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Assessing Pre-Service Teachers' Analytical Thinking in Science Fundamentals through a Moodle-Based Online Test

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ABSTRACT

Purpose of the study: This study aims to assess the analytical thinking skills of second-year pre-service teachers in the Concepts of Science course using a Moodle-based online assessment, emphasizing higher-order cognitive skills in Bloom's taxonomy.

Methodology: A descriptive quantitative design was employed involving 58 students from the Primary School Teacher Education (PGSD) program. Data were collected through a Moodle-based online test consisting of 20 items measuring analytical thinking at the analyzing level (C4), focusing on differentiating, organizing, and attributing in fundamental science topics. Descriptive statistics were used to analyze students' performance levels.

Main Findings: The findings show that approximately 62% of students achieved a moderate level of analytical thinking. Students performed better in identifying relationships between variables and interpreting experimental results, while difficulties were observed in organizing and evaluating scientific information. This indicates that Moodle-based assessments are effective in measuring analytical thinking but require instructional reinforcement to strengthen higher-order cognitive processes..

Novelty/Originality of this study: This study provides empirical evidence on the effectiveness of Moodle-based assessments in evaluating analytical thinking skills aligned with Bloom's taxonomy in science teacher education. It highlights the potential of digital assessment platforms to support valid, efficient, and scalable measurement of pre-service teachers' analytical competencies.

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1. INTRODUCTION

Analytical skills are a crucial cognitive skill in science education, especially for prospective teachers. Analytical skills are crucial in science because they enable learners to solve complex problems and think logically [1]. These skills help break down complex concepts into simpler parts, making them easier to understand and solve problems. Analytical thinking skills (C4) according to Bloom's taxonomy include three main aspects: differentiating, organizing, and attributing information. In an educational context, these skills enable prospective teachers to not only understand science concepts but also relate them to real-world contexts relevant to their students. Distinguishing important from irrelevant information, organizing information systematically, and attributing or deconstructing information to understand the perspective, bias, or intent behind it are essential skills for teachers in designing effective learning [2]-[5].

These analytical thinking skills are essential in science teaching because they help prospective teachers develop critical thinking in dealing with more complex and real-world problems, rather than simply memorizing information. Research shows that analytical skills are essential in developing systematic and critical thinking, which is necessary for teaching students in-depth science concepts. [6]-[8]. This ability also enables prospective teachers to assist students in identifying, understanding, and solving complex science problems through an analysis-based approach [9]-[11].

However, the phenomena occurring in the field show that many prospective teacher students still experience difficulties in applying science concepts to real problem analysis. Study by Hasnawati et al. [12] and Ding et al. [13] noted that although students have a basic understanding of science concepts, many of them have difficulty relating these concepts to more complex and contextual real-world situations. This also indicates that measuring analytical thinking skills in prospective teachers still requires a more effective and structured approach [14]-[16]. It's crucial for educational institutions to measure and develop prospective teachers' analytical skills through various assessment tools, including technology-based tests like Moodle, to ensure they are prepared to face the challenges of modern education. With technological advancements, online learning has become one method used to support higher education [17]-[19]. Learning Management System (LMS) platforms such as Moodle enable more effective technology-based evaluation, including measuring analytical thinking skills. According to Koneru [20] in his research, he revealed that Moodle is effective for assessing higher-order thinking skills, such as analysis, in a more objective and standardized manner. Other studies also show that LMS can increase interaction and ongoing feedback, thereby significantly supporting the development of students' critical thinking skills [21]-[24].

By using Moodle-based tests, lecturers can measure students' analytical abilities more efficiently, provide real-time feedback, and enable students to develop their critical thinking skills in a more interactive and technology-based context [25], [26]. Research results Hwang & Chang [26] also show that technology-based assessment can improve motivation and learning outcomes through effective formative feedback.

Over the past decade, online testing has evolved from a supplementary assessment tool into an integral component of digital learning environments, driven by advances in learning management systems and educational technology. Online assessments now enable more flexible, scalable, and data-driven evaluation processes, allowing for automated scoring, immediate feedback, and alignment with higher-order cognitive skills. Despite these advancements, most existing research continues to emphasize general learning outcomes, while the measurement of analytical thinking skills through technology particularly Moodle-based online tests remains limited. Assessment practices are still largely dominated by paper-based or conventional face-to-face formats, which do not fully leverage the capacity of digital platforms to systematically capture and analyze students' analytical processes [27]-[29]. Therefore, there is a significant research gap in measuring the analytical thinking skills of prospective elementary school teachers using LMS platforms such as Moodle [30]. Consequently, a substantial research gap persists in the use of LMS-based online assessments, such as Moodle, to measure the analytical thinking skills of prospective elementary school teachers.

Despite the rapid development of online assessment technologies, assessment practices in teacher education remain largely centered on general learning outcomes and conventional testing formats, with limited empirical attention to the systematic measurement of analytical thinking skills through LMS platforms such as Moodle. In particular, research that explicitly measures core analytical processes—differentiating, organizing, and attributing information—within digital assessment environments is still scarce, leaving a significant gap in the evaluation of higher-order cognitive skills in science education. To address this gap, the present study proposes a Moodle-based online assessment model that positions the platform not merely as a delivery system, but as an analytical measurement tool for assessing prospective teachers' analytical thinking skills in the Basic Science Concepts course. The novelty of this study lies in the integration of a technology-based assessment approach with a clearly defined analytical thinking framework aligned with the analyzing level (C4), thereby offering a more structured and measurable evaluation of science-related analytical skills [24], [32]. This solution is urgently needed as teacher education programs increasingly rely on digital and blended learning, yet lack valid and scalable instruments to assess higher-order thinking skills. By providing empirical evidence on the effectiveness of Moodle-based online tests for measuring analytical thinking, this study contributes to the advancement of digital assessment methods and supports the development of innovative, technology-driven curricula and assessment models in higher education.

2. RESEARCH METHOD

This study used a descriptive quantitative design to assess prospective teachers' analytical thinking skills in the Basic Concepts of Science course through a Moodle-based online test. This study focused on measuring three aspects of analytical thinking contained in the revised Bloom's taxonomy: differentiating, organizing, and attributing. The designed test refers to the ability to distinguish relevant from irrelevant information, organize information systematically, and attribute information to identify perspectives or biases underlying scientific arguments. The assessment was conducted online using the Moodle platform, which allows for more objective and efficient technology-based evaluation.

Participants in this study were 58 student teachers enrolled in the second year of the Elementary School Teacher Education study program. These students were taking the Basic Concepts of Science course, which covers fundamental topics in natural science. Prior to the test, all participants were given an explanation of the procedures for using Moodle for online testing. Participants consisted of 47 females and 11 males, aged 19 to 21. The test was administered voluntarily, and informed consent was obtained.

The instrument used in this study was a Moodle-based online test designed to measure analytical thinking skills in three cognitive processes: differentiating, organizing, and attributing. The test consisted of 24 questions, including multiple-choice and essay questions. Each question was developed with reference to analytical ability indicators according to Bloom's taxonomy, as follows:

Table 1. Research on weather/rain prediction

Analytical Process	Operational Definition	Example Focus Questions
Differentiating	Identifying relevant information from irrelevant information.	Selecting variables that influence a physical or chemical phenomenon.
Organizing	Organize ideas or concepts systematically and find relationships between elements.	Arranging experimental steps or classifying science concepts.
Attributing	Be aware of the viewpoint or assumptions underlying a material or argument.	Identify hidden assumptions or biases in scientific experiments or theories.

This test focuses on analytical skills related to basic science concepts such as energy, force, matter, and chemical change. The assessment was conducted through the Moodle platform using the Quiz module to administer the test online. The test was administered over a 60-minute period, with randomized question assignments and automated scoring for multiple-choice questions. Participants received automatic feedback for multiple-choice questions immediately after completing the test, while descriptive questions were manually graded by the researcher. Prior to the test, participants received a brief orientation on how to access and take the test through Moodle.

Data obtained from Moodle was downloaded from the Gradebook module and analyzed using descriptive statistics to obtain an overview of participants' analytical thinking skills. The analysis included:

a. The overall mean score for each participant.
b. The standard deviation (SD) and score range (minimum–maximum) to examine variations in analytical thinking skills.
c. Ability categories (high, medium, low) based on percentiles or assigned score divisions.

In addition, item analysis was conducted to evaluate which analytical processes (differentiating, organizing, or attributing) were strongest or weakest. Score distribution graphs were used to visualize the overall results and identify areas where participants demonstrated strengths or weaknesses in analytical thinking

3. RESULTS AND DISCUSSION

The results of descriptive statistics show that the average value of analytical thinking ability of prospective teacher students is 68.03, which is in the medium category. Based on the grouping of scores using the mean ± standard deviation approach, the frequency distribution shows that the medium category dominates, namely 24 students (41.4%), followed by the low category of 23 students (39.7%), and the high category of 11 students (19.0%). The data is described in Table 1.

Table 1. Description of the analytical ability of prospective elementary school teachers

Statistic	Value
Sample Size (N)	58
Minimum Score	20.8
Maximum Score	95.8
Mean	68.03
Median	70.8
Mode	54.2
Standard Deviation (SD)	13.05

These findings indicate that although most students have achieved a moderate level of analytical thinking ability, the proportion of students in the low category is still relatively large and almost equal to the moderate category. The median value of 70.8 strengthens the position of students' analytical ability in the moderate category, while the mode value of 54.2 indicates that the most frequently occurring score is still in the low category range. This pattern reflects the existence of quite significant variations in analytical ability among students, and indicates that mastery of analytical thinking skills, especially in differentiating, organizing, and attributing information to basic scientific concepts, has not developed evenly.

During the test, the researcher utilized the monitoring feature in Moodle to observe students' test-taking processes in real time. The assessment was conducted in the classroom under the supervision of the course instructor, and students were allowed to use various devices such as laptops, smartphones, or tablets. Through the activity log and quiz attempt details, the researcher could track completion time, number of attempts, and response patterns for each item. This information provided a more comprehensive understanding of how students analyzed information, made decisions, and revised their answers throughout the test. The following figure 1. illustrates the monitoring dashboard used to evaluate students' cognitive engagement during the test, allowing the analytical thinking process to be recorded digitally while remaining integrated with in-class learning activities.

Figure 1. Monitoring of students' test performance via Moodle dashboard

A total of 58 prospective teachers in the Elementary School Teacher Education study program participated in this test. All respondents had taken a course on basic science concepts and completed an online test using Moodle. The analytical skills test consisted of 24 multiple-choice questions. Each question had a correct weight of 0.42 and measured three aspects of analytical thinking skills according to the revised Bloom's taxonomy: differentiating, organizing, and attributing. Students' scores were converted and calculated on a scale of 100.

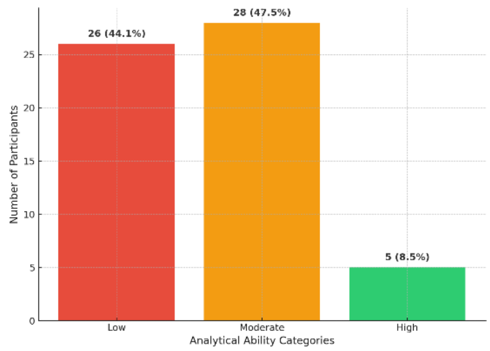

Figure 2. Analytical Skills of Pre-Service Teachers

Figure 2 shows the distribution of analytical thinking ability categories among 58 student teachers enrolled in the Basic Concepts of Science course. This category reflects the participants' ability level based on the scores obtained in the Moodle-based test, which is designed to measure analytical thinking skills in a science context. Most participants (approximately 62%) fell into the medium category, indicating adequate analytical thinking skills but with room for improvement. Approximately 26% of participants fell into the High category, indicating strong analytical skills in distinguishing relevant from irrelevant information. However, approximately 12% of participants fell into the Low category, indicating that this group may need additional assistance in developing their analytical thinking skills.

This distribution highlights the importance of targeted interventions to strengthen specific aspects of analytical thinking skills, particularly Organizing and Attributing, where some participants demonstrated limitations. This distribution pattern confirms that students' scientific analytical skills are still centered at the intermediate level, which, according to Anderson & Krathwohl [2], reflects a cognitive stage where individuals are able to decipher information but have not yet fully evaluated conceptual structure or meaning. This condition aligns with research by Liu et al. [22], which found that pre-service teachers generally demonstrated mid-level analytical performance strong in concept identification but weak in generalization and application of scientific principles to real-world situations. Furthermore, the wide variation in abilities among students suggests that the process of internalizing analytical thinking is strongly influenced by learning experiences and the quality of pedagogical interactions. According Ding et al. [11] emphasized that higher analytical skills develop when students are actively engaged in exploratory and reflective activities, such as problem-based experiments and project-based learning. Therefore, although the proportion of high categories indicates promising cognitive potential, the presence of groups with low categories indicates a gap that needs to be bridged through a differentiated learning approach and continuous formative assessment.

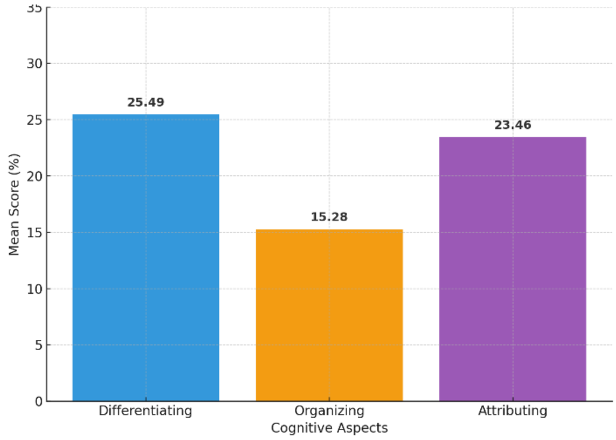

Figure 3. Mean Score Analaytical Thinking Aspects

Figure 3 shows a comparison of the average achievement of students' analytical skills based on the three main aspects of Analytical Skills according to Bloom's Taxonomy: Differentiating, Organizing, and Attributing. Differentiating showed the highest average score (25.49), indicating that most participants were able to differentiate scientific information quite well. However, a large variation (standard deviation of 7.60) indicated significant differences between participants. Organizing had the lowest average score (15.28), indicating that students had difficulty organizing and connecting scientific information. The lowest score (0.0) in several participants indicated that some groups had not mastered this aspect at all. Attributing obtained a higher average score (23.46) than organizing, but still showed large variation, with the lowest score at 8.4 and the highest at 33.6.

Theoretically, this pattern confirms that students find it easier to master basic analytical skills, such as sorting relevant information or identifying important variables, than advanced analytical skills that require integration and reflective assessment of scientific arguments. Attributing skills are the pinnacle of the analytical process because they require epistemological awareness of the intent, value, and bias within a concept [2]. This phenomenon also aligns with research by Osiesi et al. [33] and Adeshola & Abubakar [34], which emphasized that although online learning and technology-based assessments such as Moodle can help measure higher-order thinking skills efficiently, the highest achievement still occurs in more concrete cognitive dimensions. The organizing and attributing aspects require learning strategies that encourage reflection, scientific argumentation, and context-based problem-solving. Therefore, these findings emphasize the need for digital assessment designs that not only focus on conceptual mastery but also stimulate reflective analytical skills through the integration of adaptive feedback and inquiry-based tasks.

3.1. Diferentiating

The Differentiating aspect measures students' ability to distinguish between relevant and irrelevant information and identify important variables in scientific phenomena. The average score for the Differentiating aspect was 25.49, indicating that most participants had a fairly good ability to distinguish relevant from irrelevant information. This ability is a fundamental aspect of analytical thinking that enables students to identify important variables in scientific phenomena. This achievement indicates that students generally can sort information well, although there is still room for improvement, especially in more complex aspects such as connecting information or assessing the deeper meaning of the data. Students tend to be able to recognize the main elements of scientific events and select significant data to explain cause-and-effect relationships. High achievement in this aspect indicates that students have a strong foundation in analytical thinking, especially in sorting complex information.

The cognitive process of analysis consists of three sub-processes: differentiating, organizing, and attributing. In the differentiating stage, individuals identify and sort relevant information and ignore irrelevant information, thus making the knowledge structure more focused and meaningful [2]. In the context of cognitive structures, differentiating involves information processing activities in working memory and conceptual knowledge stored in long-term memory [35]-[37]. Thus, this ability does not stand alone, but is built on the ability to understand (comprehension) and apply (application). According Marzano &. Kendall [38], analytical activities such as matching and classifying are the initial part of the cognitive system that allows students to create new conceptual connections and assess the relevance of knowledge elements.

In science-based learning, differentiating skills emerge when students identify important variables in experiments or distinguish relevant evidence from irrelevant data [39]-[41]. This process strengthens cognitive structures through active engagement in higher-order thinking skills. Thus, the more frequently students are confronted with complex situations that require data-based sorting and reasoning, the more the cognitive structures that support their analytical skills develop. Overall, differentiating is built on the interaction between conceptual knowledge and metacognitive processes, where students use analytical strategies to sort, compare, and relate information, forming an important foundation for scientific analysis and critical thinking skills. This result is in line with [2], which emphasizes that the skill of differentiating is the initial foundation of critical scientific thinking.

3.2. Organizing

The organizing aspect assesses students' ability to group, organize, and structure scientific information into logical relationships. The average score for the organizing aspect was 15.28, indicating that students still struggle to organize and structure information systematically. Although participants grasp basic concepts, they tend to struggle to synthesize diverse scientific information into a coherent and organized structure. Lower scores on this aspect indicate a need for improvement in students' skills in connecting concepts and organizing knowledge systematically, particularly in more complex, project-based science contexts. Students demonstrated a relatively good ability to organize concepts and experimental steps, but still struggled to build a coherent conceptual framework to fully explain scientific phenomena. This indicates the need for practice in linking basic science concepts into a more systematic knowledge structure. Analytical (organizing) skills are built into the cognitive structure through the process of grouping and rearranging previously sorted information elements into a coherent and meaningful knowledge system. This process marks a shift from simply recognizing pieces of knowledge to establishing structured conceptual relationships within an individual's long-term memory.

According to Anderson & Krathwohl [2], The organizing aspect of analytical skills reflects students' ability to recognize relationships between elements of knowledge and organize them into a logical and systematic structure. This requires activation of working memory and metacognitive skills, as individuals must integrate new information with existing knowledge in their cognitive structure [42]. This organizing process leads students to connect various scientific concepts, discover patterns, and build new hierarchical knowledge.

In the perspective of Piaget's cognitive theory, organizational function is a natural mechanism that allows individuals to integrate various experiences into a coordinated system of understanding [43]-[45]. The cognitive structures developed through this organization help students balance the processes of assimilation (incorporating new information into existing schemas) and accommodation (changing old schemas to fit new information). Thus, organizing skills result from the interaction between internal constructs and adaptation to external experiences. In the context of science learning, organizing occurs when students group experimental data, create tables of relationships between variables, or map scientific concepts into diagrammatic models. These activities strengthen cognitive structures by instilling logical order in new knowledge. This finding strengthens the research results of [28], which showed that organizing scientific concepts is a common challenge for prospective teachers in the early stages of developing science pedagogical competencies.

3.3. Atributing

The attributing aspect relates to students' ability to assess the perspective, bias, or intent behind scientific information. The average score for the attributing aspect was 23.46, indicating that students still have some difficulty assessing perspective, assessing bias, or analyzing the intent behind the information provided. Although students have a fairly good ability to analyze information, they still need to practice the skills to recognize assumptions, biases, or deeper contexts in scientific arguments. This reflects that students have not been fully trained in critical reflection on scientific data or arguments, which are higher-order thinking skills that are essential in science education. Students still have difficulty identifying the values or assumptions underlying a scientific argument, especially in the context of questions that require critical analysis of data and hypothetical statements.

Attributing is the ability to identify the point of view, motive, or purpose behind a statement or information [2]. This process demands higher cognition because students must connect factual knowledge with the social context or values inherent in the information. Within the cognitive structure, this aspect integrates conceptual knowledge with metacognitive processes, where individuals assess the relevance, validity, and purpose of information [2]. Further, Schraw & Moshman [46] states that attribution skills play a crucial role in the development of metacognition, namely awareness and control over how knowledge is processed and used. This suggests that attribution builds a more reflective and critical cognitive structure, rather than simply organizing data [47].

In science learning, attribution skills emerge when students are able to determine the validity of data sources, compare theoretical perspectives, or connect experimental results to scientific concepts and real-world contexts. These activities help broaden and deepen cognitive structures through critical assessment of received information. Therefore, building attribution skills into cognitive structures means training students not only to recognize and organize information but also to critically examine and interpret it, which is the foundation for reflective and evaluative thinking. Low achievement in this aspect was also found in research by Li [48], Fitriani et al. [49], Liu & Pásztor [50], which stated that evaluative and reflective skills are the most challenging parts of the analytical thinking process for prospective science teachers.

Overall, the three aspects of analytical ability showed a consistent pattern: differentiating ability was in the high category, organizing ability was in the medium category, and attributing ability was in the medium to low category. These results indicate that students tend to be stronger in their ability to recognize and sort information, but still need to strengthen their ability to structure and evaluate scientific information in depth. The implementation of Moodle-based tests has proven effective in assessing analytical ability objectively, efficiently, and transparently. This system allows lecturers to conduct automated assessments and provides direct feedback to students. This finding is in line with Ngulube & Ncube [51], which shows that LMS platforms like Moodle can improve the reliability of higher-order thinking skills assessments. The use of this platform also opens up opportunities for developing cognitive-based digital assessment models that support the improvement of scientific literacy and critical thinking skills in prospective teachers. The results of this study reinforce the importance of integrating digital assessments into teacher education curricula, not only as evaluation tools but also as vehicles for reflective learning. By understanding the distribution of students' analytical abilities, lecturers can design more adaptive learning interventions, for example by providing data-driven feedback to strengthen areas of organizing and attributing.

Overall, these findings indicate that prospective teachers have stronger abilities in Differentiating compared to Organizing and Attributing. The Differentiating aspect, which received the highest score, indicates that students are better able to distinguish between relevant and irrelevant information. However, skills in organizing and critically evaluating information need to be strengthened, which can be achieved through a project-based learning approach and deeper reflection. This reflects that most students are able to sort out relevant information, but struggle to organize it systematically (Organizing) and assess assumptions or biases in scientific arguments (Attributing). This pattern indicates the need for a learning approach that emphasizes not only conceptual understanding but also develops students' abilities to analyze, organize, and critically evaluate information.

For example, in a science-based project, students could be asked to distinguish between relevant and irrelevant experimental data, organize experimental data into a clear format, and assess any assumptions or biases that might be present in their experimental results. This would provide a more hands-on experience in honing analytical thinking skills and help students understand the connection between scientific concepts and their real-life applications. According Williamson [52] and Thomas [53] emphasizes that a project-based approach helps students develop analytical thinking skills, as these projects often involve processing information in a more complex and open-ended real-world context. The use of LMS as a means for assessment provides the opportunity for openness and speed of access to results [54]-[57]. Furthermore, integrating Micro-Project Based Learning with a Learning Management System (LMS) like Moodle will strengthen this approach by enabling continuous, technology-based assessment to provide immediate feedback to students. With faster, data-driven feedback, students can gradually improve their critical and analytical thinking skills.

Learning Management Systems (LMS) are widely used in educational settings to support teaching and learning practices, including the assessment of learning outcomes. The C4 domain, which focuses on analytical skills, can be effectively assessed using LMS tools and features. Moodle provides a range of customizable assessment features that can be designed to assess learners' analytical abilities. The incorporation of extensions such as CodeRunner enables immediate feedback and supports adaptive learning processes, both of which play a vital role in fostering and evaluating analytical skills, particularly in programming-related courses [58]-[60]. Through real-time feedback, students are able to refine their problem-solving strategies and analytical reasoning in an iterative and systematic manner. Moodle enables collaborative learning environments that support the development of analytical skills through structured group discussions and problem-solving tasks. Previous studies indicate that the use of Moodle in collaborative learning contexts has a positive impact on the quality of group interactions and problem-solving performance, both of which are essential elements of analytical thinking [60]. Moodle represents a comprehensive platform for evaluating learning outcomes, particularly those related to analytical skills at the C4 level. Its feature such as immediate feedback mechanisms, support for collaborative learning, and the use of learning analytic contribute to its effectiveness in both enhancing and assessing students' analytical competencies. Findings from previous studies consistently indicate that Moodle-based assessment practices can lead to improved learning outcomes and promote the development of higher-order analytical thinking skills.

4. CONCLUSION

The results of this study indicate that a Moodle-based analytical skills test implemented in the Basic Concepts of Science course can identify the analytical skills of prospective teachers in a structured and objective manner. The test results revealed that most students were in the moderate category, with the highest scores in the

Differentiating aspect, which measures students' ability to distinguish relevant from irrelevant information. Meanwhile, the Organizing and Attributing aspects showed lower achievement, with students experiencing difficulties in organizing information systematically and assessing assumptions or biases in scientific arguments. Thus, the results of the Moodle-based analytical skills test provide a clear picture of the analytical thinking skills of prospective science teachers. The Moodle-based assessment approach has proven effective in measuring Higher Order Thinking Skills (HOTS) because it provides a fast, transparent, and data-driven assessment that allows students to receive instant feedback. These results emphasize the importance of using digital platforms to identify areas of skill that need strengthening, such as the organization and evaluation of scientific information. Based on these findings, the Moodle-based test can be used as a more efficient and objective assessment model to support the development of analytical thinking skills of prospective teachers. The results of this test also provide valuable information for developing a more focused curriculum and learning interventions, particularly in improving students' abilities in more complex areas, such as organizing and evaluating information. Thus, the Moodle-based test serves not only as an evaluation tool but also as a diagnostic instrument for designing more effective technology-based learning strategies to improve the analytical thinking skills of prospective science teachers.

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USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

The authors declare that no artificial intelligence (AI) tools were used in the preparation, analysis, or writing of this manuscript. All aspects of the research, including data collection, interpretation, and manuscript preparation, were carried **out** entirely by the authors without the assistance of AI-based technologies.

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