



The Characteristics of the Thinking Scale of Class X Students on the Water Cycle Material

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Abstract: This study aims to describe the characteristics of the systems thinking abilities of Class X students in the water cycle material across the cognitive and affective domains. The research uses a quantitative descriptive approach with a survey method. The research sample consists of 80 Class X students from SMA Negeri 10 Semarang, selected through purposive sampling. The research instruments included a multiple-choice test to measure systems thinking abilities in the cognitive domain and attitude questionnaires to measure the affective domain. The instruments were developed based on a hierarchical systems thinking framework and a systems thinking scale. The data were analyzed descriptively and tested using the Pearson Product Moment correlation. The results show that the cognitive domain systems thinking abilities are in the high category, particularly at the analysis level, where more than 70% of students reached the high category, while the synthesis and implementation levels are in the moderate category. The affective systems thinking abilities are generally in the moderate category, with percentages ranging from 52.50% to 81.25%. There is a very strong and significant relationship between the cognitive and affective domains at the same level is considered low to moderate. These findings highlight the need for more context-rich integrative learning to optimize students' systems thinking abilities.

Keywords: System thinking; water cycle; cognitive; affective; biology learning

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INTRODUCTION

21st-century education requires students to possess higher-order thinking skills to solve complex, interconnected problems. System thinking is a key skill in science. It involves understanding how system components interact, recognizing cause-and-effect patterns, and analyzing how changes in one component affect the whole system (Orgill et al., 2019). This skill helps students integrate concepts and analyze system dynamics and feedback loops (Dolansky et al., 2020). Systems thinking is crucial for understanding global challenges, such as climate change, pollution, and water crises, which cannot be solved linearly (Bowers & Eidin, 2024).

However, its implementation in schools still faces challenges. Specifically, biology teaching tends to focus on mastering concepts in isolation, leaving students underprepared to understand the interconnections among processes in natural systems. In support of a more integrated approach, previous studies have shown that system-based learning and real-world phenomena can enhance students' holistic understanding of environmental dynamics (Gilissen et al., 2020; Orgill et al., 2019). Nevertheless, without a clear mapping of students' abilities, this approach has not been optimally implemented.

In Indonesia, a linear conceptual approach in biology limits students' ability to grasp complex interactions, especially in biogeochemical topics such as the water cycle (Santia & Hidayati, 2024). As a result, students struggle to integrate processes such as evaporation, condensation, infiltration, and runoff, leading to misconceptions

(Chaidir et al., 2024; Sari & Ferry, 2024). Yet, the water cycle involves simultaneous interaction of physical, biotic, and abiotic components, so its teaching requires a systemic approach.

Several studies show that students' systems thinking abilities can be measured using the System Thinking Hierarchical (STH) approach, which tracks skill growth from spotting parts to understanding interactions (Assaraf & Orion, 2010; Rachmat et al., 2023). The STH approach is recommended because it provides a clear, ordered way to gauge students' abilities. However, research on students' systems thinking about the water cycle in local settings remains rare (Nofiana, 2018). Also, there is not much thorough data on students' systems thinking profiles when using the STH approach.

This study aims to identify and describe the characteristics of Class X students' systems thinking abilities in SMA Negeri 10 Semarang regarding the water cycle material, focusing on both the cognitive and affective domains according to the STH levels. The selection of this school was based on the heterogeneous academic characteristics of the students, which are representative of the profile of public urban schools, thereby providing a contextualized view of their abilities. The research results are expected to provide empirical data to inform the development of more systemic, contextual, and curriculum-aligned biology learning strategies, in line with the principles of the *Kurikulum Merdeka* (Adinata & Setiawan, 2024; Khozin et al., 2020).

METHOD

This study uses a quantitative, descriptive survey design to describe the characteristics of Class X students' systems thinking abilities in the water cycle, focusing on cognitive and affective domains. The research was conducted at SMA Negeri 10 Semarang during the second semester of the 2024/2025 academic year. The procedure included selecting subjects, designing and testing instruments, and collecting and analyzing data. Data collection took place during a single biology lesson using a Google Form, accessed via barcode and completed under teacher and researcher supervision.

The study population is all 360 Class X students. Using the Slovin formula with a 10% margin of error, 80 students were selected as a representative sample. Purposive sampling was applied based on these criteria: (1) having studied the water cycle material per *Kurikulum Merdeka*, (2) active participation in biology lessons, and (3) willingness to be respondents. Subjects were Phase E Class X students, aged 15–16, both male and female, from regular classes without division by concentration. This ensured relatively homogeneous academic characteristics, since curriculum, materials, and evaluation systems are applied uniformly across all regular classes.

The research instruments include a cognitive test and an affective questionnaire (Table 1). Both were developed based on the Systems Thinking Hierarchical (STH) framework (Assaraf & Orion, 2005) and the Systems Thinking Scale (STS) (Dolansky et al., 2020). The cognitive test has 16 multiple-choice questions that measure systems thinking in the cognitive domain (analysis, synthesis, and implementation). Each correct answer scores 1; incorrect answers score 0. The affective questionnaire contains 75 statements on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). It measures students' awareness of systems, component interconnections, and responsibility toward the environment. The high number of items ensures comprehensive coverage at each systems-thinking level, thereby improving reliability. Negative statements are reverse-scored to maintain consistent assessment direction.

The validity and reliability of the instruments were tested using SPSS. Item validity was assessed via item-total correlation analysis. Reliability was high, with Cronbach's alpha of 0.920 for the test and 0.964 for the questionnaire, both very high. This shows the instruments are valid and reliable for measuring students' knowledge and attitudes (Sugiyono, 2020). High reliability ensures that the data accurately reflect students' systems-thinking abilities.

Table 1. Levels of the systems thinking scale as measured in the test and questionnaire instruments

Levels of the Systems Thinking Scale	Test Indicators	Test Items	Questionnaire Indicators	Questionnaire Items
Analysis	(1) Identifying the components and processes within a system	1	(1) Seeking to understand the perspective of all parties (2) Analyzing specific events (3) Understanding chains of events (5) Recognizing recurring patterns (6) Viewing problems as interconnected issues (7) Considering cause-and-effect relationships (8) Considering relationships among individuals (18) Recognizing the influence of past events (19) Taking history and culture into account (20) Recognizing differences in outcomes resulting from system conditions.	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 66, 67, 68, 69, 70, 71, 72 73, 74, 75
Synthesis	(2) Identifying simple relationships among components (3) Identifying dynamic relationships (4) Organizing components and interactions (5) Identifying cycles of matter and energy	2 3, 4, 5, 6, 7, 8, 9,10,	(4) Involving others in the solution (10) Proposing solutions with systemic impact (11) Recognizing the impact of changes on the system as a whole (14) Believing that small changes can havemajor effects (15) Recognizing the interconnections among changes (17) using strategies that do not rely on memory	12, 13, 14, 15, 34, 35, 36, 37 38, 39, 40, 41 50, 51, 52, 53, 54, 55, 56, 57, 62, 63, 64, 65,
Implementation	(6) Recognizing the hidden dimensions of a system (7) Making generalizations (8) Thinking temporally	11, 12, 13, 14, 15, 16.	(9) Recognizing that systems are constantly changing (12) Understanding the importance of collective action (13) Considering vision and mission (16) Understanding the impact of change on individuals	30, 31, 32, 33 42, 43, 44, 45, 46, 47, 48, 49, 58, 59, 60, 61

Based on the instruments presented in Table 1, data were collected during a single online biology learning session, conducted under the supervision of both the teacher and the researcher to ensure proper implementation and accurate responses. The data obtained were then analyzed using descriptive statistics, including the mean score (M), standard deviation (SD), minimum and maximum scores, and the percentage of achievement at each ability level. Students' systems thinking scores

were classified into low, moderate, and high categories based on the criteria proposed by Azwar (2012). The score categories were determined using Azwar's (2012) classification, which comprises three levels: low ($X < M - SD$), moderate ($M - SD \leq X < M + SD$), and high ($X \geq M + SD$), as shown in Table 2. Furthermore, to examine the relationship between systems thinking in the cognitive and affective domains, A Pearson Product Moment correlation was performed at $\alpha = 0.05$. The results were then interpreted using the criteria proposed by Sugiyono (2020), ranging from very low to very strong, as shown in Table 3.

Table 2. Categories of students' systems thinking scores

Domain	Level	Low	Moderate	High
Affective (Questionnaire)	Analysis	$X < 3,10$	$3,10 \leq X < 4,14$	$X \geq 4,14$
	Synthesis	$X < 3,17$	$3,17 \leq X < 4,22$	$X \geq 4,22$
	Implementation	$X < 3,09$	$3,09 \leq X < 4,14$	$X \geq 4,14$
Cognitive (Test)	Analysis	$X < 0,52$	$0,52 \leq X < 1,21$	$X \geq 1,21$
	Synthesis	$X < 0,59$	$0,59 \leq X < 1,09$	$X \geq 1,09$
	Implementation	$X < 0,63$	$0,63 \leq X < 1,11$	$X \geq 1,11$

Table 3. Interpretation of correlation coefficients

Interval Correlation	Levels of Relationship
0.00 – 0.199	Very Low
0.20 – 0.399	Low
0.40 – 0.599	Moderate
0.60 – 0.799	Strong
0.80 – 1.000	Very strong

RESULTS AND DISCUSSION

Cognitive Systems Thinking Ability

Systems thinking characteristics refer to students' ability to understand phenomena holistically by considering the interrelationships among components within a system. In the context of the water cycle, systems thinking is particularly important because processes such as evaporation, condensation, and infiltration interact to form a dynamic, integrated system. According to Assaraf & Orion (2005), systems thinking develops gradually and hierarchically, beginning with the recognition of system components and progressing to the application of understanding in complex situations.

Based on the test and questionnaire analyses, the profile of tenth-grade students' cognitive systems thinking ability regarding the water cycle can be described in greater detail, as presented in Table 4.

Table 4. Results of tenth-grade students' cognitive systems thinking ability on the topic of the water cycle

Levels of thinking	Indicators STH	Categories	Frequency of Each Indicator	Percentage
Analysis	(1) Identifying components and processes within a system	Low	11	13,75%
		Moderate	0	0,00%
		High	69	86,25%
Synthesis	(2) Identifying simple relationships among components	Low	7	8,75%
		Moderate	0	0,00%
		High	73	91,25%
	(3) Identifying dynamic relationships	Low	8	10,00%
		Moderate	7	8,75%
		High	65	81,25%

Levels of thinking	Indicators STH	Categories	Frequency of Each Indicator	Percentage
	(4) Organizing components and interactions	Low	18	22,50%
		Moderate	17	21,25%
		High	45	56,25%
	(5) Identifying cycles of matter and energy	Low	4	5,00%
		Moderate	8	10,00%
		High	68	85,00%
Implementation	(6) Recognizing the hidden dimensions of a system	Low	7	8,75%
		Moderate	14	17,50%
		High	59	73,75%
	(7) Making generalizations	Low	4	5,00%
		Moderate	9	11,25%
		High	67	83,75%
	(8) Thinking temporally	Low	9	11,25%
		Moderate	4	5,00%
		High	67	83,75%

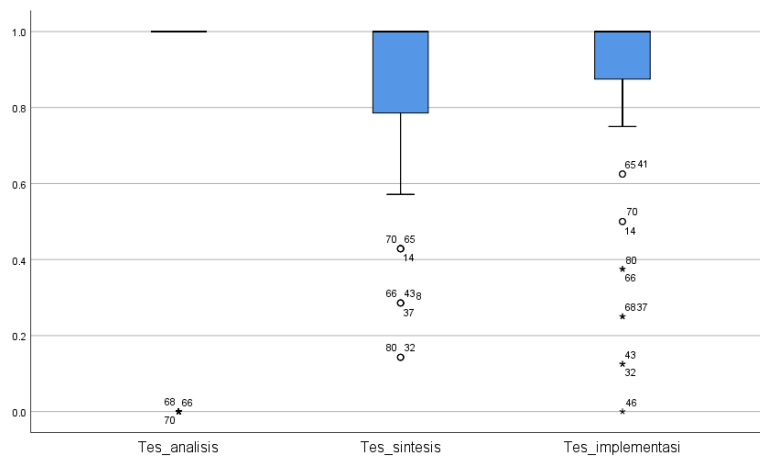


Figure 1. Profile of cognitive systems thinking ability

Further, the profile of students' cognitive systems thinking ability at each level is presented in Figure 1. In general, students' systems thinking ability was categorized as high across almost all indicators of the System Thinking Hierarchical (STH) framework. This finding indicates that students understood the water cycle as an integrated system rather than merely as a series of separate processes (Nuraeni et al., 2020).

At the analysis level, students' achievement was very high, with 86.25% falling into the high category on the indicator of identifying system components and processes. The mean score of 0.86 indicates consistent student performance within the high category. These results suggest that students were able to recognize the main components of the water cycle and understood simple cause-and-effect relationships among its processes. This high achievement may be attributed to the nature of the topic, which is closely related to students' everyday experiences and therefore facilitates conceptual understanding. This finding is consistent with previous studies by Hidayani (2023) and Febrianti & Hamimi (2024), which showed that learning based on real-world phenomena can strengthen students' conceptual understanding of biogeochemical cycles.

At the synthesis level, students' achievement varied across indicators. The indicator identifying simple relationships among components showed the highest percentage in the high category (91.25%), while the indicator identifying cycles of

matter and energy was also categorized as high (85.00%). However, for the indicator organizing components and interactions, the percentage in the high category decreased to 56.25%. Overall, the mean score of 0.84 indicates that students' synthesis ability remained in the high category, although the variation across indicators suggests mastery of these skills was not yet evenly distributed. This finding implies that although students were able to recognize relationships among processes, some still experienced difficulty in integrating all system components dynamically. According to Rahmat et al. (2024), synthesis-level ability requires higher-order thinking because it involves the simultaneous integration of multiple variables, and therefore requires contextual and reflective learning.

At the implementation level, students' cognitive systems thinking ability also showed a strong tendency, particularly in the indicators of making generalizations and thinking temporally, both of which reached 83.75% in the high category. These results indicate that students had begun to apply their conceptual understanding to identify general patterns and to understand the dynamics of the water cycle over time. The mean score of 0.87 further confirms that achievement at the implementation level was in the high category. This finding supports previous studies (Ekselsa et al., 2023; Rahmayuni et al., 2024) that emphasize that project-based learning and sustainability-related issues can promote the development of systems thinking to a more applied level.

Nevertheless, the presence of students in the low and moderate categories, particularly on the indicator of recognizing the hidden dimensions of a system, suggests that further strengthening of advanced systems thinking is still needed. According to Fauzi & Wicaksono (2021), mastery of higher-level systems thinking requires repeated practice through learning activities that emphasize complex analysis and critical reflection. Overall, these results indicate that students' cognitive systems thinking ability has developed well, especially in the analytical aspect. However, further reinforcement is still needed in the synthesis and implementation aspects so that students' systemic understanding becomes more comprehensive and in-depth, as proposed by Assaraf & Orion (2005).

Affective Systems Thinking Ability

The results of the analysis of systems thinking ability in the affective domain are presented in Table 5 and Figure 2. In general, students' affective ability was categorized as moderate across almost all indicators of the System Thinking Scale (STS). This suggests that strong cognitive understanding has not yet been fully internalized into attitudes, awareness, and a tendency toward systemic thinking (Istiana et al., 2020).

Table 5. Results of tenth-grade students' affective systems thinking ability on the topic of the water cycle

Levels of thinking	Indicators STS	Categories	Frequency of	
			Each Indicator	Percentage
Analysis	(1) Seeking to understand the perspectives of all stakeholders	Low	3	3,75%
		Moderate	55	68,75%
		High	22	27,50%
	(2) Analyzing specific events or incidents	Low	10	12,50%
		Moderate	42	52,50%
		High	28	35,00%
	(3) Understanding the chain of event	Low	2	2,50%
		Moderate	48	60,00%
		High	30	37,50%

Levels of thinking	Indicators STS	Categories	Frequency of	
			Each Indicator	Percentage
Synthesis	(5) Identifying recurring patterns	Low	7	8,75%
		Moderate	49	61,25%
		High	24	30,00%
	(6) Viewing problems as interconnected issues within a broader system	Low	4	5,00%
		Moderate	59	73,75%
		High	17	21,25%
	(7) Considering cause-and-effect relationship	Low	2	2,50%
		Moderate	62	77,50%
		High	16	20,00%
	(8) Taking into account interpersonal relationships	Low	4	5,00%
		Moderate	55	68,75%
		High	21	26,25%
	(18) Recognizing the influence of past events	Low	2	2,50%
		Moderate	61	76,25%
		High	17	21,25%
	(19) Paying attention to historical and cultural contexts	Low	4	5,00%
		Moderate	51	63,75%
		High	25	31,25%
	(20) Acknowledging that different system conditions may produce different outcomes	Low	3	3,75%
		Moderate	57	71,25%
		High	20	25,00%
(4) Involving other parties in developing solutions.	Low	6	7,50%	
	Moderate	57	71,25%	
	High	17	21,25%	
(10) Proposing solutions that generate systemic impact.	Low	2	2,50%	
	Moderate	56	70,00%	
	High	22	27,50%	
(11) Recognizing that changes in one part of the system affect the system as a whole	Low	2	2,50%	
	Moderate	52	65,00%	
	High	26	32,50%	
(14) Believing that small changes can produce substantial effects	Low	3	3,75%	
	Moderate	54	67,50%	
	High	23	28,75%	
(15) Recognizing the interdependence among changes.	Low	6	7,50%	
	Moderate	53	66,25%	
	High	21	26,25%	
(17) Using strategies that do not rely solely on memory.	Low	3	3,75%	
	Moderate	58	72,50%	
	High	19	23,75%	
Implementation	(9) Recognizing that systems are constantly changing.	Low	2	2,50%
		Moderate	65	81,25%
		High	13	16,25%
	(12) Understanding the importance of collective action.	Low	2	2,50%
Moderate		61	76,25%	
High		17	21,25%	
(13) Considering the organization's vision and mission	Low	2	2,50%	
	Moderate	64	80,00%	
	High	14	17,50%	
(14) Understanding the impact of change on individuals.	Low	3	3,75%	
	Moderate	54	67,50%	
	High	23	28,75%	

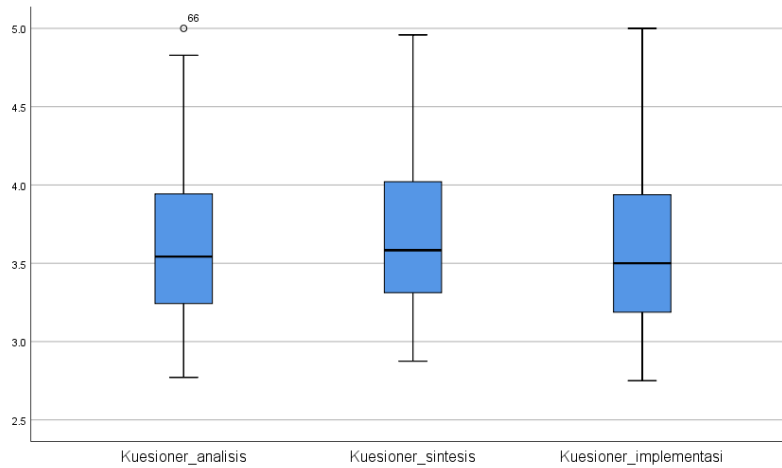


Figure 2. Profile of affective systems thinking ability

At the affective analysis level, most students were classified in the moderate category, with percentages ranging from 52.50% to 77.50% on the indicators of analyzing specific events, understanding chains of events, and considering cause-and-effect relationships. This tendency is reflected in the mean score of 3.62, indicating that students' awareness of systemic interrelationships remains moderate. These findings suggest that students have developed an initial awareness of system interconnections; however, such awareness has not yet evolved into a stable reflective attitude. This result is consistent with Istiana et al. (2020) and Permatasari et al. (2020), who argued that conceptual mastery does not necessarily correspond directly to the development of attitudes.

At the affective synthesis level, most students also fell within the moderate category, with percentages ranging from 65.00% to 72.50%. The mean score of 3.69 indicates that students' systems thinking attitudes at this level remained moderate. The indicators related to recognizing the impact of change on the system as a whole and believing that small changes can produce substantial effects demonstrate the emergence of systemic awareness among students. This suggests that they have begun to view the water cycle as an integrated and interdependent system, although this understanding has not yet been fully internalized as a consistent attitude. The relatively low proportion of students in the high category for the indicators of involving others in problem solving and recognizing the interdependence of changes indicates that students still experience difficulties in developing collaborative and participatory attitudes. As a result, systemic problems tend to be perceived as matters of individual rather than collective responsibility. This condition is in line with Maryani et al. (2021) and Nurida et al. (2022), who emphasized that the development of systems thinking attitudes is influenced by social experience and collaborative interaction in the learning process.

At the affective implementation level, student achievement showed the lowest tendency compared with the analysis and synthesis levels. Most students were categorized as moderate, with percentages ranging from 76.25% to 81.25%, whereas the proportion in the high category ranged only from 16.25% to 28.75%. The mean score of 3.61 indicates that achievement at this level also remained moderate. The indicators of recognizing that systems are constantly changing and considering collective vision and mission showed the lowest percentages in the high category, suggesting that students still encounter difficulties in internalizing systemic awareness into long term orientation and concrete action. These findings indicate that students'

attitudes remain largely conceptual and have not yet been fully manifested in commitment, concern, or a sustained tendency to act. This is consistent with Adinata & Setiawan (2024) and Wulandari et al. (2024), who argued that systemic attitudes are not formed instantly, but rather require experiential learning, direct engagement with environmental problems, and continuous reflection. Overall, these results indicate a gap between cognitive and affective abilities, students have been understood the concept of the water cycle systemically, but have not fully internalized it as an attitude and way of thinking.

Relationship Between Affective and Cognitive Systems Thinking Abilities

The relationship between affective and cognitive systems thinking abilities is presented in Table 6. The analysis shows that relationships within each domain were strong to very strong, whereas relationships between the cognitive and affective domains at the same level were low to moderate. These findings indicate that the development of systems thinking does not occur linearly across the cognitive and affective dimensions; rather, it develops gradually through a process influenced by instructional design and students' learning experiences in understanding complex environmental phenomena (Shofatun et al., 2024; Ulfah & Arifudin, 2021)

Table 6. Relationship between affective and cognitive dimensions of systems thinking

	Affective			Cognitive		
	Analysis	Synthesis	Implementation	Analysis	Synthesis	Implementation
Affective						
Analysis	1,000					
Synthesis	0,907**	1,000				
Implementation	0,839**	0,896**	1,000			
Cognitive						
Analysis	0,154	0,174	0,126	1,000		
Synthesis	0,134	0,213	0,126	0,584**	1,000	
Implementation	0,163	0,174	0,123	0,508**	0,861**	1,000

**Correlation is significant at the 0.01 level (2-tailed).

Within the affective domain, the very strong interlevel correlations between analysis and synthesis ($r = 0.907$), analysis and implementation ($r = 0.839$), and synthesis and implementation ($r = 0.896$; $p < 0.01$) indicate that systems thinking attitudes develop in an integrated manner. However, the predominance of the moderate category in the descriptive results suggests that such development is still at an early stage of internalization. This condition implies that although the interrelationships among indicators are already structurally strong, the intensity and consistency of students' attitudes have not yet been fully established. These findings suggest that strengthening attitudes and systemic awareness requires learning experiences grounded in authentic contexts and sustained reflection (Adinata & Setiawan, 2024; Rahmi & Nurhidayati, 2023). Other studies have also shown that the integration of local contexts and contemporary environmental issues can strengthen the development of environmentally responsible attitudes in a more consistent manner (Khozin et al., 2020; Putri, 2021).

Within the cognitive domain, the very strong relationship between synthesis and implementation ($r = 0.861$; $p < 0.01$) indicates that the ability to integrate system components is an important prerequisite for applying advanced systems thinking. This result is consistent with findings that higher-order thinking skills in biology learning develop more optimally when students engage in contextual, phenomenon-based problem-analysis activities (Alfidda Salsabilla & Anggraini, 2025; Rahmat et al., 2024).

Meanwhile, the relationship between analysis and synthesis ($r = 0.584$; $p < 0.01$) and that between analysis and implementation ($r = 0.508$; $p < 0.01$) were classified as moderate, indicating that mastery of basic concepts does not fully guarantee the ability to apply systemic understanding comprehensively in the absence of integrative and reflective learning strategies (Assaraf & Orion, 2005).

Inventive ability (test-based) and affective ability (questionnaire-based) at each level of systems thinking showed very low correlations, ranging from $r = 0.123$ to $r = 0.213$, and were not statistically significant ($p > 0.01$). These values indicate that students' cognitive achievement was not meaningfully associated with their systems thinking attitudes. Substantively, this finding points to a gap between conceptual understanding and the internalization of systemic attitudes. This condition aligns with Dolansky et al. (2020), who emphasized that systems-thinking attitudes are not formed solely through mastery of subject matter but rather require continuous reflection and habituation. It is further supported by Adinata & Setiawan (2024), who argued that the development of systemic attitudes requires meaningful, context-based learning experiences

Taken together, these findings underscore the need for biology instruction that emphasizes not only conceptual understanding, but also authentic experience, critical reflection, and students' engagement with real environmental issues, so that the development of systems thinking can proceed in a more balanced manner across the cognitive and affective domains. This implication suggests that water cycle material has the potential to serve as a strategic medium for integrating these two domains in a contextual and meaningful way. Nevertheless, these findings should be interpreted with caution due to several limitations, including the number and characteristics of the sample, the focus on a single learning topic, the use of affective instruments based on students' self-perceptions, and the descriptive research design, which does not allow for an in-depth explanation of causal relationships.

CONCLUSION

The findings of this study indicate that the systems-thinking abilities of tenth-grade students in the context of water-cycle learning differ across the cognitive and affective domains. While cognitive ability was categorized as high, affective ability remained moderate. This suggests that students' conceptual understanding of the water cycle has not been fully translated into systems thinking attitudes, thereby revealing a gap between conceptual mastery and attitudinal development. Accordingly, biology instruction should incorporate contextual, reflective, and authentic learning strategies to support a more balanced and sustained development of systems thinking across both domains. Future studies should develop biology instruction that places a stronger emphasis on enhancing the affective domain of systems thinking through contextual approaches and the use of authentic environmental issues. Subsequent research should also adopt experimental or quasi-experimental designs to test the effectiveness of instructional interventions in integrating the cognitive and affective dimensions of systems thinking. Furthermore, the limitations of the present study, including the relatively small sample size and reliance on self-report affective instruments, need to be addressed in future investigations to yield more comprehensive and robust findings.

RECOMMENDATIONS

In light of the findings, future studies should develop biology instruction that places stronger emphasis on enhancing the affective domain of systems thinking

through contextual approaches and the use of authentic environmental issues. Subsequent research should also adopt experimental or quasi experimental designs to test the effectiveness of instructional interventions in integrating the cognitive and affective dimensions of systems thinking. Furthermore, the limitations of the present study, including the relatively limited sample size and the use of self report based affective instruments, need to be addressed in future investigations in order to generate findings that are more comprehensive and robust.

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