0.477	0.329	0.003	Valid
P10	0.531	0.329	0.001	Valid
P11	0.708	0.329	0.000	Valid
P12	0.757	0.329	0.000	Valid
P13	0.810	0.329	0.000	Valid
P14	0.656	0.329	0.000	Valid
P15	0.578	0.329	0.000	Valid
P16	0.605	0.329	0.000	Valid
P17	0.725	0.329	0.000	Valid
P18	0.711	0.329	0.000	Valid
P19	0.455	0.329	0.005	Valid
P20	0.759	0.329	0.000	Valid

In addition to validity testing, the research instrument was also tested for reliability to determine the consistency level of the questionnaire items. The analysis results showed that the obtained Cronbach's Alpha value was 0.910. This value falls within the category of highly reliable because it exceeds 0.90. This indicates that the instrument has a very high level of consistency and is capable of producing stable data when used in similar measurements. The results of the instrument reliability test are presented in Table 2.

Table 2. Instrument Reliability Test Results

Variable	Cronbach's Alpha	Criteria
Students' Perceptions	0.910	Highly Reliable

Based on the results of the validity and reliability tests, it can be concluded that all statement items in the research instrument fulfilled the requirements as a valid and reliable data collection tool. Therefore, the instrument is appropriate for measuring Elementary Education students' perceptions of the Advanced Fundamental Science Concepts course in supporting the teaching competencies of prospective elementary school teachers.

Percentage of Elementary Education students' understanding of fundamental science concepts

To obtain an overview of Elementary Education students' level of understanding of fundamental science concepts, a percentage analysis was conducted for each questionnaire item covering aspects of conceptual understanding, attitudes toward science, the relevance and application of science concepts, and scientific reasoning abilities. The results of the percentage analysis are presented in the following graph to illustrate the tendency of students' responses for each measured indicator.

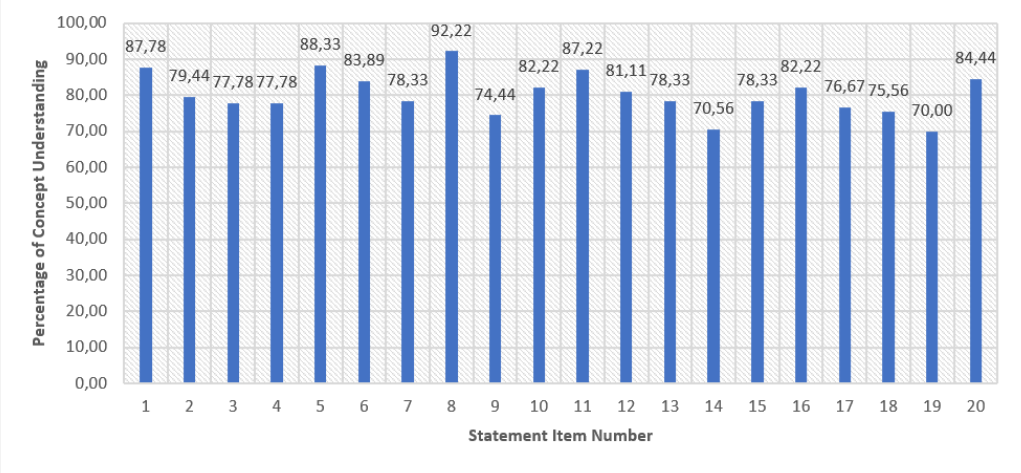

Figure 1. Level of Understanding of Advanced Basic Science Concepts Among Elementary School Teacher Education Students

The analysis results indicate that Elementary Education students possess a high level of understanding of fundamental science concepts. The most prominent finding was observed in item 8, which obtained the highest percentage of 92.22%, indicating that students are highly aware of the importance of mastering fundamental science concepts as prospective elementary school teachers. In addition, item 5 (88.33%) and item 1 (87.78%) demonstrate that students understand science not merely as memorization, but also as a process of scientific reasoning used to explain natural phenomena. These findings suggest that students have developed a strong conceptual awareness regarding the nature of science and its relevance to learning.

Nevertheless, several findings reveal that students still encounter difficulties in scientific reasoning skills. Item 19 obtained the lowest percentage at 70.00%, indicating that students still experience difficulties in drawing conclusions based on scientific data. Furthermore, item 14 (70.56%) and item 9 (74.44%) suggest that some students still perceive science concepts as abstract and difficult to understand without assistance from lecturers or other learning resources. These findings indicate that strengthening analytical skills, data interpretation abilities, and practice-based learning remains necessary in the Advanced Fundamental Science Concepts course.

To obtain a more comprehensive overview of Elementary Education students' perceptions of the Advanced Fundamental Science Concepts course, the percentage results for each questionnaire item were further categorized into four main aspects: understanding of fundamental science concepts, attitudes toward science, relevance and application of science concepts, and scientific reasoning abilities. This categorization was conducted to facilitate the identification of the most dominant aspects as well as aspects that still require improvement in the learning process. The average percentage for each aspect was calculated based on the overall item scores representing each indicator. The analysis results were then presented in the form of a graph showing the average percentages for each aspect in order to provide a clearer visualization of the trends in students' perceptions.

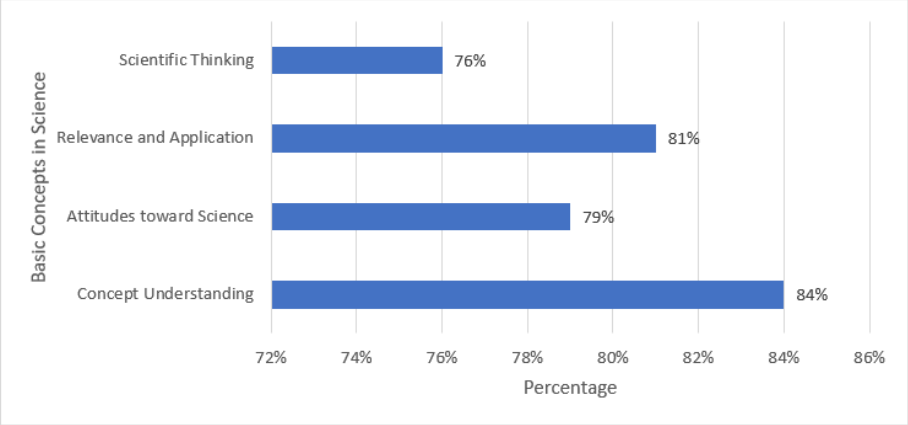

Figure 2. Level of Understanding of Advanced Science Concepts Based on Content Areas

Based on the graph, it can be seen that the aspect of understanding fundamental science concepts obtained the highest percentage compared to the other aspects, indicating that students have developed a relatively strong understanding of the nature and fundamental concepts of science. Meanwhile, the aspect of scientific reasoning abilities showed a relatively lower percentage, particularly in students' abilities to draw conclusions and analyze scientific data independently. These findings indicate that students have developed good conceptual awareness regarding the importance of science as prospective elementary school teachers; however, they still require further strengthening in scientific and analytical thinking skills. Overall, these results demonstrate that the Advanced Fundamental Science Concepts course has contributed positively to the development of Elementary Education students' competencies, although several aspects still need to be optimized through more contextual and practice-based learning approaches.

Student interview results

The interview results revealed that most students had positive perceptions of the Advanced Fundamental Science Concepts course because it was considered helpful in understanding natural phenomena in a more systematic and contextual manner. Students stated that science learning became easier to understand when lecturers connected the material to everyday life, used real-life examples, and incorporated discussions and simple practicum activities into the learning process. Several students also expressed that the course increased their awareness of the importance of mastering science concepts as prospective elementary school teachers. Furthermore, students perceived science learning not merely as memorization, but as a process of scientific reasoning that can be used to explain various phenomena in the surrounding environment.

Nevertheless, the interview findings also showed that some students still experienced difficulties in understanding abstract science concepts and in drawing conclusions based on observational data. Some students admitted that they still depended on lecturers' explanations or additional learning resources when dealing with materials requiring deeper analysis (Zebua, 2025). Students also stated that practicum activities and experiment-based learning still need to be enhanced so that scientific and analytical thinking skills can develop more optimally. These interview findings strengthen the questionnaire results, which indicated that scientific reasoning abilities remain one of the aspects requiring further improvement in the Advanced Fundamental Science Concepts course.

Discussion

The findings of this study indicate that Elementary Education students have positive perceptions of the Advanced Fundamental Science Concepts course in supporting the teaching competencies of prospective elementary school teachers. This finding is reflected in the high percentages obtained in the aspects of understanding fundamental science concepts (84%) and the relevance and application of science concepts (81%). These results suggest that students not only understand science as a collection of concepts, but also as a process of scientific reasoning that is relevant to everyday life and instructional practices in elementary schools. This finding is consistent with the constructivist perspective, which states that understanding scientific concepts becomes more meaningful when students are able to connect concepts with real experiences and everyday life contexts (Bybee, 2014; O'Connor, 2022; Zajda, 2021). Furthermore, a strong mastery of science concepts serves as an essential foundation for developing the professional competencies of prospective elementary school teachers, particularly in designing contextual and problem-solving-based instruction (Darling-Hammond et al., 2020).

One of the most interesting findings of this study is the high percentage obtained for the item indicating that students perceive science as a process of scientific reasoning rather than mere memorization. This finding is important because previous studies frequently reported that Elementary Education students tended to view science as a subject closely associated with memorizing concepts and formulas (Irfan et al., 2020). This shift in perception indicates a positive development in science learning at the higher education level, particularly in the Advanced Fundamental Science Concepts course. On the other hand, the researchers also found that the aspect of scientific reasoning abilities obtained the lowest percentage among all aspects, namely 76%. This result is noteworthy because although students have understood the importance of science and demonstrated positive attitudes toward science learning, some still experience difficulties in drawing conclusions based on scientific data and conducting independent analyses.

These findings reveal a gap between students' conceptual understanding and their scientific reasoning skills. This condition may be caused by learning processes that are still more focused on content comprehension rather than direct scientific investigation practices. According to Lederman et al. (2014), scientific reasoning skills are developed not only through theoretical mastery but also through repeated experiences involving observation, experimentation, data interpretation, and reflective discussion. Therefore, although students already possess positive perceptions of science, their scientific reasoning abilities have not yet developed optimally. These findings demonstrate that science education in teacher preparation programs still requires stronger emphasis on scientific practices and data-based problem-solving activities.

The findings of this study are consistent with several previous studies showing that positive student perceptions of science learning are associated with increased learning motivation and professional readiness among prospective teachers (Barenthien et al., 2020; Fuchs et al., 2022). Research conducted by Rahmawati et al. (2020) showed that positive attitudes toward science can increase student engagement in the learning process and strengthen conceptual understanding of scientific concepts. Another study by Pathoni et al. (2020) also found that science learning based on science process skills can improve students' critical thinking and problem-solving abilities. However, this study differs from previous research because it specifically highlights the relationship between students' perceptions of the Advanced Fundamental Science Concepts course and the teaching competencies of prospective elementary school teachers. Therefore, this study contributes new insights into understanding how perceptions of science courses may influence the professional readiness of Elementary Education students.

From a theoretical perspective, the findings of this study support the self-efficacy theory proposed by Haberbosch et al. (2025), which states that positive perceptions of learning experiences can influence individuals' beliefs in their own abilities. Students who possess positive perceptions of science learning tend to demonstrate greater confidence in understanding scientific concepts and teaching them to elementary school students (Aripin et al., 2022; Makhambetova & Magauova, 2022). Nevertheless, this study also indicates that conceptual self-efficacy has not been fully accompanied by strong scientific reasoning abilities. This condition suggests that conceptual mastery and analytical skills are two interconnected aspects that require different instructional strategies for their development.

In terms of generalization, the findings of this study indicate that the Advanced Fundamental Science Concepts course plays an important role in shaping Elementary Education students' perceptions and professional readiness. Although the study was conducted within the context of a particular study program, the results may provide a general overview of the challenges of science education in elementary teacher preparation programs in Indonesia. However, the generalization of the findings remains limited due to the relatively small number of respondents and the fact that the study involved only one higher education institution. In addition, this study primarily employed a descriptive approach and therefore has not been able to explain the causal relationship between students' perceptions and teaching competencies in greater depth.

Based on these limitations, future studies are recommended to employ mixed methods approaches or inferential analyses so that the relationships among students' perceptions, self-efficacy, and teaching competencies can be examined more comprehensively. Future research may also involve larger samples from various higher education institutions to increase the generalizability of the findings. Furthermore, the development of experiment-based, inquiry-based, or project-based learning models may be investigated to determine their effects on improving the scientific reasoning abilities of Elementary Education students. Therefore, this study is expected to contribute to the development of science education in teacher preparation programs and serve as a basis for evaluating the curriculum of the Advanced Fundamental Science Concepts course in the future.

Conclusion

The Advanced Fundamental Science Concepts course plays a strategic role in shaping the academic and professional readiness of Elementary Education students as prospective elementary school teachers, particularly in developing scientific reasoning, conceptual understanding, and awareness of the relevance of science in everyday life. This study demonstrates that science education in teacher preparation programs should not focus solely on content mastery, but also needs to emphasize the strengthening of analytical skills, data interpretation abilities, and the contextual application of scientific concepts. Learning experiences involving scientific practices, reflective discussions, and connections with real-world phenomena constitute important aspects in improving the quality of science education for prospective teachers. Therefore, the development of more active, contextual, and inquiry-based learning strategies should continue to be promoted so that students not only understand science theoretically, but are also able to transform it into meaningful learning experiences for elementary school students in the future.

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