Supplementary Material

This documents provides the two supplementary material below:

- Supplementary Material 1. Additional Teacher Information
- Supplementary Material 2. Example Chat Prompt (shared during workshop)
- Supplementary Material 3. Data Analysis Result: Themes, Categories, and Codes

Supplementary Material 1. Additional Teacher Information

Teaching and GenAI experiences of participant teachers (*N*=23)

Descriptor	Response Categories	Frequency	Descriptor	Response Categories	Frequency
Years of Teaching Experience	0.5–1.5 years	16	Teaching Grades	Kindergarten (K)	4
	2–4 years	5		Grades 1–3	7
	5+ years	2		Grades 4–6	12
Self-perceived level of GenAI Use	Beginner	14	GenAI Tools Used (multiple selections possible)	GPT (OpenAI)	23
	Intermediate	8		Magic School AI	5
	Advanced	1		Others (e.g, Gemini)	3
Frequency of Days Using GenAI Tools for Instructional Assistance Purposes	Two days or less	16	Positivity Toward Using GenAI for Instructional Design	Negative	1
	3-5 days a week	6		Neutral	6
	Daily	1		Positive	16

Supplementary Material 2. Example Chat Prompt (shared during workshop)

Workshop activity:
Effective use of GenAI for ESA-focused lesson design

how can we effectively use AI for lesson design?

- What should we ask?
- How should we ask?
- How will you break down your questions?

AI-assisted Backward Unit Design? Consider:

Your ownership is critical. You need a CONVERSATION to reach desirable responses from AI.

- BEFORE you start a chat (and if preferred): Let your AI know who you are: You can customize settings.
- START a chat by assigning a role to your AI agent.
- CONVERSATION PATTERN will be:
  a. Give SPECIFIC PROMPTs.
     - Precisely identify expected outcomes.
     - BREAK DOWN question prompts into smaller chunks.
  b. EVALUATE AI outcomes.
     - Know that the outcomes are not as satisfactory as you would expect.
  c. REPEAT 'a' and 'b' until you get closer to the outcomes you will get satisfied.
- Your AI agent will REMEMBER the prior chat content.
  a. If you want to start a chat about a separate topic, start a NEW chat.

Example Chat Prompts??

Reference, apply, and modify prompts/suggestions in the following pages.
They are not one-size-fits-all answers.
[In following pages, I put my note to you in brackets]

Situation 1. Introduce AI the overall unit composition

As an expert in designing science units for Kindergarten to 12th-grade classrooms, I invite you to develop a science unit tailored to X-number Y-minute class periods. This unit aims to help Nth-grade students achieve the following performance expectations:

1. [Performance expectation statement here]
2. [Performance expectation statement here]

[NOTE: you should have identified performance expectations from NGSS.]

Situation 2. Ask which ESA topics to integrate

I'd like to design my lessons to help promote environmental science agency (ESA). ESA means [Here, write down your understanding of ESA. you can also put some examples we learned from the course so that your GenAI can better understand what it means]

Particularly, I want to address environmental science agency by [here put your initial ideas]. Suggest me example ways to address ESA in this lesson [you can add a brief description of the lesson or performance expectations here]

Situation 3. Outline lessons

Thank you for suggesting ESA topics A and B. I aim to integrate these into a unit designed for Nth-grade students, consisting of X-number Y-minute class periods, in which I expect students to [performance expectation 1, 2, etc.].

Throughout the unit, students will engage with disciplinary core ideas such as [specific ideas], crosscutting concepts including [specific concepts], and science and engineering practices like [specific practices].

To structure the unit, I will adopt the 5E instructional model, ensuring each lesson progresses through Engage, Explore, Explain, and Elaborate stages, with Evaluation incorporated into every lesson.

Now, I seek your assistance in outlining the lessons. Please provide a brief description (one to two sentences) for each lesson.

Situation 4. Break down lesson outlines

[You should have identified lesson outlines. Refer to Situation 3]

The first lesson will [PUT GenAI's DESCRIPTION of the FIRST LESSON]. Please help me develop the followings for the first lesson:

1. Learning Goals: Develop three learning goals that utilize verbs from Bloom's Taxonomy,
2. Exit Assessment Questions: Generate three exit assessment questions aligned with the learning goals to evaluate students' understanding and achievement.

Situation 5. Continue adding lesson details

I would like to make the first lesson will be aimed at [the goals GenAI suggested, and then YOU chose to set for this lesson]. About this lesson, please provide the following details:

1. Example lesson opening questions you can use to gather students' attention
2. Example activities students can do in this lesson, which will last 10 to 15 minutes, including the procedure of activities

Situation 6. Follow up on details

Thanks for your suggestion. I would like to further refine your suggestion of lesson opening questions and student activities. Would you please recommend for the following?

1. About opening questions: I like your ideas of lesson opening questions such as [put the questions you chose from previous GenAI's output]. I want to ask those questions by showing students the image or video of natural phenomena so as to capture students' attention.
2. About activities: I like your ideas of student activities such as [put the activities you chose from previous GenAI's output]. I'd like to make accommodation or modification plans for students with special needs.

Play with the example prompts: Apply, modify, & create your own ones

Keep the chat log and please share it with me when you submit your project.

Discussion: your prompt strategies? What worked? What didn't?

Supplementary Material 2. Data Analysis Result: Themes, Categories, and Codes

RQ 1. How did science teachers use GenAI for their ESA-focused science lesson design projects?

Themes	Categories	Codes
1. Deepening Conceptual Understanding	1.1. Enhancing teacher understanding of science instructional concepts covered in the course	1.1.1. Explaining NGSS dimensions and applications 1.1.2..Explaining instructional terms (e.g., epistemic, nature of science, CER)
	1.2. Enhancing teacher understanding of ESA	1.2.1. Explaining the concept of ESA 1.2.2. Suggesting examples of ESA integration into science learning
	1.3. Enhancing teacher understanding of science concepts and phenomena	1.3.1. Explaining specific science concepts covered by their lessons 1.3.2. Explaining anchoring phenomena covered by their lessons
2. Shaping Lesson Components	2.1. Outlining the overall lesson flow	2.1.1. Outlining the overall lesson flow by providing AI with core lesson topics 2.1.2. Outlining the overall lesson flow by providing AI with NGSS performance expectations
	2.2. Developing specific lesson design components	2.2.1. Identifying teacher strategies aligned with the 5E instructional model 2.2.2. Identifying student activity details 2.2.3. Identifying anchoring phenomena suitable for the lesson's core science topics 2.2.4. Drafting assessment questions 2.2.5. Developing accommodation plans for students with special needs
	2.3. Developing instructional prompts for actual lesson implementation	2.3.1. Drafting teacher questions to use during instruction 2.3.2. Predicting students' responses to teacher questions and instructions 2.3.3. Rephrasing scientific concepts to align with students' grade level 2.3.4. Drafting safety instructions
	2.4. Developing instructional materials for actual lesson implementation	2.4.1. Exploring instructional resources suitable for lesson content 2.4.2. Structuring student handouts 2.4.3. Translating instructional prompts or materials
3. Integrating ESA into Science Instruction	3.1. Adjusting lesson components to foster ESA	3.1.1. Refining learning goals to explicitly address ESA 3.1.2. Refining student activities to address ESA 3.1.3. Exploring action-based projects to foster ESA within and beyond classrooms 3.1.4. Creating assessments to measure student understanding of ESA and its application

	3.2. Exploring environmental issues for lesson content	3.2.1. Exploring local environmental phenomena and issues relevant to students' communities 3.2.2. Exploring global environmental phenomena and issues affecting students' lives
	3.3. Integrating ESA with other subjects	3.3.1. Exploring ways to integrate with social sciences 3.3.2. Exploring ways to integrate with language arts 3.3.3. Exploring ways to integrate with math
	3.4. Developing ESA-related instructional prompts	3.4.1. Drafting instructional prompts to introduce the term ESA and examples 3.4.2. Creating reflective prompts to encourage students to consider their role in addressing environmental challenges
	3.5. Developing ESA-related instructional materials	3.5.1. Exploring community-based resources (e.g., local experts, environmental organizations) 3.5.2. Integrating technology tools (e.g., simulations, virtual labs) to explore environmental issues

RQ 2. What challenges did teachers address in using GenAI for the lesson design process

Themes	Categories	Codes
Ensuring the quality of GenAI output	4.1. Giving prompts to result in satisfactory GenAI output	4.1.1. Engaging in long, iterative prompting 4.1.2. Elaborating backward design
	4.2.Evaluating the reliability of GenAI output	4.2.1. Cross-checking GenAI-suggested environmental issues with credible sources (e.g., academic reports, government data, or local data). 4.2.2. Looking for original sources of GenAI output
Aligning GenAI Outputs with Teachers' Specific Visions for Lessons	5.1. Aligning GenAI output with teachers' instructional contexts	5.1.1. Aligning GenAI output with the school's curricular schedule. 5.1.2. Aligning GenAI output with contextual resources of teachers' schools.
	5.2. Aligning GenAI output with students' learning contexts	5.2.1. Modifying GenAI output to align with students' local and cultural contexts. 5.2.2. Modifying GenAI output to align with students' specific learning needs.