

# Phenomenon-Based Learning on Rare Earth Mining

: Impacts on Students' Attitudes toward Sustainability,  
Environmental Awareness, and Environmental Education Awareness

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# The hidden costs of human progress

Global calls for sustainable development emphasize balancing human advancement with ecological preservation. While some impacts—like smog or deforestation—are universally recognized, transboundary environmental phenomena often remain invisible to the public, despite devastating local consequences.

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The Visible

7  
VIB

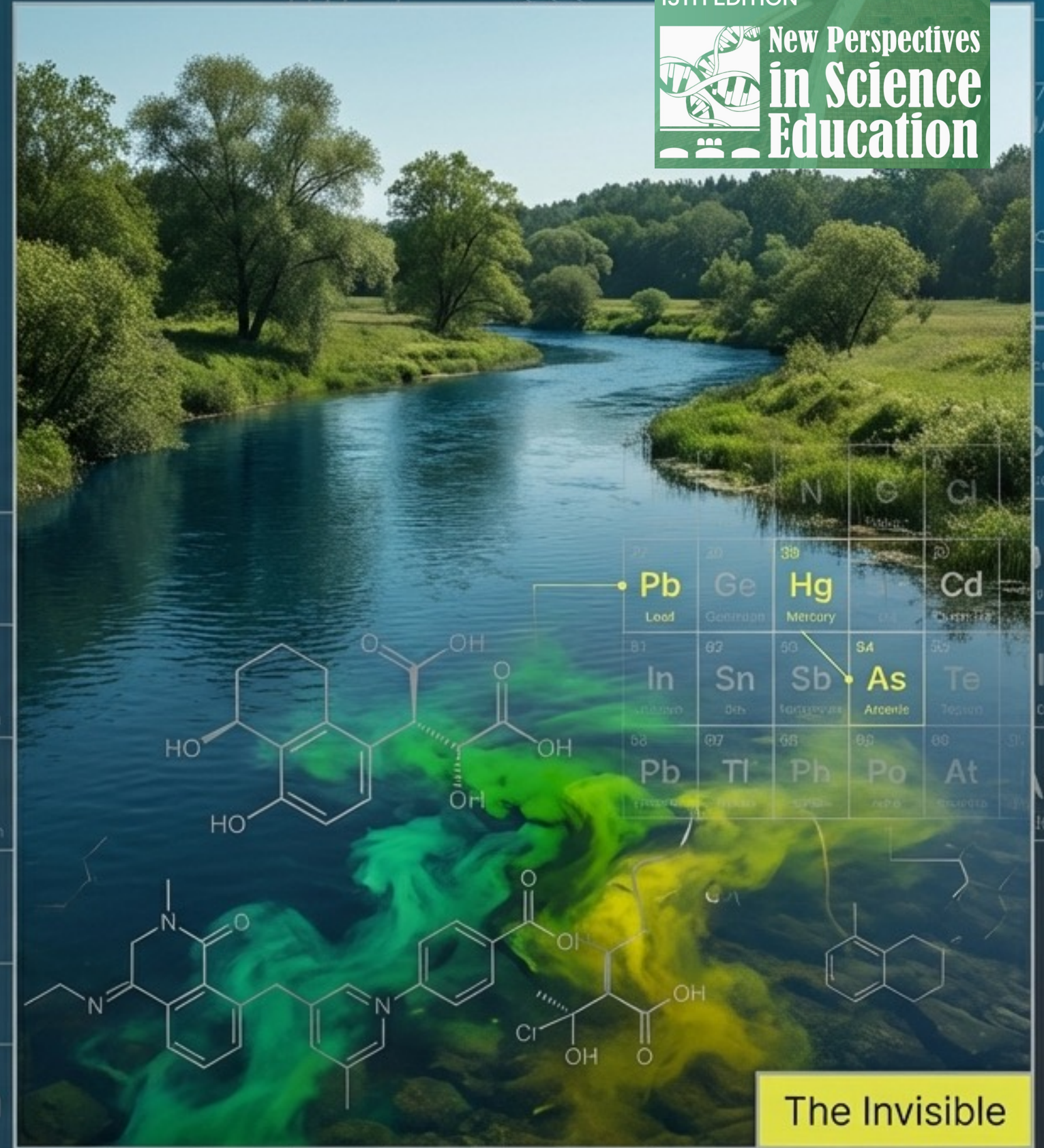
23  
Fe  
Iron

48  
Rb  
Rubidium

79  
Tm  
Thulium

108  
Rb  
Rutherfordium  
(108)

031  
Pm  
Promethium  
(28)



The Invisible

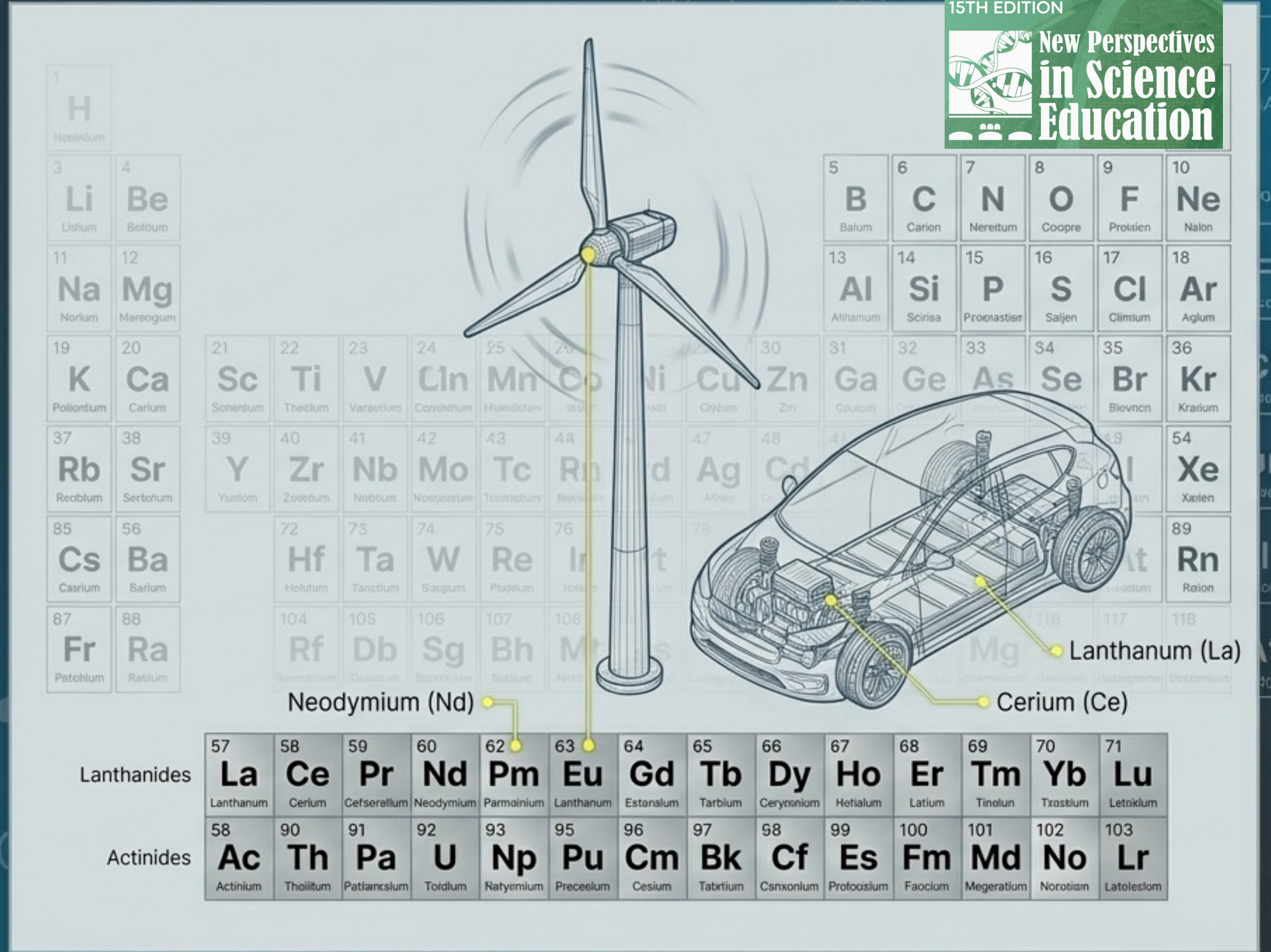
# The educational blind spot in the high-tech supply chain

Rare Earth Elements (REEs) like Neodymium, Lanthanum, and Cerium are the backbone of modern technology. Yet, the 150-year-old periodic table is often taught as abstract memorization. The 17 REEs are entirely excluded from Thailand's basic education curricula, leaving students disconnected from the materials powering their daily lives.

Can people hold their environmental awareness without knowledge?

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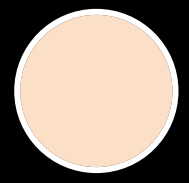
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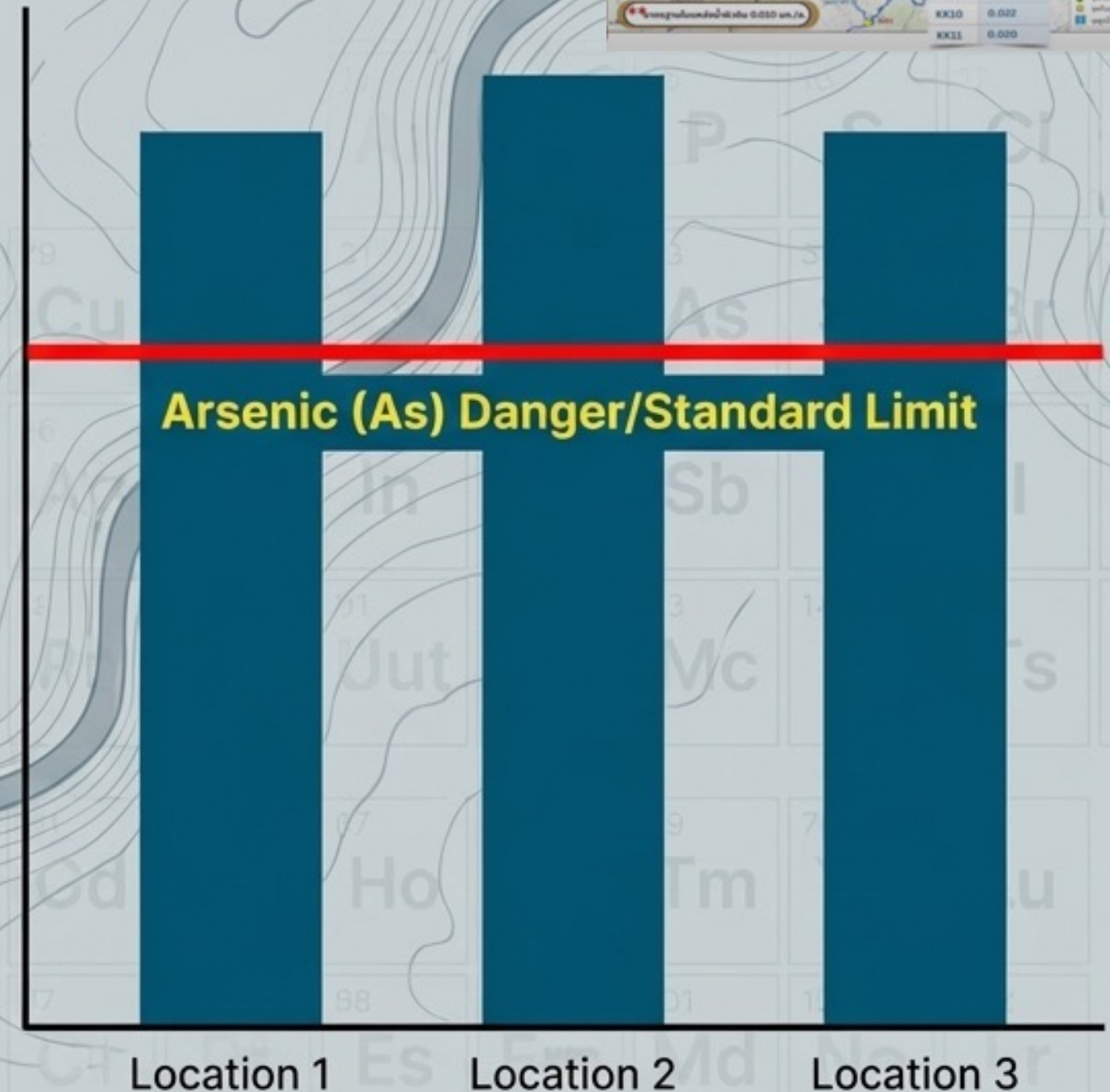


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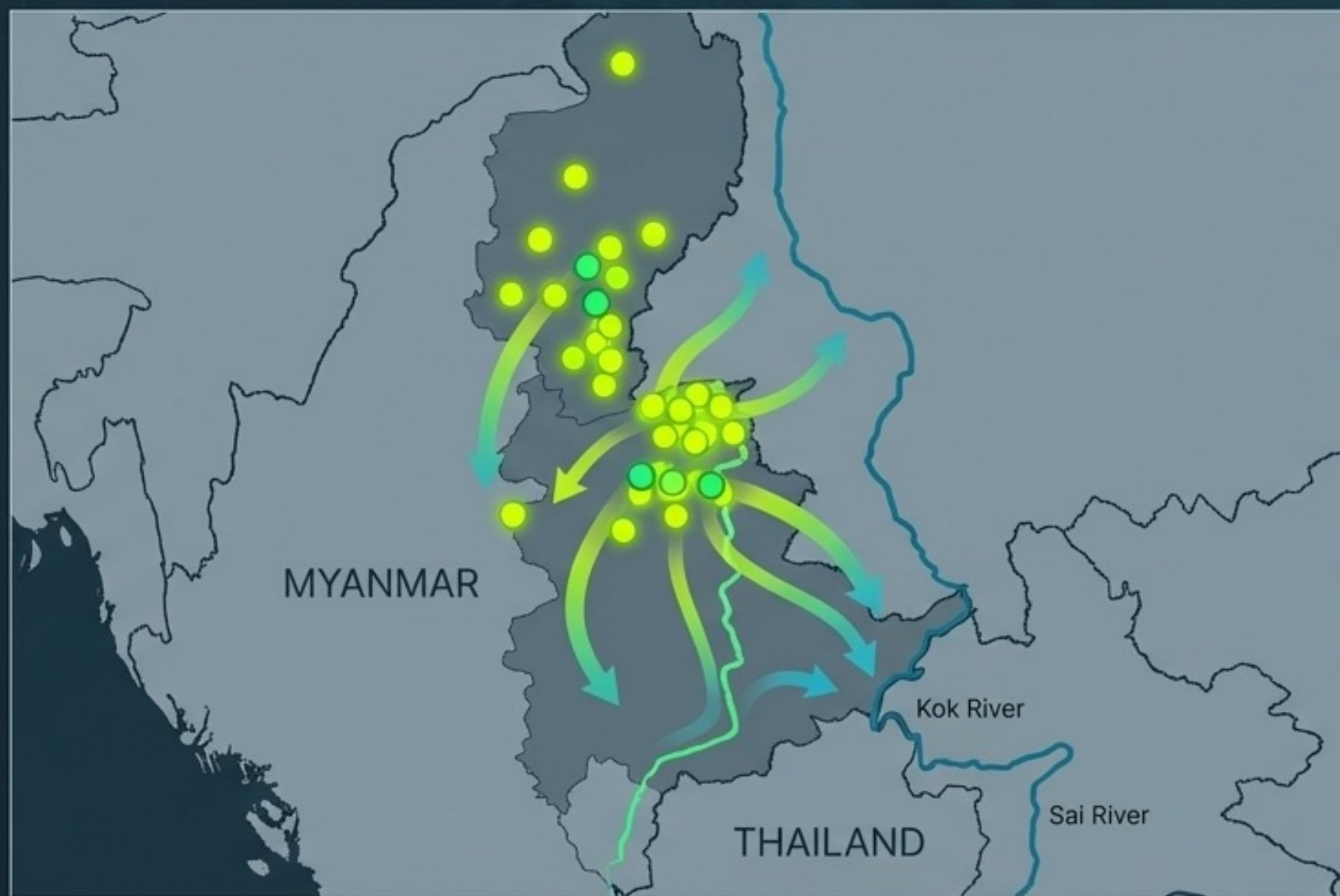
# The focal phenomenon: Contamination in the Kok River

The intervention began with a Thai national broadcast reporting mass fish deaths in the locally vital Kok River. This severely impacted local agricultural livelihoods and fisheries due to acute health risks and public fear of consumption.



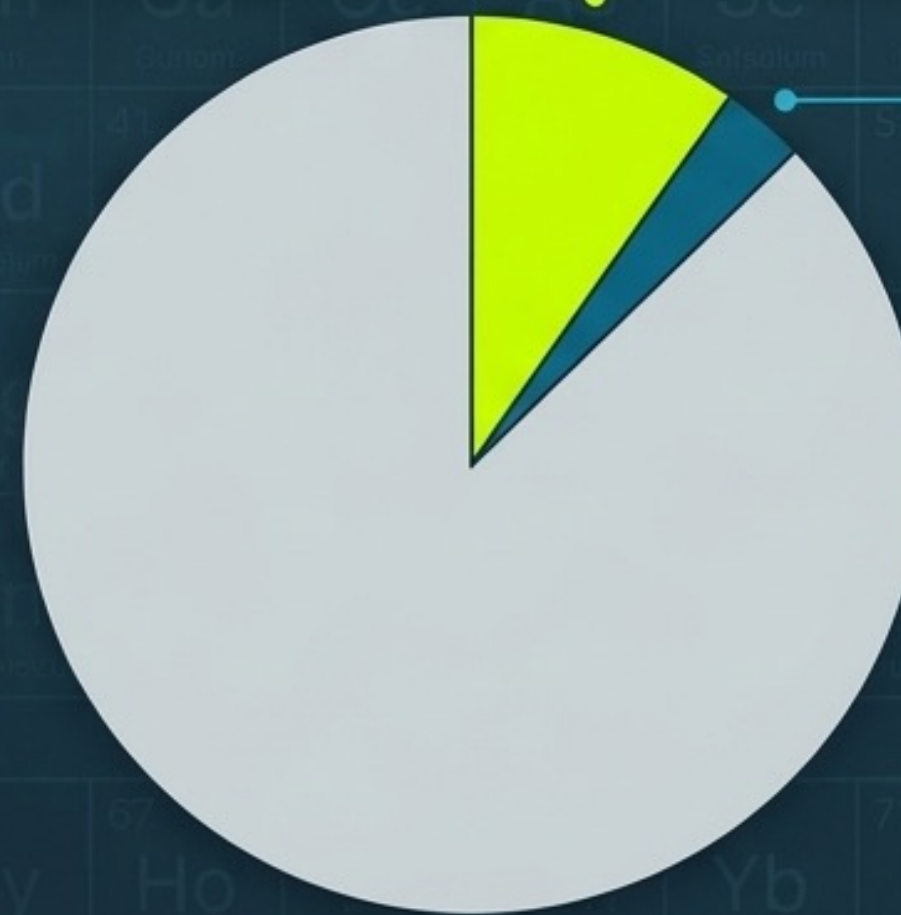
# Tracing the toxicity to the global high-tech supply chain

Students tracked the source of the river's contamination to hundreds of rare earth mining sites in Kachin and Shan States, Myanmar, which feed the global supply chain for modern technologies.

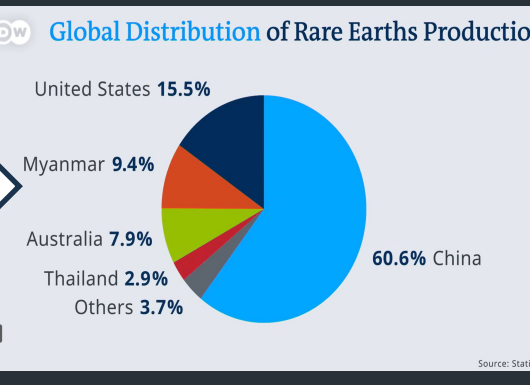
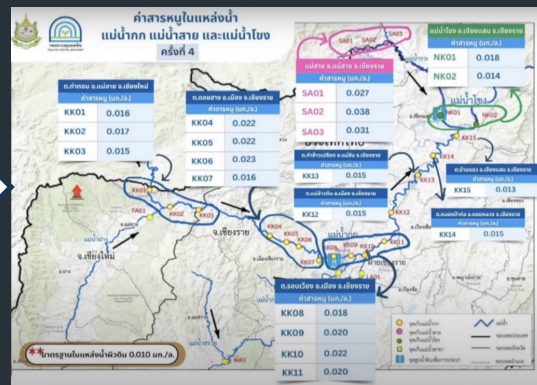


**Myanmar: 9.4%**  
of Global Supply

**Thailand: 2.9%**  
of Global Supply



Phenomenon-Based Learning (PhBL) begins by introducing a real-world phenomenon and then uses driving questions to spark students' thinking and guide their learning process.



What happened, and how did it affect living organisms and people in the local area?

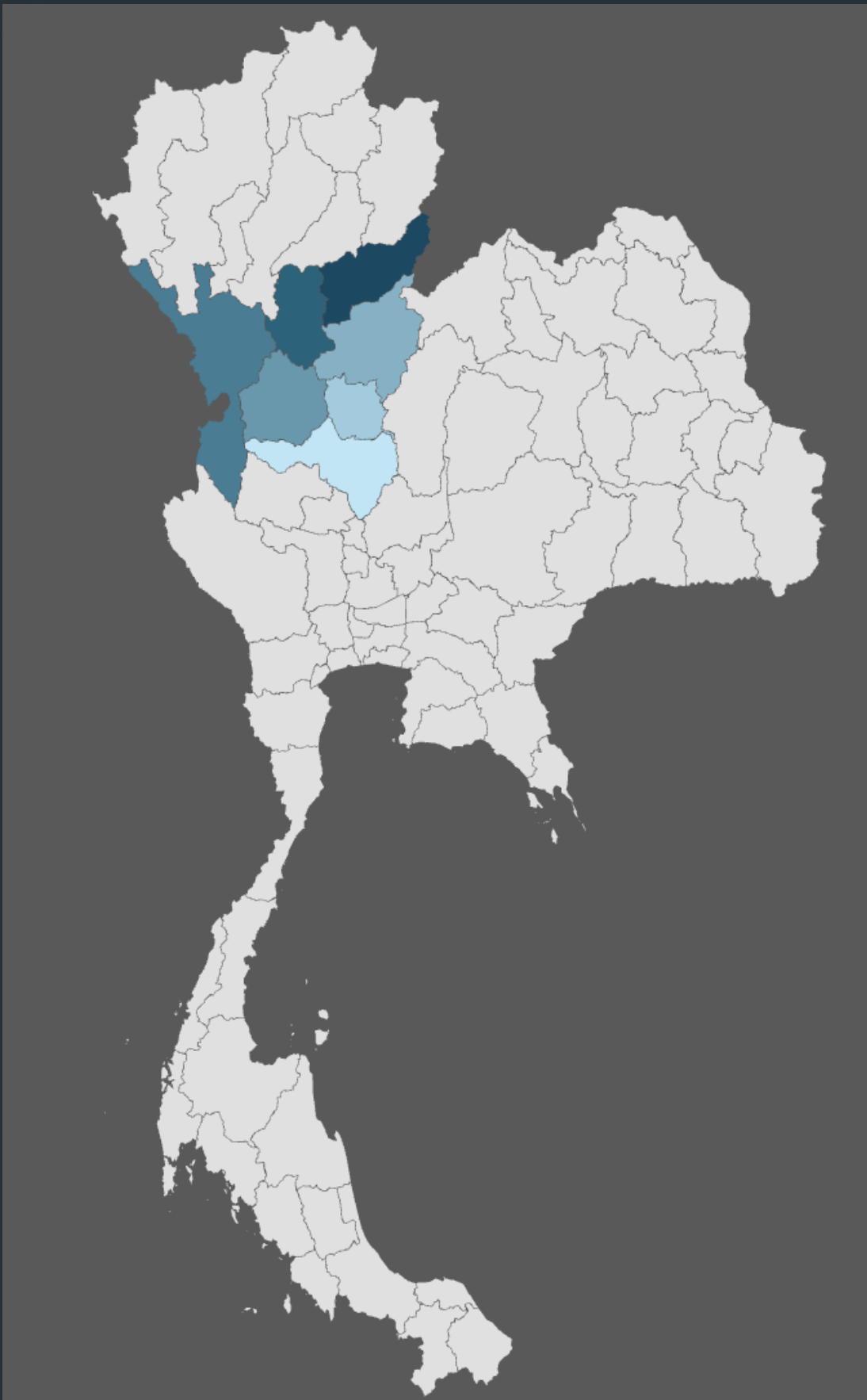
Why was a large amount of arsenic detected in the Kok River?

What purposes do major powers use rare earth elements?

What are the key properties of rare earth elements, and what types of industries are they used in?

For students in the SMTE program, what are your views on this situation?





## THE TARGET GROUP

570 Grade 10 SMTE students across the 19 schools in lower North region of Thailand.  
(total respondents = 529)

## RESEARCH DESIGN

a one-group post-test only design

## RESEARCH OBJECTIVES

1. To determine the level of environmental education awareness, environmental awareness, and **attitudes toward sustainability** among students after learning through Phenomenon-Based Learning on Rare Earth Mining.
2. To examine whether environmental education awareness and environmental awareness can be used to predict students' **attitudes toward sustainability**.

A questionnaire adapted from Michalos (2012, 2015) was used in this study. The modified instrument included 21 self-assessment items on a 5-point Likert scale, covering attitudes toward sustainability, environmental awareness, and environmental education awareness.

### Attitude Toward Sustainability (AS)

10 survey items

Internal Reliability:  
Coefficient H = 0.89

### Environmental Awareness (EA)

4 survey items

Internal Reliability:  
Coefficient H = 0.74

### Environmental Education Awareness (EEA)

7 survey items

Internal Reliability:  
Coefficient H = 0.87

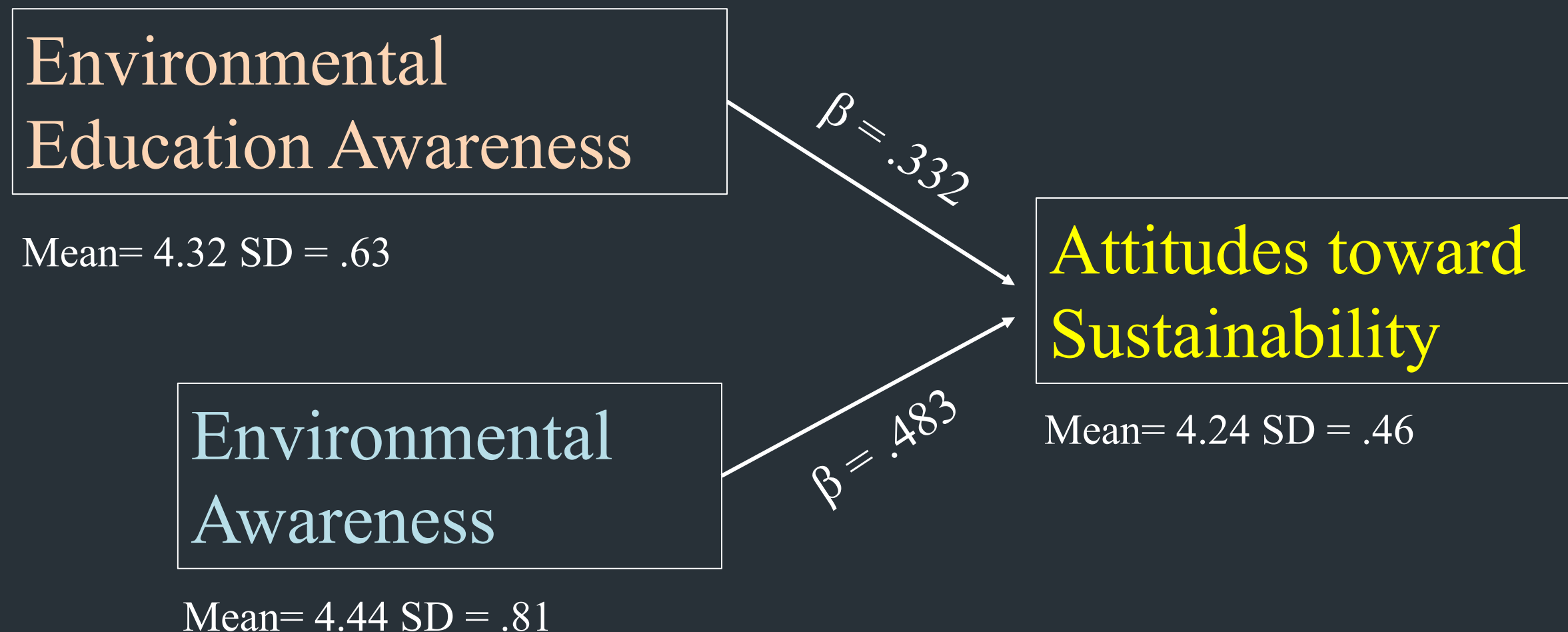
Statements	Standard estimate
<b>Attitudes toward sustainability (H= 0.89)</b>	
1. Increasing opportunities for people to live longer and healthier lives promotes sustainable development.	0.683
2. Protecting the environment is essential for sustainable development.	0.658
3. Economic development is necessary for sustainable development.	0.654
4. Sustainable development requires reducing all types of waste.	0.608
5. Human actions affect the atmosphere and the Earth's climate system.	0.529
6. Biodiversity conservation, meaning the preservation of the number and variety of living organisms, is essential for sustainable development.	0.736
7. Sustainable development requires respect for human rights.	0.646
8. Sustainable development depends on the use of renewable resources.	0.654
9. Sustainable development involves reflecting on the meaning of quality of life.	0.696
10. Being a good citizen is necessary for sustainable development.	0.659

<b>Environmental awareness (H=0.74)</b>	
11. I believe I can contribute to environmental conservation through my behavior.	0.577
12. Everyone has a responsibility to protect the environment.	0.505
13. Each person has a responsibility to integrate knowledge of science, mathematics, and technology with environmental issues.	0.710
14. Environmental issues should receive greater attention at the national level.	0.716
<b>Environmental education awareness (H=0.87)</b>	
15. Integrating environmental issues into education is important.	0.650
16. School activities related to the environment (e.g., Environment Day, field trips, exhibitions) are very important.	0.635
17. If I knew more about Rare Earth, I would apply environmental considerations in daily life.	0.659
18. All students should be required to take environmental courses.	0.649
19. Learning in school influences my attitudes toward the environment.	0.743
20. Learning in school influences my knowledge of the environment.	0.773
21. Learning in school influences my behavior toward environmental conservation.	0.749

CFI=0.912, TLI=0.901, RMSEA = 0.0658

One open-ended question: *“How has today’s orientation activity influenced changes in yourself regarding environmental conservation and sustainable development?”*





$R^2 = .565$ , Adjusted  $R^2 = .564$ , with RMSE = .309

EA ( $b = 0.386$ ,  $SE = 0.0317$ ,  $t = 12.18$ ,  $p < .001$ ,  $\beta = .483$ , 95% CI [0.406, 0.561])

EEA ( $b = 0.247$ ,  $SE = 0.0295$ ,  $t = 8.36$ ,  $p < .001$ ,  $\beta = .332$ , 95% CI [0.254, 0.410])

Theme	Description/Code [Frequency]	Example
Environmental awareness	Students demonstrated environmental awareness, reflected in students' recognition of environmental problems, perceived importance of natural resources, understanding of environmental impacts, and appreciation of nature's value.	<i>"It made me see the importance of the environment and natural resources."</i> [S-271]
	<b>[EA: 240]:</b> Perceived problem/awareness/positive or negative impacts/ value	<i>"...aware of global environmental impacts, and everyone must help protect the environment."</i> [S-298]
Environmental conservation awareness	Demonstrated intention to conserve the environment, care for nature, protect the planet, and improve environmental condition.	<i>"It made me want to protect the environment."</i> [S-441].
	<b>[ECA: 210]:</b> Conserve/care for/protect/improve	<i>"It made me realize how important the environment is, and everyone should help protect it."</i> [S-394].
Gain New Knowledge	Direct learning outcomes, reflected in gaining new knowledge, deeper understanding, and learning previously unknown information.	<i>"It gave me knowledge about environment..."</i> [S-249]
	<b>[GK: 170]:</b> gaining new knowledge/ information/more understand about environment	<i>"I gained more knowledge about the environment and can be applied in daily life."</i> [S-263]
Environmental responsibility	Demonstrated clearly environmental behavioral intentions, including reducing plastic use, waste separation, saving electricity and water, planting trees, and using resources efficiently.	<i>"I will help plant trees."</i> [S-43]
	<b>[ER: 120]:</b> Action/ reducing plastic use/ waste separation/using resources efficiently	<i>"Today's activity made me want to use fewer plastic bags and start separating my trash to help the environment."</i> [S-223]

Changing agent	Evidence of personal agency, reflected in intentions to change one's own behavior, start with oneself, encourage others, and shift personal mindsets.	<i>"I'll share what I learned with others using simple words..." [S-210]</i> <i>"I will improve environment starting from myself" [S-226]</i>
	<b>[EG: 95]</b> change behavior, telling other people to change behavior, change mindset	
Sustainability	Emphasis on sustainability, including sustainable development, consideration for future generations, and the balance between economic growth and environmental protection.	<i>"It made me realize the goal of the SMTE class, to develop the country in a sustainable way without harming the environment." [S-248]</i> <i>"...the importance of protecting the environment and managing in a sustainable way." [S-511]</i>
	<b>[SD:45]:</b> sustainability, sustainable development, balance between economic and environment	
Gain New Knowledge about Rare Earth	Explicit expressions of increased knowledge about rare earth elements, rare minerals and mining	<i>"I learned more about rare earth." [S-444, S-448, S-553]</i> <i>"...part of environmental damage comes from consuming and producing rare earth...I want to help protect the Earth." [S-484].</i>
	<b>[GKR: 8]</b> rare earth elements, rare earth minerals, rare earth mining	
General Positive Feeling	Response positive emotion in general, such as feeling very good, enjoying the activity, and liking.	<i>"I feel proud to study in this class, and it has changed my way of thinking." [S-8]</i>
	<b>[EF:35]</b> good, very good, great, enjoy, like today activity	

*“I gained more knowledge about the environment and can be applied in daily life.” [S-263]*

**Environmental Education Awareness**

Mean= 4.32 SD = .63

**Environmental Awareness**

Mean= 4.44 SD = .81

*“It made me see the importance of the environment and natural resources.” [S-271]*

$\beta = .332$

$\beta = .483$

*“It made me realize the goal of the SMTE class, to develop the country in a sustainable way without harming the environment.” [S-248]*

**Attitudes toward Sustainability**

Mean= 4.24 SD = .46

- Rare earth elements are often not presented in ways that students can easily recognize or relate to. This limits students' understanding of the completeness of the periodic table and its relevance to contemporary issues.
- Abstract concepts can be made more meaningful by linking them to real-world phenomena.
- Real-world cases can stimulate students' thinking and foster environmental awareness.
- This approach may also support behavioral change by strengthening students' values and sense of responsibility as citizens.
- It can be implemented effectively even in online learning environments and with large numbers of students.

# Thank you

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