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## **Competing Perspectives on Water Pollution for High School Students: A Q-Method Approach and Extended AI-Based Responses**

Chul-Young Roh<sup>a\*</sup>, Yoonseo Jung<sup>b</sup>

<sup>a</sup>Former Associate Professor, Ph.D. Department of Health Sciences, Lehman College/CUNY, New York, USA

<sup>b</sup>Carbondale Community High School, IL, USA

<sup>a</sup>Email: [croh57@gmail.com](mailto:croh57@gmail.com), <sup>b</sup>Email: [cutyjung77@gmail.com](mailto:cutyjung77@gmail.com)

### **Abstract**

High school environmental education faces significant challenges from diverse competing perspectives, ranging from sustainability advocates to political conflicts and economic interests. This study critiques existing research on environmental education based on two key points: Firstly, the conventional approach to high school environmental education predominantly concentrates on nature-related aspects. Past research overlooks political, economic, and community dimensions, essentially providing an incomplete view of environmental education. Secondly, little empirical research has compared human perspectives on environmental education with generative AI-based viewpoints. This comparison can contribute to enhancing the holistic view of environmental education by incorporating diverse human perspectives alongside AI-generated responses. This study employs the Q-methodology that can uncover latent viewpoints by analyzing diverse opinions. Moreover, the study attempts to compare the differences and similarities of responses from generative AI chatbots and humans. While some issues receive recognition from both humans and AI, others are acknowledged only by humans. Combining the insights from the Q-methodology and the comparison of human and AI chatbot responses, this research contributes to a deeper understanding of water-related environmental education and perspectives.

**Keywords:** Environmental Education; Water Pollution; Generative AI chatbots; Q-methodology.

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\* Corresponding author.

## **1. Introduction**

High school environmental education faces substantial challenges in providing comprehensive insights into intricate ecological systems. Incorporating diverse and sometimes conflicting perspectives, spanning from nature-based solutions to political consensus and environmental protection campaigns, is a complex undertaking for environmental education programs [1,2,3,4]. In the environmental context, government rules, community efforts, and market forces are connected to the balance between personal interests and shared responsibility. Assessing the right solutions is challenging, especially for environmental education programs [5,6]. However, the high school educational system currently lacks diverse competing perspectives on the environmental ecosystem [7,8,9]. In light of the intricate environmental challenges, the development of holistic education programs is essential. A key aspect is grasping the complex relationships between ecological systems, political factors, and economic aspects [10]. This thorough comprehension of environmental issues can effectively construct the foundation of environmental education programs to address our numerous environmental challenges. This study examines diverse viewpoints on environmental education and the perspectives of key stakeholders. Our study employed Q-methodology, engaging diverse participants, including high school students, educators, and policy experts. This research demonstrates the differing and converging viewpoints between humans and generative AI regarding environmental issues. We employed a Q-method design and posed identical Q-statements to both generative AI chatbots and humans. Our comparative approach reveals differences and similarities in viewpoints regarding water pollution between humans and generative AI chatbots. The whole picture of the paper is designed as follows. The paper begins with a comprehensive literature review, critically examining environmental education programs and government, market, and community involvement in environmental policies. We address previous research limitations, primarily focusing on nature and the environment, neglecting political, economic, and community aspects. The subsequent section outlines the Q-method approach and details regarding Q-statements and participants. The Q-method procedure, including Q-factor analysis, produces our empirical findings regarding key competing viewpoints on environmental education. These findings depict both shared and distinct perspectives between humans and generative AI chatbots. Furthermore, we identify consensus statements by comparing human and AI chatbot responses. In the paper's final sections, we discuss the implications of our research and key findings and propose further research.

## **2. Literature Review**

### ***2.1. Critics of Current Environmental Education and Campaign***

Studies on environmental education have explored various approaches. For instance, Aguirre and his colleagues [11] developed a teacher professional development program to address social justice issues related to the Flint water crisis. Yang and Guan [12] found that group discussions, case studies, and field trips fostered critical thinking and collaboration among students. Karataş and Karataş [13] highlighted the importance of interdisciplinary collaboration and educational strategies in preventing water pollution. Stefanakis [14] provided case studies addressing water pollution and promoting global environmental education. Recent research has explored the impact of environmental education campaigns and political ideology on ecological management issues. For example, Carter [15] advocates for increased support for environmental education in high schools and argues that ecological neoliberalism can exacerbate poverty and de-politicize environmental concerns in

Carbondale, Illinois. DeBoer and his colleagues [16] also call for long-term monitoring and adaptive management to promote ecosystem sustainability in the Illinois River. Finally, Vena [17] analyzes Cook County's interwar stream cleanup, highlighting the role of forest preserves and the impact of industrialization on pollution in the region. Public awareness and attitudes still play a pivotal role in water quality enhancement. Some studies have scrutinized knowledge and conduct regarding environmental matters. For instance, a survey encompassing students and educators in Bangkok, Thailand (n=240) uncovered that 68% maintain favorable stances toward wastewater discharge [13]. Respondents endorsed obligatory environmental education within schools and advocated for wastewater education to incite behavioral transformation. Similarly, Zsóka and his colleagues [18] examined the influence of environmental education on the ecological cognition, attitudes, and behavior of Hungarian high school and university students. Their distinctive survey analysis classified participants into five groups based on their environmental cognizance, attitudes, behavior, and awareness. Likewise, Bezeljak and his colleagues [19] investigated the affiliation of Austrian middle school students with nature, a pivotal facet of pro-environmental conduct in Education for Sustainable Development. Through the 'Inclusion of Nature in Self' (INS) scale, this study explored the nexus between preadolescents (n=651) from urban middle schools and their connection to the natural world. Nevertheless, more research is required to explore the competing paradigms of market incentives versus government regulations or individual behaviors versus communal influences. Effective environmental education is a conduit between research and pragmatic implementation, cultivating diverse stakeholder collaborations to confront evolving environmental challenges [20]. However, scant research has addressed the comprehensive perspectives of various stakeholders on environmental issues, such as water pollution and climate change, spanning government, market, business, and community standpoints. Few studies have advocated for a holistic viewpoint on environmental issues, encompassing community, business, government, and political perspectives. For instance, Bellino and Adams [21] introduced a novel environmental education (EE) approach, transcending conventional nature-based and pro-environmental models. They proposed a critical urban environmental pedagogy (CUEP) grounded in critical pedagogy and participatory methodologies. The CUEP examines socioenvironmental quandaries in urban settings through the lens of youth. Its pillars entail (1) integration of critical pedagogy and social theory, (2) utilization of participatory techniques to scrutinize local contexts, and (3) cultivation of a political ecology framework to fathom urban socio-environmental dynamics. Despite the present discourse on the imperative of a comprehensive environmental approach that simultaneously considers the market, governmental, and political dimensions, empirical research on how secondary schools confront current environmental challenges from a holistic perspective remains limited.

## ***2.2. Environmental Stakeholders: Government, Market, and Community***

Current studies on environmental issues mainly involve interdisciplinary perspectives. A multidisciplinary approach with stakeholders from various academic fields is essential to address ecological problems comprehensively. The interdisciplinary literature review draws on wide-ranging findings from environmental stakeholder approaches, education and campaign strategies, public perception research, and ecological case studies. Prior research on environmental stakeholders, such as the government, market, and community, provides diverse findings, including transparency, policy solutions, institutional rules, and trust. For example, recent research has examined various policy instruments pertaining to environmental issues. These studies

encompassed topics such as the regulation of water pollution from agricultural sources [22], the Federal Water Pollution Control Act [7], pollution management within the framework of the Clean Water Act [23], and the broader domain of water pollution regulation [8]. In the Flint water crisis context, scholarly investigations have been conducted. Heard-Garris and his colleagues reviewed its water crisis of historical background and origins [24], and Masten, Davies, and McElmurry also explored the crisis in terms of engineering and chemistry [9]. Additionally, Morckel and Terzano analyzed the issue of trust deficit among Flint residents [6]. Other notable studies have delved into various aspects of water governance challenges, as exemplified by Shiva's work [25]. Furthermore, Schnier, Cai, and Cao conducted research on human-induced effects on fish populations in the Fox River in Illinois [26].

### ***2.3. Diverse Evaluation Perspectives: Public Perceptions and Policy Effectiveness***

Recent studies on environmental evaluations cover public opinions, citizen evaluation, and psychological aspects. For instance, Larson and his colleagues [27] emphasize the significance of diverse assessments of ecosystem services for natural resource management. Ghorabae and his colleagues [28] propose a fuzzy set theory to enhance accuracy and reliability in evaluating green suppliers. Jung and his colleagues [29] demonstrate the efficacy of multivariate analysis techniques in environmental monitoring and management. Wilson, Daly, and Gordon [30] discuss the psychological mechanisms contributing to environmental problems. Pieper and colleagues [31] propose more accurate testing methods to assess lead levels in water systems. Jayaswal, Sahu, and Gurjar [32] stress integrated approaches for efficient water treatment. Overall, strict adherence to environmental protection policies benefits the environment and humanity. Aligning these policies with the goals of relevant stakeholders enhances policy effectiveness [33].

### ***2.4. Limitations in Past Research***

Most research focuses on narrow aspects of nature-based and social solutions, overlooking holistic perspectives. The absence of extensive research, particularly regarding water-related topics in high school settings, hinders a comprehensive examination of various factors encompassing nature, humanity, and society. High school environmental education struggles to address the complexities of water-related challenges, which span scientific, environmental, societal, and political dimensions. The full spectrum of perspectives from teachers, scientists, policymakers, and communities in addressing water issues within environmental education remains unaddressed. Little empirical research compares the heterogeneous perspectives between humans and generative AI chatbots in the context of environmental education, which could contribute to a more comprehensive understanding of water issues. Empirical research on different perspectives between humans and generative AI chatbots is still in its early stages [34]. Comparing the differences and similarities in human and generative AI perspectives can help uncover overlooked definitions related to water pollution. By applying Q-methodology to generative AI chatbot responses, we can identify hidden aspects that might be missing in human responses alone. This comparative analysis can illustrate distinct perspectives of generative AI in contrast to human perceptions.

### **3. Research Method**

#### ***3.1. Research Framework with Q-method Approach***

The Q-method approach is highly relevant for exploring complex issues by systematically and comprehensively capturing subjective perspectives [35, 36]. This method proves particularly beneficial in understanding diverse viewpoints and revealing underlying cognitive patterns crucial for addressing complicated environmental challenges. Firstly, the Q-method approach addresses multifaceted issues with multiple dimensions and perspectives. It allows individuals to express nuanced viewpoints, capturing intricacies that quantitative or qualitative methods may miss, especially in complex environmental contexts. Secondly, the Q-method goes beyond surface-level responses by prompting participants to rank and explain opinions, unveiling competing environmental viewpoints. Thirdly, pattern identification through factor analysis can uncover commonalities and differences among participants and can identify hidden views in environmental debates. Lastly, the Q-method inspires a comprehensive examination of multifaceted issues, fostering a holistic understanding crucial for complicated ecological topics. It allows us to balance objectivity and subjectivity in a perception-based inquiry regarding environmental issues. The Q-method can be applied to the intricate environmental challenges of high school students, revealing diverse perspectives. Generative AI is also employed to address these competing environmental views. Comparing AI responses with Q-method results can disclose more diverse understandings derived from generative AI's unique perspectives. The comparative approach can uncover insights that humans might overlook and reveal hidden viewpoints. Integrating AI with the Q-method deepens our understanding of these often-neglected aspects even more. Generative AI's data-driven approach can foster diverse perspectives on environmental education discussions. This study employs the Q-method approach, consisting of several empirical analysis stages, as shown in Figure 1. These stages include (1) research background and re-viewing past research on water and environmental issues, (2) conducting interviews with high school students, teachers, and policy experts to create Q-statements and chat interactions with AI chatbots, (3) selecting survey participants to respond to Q-statements from both humans and AI chatbots, (4) performing Q-method factor analysis with STATA's 'qfactor' command code, and (5) interpreting and categorizing factors to compare the differences and similarities between human and AI chatbots and to draw conclusions and implications. Considering our comprehensive literature review and the limitations of past research, we have formulated three distinct research inquiries. The first question is ① whether humans and AI chatbots have similar or different views on what causes water pollution and how to solve it (Question 1). The second question asks ② whether generative AI chatbots tend to generate more common consensus on water pollution topics than humans (Question 2). The third question tests ③ whether people and AI chatbots can share some perspectives as a common agreement on water pollution (Question 3). In this study, we investigate differences among three groups: Group 1 (human respondents), Group 2 (generative AI chatbot respondents), and Group 3 (combined respondents from Group 1 and Group 2). The composition of factors and viewpoints displays both unique and shared aspects among these three groups, as depicted in Figure 1.



**Table 1:** Q-statements.

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Please respond to the following 20 questions in order from most agreeable (+5) to strongly agreeable (+4), agreeable (+3), slightly agreeable (+2), agreeable neutral (+1), neutral (0), disagreeable neutral (-1), slightly disagreeable (-2), disagreeable (-3), **strongly** disagreeable (-4), and most disagreeable (-5). It is better to respond to the questions so that the frequency of neutral is approximately 20% of the total, and the frequency of strongly agree and strongly disagree is relatively low, representing a normal distribution.

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- Q1. Do you agree that high school students are aware of water pollution issues?
  - Q2. Do you agree that the community's underground water quality is acceptable?
  - Q3. Do you agree that the community's surface water quality is acceptable?
  - Q4. Do you agree that high school students should take action to conserve water or preserve water quality, such as participating in campaigns?
  - Q5. Do you agree that people should reduce shower usage to conserve water better?
  - Q6. Do you agree that high school students should spend extra time learning about water issues?
  - Q7. Do you agree that the quality and amount of water has changed due to climate change?
  - Q8. Do you agree that people should be responsible for keeping drinking water clean?
  - Q9. Do you agree that people should pay more taxes to sustain and preserve water?
  - Q10. Do you agree that people should donate money to sustain better and preserve water?
  - Q11. Do you agree that high school students should initiate campaigns regarding water pollution and preservation?
  - Q12. Do you agree that high school students' perspectives will change if they become more exposed to water-issue campaigns?
  - Q13. Do you agree that government officials are fulfilling their responsibility for protecting water resources?
  - Q14. Do you agree that high school students should try to conserve water or preserve water quality?
  - Q15. Do you agree that people's perspectives have changed about water issues due to global warming?
  - Q16. Do you agree that our community can educate high school students well regarding water-related issues?
  - Q17. Do you agree that the factory should be discarded if a small factory with around ten employees contaminates water?
  - Q18. Do you agree that the factory should be discarded if a big factory with around 10,000 employees contaminates water?
  - Q19. Do you agree that if people drink polluted water and get cancer, the government must provide them with funds?
  - Q20. Do you agree that the factories should put effort into conserving water and preserving water quality?
- 

The Q-statements were designed based on previous literature reviews, interviews with students, teachers, and policy experts, and chat results from the AI chatbots. Figure 2 displays the distribution of responses to the 20 Q-statements. This study included both humans and generative AI chatbots (including ChatGPT and ChatSonic) in the participant sample, which we refer to as the P-sample. The survey had 42 participants, consisting of 28 high school students and 5 high school teachers in the state of Illinois in America, 5 professors, and 4 graduate students in America. However, only 31 of these participants were included in the Q-method analysis data. The remaining 11 individuals had response styles that were deemed unsuitable for the Q-method. The AI chatbots were repeatedly asked to rate their degree of agreement or disagreement with the 20 Q-statements, with five repetitions each. However, other AI chatbots such as Perplexity, Replica, and YouChat were excluded due to their inadequate responses. Examples of chatbot responses to the Q-statements is displayed in Appendix E.

### **3.3. Q-Method Procedure with Factor Analysis**

The process of identifying distinguishing and consensus statements in the Q-method involves several steps. Firstly, Q-methodology displays how our research data collects the data from participants' subjective rankings of statements or items (See Figure 1). Secondly, the Q-sorting in the Q-method requires respondents to rank a set of statements on a scale ranging from strongly disagree to strongly agree, using a modified rank-ordering procedure (see Table 1 and Figure 2). This Q-method approach adopted 20 Q-statements about water pollution and then used factor analysis to group participants into three categories: humans, AI chatbots, and a combination of both. Thirdly, the Q-method factor analysis used the 'qfactor' command in STATA version 17.

Appendix A, B, C, and D show the statistical results of the Q-method factor analysis. Fourth, we identified distinguishing and consensus statements. The ranked Z-scores from disagreement to agreement are used to identify distinguishing statements and consensus statements across factors. Finally, we interpreted key viewpoints representing unique factors in Group 1(Humans), Group 2(AI Chatbots), and Group 3(Humans + AI Chatbots) based on the unique Q-statements' characteristics.

#### **4. Empirical Results**

##### ***4.1. Testing Question 1: Different Perspectives from Humans and Generative AI Chatbots***

Question 1 tests whether humans and AI chatbots may have different perspectives on water pollution. Table 2 shows that Group 1 generates five factors, Group 2 three factors, and Group 3 five factors from the Q-method process. More specifically, Table 2 and Table 4 illustrate that Group 1 provides five competing perspectives from 31 human responses: H-F1 (Libertarian Market-driven View), H-F2 (Skeptical View of Community Initiatives), H-F3 (Balanced View between Market & Government), H-F4 (Individualistic View), and H-F5 (Government-driven Environmentalism & Education Campaign).

In contrast, Group 2 from 10 AI chatbot responses produced three competing perspectives: AI-F1 (Pragmatic Environmentalism), AI-F2 (Small Government-driven Environmentalism), and AI-F3 (Big Government-driven Environmentalism). In addition, Group 3 provides five competing perspectives on water pollution: HAI-F1(Anthropocentric Environmental Identity), HAI-F2(Environmental Protection and Market driven Model), HAI-F3(Conservative Libertarian Identity), HAI-F4(Individualistic Environmentalism), and HAI-F5(Individualism & Firm Responsibility).



**Table 2:** Factor scores: humans, chatbots, and combined humans & chatbots.

	Variables	Humans(Group1)					AI-C(Group2)			Humans + AI-C(Group3)				
		5 Factors					3 Factors			5 Factors				
		H-F1	H-F2	H-F3	H-F4	H-F5	AI-F1	AI-F2	AI-F3	HAI-F1	HAI-F2	HAI-F3	HAI-F4	HAI-F5
H U M A N S	H1	0.58								0.57				
	H2				0.63									0.65
	H3									0.64				
	H4	0.76								0.82				
	H5													
	H6	0.87								0.87				
	H7				0.78									
	H8	0.67								0.66				
	H9										0.68			
	H10	0.73								0.72				
	H11													-0.69
	H12		0.71								0.59			
	H13	0.92								0.91				
	H14			0.83								0.80		
	H15		0.63											
	H16													
	H17			0.89								0.89		
	H18				0.76									
	H19		0.76								0.73			
	H20									0.66				
	H21													
	H22	0.79								0.83				
	H23			0.86								0.88		
	H24		0.69								0.82			
	H25	0.79								0.77				
	H26					0.60								0.55
	H27					-0.79								-0.70
	H28													
	H29			0.75								0.74		
	H30		0.73								0.84			
	H31		0.64								0.82			
C H A T B O T S	ChatGPT1							0.85			0.93			
	ChatGPT2					0.92			0.87					
	ChatGPT3						0.71			0.89				
	ChatGPT4					0.96			0.91					
	ChatGPT5					0.98			0.92					
	ChatSonic1						0.97			0.69				
	ChatSonic2						0.97			0.69				
	ChatSonic3					0.85				0.70				
	ChatSonic4					0.73				0.67				
	ChatSonic5							0.81		0.73				

Notes: Factor scores were calculated based on Brown's formula. Factor loading values can range from -1.00, indicating an entirely negative association, to +1.00, indicating a fully positive association, with 0 showing no relationship between the factor and the measured variable. The factor scores of the Q-method analysis were statistically significant at the 0.05 level ( $p < 0.05$ ).

Table 3 reveals that the Q-statements representing these competing factors in Groups 1 and 2 illustrate different viewpoints on water pollution issues. The high-lighted Q-statements in Group 1 differ from those in Group 2, and the degree of agreement or disagreement also varies across factors. These differences in the distribution or illustration of factors across the three groups suggest that humans and AI chatbots hold distinct perspectives on water pollution, thus supporting Question 1. The score of Q-statements derived from the Z score distribution for each factor indicates the level of agreement or disagreement, ranging from strongly agree (+5) to strongly disagree (-5), with 0 denoting neutrality. Using the factor analysis results obtained from three groups, the

interpretation of those views represented by each factor is as follows.

**Table 3:** Distinctive statements across three groups.

Group1	Factors	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
Humans	H-F1	-3	5	0			2	1	5	-3	-3			-1	3	0	0	-3	-4	-3	
	H-F2	-4	-1	-3			3	0	3	-1	-3			-3	0	-3	-3	1	2	5	
	H-F3	-3	-3	-4			0	5	5	-1	0			-3	3	0	-1	-3	-3	0	
	H-F4	-3	3	3			-3	5	5	-3	0			-4	0	-1	2	0	-3	1	
	H-F5	-1	1	0			0	-3	-3	5	2			-3	-3	-4	3	-1	0	5	
Group 2	Factors	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
AI-C	AI-F1		3	3		3				2								-2	-2		
	AI-F2		3	3		5				-2								5	4		
	AI-F3		-2	-2		3				3								4	3		
Group 3	Factors	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
Humans + AI-C	HAI-F1	-3	3	-1	3			1		-3	-3	2	0	-3		0		-3	-4		
	HAI-F2	-4	-1	-3	2			3		-3	-3	0	0	-3		-3		5	1		
	HAI-F3	-3	-3	-4	2			5		-1	-1	1	0	-3		3		-3	-3		
	HAI-F4	-1	1	0	0			-4		5	2	3	0	-3		-3		-1	0		
	HAI-F5	5	1	3	-3			5		-3	0	-1	-3	-4		0		2	0		

Notes: The numbers in the table indicate the level of agreement or disagreement, ranging from strongly agree (+5) to strongly disagree (-5), with 0 denoting neutrality. The ranking score results of the Q method analysis were statistically significant at the 0.05 level ( $p < 0.05$ ).

**4.2. Interpreting Key Perspectives from Group 1, Group2, and Group3**

Group 1, consisting of only human respondents, generated five viewpoints on water pollution issues (see Table 2, Table 3, and Table 4). Firstly, Table 3 shows that Factor H-F1 (Market-driven View) opposes business or factory closure due to water pollution (Q17= -3; Q18= -4) and taxation for water problem solutions (Q19=-3). Next, Table 3 illustrates that Factor H-F2 (Skeptical View of Community Initiatives) opposes community education for high school students about water issues (Q16= -3) and views high school students as largely ignorant about water issues (Q1= -4). Table 3 displays that Factor H-F3 (Balanced View between Market & Government) emphasizes citizen responsibility to keep the water clean (Q8= +5) but opposes business closure due to water pollution (Q17= -3; Q18= -3), with high school students recognizing conflicting perspectives on environmental protection (Q14= +3). Table 3 shows that Factor H-F4 (Individualistic View with Pro-Environmental Citizenship) opposes government responsibility for water issues (Q13= -4) and taxation (Q9= -3) but emphasizes individual responsibility towards the environment and water issues (Q8= +5). Finally, Table 3 demonstrates that Factor H-F5 (Government-driven Environmentalism & Education Campaign) supports government taxation (Q9= +5) and government support for cancer patients affected by water pollution (Q19= +5). This factor favors community education for high school students (Q16= +3) over direct student involvement in environmental campaigns (Q14= -3) but opposes sole government responsibility for water issues (Q13= -3).

Group 2 generates three views from generative AI chatbots. Factor analysis results from Group 2 are shown in Table 2 and Table 4. First, the AI-F1 factor (Pragmatic and Moderate Environmentalism) opposes business closures that cause water pollution (Q17= -2; Q18=-2) but supports paying more taxes to conserve water (Q9=+2) and emphasizes the need for citizen water conservation (Q5=+3). Next, the AI-F2 factor (Small Government driven Environmentalism) strongly supports the creation of businesses causing water pollution (Q17= +5; Q18= +4) but opposes tax levies for solving environmental problems (Q2= -2) from a small government perspective. Finally, the AI-F3 factor (Big Government driven Environmentalism) strongly supports environmentalism that eliminates polluting businesses (Q17=+4; Q18=+4) and tax levies to solve environmental problems (Q9= +3) from a big government perspective. Group 3 represents the combined responses from Group 1(humans) and Group 2 (generative AI Chatbots) and provides five viewpoints (see Table 2 and Table 4). Above all, HAI-F1 (Campaign-based Anthropocentric Environmental Identity) opposes business closures due to water pollution (Q17=-3; Q18=-4) and taxation for environmental protection or collective donation activities (Q9=-3; Q10=-3). This factor supports high school students' involvement in environmental campaigns (Q4=+3). Next, HAI-F2 (Environmental Protection and Market-driven View) in Group 3 strongly supports business shutdown due to water pollution (Q17=+5) but opposes tax imposition and donation collection for market-based solutions (Q9=-3; Q10=-3). HAI-F3 (Conservative Libertarian Model) opposes the exclusion of polluting businesses from the market (Q17=-3; Q18=-3) and argues against government responsibility for environmental problems (Q13=-3). HAI-F4 (Individualistic Egocentric Environmentalism) supports tax imposition for environmental problems (Q9=+5) but opposes government responsibility for environmental issues (Q13=-3). This factor denies the relation of climate change to environmental issues (Q7=-4) and citizen awareness (Q15=-3). Finally, HAI-F5 (Individualism & Firm Responsibility) opposes the government's sole responsibility for environmental problems (Q13=-4) and taxation for environmental protection (Q9=-3). This factor opposes high school students' involvement in environmental campaigns (Q4=-3), supports small factories' closure for causing water pollution (Q17=+2), and highlights companies' responsibility for environmental protection. In summation, the Z-scores affiliated with each Q-statement within Table 3 facilitate our comprehension of the attributes pertaining to the previously discussed factors. This comprehension extends across diverse perspectives encompassing both human and AI-chatbot inputs, comparatively examined within the context of Group 1, Group 2, and Group 3. Table 4 provides a summary platform, effectively presenting the unique viewpoints emanating from the distinct constituencies of Group 1, Group 2, and Group 3.

**Table 4:** Distribution of diverse views between humans and generative AI chatbots.

<b>Group1</b> <b>Humans</b>	<b>H-F1</b>	<b>Libertarian Market View Against Environmentalism</b>
	<b>H-F2</b>	<b>Skeptical View of Community Initiatives</b>
	<b>H-F3</b>	<b>Balanced View between Market &amp; Government(Pragmatism=AI-F1)</b>
	<b>H-F4</b>	<b>Individualistic View with Pro-environmental Citizenship</b>
	<b>H-F5</b>	<b>Government driven Environmentalism &amp; Education Campaign(=AI-F3)</b>
<b>Group2</b> <b>AI Chabots</b>	<b>AI-F1</b>	<b>Pragmatic and Moderate Environmentalism</b>
	<b>AI-F2</b>	<b>Small Government driven Environmentalism</b>
	<b>AI-F3</b>	<b>Big Government driven Environmentalism</b>
<b>Group3</b> <b>Humans</b> <b>+</b> <b>AI Chabots</b>	<b>HAI-F1</b>	<b>Anthropocentric Environmental Identity</b>
	<b>HAI-F2</b>	<b>Environmental Protection and Market driven Model</b>
	<b>HAI-F3</b>	<b>Conservative Libertarian Identity</b>
	<b>HAI-F4</b>	<b>Individualistic Ecocentric Environmentalism (AI-C responses not found)</b>
	<b>HAI-F5</b>	<b>Individualism &amp; Firm Responsibility (AI-C responses not found)</b>

**4.3. Testing Question 2: Comparing Consensus Statements between Humans and AI Chatbots**

Question 2 tests whether generative AI chatbots can generate more agreement on water pollution issues than humans because humans often struggle to reach agreements due to competing interests and moral values. To test Question 2, this study compared the number of consensus statements among the 20 Q-statements from Group 1, Group 2, and Group 3 (see Table 4). The results show that Group 2 AI chatbots had seven common statements (Q4, Q6, Q11, Q12, Q14, Q19, Q20), whereas Group 1 humans had only three (Q11, Q12, Q20), thus supporting Question 2. It is also worth noting that the common statements from Group 2 included those from Group 1.

**4.4. Testing Question 2: Comparing Consensus Statements between Humans and AI Chatbots**

Question 3 tests whether humans and AI chatbots can agree on certain viewpoints regarding water pollution. According to Table 5, all three groups supported the Q20 statement emphasizing the importance of businesses' efforts in preserving and producing good water. Additionally, both Group 1 and Group 2 agreed on the Q11 and Q12 statements, and these shared viewpoints support Question 3.

**Table 5:** Consensus statements among Group1, Group2, and Group 3.

Group1	Factors	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	
<b>Humans</b>	H-F1											-1	0									5
	H-F2											0	0									5
	H-F3											1	3									5
	H-F4											0	0									5
	H-F5											3	0									5
Group2	Factors	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	
<b>AI-C</b>	AI-F1				5		4					5	4		5					5	5	
	AI-F2				5		4					5	3		3					5	4	
	AI-F3				5		4					4	3		5					4	5	
Group3	Factors	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	
<b>Humans + AI-C</b>	HAI-F1																					5
	HAI-F2																					5
	HAI-F3																					5
	HAI-F4																					5
	HAI-F5																					5

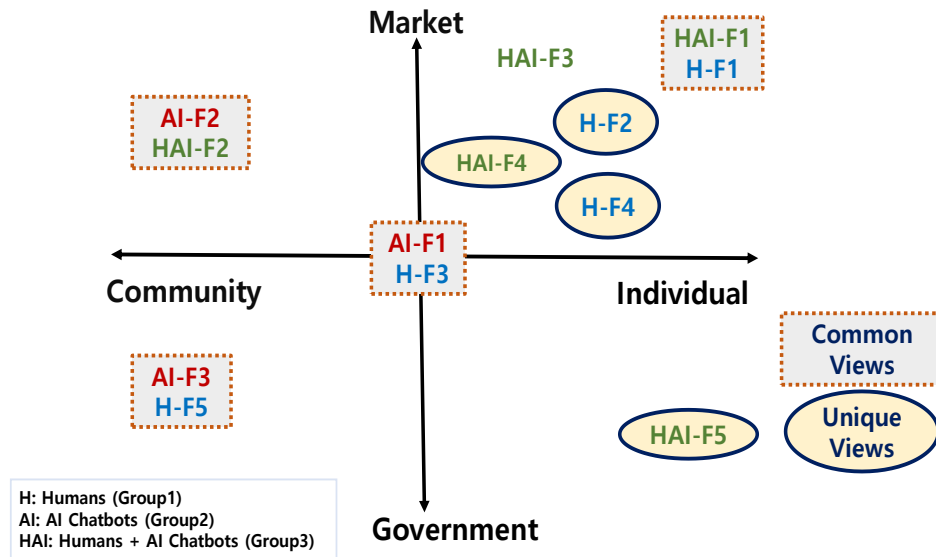
Notes: The numbers in the table indicate the level of agreement or disagreement, ranging from strongly agree (+5) to strongly disagree (-5), with 0 denoting neutrality. The results of the Q-method analysis for consensus statements were statistically significant at the 0.05 level ( $p < 0.05$ ).

**4.5. Testing Question 1 and Question 3**

Figure 3 enables us to underscore both the commonalities and disparities among the factors within Group 1, Group 2, and Group 3. It offers a comprehensive visualization for comparing various factors categorized along two dimensions: (1) market vs. government and (2) individual vs. community.

This analysis encompasses a comparative evaluation of perspectives concerning the differentiation between individuals and communities and government and market entities. This visual representation provides an

opportunity to revisit and assess Question 1 and Question 3.



**Figure 3:** Competing perspectives: humans and generative AI Chatbots.

Figure 3 provides a comprehensive representation of the variations in perspectives regarding water pollution across the three groups: Group 1, Group 2, and Group 3. By examining the distribution patterns of these perspectives, we can identify hidden insights into the distinctive characteristics that shape the stance of each group on water pollution issues. For example, we observe that HAI-F4 and HAI-F5 in Group 3 do not align with the responses from AI chatbots in Group 2, and H-F2 and H-F4 in Group 1 also diverge from AI chatbot responses in Group 2, which tests our Question 1. Conversely, factors such as AI-F1 and H-F3 and AI-F3 and H-F5 exhibit highly similar viewpoints across Group 1 and Group 2, thus providing support to our research Question 3.

## 5. Conclusions

### 5.1. Summary

This paper, relying on Q-methodology and generative AI chatbot responses, aims to uncover new perspectives on water-related environmental issues. While traditional surveys may be limited to exploring concealed human subjectivity, Q-methodology can reveal unrecognized perspectives through Q-statements derived from diverse hidden opinions. This research identified similarities and differences in complicated environmental issues by comparing human and AI-Chatbot-based views. Firstly, the human response group had five unique perspectives, while the AI-Chatbot response group had three. The AI-based perception framework did not consider some factors unique to human responses. Secondly, the comparison between human and AI-Chatbot perceptions on the 20 Q-statements showed that AI responses have more common areas than human responses. Finally, humans

and AI agree on three statements among the twenty Q-statements, namely Q11, Q12, and Q20. For instance, Q20 highlights the importance of companies actively participating in environmental protection and water problem-solving, which both humans and AI chatbots support.

### **5.2. Implications**

This study presents a diverse range of perspectives on environmental issues within the context of high school education. The utilization of Q-methodology in this research yields a variety of qualitative data that complements the quantitative findings from factor analysis. Moreover, the study contributes to potential exploratory investigations into the design and structure of environmental education curricula for young students, particularly valuable when there's limited knowledge about complex environmental discussions in high school settings. Our findings also have implications for policymaking and decision-making contexts. They offer insights into strategic educational approaches incorporating various viewpoints, promoting more effective outcomes in youth-focused environmental education programs.

This study reveals the similarities and differences between human and AI chatbot perspectives on environmental issues. Comparing human and AI perspectives can generate more wide-ranging and holistic assessments of complex environmental problems. This study also provides advanced methodological insights into the potential of the Q-method in AI chatbots to compare the environmental viewpoints of humans and AI chatbots scientifically. This approach could pave the way for future studies to use Q-methodology in AI chatbots to assess and compare perspectives on various complex social issues.

### **5.3. Limitations and Further Research**

This study has limitations related to generalization and sample size. The Q-method analyses' findings may not represent the general population as participants are not randomly selected. Additionally, the small sample size of 41 participants limits the statistical power and generalizability of the findings. Therefore, more extensive and diverse P-samples for the Q-method should be considered in future studies to improve generalizability. It is also imperative to develop a more comprehensive understanding of how AI perceives and responds to environmental challenges compared to humans [37]. AI can simulate intricate environmental scenarios, aiding students in grasping complex ecological systems. Further research may involve incorporating generative AI into environmental education.

## **6. Author Contributions**

Conceptualization and theory design, Chul-Young Roh (CYR) and Yoonseo Jung (YJ); methodology and data collection, CYR and YJ; Survey, CYR and YJ; statistical analysis, CYR; writing, CYR and Y.J. Both authors have read and agreed to the published version of the manuscript.

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## **8. Data Availability Statement**

Survey data can be shared upon request.

## **9. Conflicts of Interest**

The authors declare no conflict of interest.

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**Table A:** Statistical results of factor analyses.

Factor	Variance	Difference	Proportion	Cumulative Proportion
<b>Responses from Humans(N=20)</b>		LR test: Independent vs. Saturated: Chi-square(465)=3,946		
Factor1(H-F1)	7.305	2.282		0.236
Factor2(H-F2)	5.023	0.394	0.162	0.398
Factor3(H-F3)	4.630	0.460	0.149	0.547
Factor4(H-F4)	4.169	1.837	0.135	0.682
Factor5(H-F5)	2.332	.	0.075	0.757
<b>Responses from AI Chatbots(N=20)</b>		LR test: Independent vs. Saturated: Chi-square(820) =.		
Factor1(AI-F1)	4.091	1.304	0.409	0.409
Factor2(AI-F2)	2.787	0.654	0.279	0.688
Factor3(AI-F3)	2.134	.	0.213	0.901
<b>Responses from Humans and AI Chatbots(N=20)</b>		LR test: Independent vs. Saturated: Chi-square(45) =.		
Factor1(HAI-F1)	11.215	2.352	0.274	0.274
Factor2(HAI-F2)	8.863	2.888	0.216	0.490
Factor3(HAI-F3)	5.976	3.027	0.146	0.636
Factor4(HAI-F4)	2.949	0.178	0.072	0.707
Factor5(HAI-F5)	2.771	.	0.068	0.775

Notes: 1) Method: Principle component factors. 2) Rotation: Orthogonal varimax.  
3) N represents the number of Q-statements.

**Table B:** Factor analyses from human responses (Group1).

<b>Distinguishing Statements for Factor 1</b>						
	Factor1(H-F1)	Factor2(H-F2)	Factor3(H-F3)	Factor4(H-F4)	Factor5(H-F5)	
Q13	-1	-3	-3	-4		-3
Q17	-3	1	-3	0		-1
Q19	-3	5	0	1		5
Q18	-4	2	-3	-3		0
<b>Distinguishing Statements for Factor 2</b>						
Q18	-4	2	-3	-3		0
Q10	-3	-3	0	0		2
Q16	0	-3	-1	2		3
Q1	-3	-4	-3	-3		-1
<b>Distinguishing Statements for Factor 3</b>						
Q2	5	-1	-3	3		1
Q3	0	-3	-4	3		0
<b>Distinguishing Statements for Factor 4</b>						
Q6	2	3	0	-3		0
Q9	-3	-1	-1	-3		5
Q13	-1	-3	-3	-4		-3
<b>Distinguishing Statements for Factor 5</b>						
Q9	-3	-1	-1	-3		5
Q8	5	3	5	5		-3
Q14	3	0	3	0		-3
Q7	1	0	5	5		-3
Q15	0	-3	0	-1		-4
<b>Consensus Statements across Five Factors</b>						
Q20	5	5	5	5		5
Q11	-1	0	1	0		3
Q12	0	0	3	0		0


**Table C:** Factor analyses from AI chatbots (Group2).

<b>Distinguishing Statements for Factor 1</b>				
	Factor1(AI-F1)	Factor2(AI-F2)	Factor3(AI-F3)	
Q1	3	-2		2
Q17	-2	5		4
Q18	-2	4		3
<b>Distinguishing Statements for Factor 2</b>				
Q5	3	5		3
Q17	-2	5		4
Q16	4	3		3
Q10	3	2		3
Q9	2	-2		3
<b>Distinguishing Statements for Factor 3</b>				
Q17	-2	5		4
Q3	3	3		-2
Q2	3	3		-2
<b>Consensus Statements across Five Factors</b>				
Q20	5	4		5
Q14	5	3		5
Q4	5	5		5
Q11	5	5		4
Q19	5	5		4
Q6	4	4		4
Q12	4	3		3

**Table D:** Factor analyses from humans and AI chatbots (Group3).

<b>Distinguishing Statements for Factor 1</b>					
	Factor1(HAI-F1)	Factor2(HAI-F2)	Factor3(HAI-F3)	Factor4(HAI-F4)	Factor5(HAI-F5)
Q17	-3	5	-3	-1	2
Q18	-4	1	-3	0	0
<b>Distinguishing Statements for Factor 2</b>					
Q2	3	-1	-3	1	1
Q10	-3	-3	-1	2	0
Q1	-3	-4	-3	-1	5
<b>Distinguishing Statements for Factor 3</b>					
Q9	-3	-3	-1	5	-3
Q2	3	-1	-3	1	1
Q3	-1	-3	-4	0	3
<b>Distinguishing Statements for Factor 4</b>					
Q9	-3	-3	-1	5	-3
Q15	0	-3	3	-3	0
Q7	1	3	5	-4	5
<b>Distinguishing Statements for Factor 5</b>					
Q1	-3	-4	-3	-1	5
Q11	2	0	1	3	-1
Q4	3	2	2	0	-3
Q12	0	0	0	0	-3
Q13	-3	-3	-3	-3	-4
<b>Consensus Statements across Five Factors</b>					
Q20	5	5	5	5	5

**Table E:** ChatGPT response to Q-statements (Example).

 Sure, I will respond to your survey questionnaire as per the given scale:

- Q1. +2 (slightly agreeable)
- Q2. +2 (slightly agreeable)
- Q3. +2 (slightly agreeable)
- Q4. +3 (agreeable)
- Q5. +2 (slightly agreeable)
- Q6. +3 (agreeable)
- Q7. +2 (slightly agreeable)
- Q8. +4 (strongly agreeable)
- Q9. +2 (slightly agreeable)
- Q10. +2 (slightly agreeable)
- Q11. +3 (agreeable)
- Q12. +2 (slightly agreeable)
- Q13. 0 (neutral)
- Q14. +3 (agreeable)
- Q15. +2 (slightly agreeable)
- Q16. +3 (agreeable)
- Q17. -3 (disagreeable)
- Q18. -3 (disagreeable)
- Q19. +3 (agreeable)
- Q20. +3 (agreeable)

Please note that these responses are based on my general knowledge and understanding of the questions. If you require any further clarification or elaboration, please let me know.