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Profile Of Critical Thinking Ability And Science Process Skills Of Junior High School Students On Coordination System Material: A Preliminary Study Based On Needs Analysis

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Abstract

The Coordination System is one of the most challenging Biology topics for junior high school students. This study aims to analyze the profiles of students' critical thinking skills (CTS) and science process skills (SPS) on this topic, and to identify learning problems as the basis for developing a Guided Inquiry learning model integrated with Interactive Flat Panels (IFP). A descriptive-quantitative approach was employed through a needs analysis survey distributed to 18 Biology teachers and 239 junior high school students in Bandung City. Questionnaire results revealed that 71.5% of students identified the Coordination System as the most difficult topic, with key factors including: content depth exceeding' abilities (72.2% of teachers), overly abstract concepts (61.1%), and limited instructional media (55.6%). Baseline control class data indicated that students' critical thinking and science process skills remained in the low category, suggesting that conventional instruction has not been able to optimally develop both competencies. These findings underscore the urgent need for innovative instructional models capable of more meaningfully enhancing students' critical thinking and science process skills on the Coordination System topic.

Keywords: Coordination System; Critical Thinking; Needs Analysis; Preliminary Study; Science Process Skills.

INTRODUCTION

Science education at the junior high school (SMP) level plays a strategic role in developing students' scientific literacy and higher-order thinking skills. In the context of the Independent

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Curriculum implemented in Indonesia, biology instruction is required not only to convey concepts informatively but also to facilitate the development of critical thinking skills (BK) and science process skills (SPS) as the foundation for 21st-century competencies (Swandana et al., 2023). The urgency of developing these two competencies is further reinforced by the low performance of Indonesian students in international assessments such as PISA and TIMSS, which consistently place scientific reasoning and problem-solving skills as areas of weakness that require serious attention (Arifin et al., 2025).

Critical thinking is a high-level cognitive ability that is essential in science learning.Face (2015)defines critical thinking as a purposeful and reflective cognitive process in forming judgments about what to believe or do, with six main indicators: interpretation, analysis, evaluation, inference, explanation, and self-regulation. Science process skills (SPS) are a set of skills used by scientists in acquiring knowledge, including observation, classification, measurement, prediction, communication, and experimentation (Rustaman et al., 2005). A recent study by Chengere et al. (2025) confirmed that well-integrated laboratory-based inquiry learning was proven to significantly increase KPS compared to traditional learning.

The Coordination System is a biology topic in ninth-grade junior high school that is consistently reported as the most difficult. This topic covers the nervous system, the hormonal system, and the sensory system, all of which are abstract, complex, and physiologically interconnected (Tekkaya, 2000). Various studies show that students experience persistent misconceptions on this material (Dikmenli, 2010), and this high level of difficulty is correlated with low student learning outcomes nationally. An analysis of the conditions of junior high school biology learning in Indonesia reveals that low student guidance and achievement (BK) and student achievement (KPS) are not solely caused by intrinsic ability factors, but also by a learning approach that is still dominated by conventional methods with limited media that do not support the visualization of abstract concepts (Antonio & Prudente, 2024).

Various learning innovations have been proposed to address this issue. The Guided Inquiry model has proven effective in improving critical thinking skills and SLP through an approach that positions students as active subjects in the discovery process with structured teacher guidance (Devi & Hariyono, 2024). Meta-analysis by Antonio & Prudente (2024) A study of 62 studies found that an inquiry-based approach produced a large effect (Hedges' g = 0.82) on students' higher-order thinking skills in science learning. The integration of Guided Inquiry with the Socioscientific Issues (SSI) approach further strengthens the relevance of the learning context to real-life science issues, thereby simultaneously improving students' learning motivation and scientific reasoning

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skills (Dusturia et al., 2024; Wulansari & Dewi, 2022).

On the other hand, the development of educational technology, particularly Interactive Flat Panels (IFPs) or interactive smartboards, offers a learning medium capable of presenting dynamic visualizations of abstract biological concepts while encouraging active student participation. The use of IFPs in the context of science learning is theoretically based on several relevant learning theories. First, Vygotsky's (1978) constructivism theory states that knowledge is actively constructed by students through interactions with a richly mediated environment, where IFPs function as cultural artifacts that mediate the process of knowledge construction within the Zone of Proximal Development (ZPD). Second, Cognitive Load Theory. Sweller (1988) stated that structured visual representations can reduce extrinsic cognitive load and optimize students' working memory capacity in processing complex biological concepts.

In terms of comparing learning media according to research Kurniawan & Hakim (2024) that the use of Interactive Flat Panel Display (IFPD) significantly increases student engagement and understanding of concepts compared to conventional media, especially in materials that require visualization of dynamic physiological processes such as the Coordination System.

However, developing a systematic, innovative learning model requires a comprehensive needs analysis based on empirical data from the field. Needs analysis serves as a bridge between actual learning conditions and the desired ideal conditions, ensuring that designed interventions are contextual, relevant, and on-target (Chananil et al., 2025). Currently, research that empirically maps the BK and KPS profiles of junior high school students on the Coordination System material while identifying the factors causing difficulties from the perspective of teachers and students is still very limited.

Based on this background, this study aims to: (1) analyze the BK and KPS profiles of junior high school students on the Coordination System material through baseline N-Gain and Effect Size data; (2) identify factors causing difficulties in learning the Coordination System from the perspective of teachers and students; and (3) map the actual conditions of Biology learning in junior high schools in Bandung City as a basis for developing a Guided Inquiry model based on SSI integrated with IFP. The findings of this study are expected to provide a real contribution to the development of more innovative Biology learning and oriented towards improving students' higher-order thinking skills.

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RESEARCH METHODS

Research Design and Approach

This research is a preliminary study with a descriptive-quantitative approach. The research design used needs analysis combined with baseline data collection from the control class. This approach was chosen because the primary objective of the study was to describe actual learning conditions and map student ability profiles (Cresswell & Creswell, 2017).

Research Subjects

The research subjects consisted of two groups. The first group consisted of 18 junior high school biology teachers in Bandung City who were selected using purposive sampling with the criteria of actively teaching Coordination System material and having at least two years of experience. The second group consisted of 239 ninth-grade junior high school students from several schools in Bandung City who were selected using proportional random sampling. N-Gain and Effect Size analyses were conducted on control class data (n=29 students) who had participated in conventional learning on Coordination System material at a public junior high school in Bandung City.

Research Instruments

The research instruments consisted of two types. First, a needs analysis questionnaire for teachers (11 items) that measured perceived level of material difficulty, factors causing difficulty, learning models used, teaching materials and media, and assessment practices. Second, a needs analysis questionnaire for students (11 items) that measured perceived level of material difficulty, factors causing difficulty, perceptions of teaching methods, and learning method preferences. N-Gain data were obtained from the results of pre-tests and post-tests of critical thinking skills based on indicators. Facione (1990) and science process skills based on Rustaman et al.'s (2005) indicators. The validity of the instrument was verified through expert judgment using Lawshe's Content Validity Ratio (CVR) formula.

Data Analysis Techniques

The questionnaire data analysis was conducted descriptively using the percentage of response frequency. The N-Gain data was calculated using the formula Hake (1998) with the following formula:

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$$n - gain = \frac{Final\ score - Initial\ score}{Max\ score - Initial\ score}$$

The N-Gain measurement is used to determine the extent of the increase. The following are the gain value categories presented in Table 1.

Table 1. Gain Value Categories

Gain Value	Information
g < 0.3	Small
0.3 < g > 0.7	Currently
g > 0.7	Tall

RESULTS AND DISCUSSION

Students' Perceptions of the Level of Difficulty of Biology Material

The results of a needs analysis questionnaire of 239 students showed that 71.5% of students (n=171) stated that the Coordination System (Nervous and Sense Organs) was the most difficult topic, followed by the Movement System or Bones and Muscles (60.7%; n=145) and the Circulatory System (38.1%; n=91). In contrast, the topics considered easiest were Characteristics and Classification of Living Things (61.5%; n=147), Inheritance of Traits/Genetics (49.8%; n=119), and the Digestive System (49.8%; n=119). Complete data is presented in Table 2.

Table 2. Students' Perceptions of the Level of Difficulty of Middle School Biology Topics

Biology Topics	Most Difficult (n)	%	Easiest (n)	%
Coordination System (Nervous System & Senses)	171	71.5	15	6.3
Muscular System (Bones and Muscles)	145	60.7	40	16.7
Bloodstream system	91	38.1	64	26.8
Inheritance of Traits (Genetics)	88	36.8	119	49.8
Digestive system	50	20.9	119	49.8

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Respiratory System	53	22.2	111	46.4
Characteristics and Classification of Living Things	60	25.1	147	61.5
Reproduction in Humans	41	17.2	101	42.3

The high percentage of students who consider Coordination Systems to be the most difficult topic is in line with the results of various international studies. Dikmenli (2010) He added that the complexity of nervous system anatomy requires a high level of spatial visualization. The abstract nature of the material and the involvement of microscopic processes make it difficult for students to construct accurate mental representations (Marbach-Ad & Stavy, 2000). This finding is also consistent with recent reports from studies in Indonesia showing that topics with abstract concepts and complex physiological processes consistently produce low N-Gain in conventional learning (Irwanto, 2022).

Factors Causing Learning Difficulties in the Coordination System

Analysis of factors causing difficulties from the students' perspective showed three dominant factors: (1) the language used was too difficult (46.4%; n=111), (2) the absence of teaching aids or learning videos (36.4%; n=87), and (3) unclear pictures in books (28.9%; n=69). From the teachers' perspective, 18 respondents identified three main factors: (1) the depth of the material was not appropriate to the students' abilities (72.2%; n=13), (2) the concepts were too abstract (61.1%; n=11), and (3) limited teaching aids and media (55.6%; n=10). Complete data is presented in Table 3.

Table 3. Factors Causing Learning Difficulties in the Coordination System According to Teachers

Factors Causing Difficulties	Frequency (n)	Percentage (%)
The depth of the material does not match the students' abilities.	13	72.2
The concept is too abstract for students	11	61.1
Limitations of teaching aids/learning media	10	55.6

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Lack of mastery of material by teachers	5	27.8
Limited class hours	4	22.2

The convergence between teacher and student perspectives indicates that the main problems are structural, namely related to the characteristics of the material and the limitations of learning media. Mulyono et al. (2023) emphasized that the limited availability of media that support social and scientific contexts is a significant barrier to the development of students' critical thinking. This finding supports the argument that learning Coordinate Systems requires an approach that can concretize abstract concepts through rich and interactive visual representations. López-Fernández et al. (2022) demonstrated that the integration of socio-scientific issues in learning abstract concepts can significantly improve critical thinking skills by providing meaningful contexts for students.

Biology Learning Profile: Teacher Perspective

Analysis of learning models shows that the conventional lecture method still dominates. Of the 18 teachers, 13 (72.2%) occasionally use lectures, while 4 (22.2%) use them frequently. The Inquiry/Discovery Learning model is only frequently used by 9 teachers (50%). Regarding teaching materials, Student Worksheets (LKPD) are the most dominant (88.9%), followed by learning videos (83.3%), textbooks (83.3%), and PowerPoint presentations (77.8%). The dominance of the lecture method and the minimal use of the inquiry approach align with the findings.Jerrim et al. (2022)who reported that the implementation of inquiry-based teaching in secondary schools is still low even though it has been proven to improve student achievement.

Regarding assessment, 44.4% of teachers stated that they frequently provide HOTS (analysis, evaluation, and creation) assessments, while another 44.4% only occasionally. The main obstacles to assessment were the very long assessment time (77.8%) and the difficulty in creating objective rubrics (33.3%). This condition indicates that the implementation of authentic assessments that support student guidance and development (BK) and KPS still faces significant practical obstacles, consistent with the findings. Chengere et al. (2025) that process-based assessment is still a major challenge for Biology teachers in developing countries.

Biology Learning Profile: Student Perspective

Of the 239 students, 78.7% expressed positive feelings about biology, and 77% considered

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it important for their daily lives. Regarding the preferred method, 62.3% (n=149) chose laboratory experiments as the most enjoyable, followed by educational games/quizzes (46.4%; n=111), lectures (34.7%; n=83), and group discussions (31.4%; n=75). This high preference for hands-on activities and gamification indicates students' readiness for active and interactive learning.

However, the reality of the frequency of practicums shows a significant gap: 54.4% of students only do practicums a few times per semester, with the main reasons being insufficient time (77.8%) and teachers preferring other methods (30.5%). This gap between student preferences and actual learning conditions aligns with issues reported in recent literature reviews. Arifin et al. (2025) A meta-analysis of inquiry studies in Southeast Asia found that the gap between the potential of IBL and its actual implementation in the classroom is primarily due to time constraints and limited facilities. This situation reinforces the need for alternative learning media, where IFP with interactive biological simulation content can be a concrete solution to bridge this gap (Kurniawan & Hakim, 2024; Sugrah & Wiyarsi, 2023).

Baseline Profile of Critical Thinking Skills and Science Process Skills

Analysis of N-Gain and Effect Size data in the control class (n=29 students) who participated in conventional learning produced the findings presented in Table 4 and Figure 1

Table 4. Summary of N-Gain and Effect Size Analysis of Conventional Learning

Indicator	Critical Thinking (BK)	Science Process Skills (SPS)
Number of Students (n)	29	29
Pre-Test Average	46.93	41.79
Post-Test Average	61.88	52.14
Difference (Post – Pre)	14.94	10.34
Average N-Gain (g̃)	0.173	0.111
N-Gain Category	Low	Low
SDpooled	16,809	15,025
Cohen's d	0.889	0.689
Cohen's d category	Large	Medium

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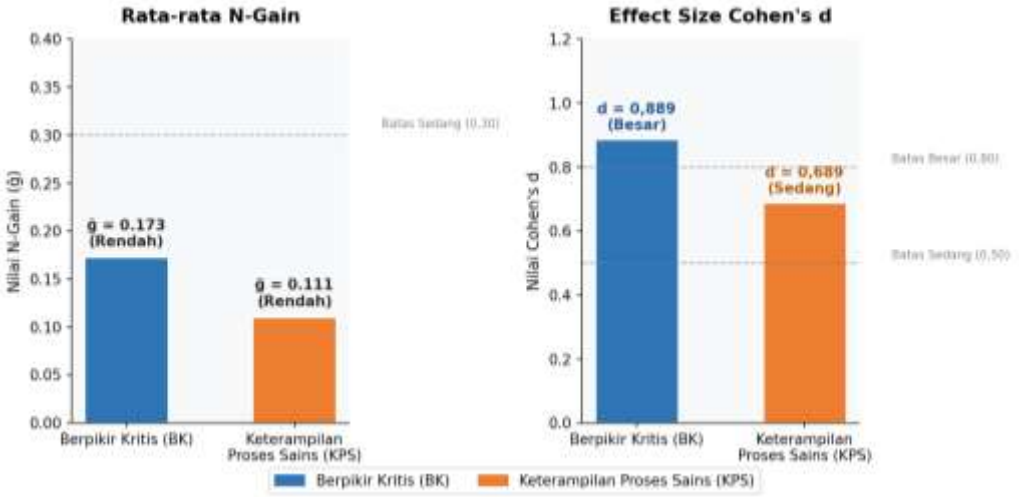


Figure 1. Comparison of N-Gain Values and Effect Size of Critical Thinking Skills and Science Process Skills in Conventional Learning

The analysis results show that the average N-Gain for BK is ḡ=0.173 and the N-Gain for KPS is ḡ=0.111, both in the low category. The individual distribution shows that only 12 students (41.4%) achieved the medium N-Gain category for BK, while 17 students (58.6%) remained in the low category. For KPS, the condition is more concerning, only 7 students (24.1%) achieved the medium category, 22 students (75.9%) were in the low category, and there were several negative N-Gain values indicating a decrease in scores. This condition is consistent with the findings Irwanto (2023) that the science process skills of students in Indonesia are still in the low category due to the dominance of conventional learning which has minimal hands-on inquiry.

Interestingly, Cohen's d Effect Size values showed different results. The d=0.889 (large) value for BK indicates that although the N-Gain is low, the difference between the pre-test and post-test is statistically significant. The d=0.689 (moderate) value for KPS also confirms the significant influence of the learning process. This phenomenon can be interpreted as meaning that the potential for increasing BK and KPS actually exists, but is not optimally utilized by conventional learning. Antonio & Prudente (2024) in their meta-analysis showed that an inquiry-based approach can significantly increase the effect size compared to traditional learning, with an average gain of 0.82 in higher-order thinking skills.

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Implications for Learning Development

The convergence of findings from three data sources, namely teacher questionnaires, student questionnaires, and baseline analysis consistently points to the urgency of developing a learning model that integrates: (1) a Guided Inquiry approach that facilitates students to actively construct knowledge; (2) a Socioscientific Issues (SSI) context that connects material to real science issues; and (3) Interactive Flat Panel (IFP) technology that provides dynamic visualization. The integration of Guided Inquiry with SSI has been proven effective in recent research. Dusturia et al. (2024) reported that the implementation of the SSI approach in science learning significantly improved students' critical thinking skills. Devi & Hariyono (2024) showed a significant increase in critical thinking when the Guided Inquiry model was integrated with SSI on climate change material.

From the perspective of learning media, Sugrah & Wiyarsi (2023) demonstrated that SSI-based learning combined with flipped classroom improves students' critical thinking skills and scientific attitudes. Wulansari & Dewi (2022) developed an SSI-based Guided Inquiry tool and reported significant improvements in critical thinking skills and environmental awareness. Kurniawan & Hakim (2024) confirmed that IFPD significantly increases engagement and conceptual understanding compared to conventional media, especially for materials requiring complex visualization. The integration of IFP with the inquiry approach and SSI in the Coordination System material is projected to increase the N-Gain of BK and KPS from low to medium or high categories, while simultaneously building the relevance of learning to students' real-life contexts.

CONCLUSION

Based on the results of the needs analysis and the collected baseline data, it can be concluded that first, the Coordination System material is the most difficult Biology topic for junior high school students (71.5%), with the main factors being abstract concepts, material depth that does not match students' abilities, and limited learning media. Second, the baseline profile of the control class's BK shows a low N-Gain category ($\tilde{g}$=0.173) with a large Effect Size (d=0.889), while the KPS is also in the low category ($\tilde{g}$=0.111) with a medium Effect Size (d=0.689), indicating potential for improvement that has not been optimally utilized by conventional learning. Third, actual learning conditions are still dominated by conventional methods with limited use of Guided Inquiry, less interactive visualization media, and less than optimal HOTS assessment. Fourth, student preferences for practicum-based learning and interactive media indicate readiness for technology-based innovation. These findings collectively emphasize the urgency and relevance of

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developing a Guided Inquiry learning model based on Socioscientific Issues (SSI) integrated with Interactive Flat Panel (IFP) as an effort to improve critical thinking skills and science process skills of junior high school students in the Coordination System material.

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