Personalized Learning for Scientific Discussion

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EDUC 846: *Personalized & Adaptive Learning*

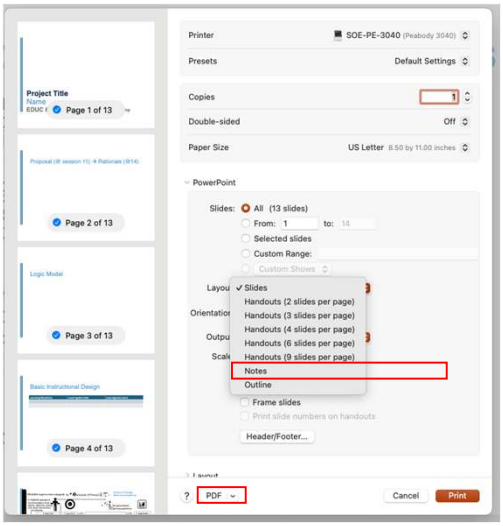
This is my Personalized Learning project. The title is “Personalized Learning for Scientific Discussion.” This project is aimed at high school students to refine their scientific misconceptions through discussion with their classmates.

Instructions & Table of Contents

- The following sections of slides should be included in a final project deck, presented in alignment with multimedia design principles, and captioned to provide a full synopsis of the project when printed/exported to PDF as “Notes” (which will show the slide and the content of the notes* pane below, one per page).
- A selection of them should be presented live during the final session, based on the length of time allotted
- A final PDF in Notes format should be submitted the night before the final session.
- As 4.1 before Session 11, then improved for Peer Review
  - Letter of Intent (PROPOSAL, which becomes a synopsis)
  - Logic Model
  - Theory of Change Diagram – Task Loop Adaptivity
  - Theory of Change Diagram – Step Loop Adaptivity
- As a draft for 4.2, then fully fleshed out on slides for Peer Review
  - Basic Instructional Design (objectives, all activities, assessments (aligned to outcomes)
- PL Design Logic, mapping to task flow diagram and noting the If/Then logic that informs the flow per learner given variable.
  - 1+ task loop, 1+ step loop
- An animated demo of each PL design logic across key points (left panel) and the impact on the user experience (right panel), with annotation.
- A conclusion that explains how this Output achieve Outcomes & Impact

*All notes should be written out completely as academic text, using APA style as a format.

Duplicate slides as needed to elaborate this deck to fit your project (delete red text)



Proposal (@ session 11) → Rationale (@14)

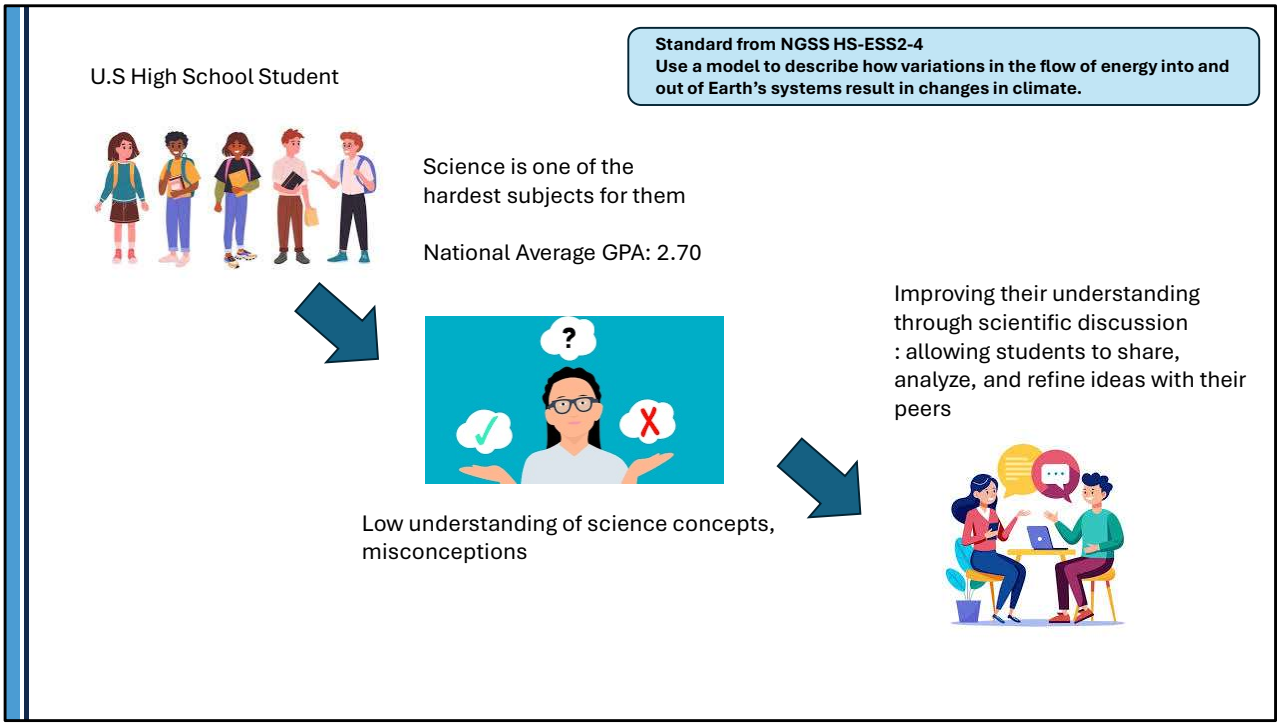
According to NCES data, the average overall GPA for high school students is 3.0, while Science average only 2.70 – the second lowest among all subjects. This is because Science requires understanding abstract concepts, complex language, and the need for a strong foundation. Students often lose interest in science, limiting their future opportunities in STEM-related careers. Keeping their interests in science, students need to be familiar with science concepts and exposed to diverse science topics so that they can keep motivated (Mamlok-Naaman, 2014). Improving students' scientific reasoning and concept understanding through discussion shows promising effects because discussions encourage students to elaborate on their prior knowledge, refine their misconceptions, and synthesize other people's thoughts(Osborne, 2010; Shemwell & Furtak, 2010). This project is designed for high school students to deepen their understanding of science concepts in the short term, and let them pursue science studies in a long-term goal.

This Personalized Learning class, grounded in social constructivism theory, which sees learning as something students build together through interaction. As the interaction opponents, each student is going to share their understanding of science concepts and misconceptions with their group or AI. The course begins with a prior-knowledge assessment, followed by two discussion phases supported by the Driving Question Board (DQB) and AI feedback loops.

Making this project align with social constructivism theory, the design intends to scaffold learners' level by installing the Driving Question Board (DQB) method. DQB is designed to reconstruct students' understanding of the content. In the process, students will start by sharing their prior knowledge, then questioning about the concept that they still need more explanation, and at the end, they will incorporate the prior knowledge and new knowledge to refine their original thoughts. DQB reduces students' burden to reconstruct their thoughts by providing proper steps aligned with the zone of proximal development.

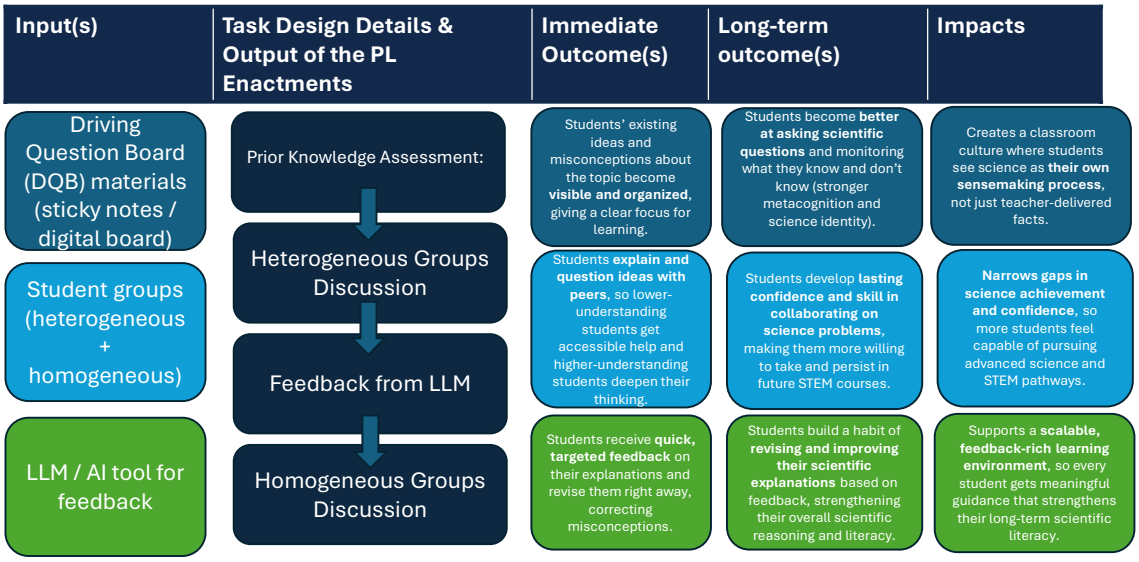
During the DQB, students are required to discuss the scientific concept. In this process, they need more personalized support and a group. In this class, students have two grouping opportunities: the first is for asking questions, and the second is for knowledge incorporation. The objects of each task are different; the first one is understanding, and the second is reasoning. An and Zhang (2024) argue that heterogeneous groups for discussion and misconception repair and homogeneous groups for synthesis and independent explanation, letting students consolidate what they've learned. To fulfill each learning object, the first task is grouped by heterogeneous, and the second is homogeneous. In the homogeneous group activity, the task-loop and step-loop are applied. Here, students who have low scores in the assessment are going to ask questions to the high achievers, and high achievers will answer questions. After this, to get step-loop feedback, they will input their understanding into generative AI and acquire some feedback.

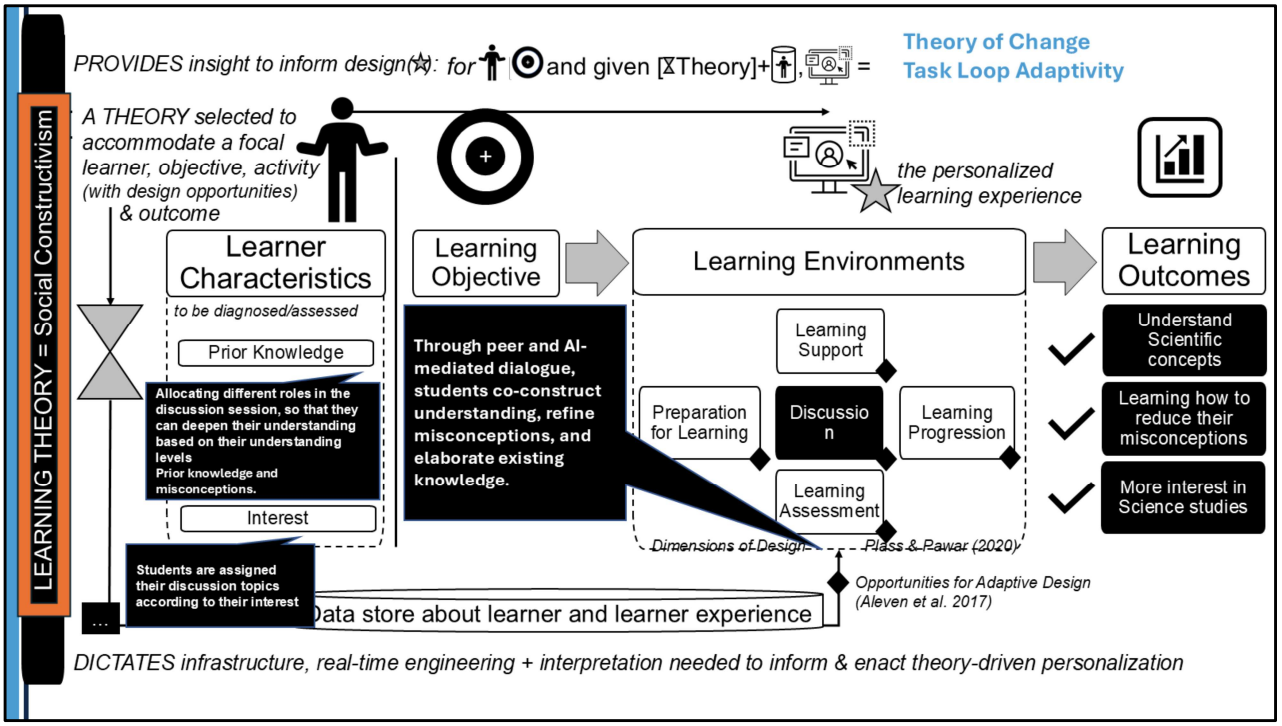
250-500 words covering all key elements of the project; problem statement including target learners, current state of practice that is insufficient, summary of evidence for a better approach that can be afforded trhough personalization, summary of a representative learning task, theory of change to be achieve through (1) task loop adaptation and (2) step loop adaptation, and output of such an adaptive design (1 each), as well as the short and long term outcomes and impact they would achieve



According to the National Center for Education Statistics (2023), the average science GPA of U.S. high school students was 2.70. Compared to other subjects, this number is the second lowest, following math. This means many high schoolers struggle to understand scientific concepts and have misconceptions. The difficulty makes high school students lose their interest in science, leading to restricted career options, especially in the STEM field. To solve this situation, provide these students to have opportunities to share, analyze, and refine ideas with their peers. This activity improves their understanding, and the best way to include these activities is by encouraging them to have scientific discussions.

Logic Model


Input(s)
Task Design Details & Output of the PL Enactments
Immediate Outcome(s)
Long-term outcome(s)
Impacts
Driving Question Board (DQB) materials (sticky notes / digital board)
Student groups (heterogeneous + homogeneous)
LLM / AI tool for feedback
Prior Knowledge Assessment:
Heterogeneous Groups Discussion
Feedback from LLM
Homogeneous Groups Discussion
Students' existing ideas and misconceptions about the topic become visible and organized, giving a clear focus for learning.
Students explain and question ideas with peers, so lower-understanding students get accessible help and higher-understanding students deepen their thinking.
Students receive quick, targeted feedback on their explanations and revise them right away, correcting misconceptions.
Students become better at asking scientific questions and monitoring what they know and don't know (stronger metacognition and science identity).
Students develop lasting confidence and skill in collaborating on science problems, making them more willing to take and persist in future STEM courses.
Students build a habit of revising and improving their scientific explanations based on feedback, strengthening their overall scientific reasoning and literacy.
Creates a classroom culture where students see science as their own sensemaking process, not just teacher-delivered facts.
Narrows gaps in science achievement and confidence, so more students feel capable of pursuing advanced science and STEM pathways.
Supports a scalable, feedback-rich learning environment, so every student gets meaningful guidance that strengthens their long-term scientific literacy.



This project is grounded on the Social Constructivism theory (

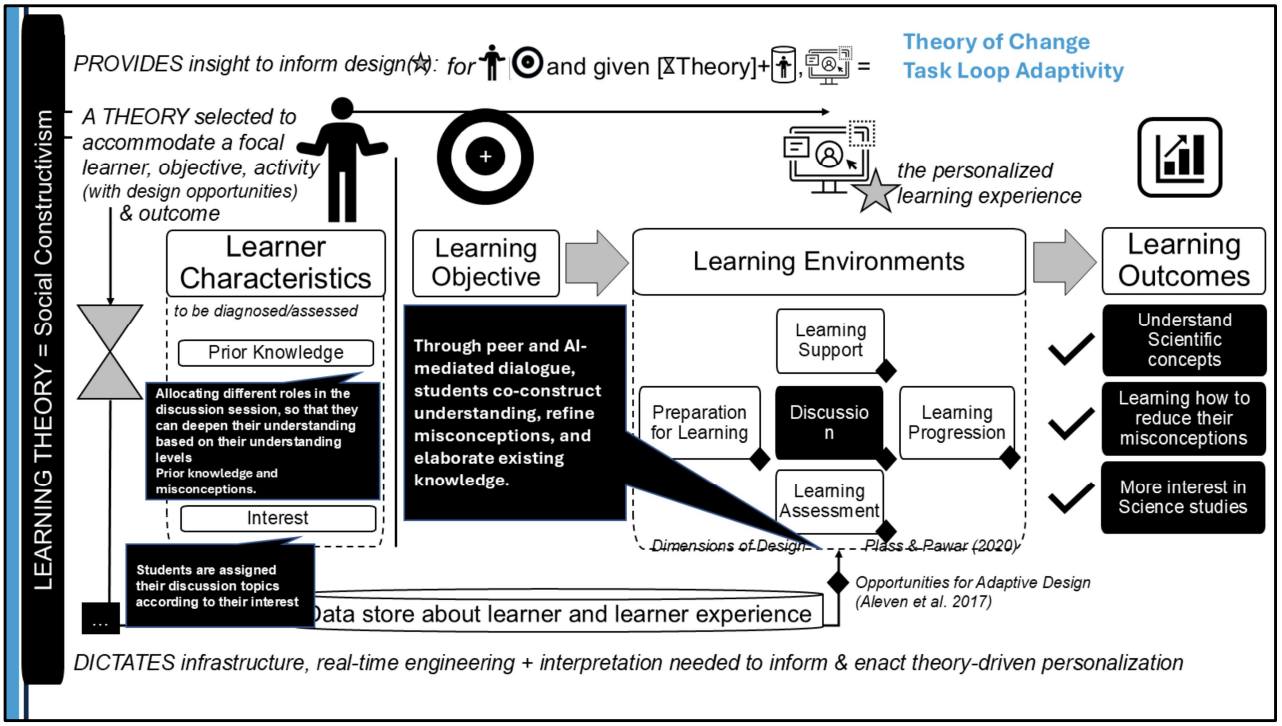


FIGURE 1 – DIAGRAM – personalizing and adapting instruction to leverage A about a learner to obtain C; design choice B draws on theory to leverage it.

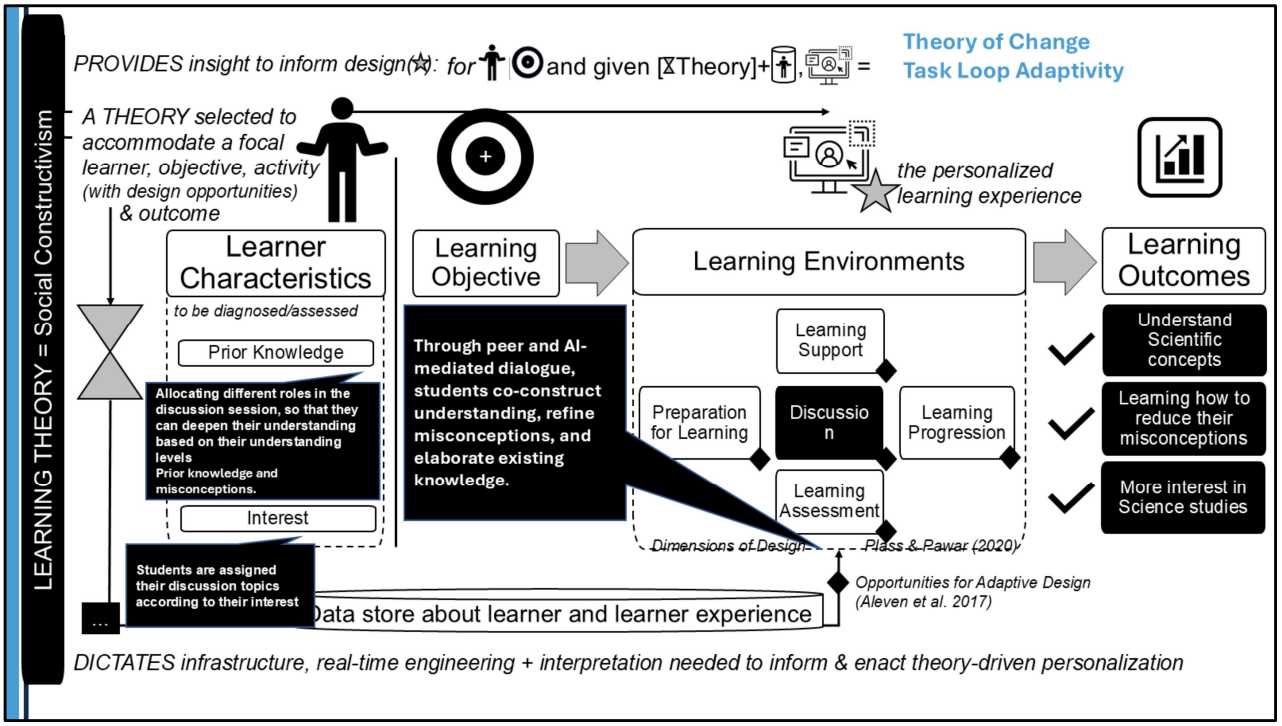


FIGURE 1 – DIAGRAM – personalizing and adapting instruction to leverage A about a learner to obtain C; design choice B draws on theory to leverage it.

Classic Instructional Design (Base Design)

National Center for Science Education. (2024). *Driving Question Boards.* https://ncse.ngo/driving-question-boards

Driving Question Board (DQB) instructions/objectives page

A **Driving Question Board (DQB)** is used to make students' ideas and questions about a phenomenon visible so those questions **drive the unit**. Its purpose is to surface prior knowledge and misconceptions, give students ownership over what they are trying to figure out, and provide a shared roadmap the class can keep revisiting as they build and refine their scientific understanding.

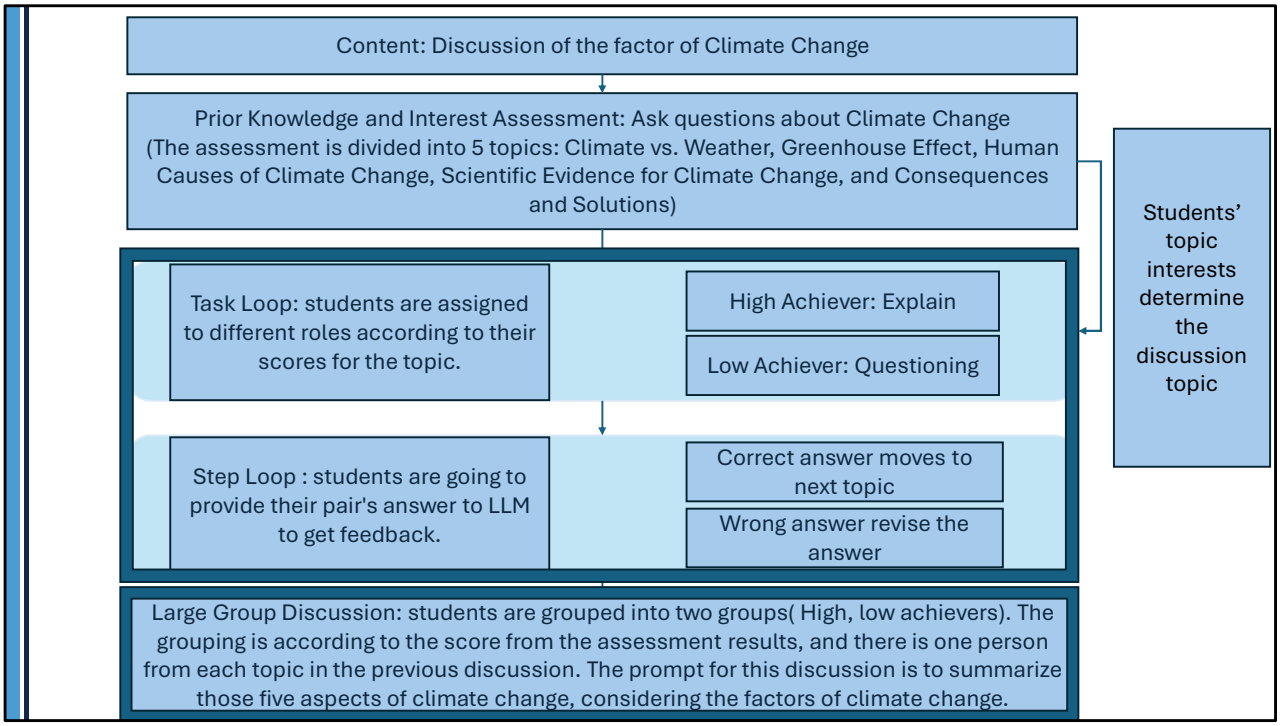
Details

It is divided into 3 steps

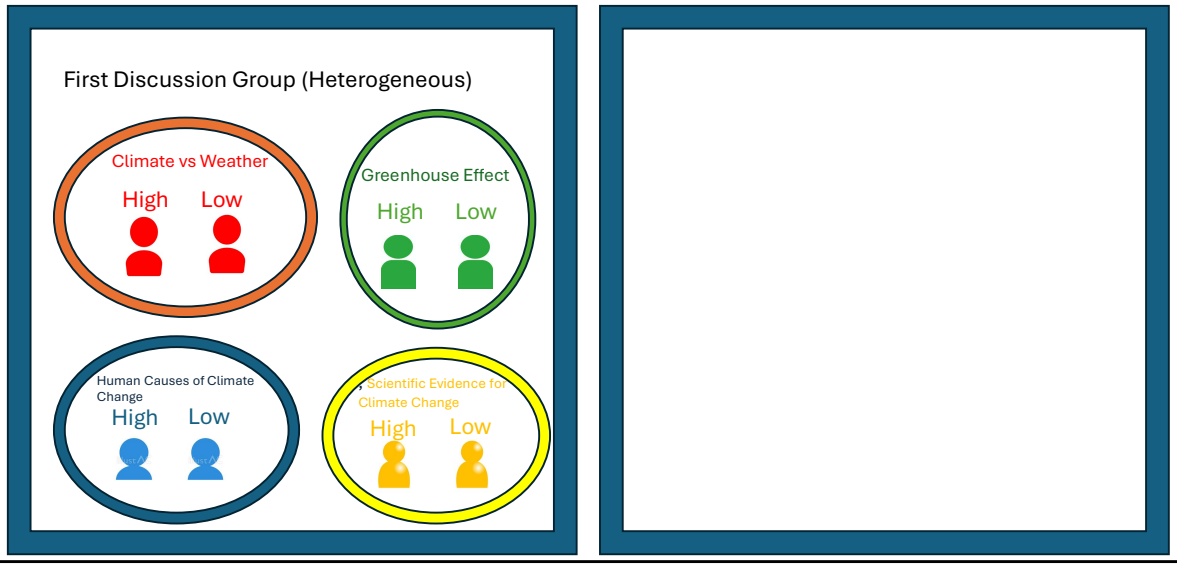
Sharing – Students share their **prior ideas and knowledge** about the topic.
Purpose: helps everyone see what they already know and what misconceptions may exist.

Questioning – Students **generate questions** about what they don't yet understand or want to learn.
Purpose: identifies knowledge gaps and builds curiosity.

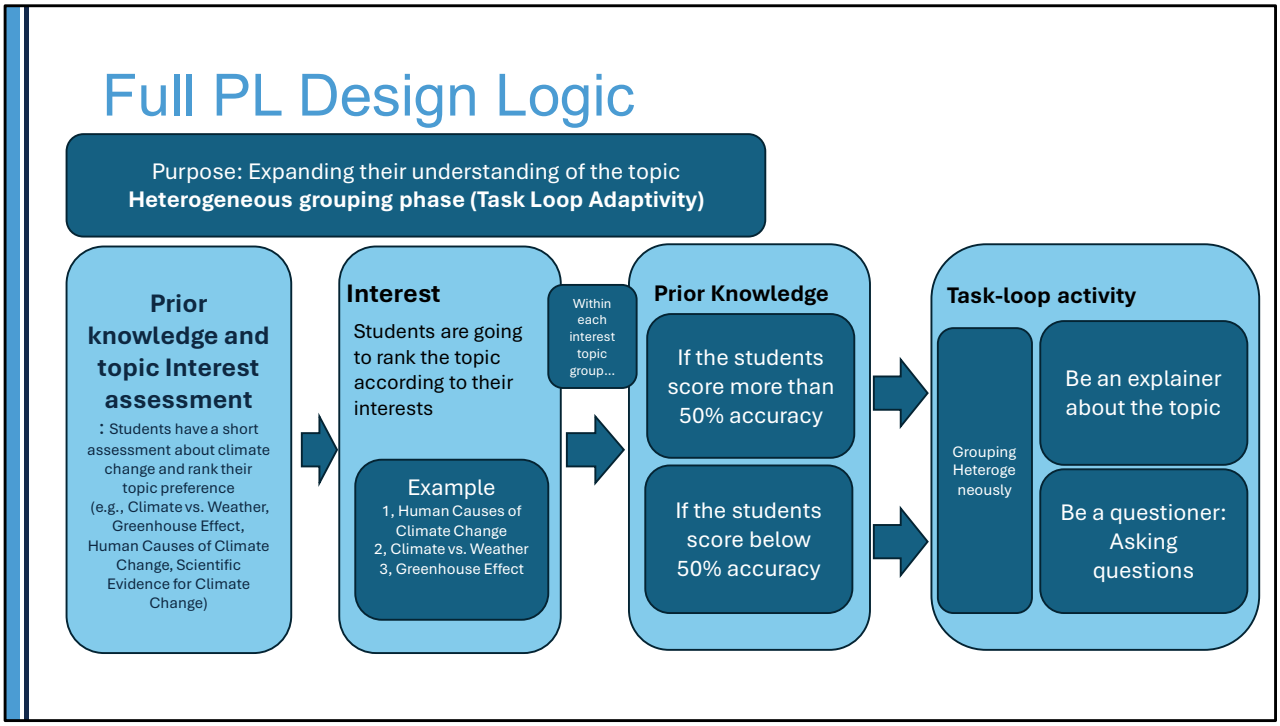
Organizing – The class **groups and connects ideas and questions** on the board to create a visual roadmap for learning.
Purpose: helps students organize their thinking and track progress as they find answers during the unit.


Content: Discussion of the factor of Climate Change
Prior Knowledge and Interest Assessment: Ask questions about Climate Change (The assessment is divided into 5 topics: Climate vs. Weather, Greenhouse Effect, Human Causes of Climate Change, Scientific Evidence for Climate Change, and Consequences and Solutions)
Students' topic interests determine the discussion topic
Task Loop: students are assigned to different roles according to their scores for the topic.
High Achiever: Explain
Low Achiever: Questioning
Step Loop : students are going to provide their pair's answer to LLM to get feedback.
Correct answer moves to next topic
Wrong answer revise the answer
Large Group Discussion: students are grouped into two groups(High, low achievers). The grouping is according to the score from the assessment results, and there is one person from each topic in the previous discussion. The prompt for this discussion is to summarize those five aspects of climate change, considering the factors of climate change.

Discussion group

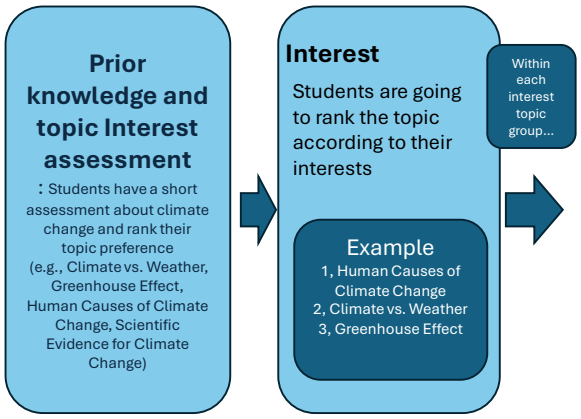


Full PL Design Logic



Full PL Design Logic

Purpose: Expanding their understanding of the topic
Heterogeneous grouping phase (Task Loop Adaptivity)



Task Loop PL Design Flow & User Experience

UNC SCHOOL OF EDUCATION

Please rank these climate-related topics from most interesting (1) to least interesting (4). Your top-ranked topic will be the one you study in your group.

- Climate vs. Weather: Climate is the long-term pattern of weather over decades, while weather describes short-term daily conditions.
- Greenhouse Effect: The greenhouse effect is the natural warming of Earth caused by gases in the atmosphere that trap heat.
- Human Causes of Climate Change Human activities—such as burning fossil fuels, deforestation, and agriculture—add extra greenhouse gases that intensify global warming.
- Scientific Evidence for Climate Change Multiple measurements like rising global temperatures, melting ice, and increased CO_2 levels all confirm that Earth's climate is warming.

Climate vs. Weather

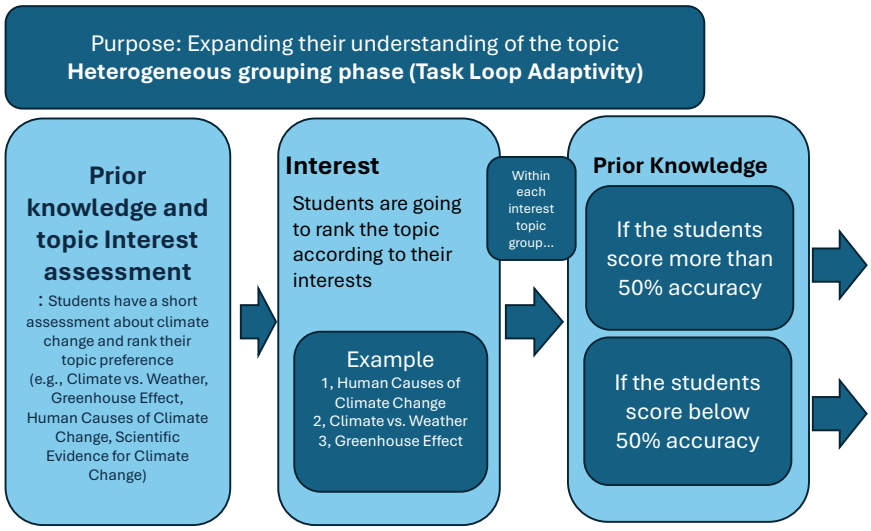
Greenhouse Effect

Human Causes of Climate Change

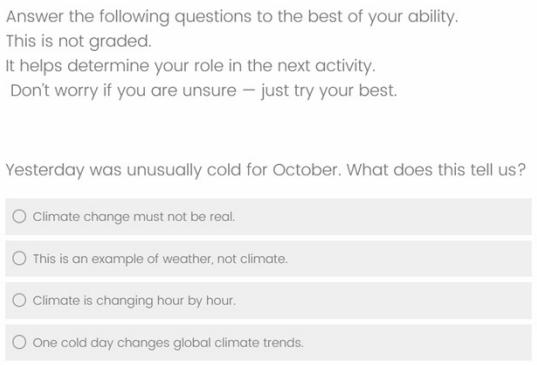
Scientific Evidence for Climate Change

Students will rank the topic preference Typically, students can work as their preference, but if the topic is overpopulated, they will be allocated to the second preference

Full PL Design Logic



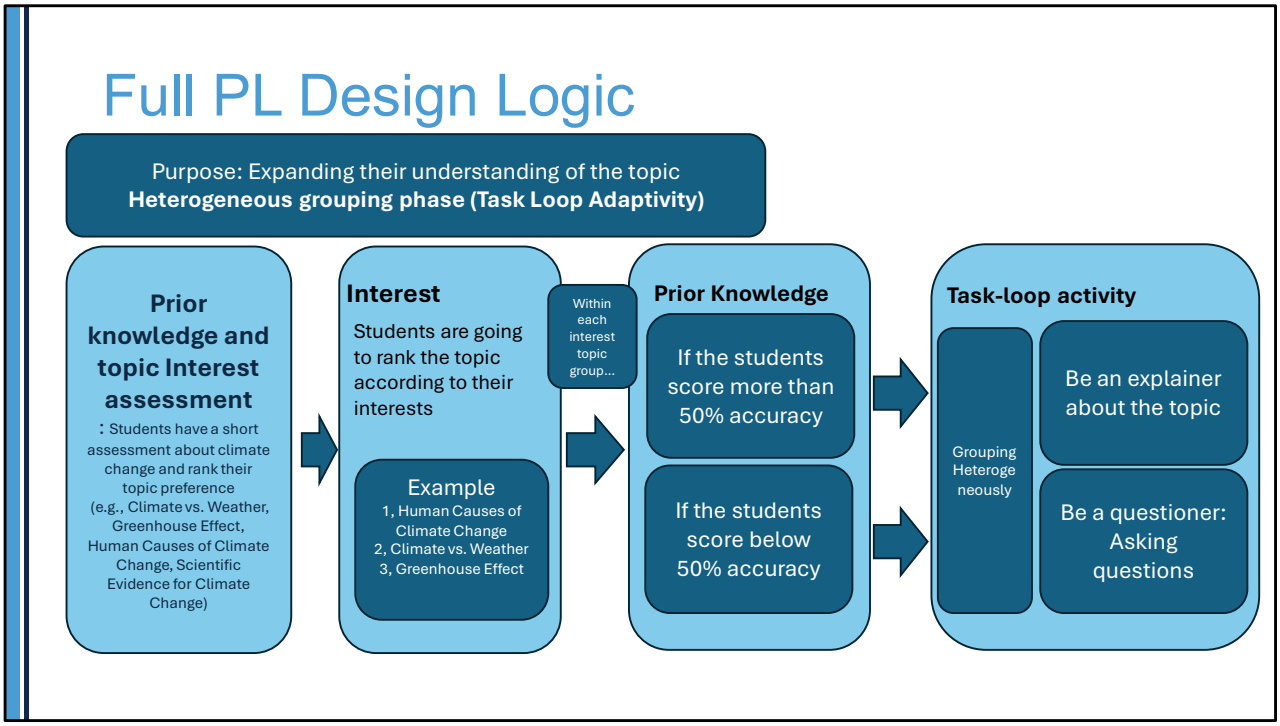
Task Loop PL Design Flow & User Experience



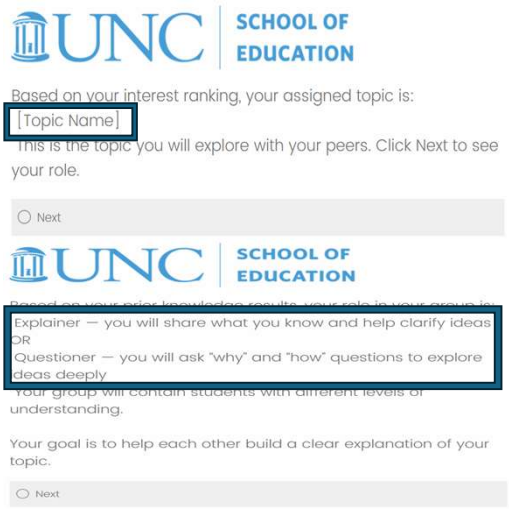
Students are going to answer the questions to assess their prior knowledge about Climate Change

There are 4 topics, and each topic has 10 questions, for a total of 40 questions to answer

Full PL Design Logic



Task Loop PL Design Flow & User Experience



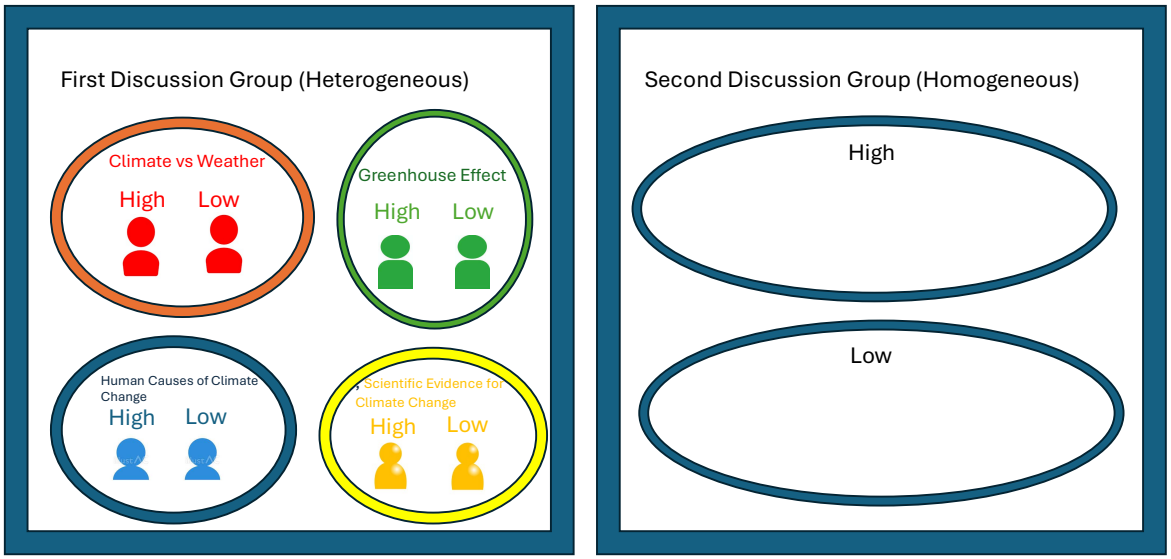
Their topic and role are assigned according to their interest and the score from the assessment

Task Loop PL Design Flow & User Experience

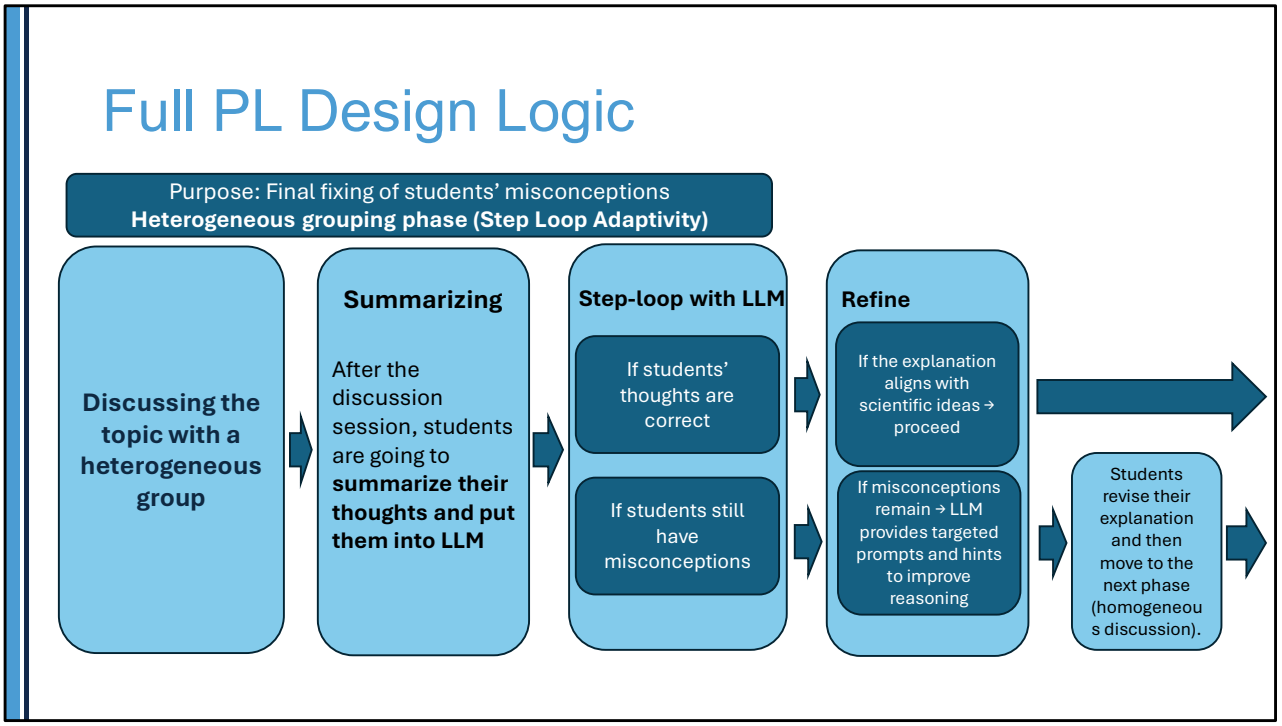
Students will get the prompt for their discussion

This is grouped as heterogeneous, which intends to expand their insights about their topic

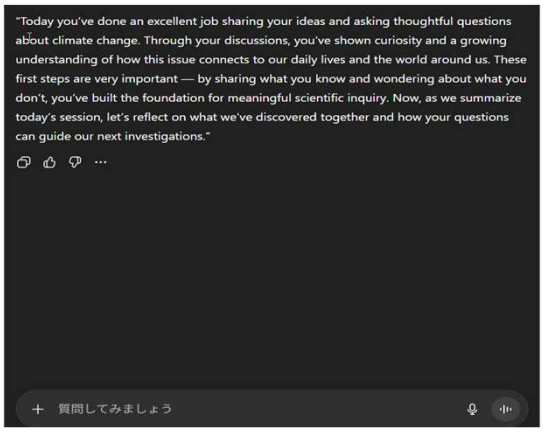
Discussion group

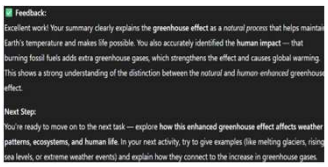


Full PL Design Logic

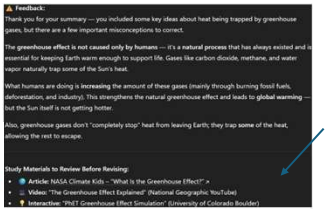


Step Loop PL Design Flow & User Experience



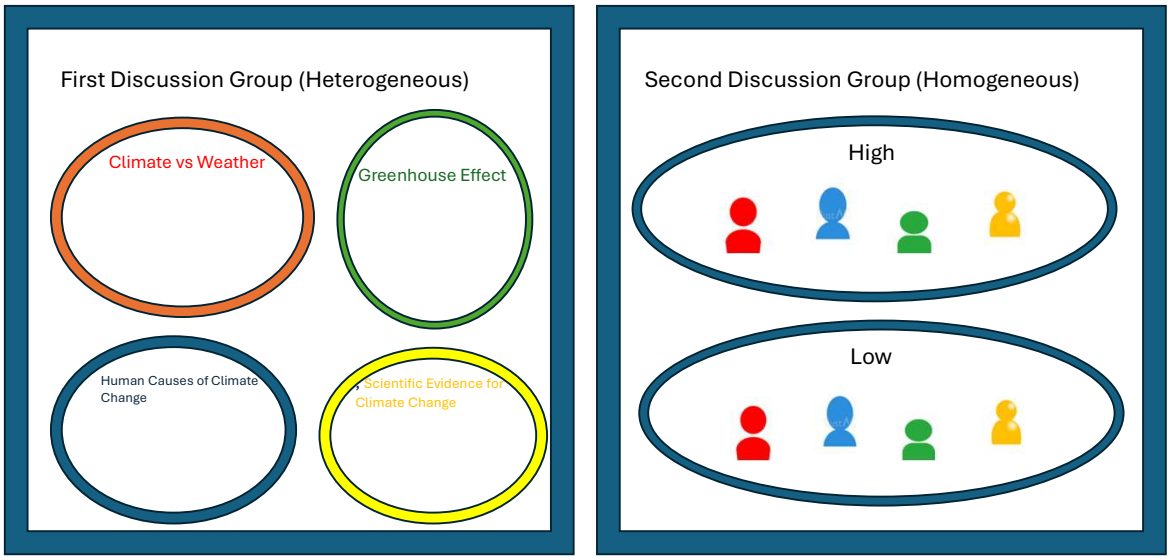


Proceed to the next homogenous group discussion



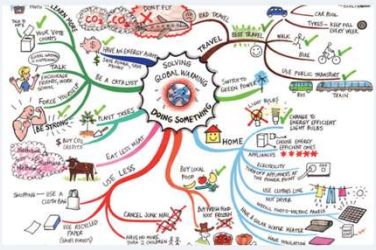
Additional learning material will be assigned

Discussion group



Classic Instructional Design (Base Design)

User-facing assessment activity



Details

•**Form Groups:**
Students are placed in **same-ability (homogeneous) groups** based on their latest understanding level.
•**Synthesize Learning:**
Each group reviews what they learned from previous discussions and **summarizes key science concepts** (e.g., causes and effects of climate change).
•**Create Final Product:**
Groups work together to produce a **summary artifact** such as a concept map, poster, or presentation showing their collective understanding.
•**Share and Compare:**
Groups **present or exchange** their work to compare explanations and highlight common ideas or remaining misconceptions.
•**Reflect:**
Students revisit the **Driving Question Board** to mark which questions are now answered and reflect on how their thinking has changed.

Goal:
To **consolidate learning and build confidence** in explaining science concepts independently.

Conclusion

- **Purpose:**
  Help high school students correct science misconceptions through personalized discussion-based learning.
- **Design:**
  Interest ranking → diagnostic → heterogeneous discussion (task-loop) → LLM feedback (step-loop) → homogeneous synthesis.
- **Theory:**
  Social constructivism + adaptive PL (Aleven et al.).
  Students learn by explaining, questioning, revising, and co-constructing meaning.
- **Impact:**
  Deeper understanding, fewer misconceptions, stronger motivation, and more equitable access to science learning.

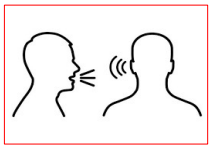
References

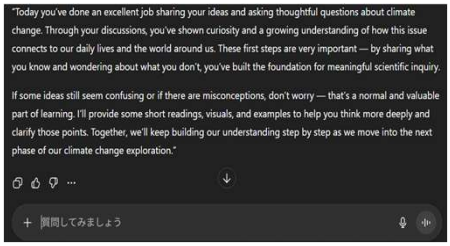
- An, S., & Zhang, S. (2024). *Effects of ability grouping on students' collaborative problem-solving patterns: Evidence from lag sequence analysis and epistemic network analysis. Thinking Skills and Creativity, 52*, 101360. https://doi.org/10.1016/j.tsc.2023.101360

  National Center for Science Education. (2024). *Driving Question Boards.* https://ncse.ngo/driving-question-boards

Classic Instructional Design (Base Design)

User-facing materials





Details

1. Form Groups:
Students are placed in **mixed-ability groups** based on diagnostic results.
2. Assign Roles:
Explainers share and clarify concepts.
Questioners ask "why" and "how" questions to deepen discussion.
3. Discuss DQB Questions:
Groups use their **Driving Question Board** to guide conversation and co-construct explanations.
4. Create Explanation & Get Feedback:
Each group writes a short explanation and submits it to the **LLM/AI tool** for feedback.
5. Revise & Reflect:
Students revise their explanation together, correcting misconceptions and strengthening understanding.

Students learn through **peer explanation, questioning, and feedback**, helping all members deepen conceptual understanding.

Logic Model

Problem Statement: students to believe they are simply “not good at science” and that science is not meant for them. Over time, this perceptioThe problem with science having the lowest GPA is that it can lead students to believe they are simply “not good at science” and that science is not meant for them. Over time, this perception reduces their interest in learning scientific concepts and may cause them to avoid science-related courses. As a result, their future career options—especially in STEM fields—can become unnecessarily limited. Therefore, a key challenge for educators is to find ways to reduce these difficulties and make science more accessible and engaging for all students.an become unnecessarily limited. Therefore, a key challenge for educators is to find ways to reduce these difficulties and make science more accessible and engaging for all students.

Theoretical framework & evidence that suggests promise of a PL-based solution :This lesson is grounded in **social constructivism**, which sees learning as something students build together through interaction. Students first take a diagnostic test and add their ideas and questions about climate change to a shared Driving Question Board, making their thinking visible. They then work in **heterogeneous groups**, where stronger students explain concepts and others ask clarifying questions, so everyone learns within their **zone of proximal development**. After drafting explanations, groups use an AI tool to get feedback and revise their ideas. At the end, **homogeneous groups** summarize and explain what they have learned. Across these steps, students repeatedly discuss, question, and refine their ideas, helping them correct misconceptions and deepen their understanding of science.

Classic Instructional Design
(Schema of the Base Design)

Learning Objectives	Learning Activities	Learning Outcomes Assessed
Heterogeneous groups (explainer & questioner roles) Students will **clarify and correct misconceptions** about climate-change concepts by explaining and questioning in mixed-ability groups.	Students work in **heterogeneous pairs/groups** based on the diagnostic results. "High understanders" explain each topic; "lower understanders" ask "why/how" questions. Each pair writes a joint explanation and submits it to the **LLM for feedback**, then revises their explanation.	Observation of **peer dialogue quality** (explanation and questioning).
Students will **synthesize and communicate** their understanding of climate-change concepts independently, without peer "experts."	Students are regrouped into **homogeneous groups** (high/middle/low) based on the initial diagnostic. Each group creates a **summary product** (concept map/poster/slide) that explains all five climate-change topics and answers key DQB questions. Groups briefly present or gallery-walk and compare their explanations.	Quality of the **group summary product** using a rubric (concept accuracy, use of evidence, clarity). Teacher check of how many original **DQB questions are now answered correctly**.

Supplemental Materials