Supporting Epistemic Agency in Collaborative Knowledge Building:
A Continued Journey

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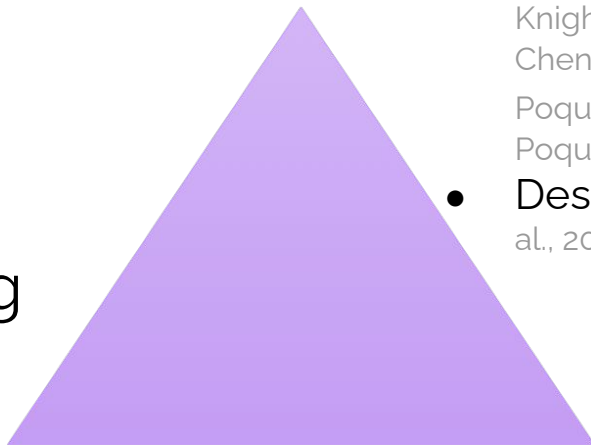
About Bodong

- Learning scientist and educational technologist by training
- Director of [Penn GSE Wonder Lab](#) and [Knowledge Building Innovation Network](#)
- Tool designer and builder
- Educator at heart

  "How can we better support human wonderment?"

Lines of Inquiry

Learning Analytics
- Temporal (Chen et al., 2017; Chen, Knight, & Wise, 2017), social (Chen & Chen, 2023; Chen & Huang, 2019; Chen & Poquet, 2023), and complex (Chen & Poquet, 2020; Chen et al., 2023)
- Design & Implementation (Chen et al., 2018; Chen & Zhu, 2019; Shui et al., 2024)

Knowledge Building
- Promisingness (Chen, 2017; Chen et al., 2015)
- Meta-discourse (Resendes, et al., 2015)
- New literacies (Chen et al., 2015; Ma et al., 2016), e.g., data literacy (Chen et al., 2023, 2024)

Digital Transformation
- Social annotation (Chen, 2019; Zhu et al., 2023)
- MOOCs (Chen et al., 2020)
- Infrastructuring (Chen, 2024)
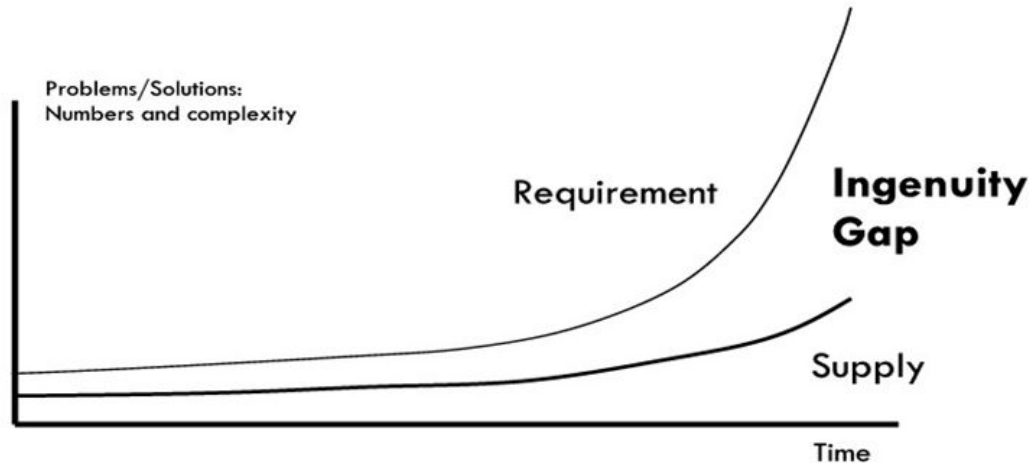
Today's Plan

- **Epistemic Agency**
  - Intelligence Augmentation
  - Knowledge Building

- **Three Studies**
  - Promisingness judgments
  - Criss-crossing idea landscapes
  - Collaborating with generative AI

- **Learning analytics and AI for epistemic agency**
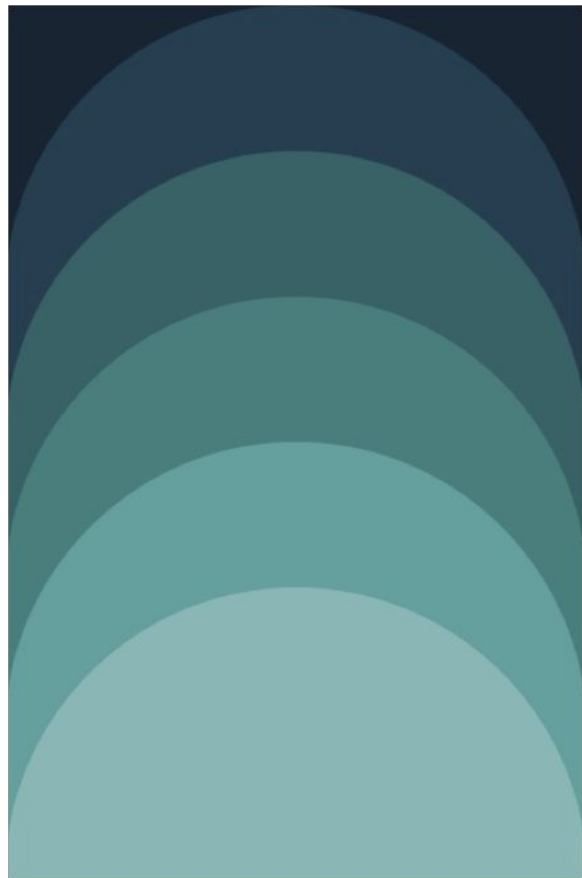
A Changing Society

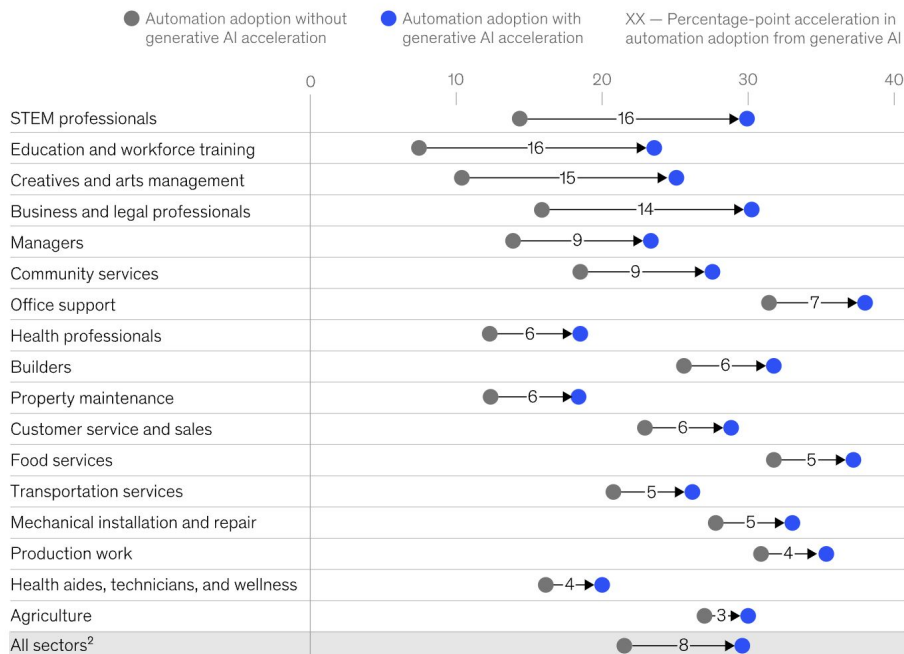# The Ingenuity Gap

(Homer-Dixon, 2002)

Jagged Technological Frontier

Dell'Acqua, F., McFowland, E., Mollick, E. R., Lifshitz-Assaf, H., Kellogg, K., Rajendran, S., Krayer, L., Candelon, F., & Lakhani, K. R. (2023). *Navigating the Jagged Technological Frontier: Field Experimental Evidence of the Effects of AI on Knowledge Worker Productivity and Quality* (SSRN Scholarly Paper 4573321). https://doi.org/10.2139/ssrn.4573321

With generative AI added to the picture, 30 percent of hours worked today could be automated by 2030.

Midpoint automation adoption[1] by 2030 as a share of time spent on work activities, US, %

● Automation adoption without generative AI acceleration　　● Automation adoption with generative AI acceleration　　XX — Percentage-point acceleration in automation adoption from generative AI

STEM professionals	16
Education and workforce training	16
Creatives and arts management	15
Business and legal professionals	14
Managers	9
Community services	9
Office support	7
Health professionals	6
Builders	6
Property maintenance	6
Customer service and sales	6
Food services	5
Transportation services	5
Mechanical installation and repair	5
Production work	4
Health aides, technicians, and wellness	4
Agriculture	3
All sectors[2]	8

[1]Midpoint automation adoption is the average of early and late automation adoption scenarios as referenced in *The economic potential of generative AI: The next productivity frontier*, McKinsey & Company, June 2023.
[2]Totals are weighted by 2022 employment in each occupation.
Source: O*NET; US Bureau of Labor Statistics; McKinsey Global Institute analysis

B. Top 15 skills for 2025

1	Analytical thinking and innovation
2	Active learning and learning strategies
3	Complex problem-solving
4	Critical thinking and analysis
5	Creativity, originality and initiative
6	Leadership and social influence
7	Technology use, monitoring and control
8	Technology design and programming
9	Resilience, stress tolerance and flexibility
10	Reasoning, problem-solving and ideation
11	Emotional intelligence
12	Troubleshooting and user experience
13	Service orientation
14	Systems analysis and evaluation
15	Persuasion and negotiation

Source

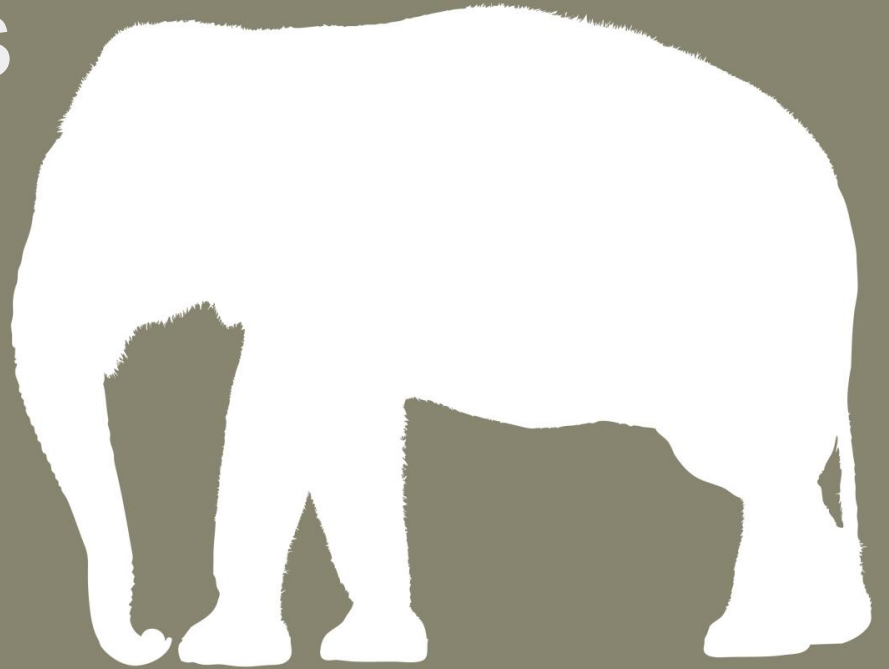Future of Jobs Survey 2020, World Economic Forum.

Epistemic Crises
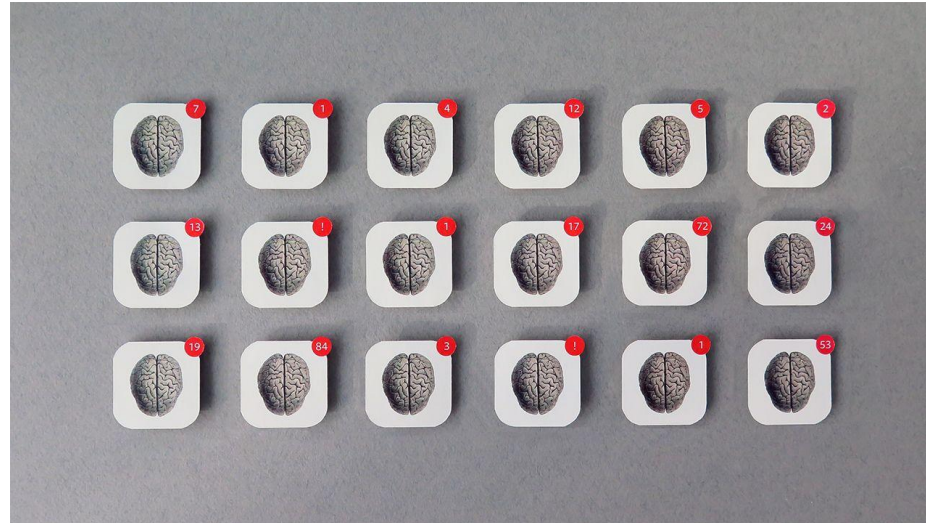
Epistemic Agency

"Epistemic agents should think of themselves as, and act as, legislating members of a realm of epistemic ends: they make the rules, devise the methods, and set the standards that bind them" (Elgin, 2013, p. 135).

With AI becoming more 'agentic', is human agency endangered?

From AI to IA, i.e. intelligence augmentation

looking for reconfigurations of
human-technology partnerships

H → H-LAM/T

Language Artifact Methodology Training

To improve human capabilities, we improve **the system** in which a human operates.
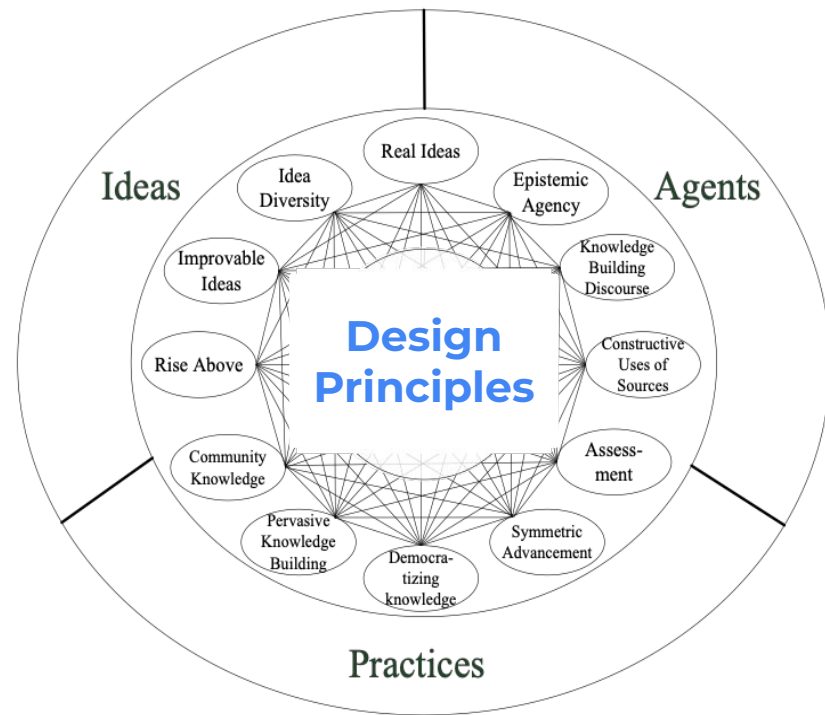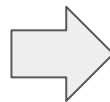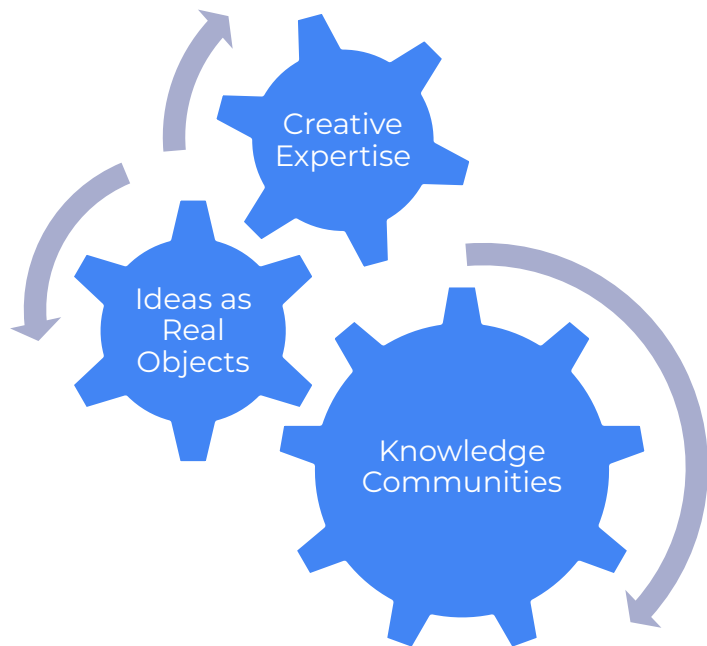
(Engelbart, 1962)

How to enhance human epistemic agency when designing systems for learning?

Knowledge Building

"is an attempt to refashion education in a fundamental way, so that it becomes a coherent effort to initiate students into a knowledge creating culture."

— Scardamalia & Bereiter, 2003

Creative Expertise

Ideas as Real Objects

Knowledge Communities

(Chen & Hong, 2016, in *Educational Psychologist*)

Ideas

Agents

Real Ideas

Idea Diversity

Epistemic Agency

Improvable Ideas

Knowledge Building Discourse

Rise Above

Constructive Uses of Sources

Design Principles

Community Knowledge

Assess-ment

Pervasive Knowledge Building

Symmetric Advancement

Democra-tizing knowledge

Practices

Tool design
Pedagogical support
Discursive practices

Knowledge Forum

Three Studies

(with a focus on design)

- Promisingness judgments (2015)
- Criss-crossing idea landscapes (2020)
- Collaborating with generative AI (2023)

#1. Promisingness Judgments

Promisingness Judgments

To decide what's worth pursuing for a community

A significant challenge in any creative processes

(Dunbar, 1995; Gardner, 1994)

An essential aspect of expertise

(Bereiter & Scardamalia, 1993; de Groot, 1978)

Creative individuals internalize the field's criteria of judgement to the extent that they have the ability to separate bad ideas from good ones, so that they don't waste much time exploring blind alleys.

— Mihaly Csikszentmihalyi, 2009

Creativity: Flow and the psychology of discovery and invention

"What we understand about expertise in general would suggest if there is an explanation of creative expertise it should lie in what creative experts know that noncreative experts do not know. In a word, creative experts can recognize *promisingness*."

— Bereiter & Scardamalia, 1993, p. 135

Surpassing Ourselves

AN INQUIRY INTO THE NATURE AND IMPLICATIONS OF EXPERTISE

Carl Bereiter
Marlene Scardamalia
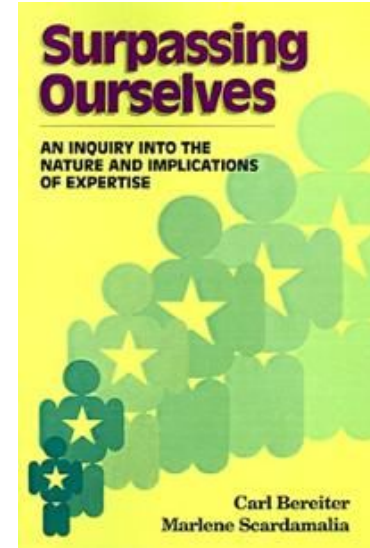
Identifying promising ideas in Grade 3

A "promising idea" ... could that idea improve? Could that idea get better?

Technological design:
- The Promising Ideas tool

Pedagogical design: Iterative cycles of collective
- promisingness judgment,
- choice making, and
- theory building

(Chen, Scardamalia, & Bereiter, 2015, *ijCSCL*)

Identifying promising ideas in Grade 3
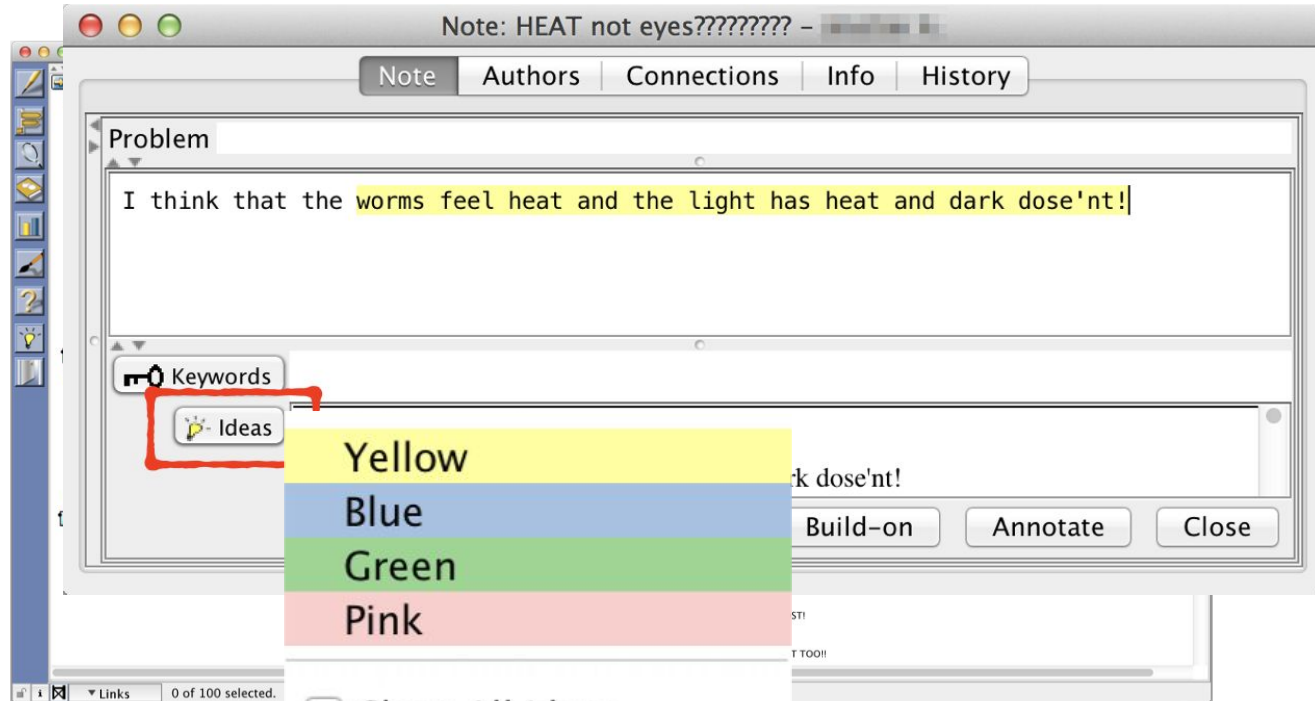
Chen, B., Scardamalia, M., & Bereiter, C. (2015). Advancing ... ...h judgments of promising ideas. *International Journal of Computer-Supported Collaborative Le...*... ...org/10.1007/s11412-015-9225-z

Identifying promising ideas in Grade 3

Chen, B., Scardamalia, M., & Bereiter, C. (2015). Advancing knowledge building discourse through judgments of promising ideas. *International Journal of Computer-Supported Collaborative Learning, 10*(4), 345–366. https://doi.org/10.1007/s11412-015-9225-z
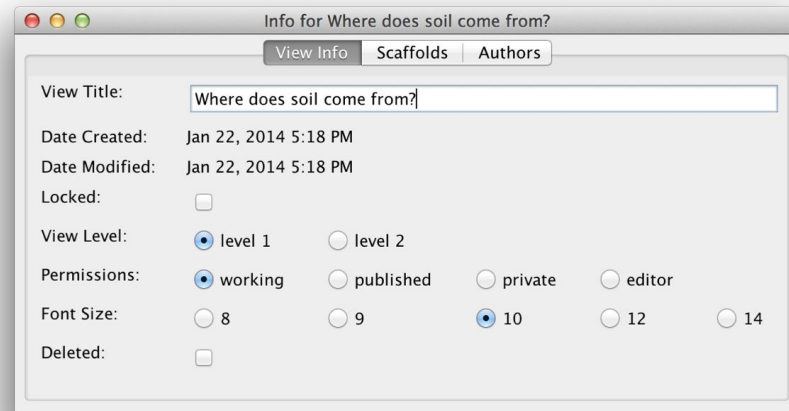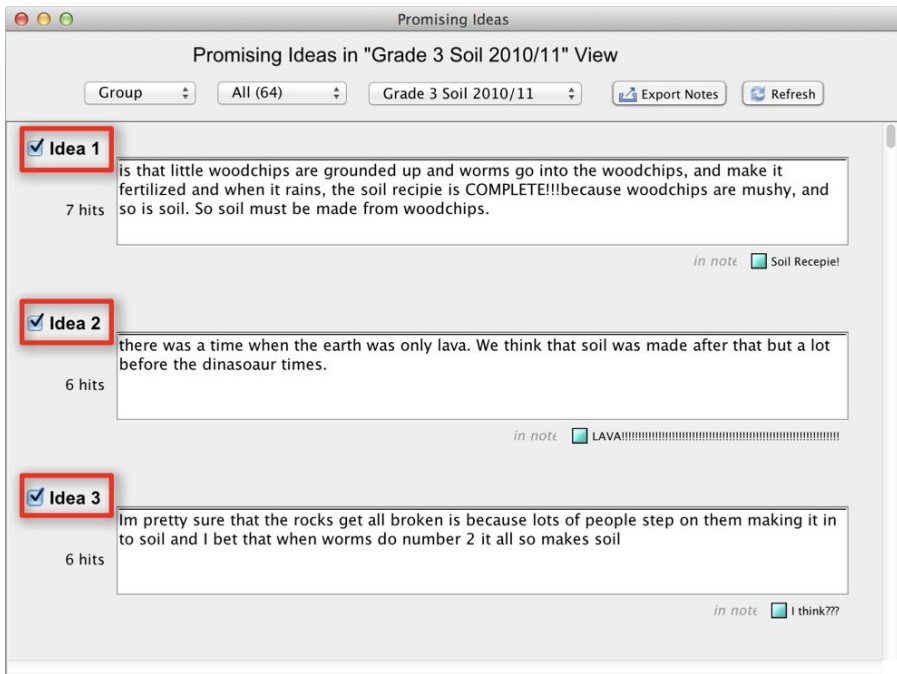
Identifying promising ideas in Grade 3

Q1: Intuitive understanding of promisingness

Constructs	Examples
Factual	• "An idea that is not incorrect." • "You promise that it is right."
High-probability of being right	• "An idea that is probably right." • "An idea that might work." • "90 % sure to be right"
Knowledge building potential	• "An idea you can spend time on." • "A question you need to know."

Chen, B., Scardamalia, M., & Bereiter, C. (2015). Advancing knowledge building discourse through judgments of promising ideas. *International Journal of Computer-Supported Collaborative Learning, 10*(4), 345–366. https://doi.org/10.1007/s11412-015-9225-z

Identifying promising ideas in Grade 3

Q2: Influence on knowledge-building discourse

Phase 1   Phase 2
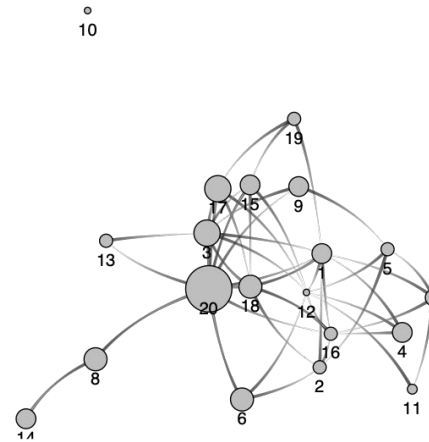
Chen, B., Scardamalia, M., & Bereiter, C. (2015). Advancing knowledge building discourse through judgments of promising ideas. *International Journal of Computer-Supported Collaborative Learning, 10*(4), 345–366. https://doi.org/10.1007/s11412-015-9225-z
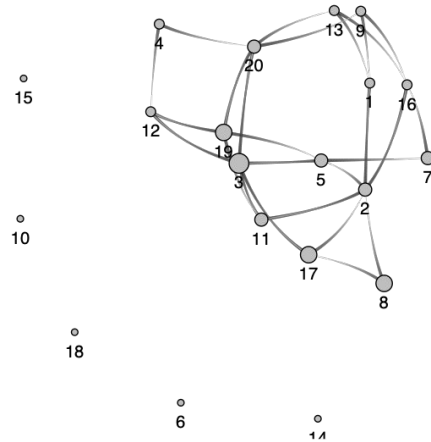
Identifying promising ideas in Grade 3

Q2: Influence on knowledge-building discourse

Chen, B., Scardamalia, M., & Bereiter, C. (2015). Advancing knowledge building discourse through judgments of promising ideas. *International Journal of Computer-Supported Collaborative Learning, 10*(4), 345–366. https://doi.org/10.1007/s11412-015-9225-z

Identifying promising ideas in Grade 3

Q3: Knowledge advancement in the community

Chen, B., Scardamalia, M., & Bereiter, C. (2015). Advancing knowledge building discourse through judgments of promising ideas. *International Journal of Computer-Supported Collaborative Learning, 10*(4), 345–366. https://doi.org/10.1007/s11412-015-9225-z
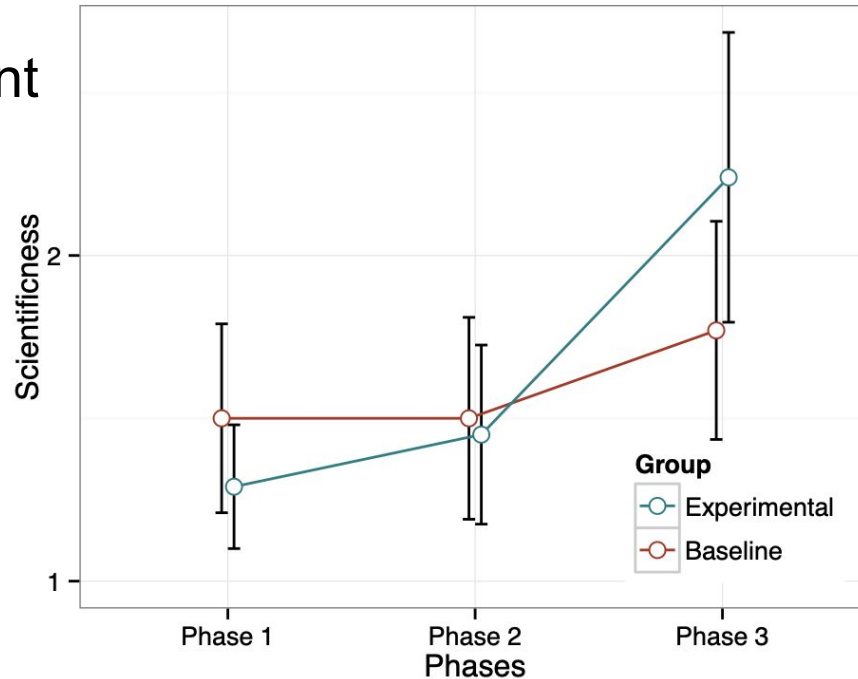
Key takeaways

- With proper supports, young students could develop intuitive understanding of promisingness and make fruitful promisingness judgments
- Promisingness judgments could facilitate community dialogues and idea improvement

2. Criss-crossing Idea Landscapes

Are students able to navigate complex idea landscapes when building knowledge for public good?
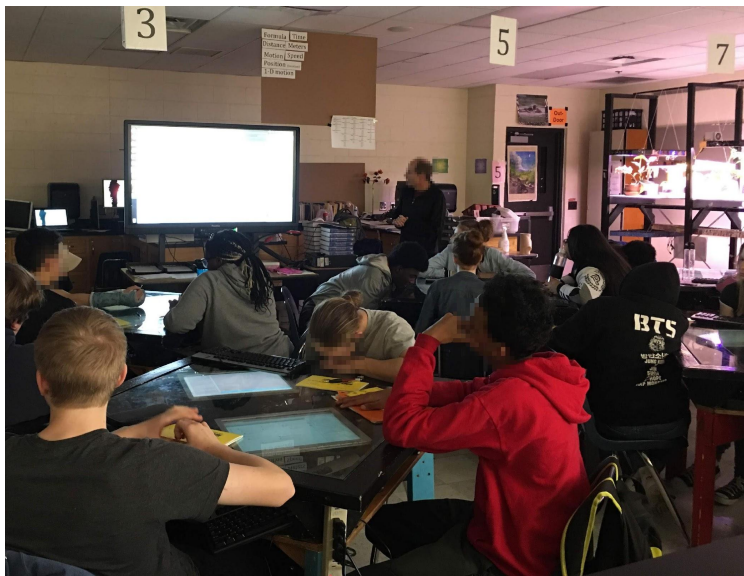
Feb. 7, 2019

GREEN
NEW DEAL

Research-Practice Partnership
since 2015

Criss-crossing idea landscapes in Grade 9

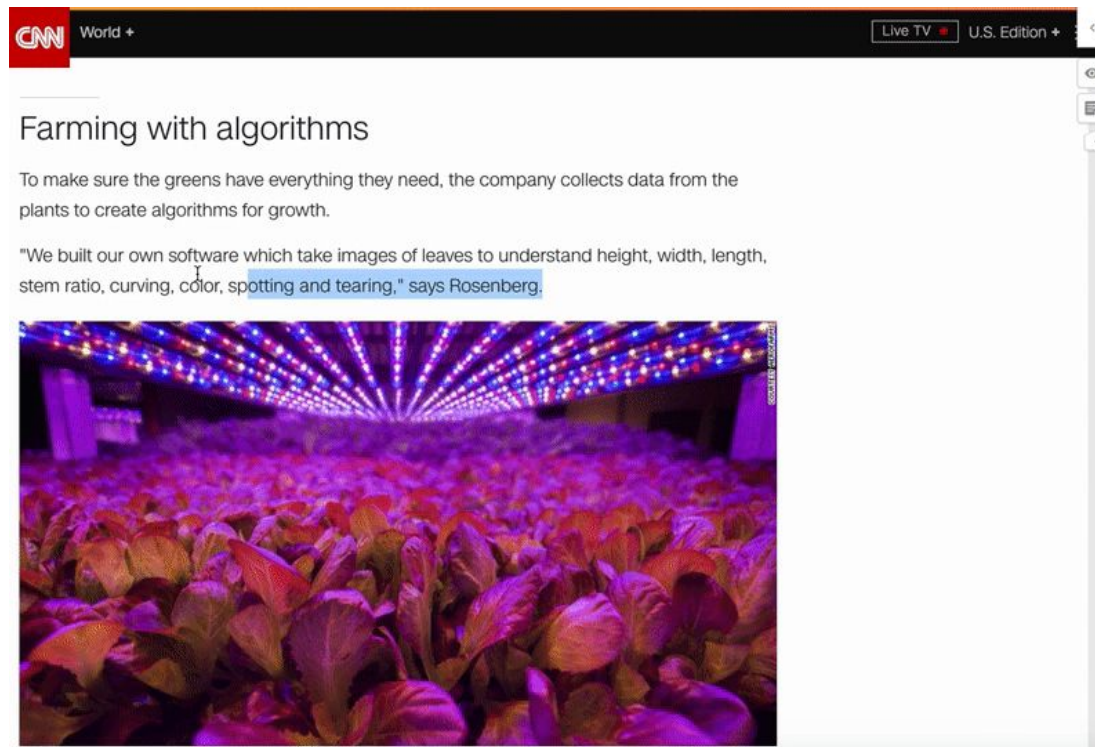**Technological design**

- The IdeaMagnets tool

Pedagogical design

- Problem finding around a "big issue" (e.g., the Green New Deal)
- Problem-centered sensemaking of public discourse
- Theory building with public sources

(Chen, Chang, & Groos, 2020)

Software features

1. **Annotate public discourse using Hypothesis**

Software features

2. **Incorporate annotations in theory building**

Pedagogical design

1. Problem finding around a "big issue" (e.g., the *Green New Deal*)

2. Problem-centered sensemaking of public discourse

3. Theory building with public sources
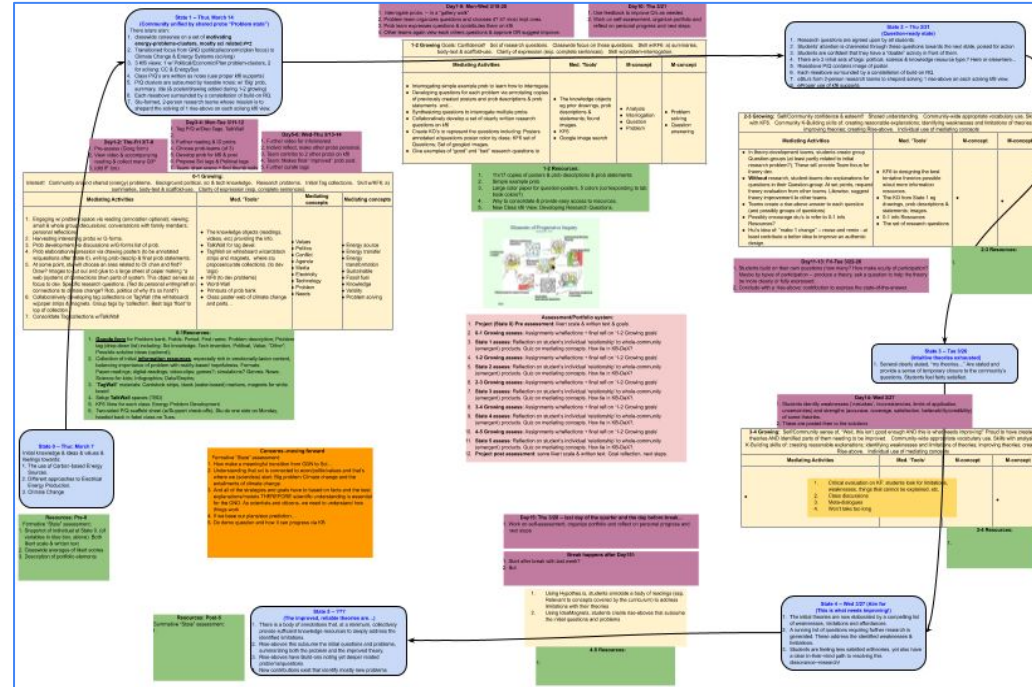
Task & participation structures
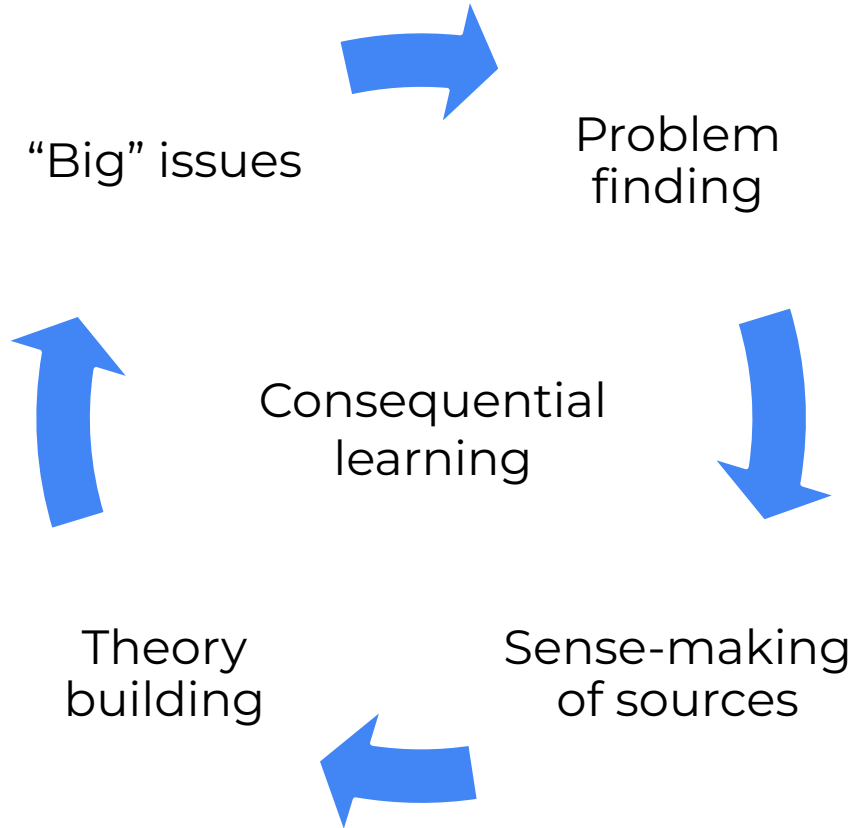
Classroom Intervention

Phase 2

Phase 1

- Elements (Chem.)
- Mining

- Energy (Phys. Sci.)
- Green New Deal
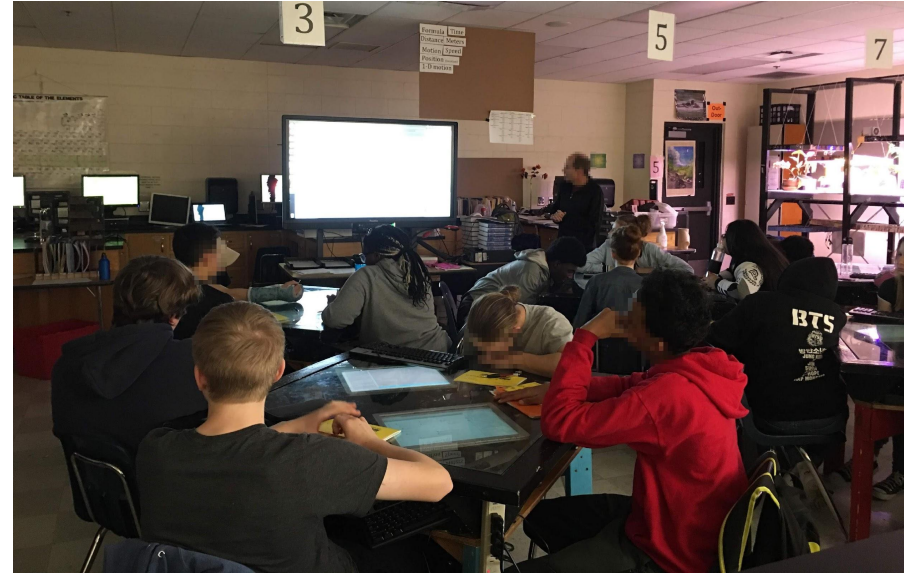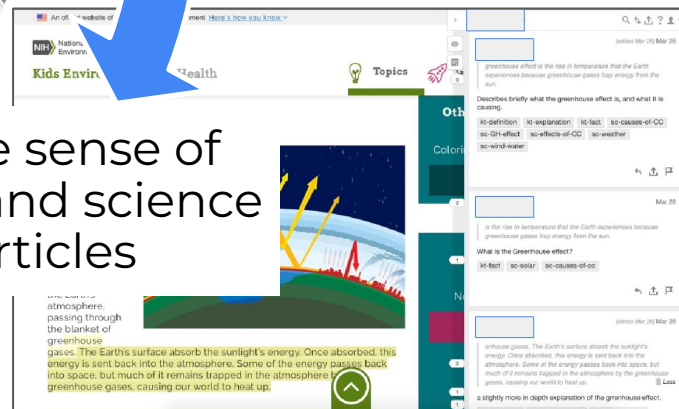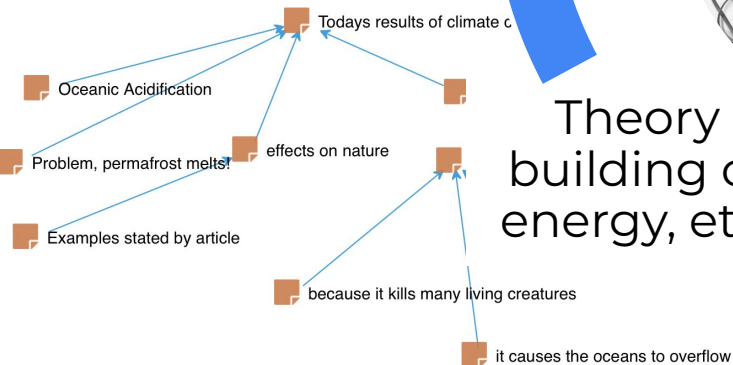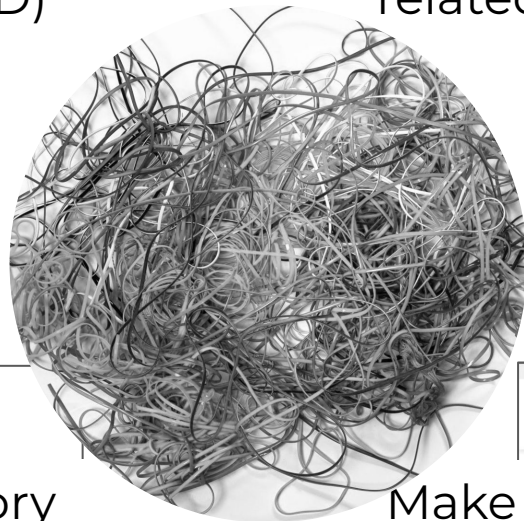
Are students able to navigate complex idea landscapes?

Data sources

- Knowledge Forum logs
- Hypothesis logs
- Student e-portfolios
- Artifact-based group interviews

Data analyses

- Statistical analysis
- Quantitative content analysis
- Grounded theory

Secondary: How did two phases compare?

Summary of discussion activities

	Web annotations			Knowledge Forum notes			
	Total	M (SD)	URLs	Total	M (SD)	Replies	Citations
Phase 1	81	5.4 (3.7)	25	85	3.7 (3.4)	45	21
Phase 2	167	8.0 (8.4)	67	130	6.8 (6.0)	85	24

A bird-eye view of discussion activities
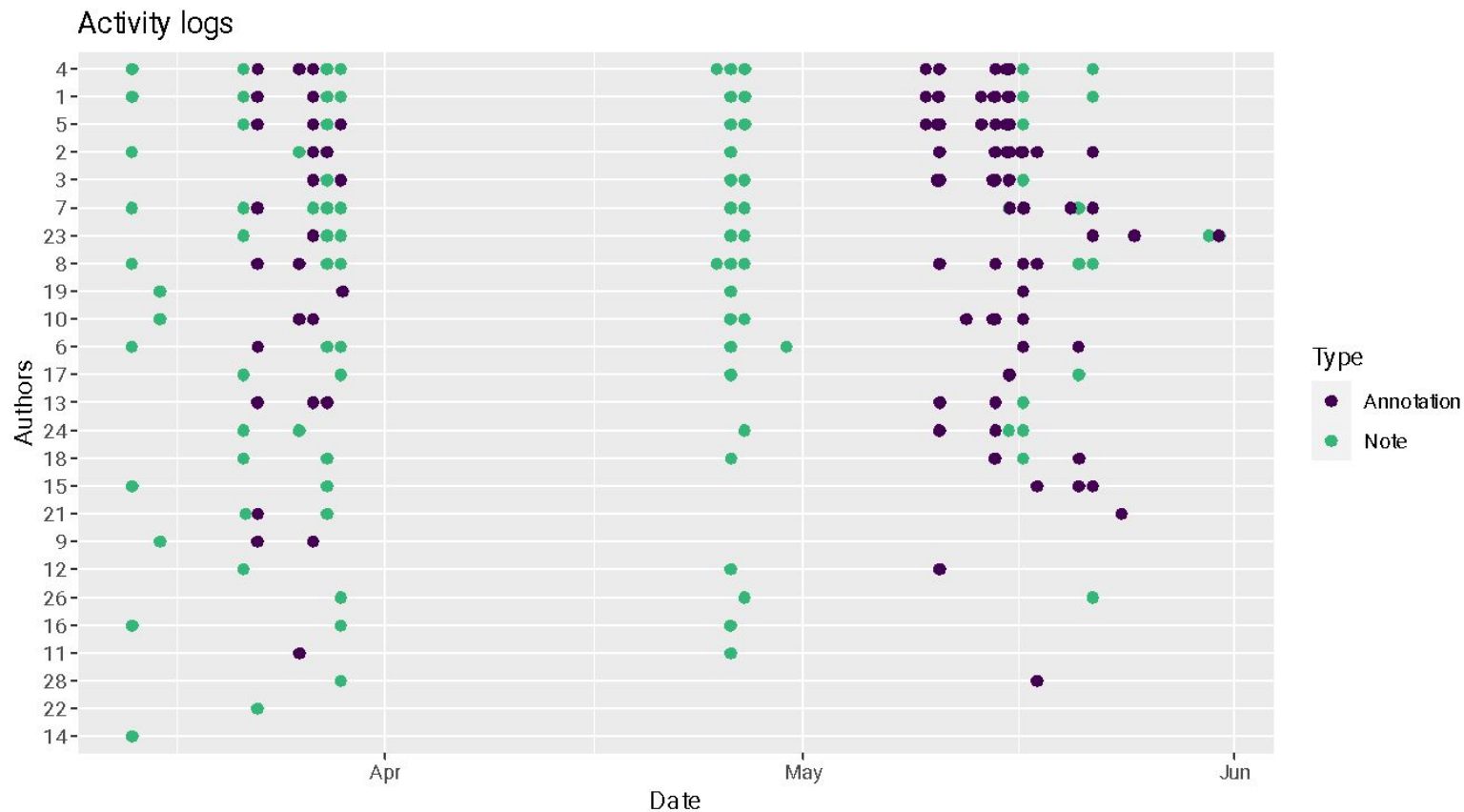
A bird-eye view of discussion activities

Activity logs -- with build-on links
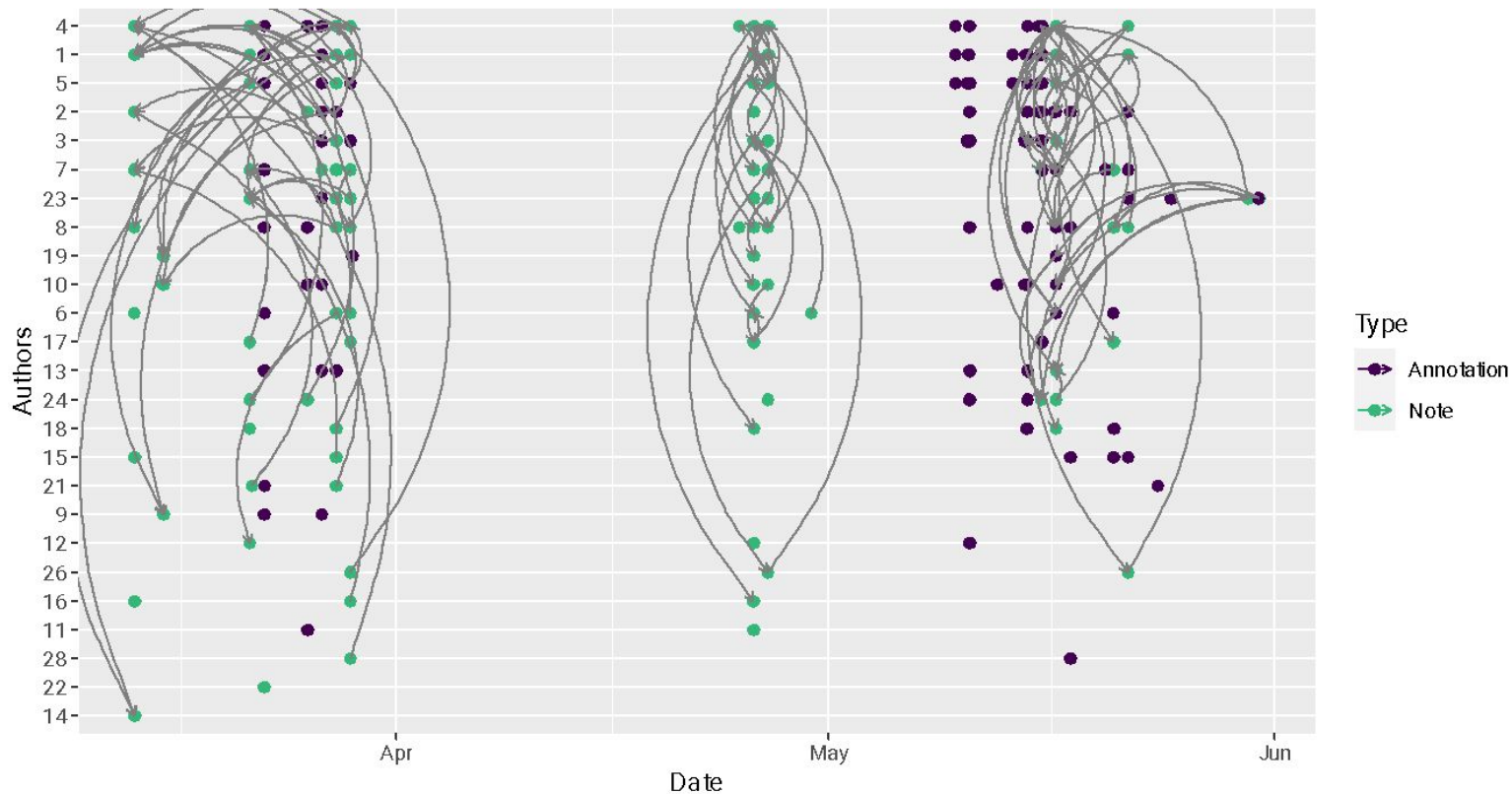
A bird-eye view of discussion activities

Activity logs -- with citation links
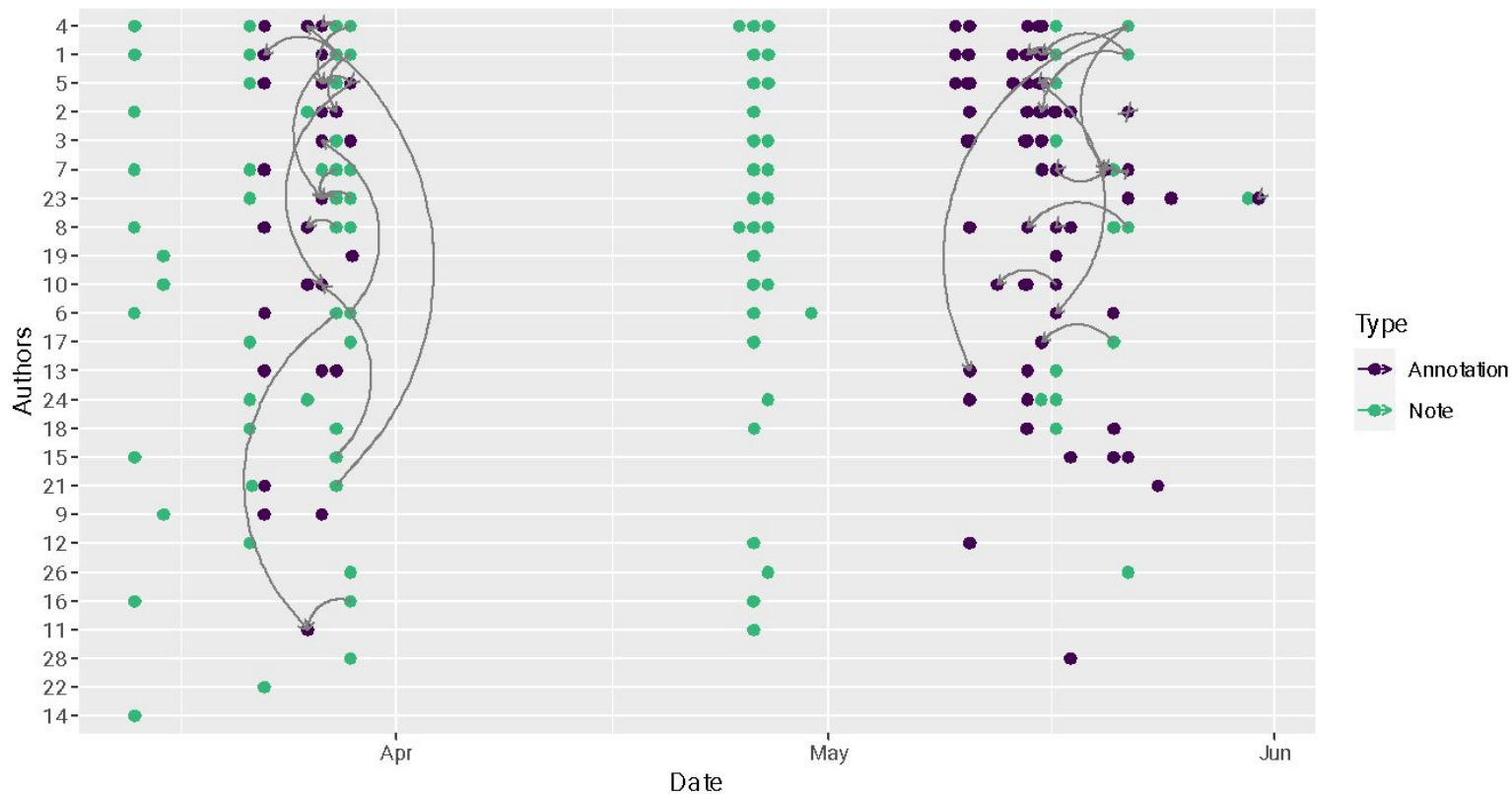
In what ways did students engage with public discourse?

Spontaneous epistemic thinking
(Barzilai & Zohar, 2016; Chinn et al., 2021)

Considering justification of claims — EC2
Noting consistency of claims — EC3
Examining source properties — EC4
Epistemic curiosity — EME1
Epistemic surprise — EME2
Planning information gathering — EMS1
Consistency with prior knowledge — EMS3
Monitoring personal certainty — EMS4
Evaluating changes to knowledge — EMS5
Noting implications of claims — EMS6
No evidence of epistemic thinking — None

Relative frequencies
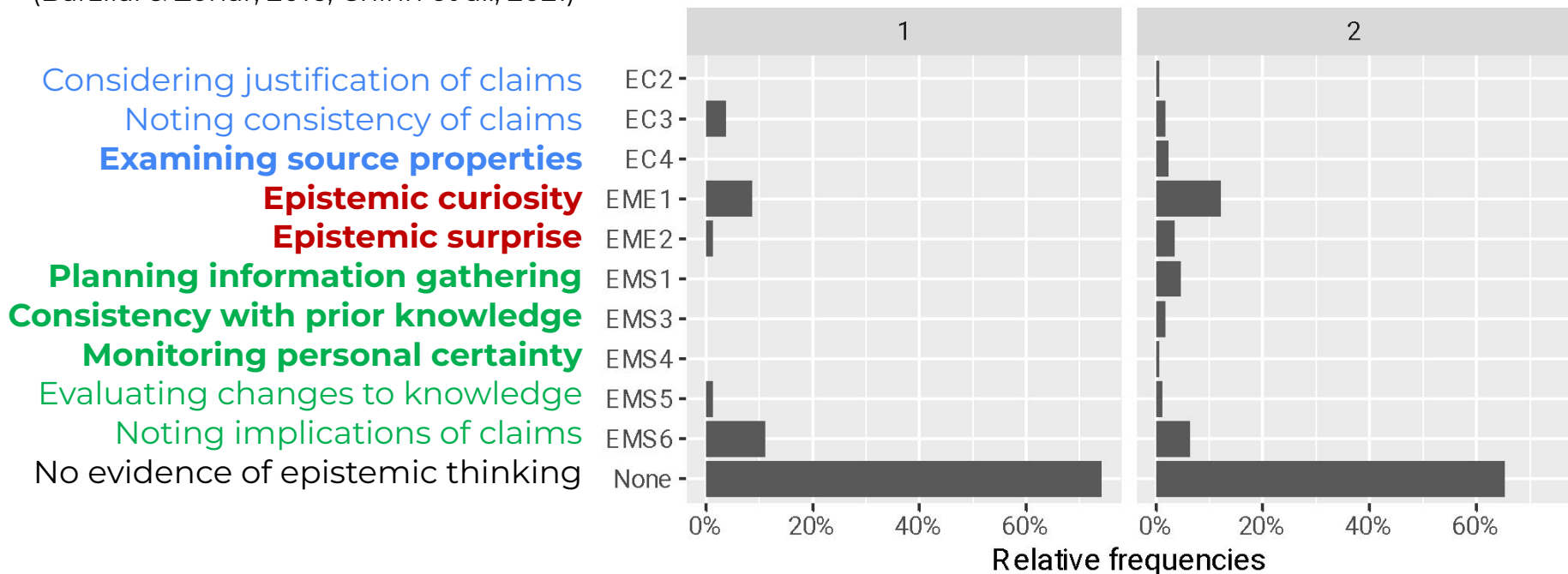
In what ways did students engage in theory building with public sources?

Theory building moves
(Lin & Chan, 2018)

Initiates with fact-seeking question
Initiates with explanation-seeking question
Provides general and intuitive reasons
Constructs elaborated explanations
Introduces superficial questions or information
Introduces deepening questions or information
Disagrees or refutes
Irrelevant or off-task notes
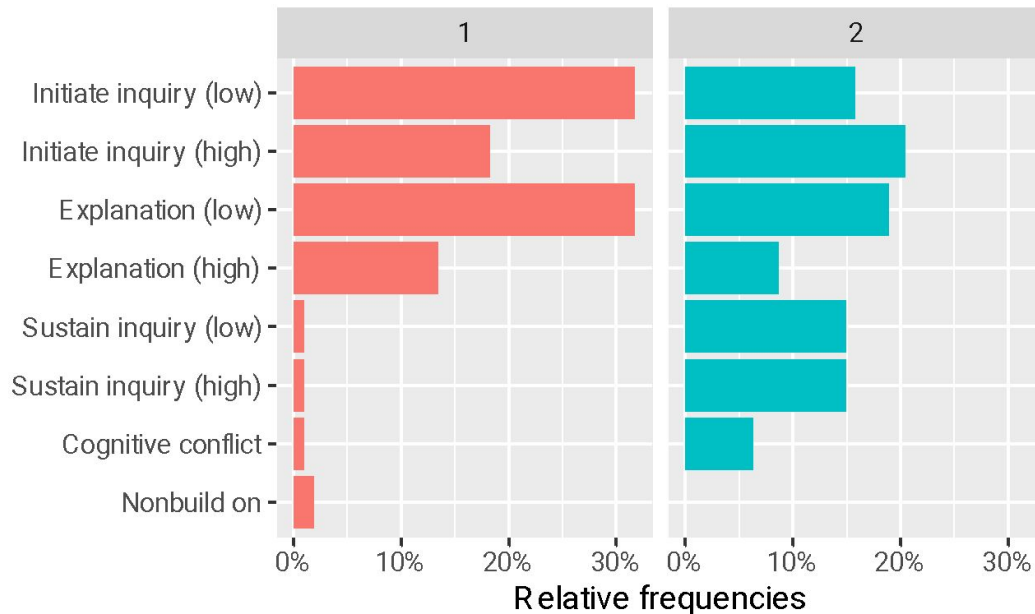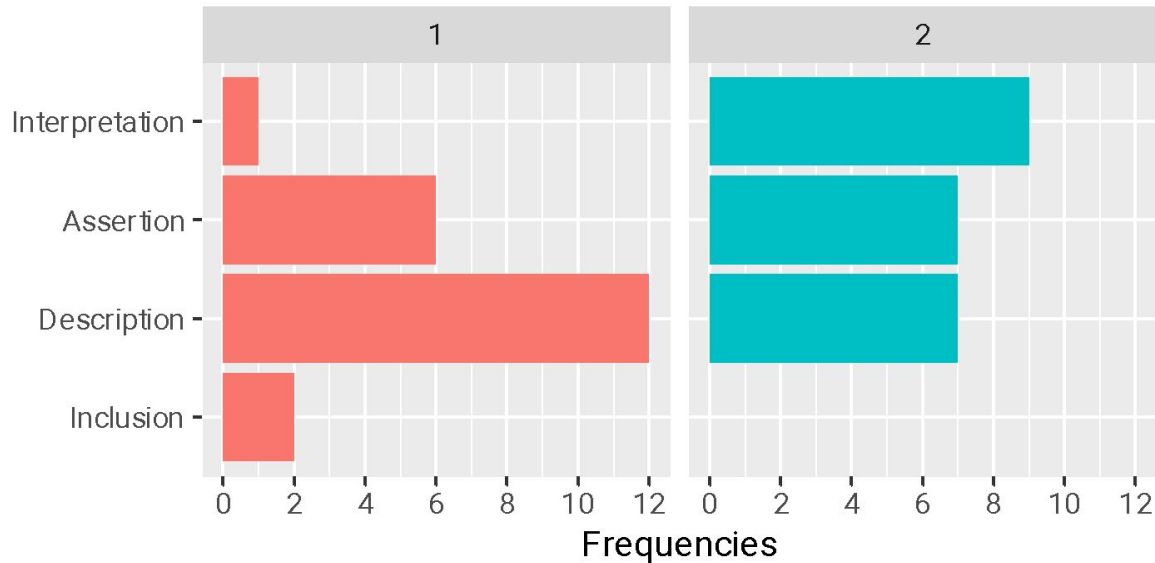
In what ways did students engage in theory building with public sources?

Why do greenhouse gases warm the planet?

Complex molecular structures

Why do greenhouse gases warm the planet?

Explanation (low)

My (source-based) theory... (source is) - Greenhouse gases absorb heat because their structures are more complicated than most gas molecules. -

Assertion

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Original Page

Why do greenhouse gases absorb heat? Greenhouse gases are more complex than other gas molecules in

This is a basic explaination about why green house gases absorb heat.

Epi. Metacog. Skills:
Noting implications

In what ways did students engage in theory building with public sources?

What is renewable energy?

answer to renewable energy

Energy we can't run out of

we need BOTH green and renewable
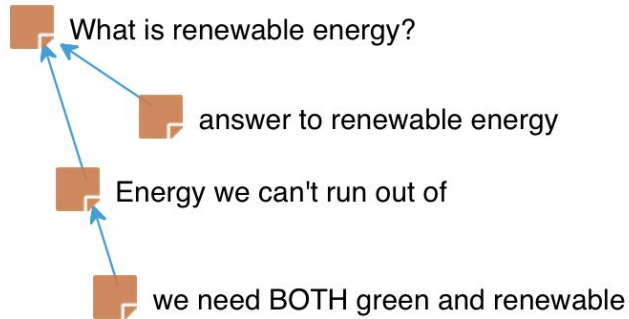
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In what ways did students engage in theory building with public sources?

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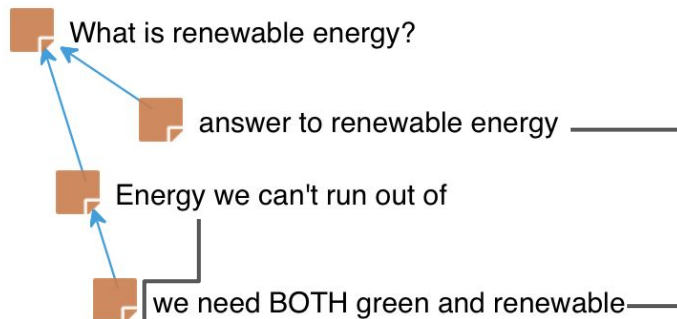
My (source-based) theory… (source is) - my thought renewable energy is a different and reliable way energy is made and used. its good for the earth's health and the atmosphere.
-

Explanation (low)

Description

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reliable sources of renewable energy like solar and wind. Unlike fossil fuels, renewables don't add greenhouse

Renewable energy is energy that does not consume any kind of fuel that we could reasonably expect to run out of at some point. We are not gonna run out of wind and sun, but we could totally run out of oil and coal. Thats the difference.

I suppose you could argue that all energy is non-renewable by definition, given the nature of energy, but the difference is orders of magnitude. It would take billions of years for the sun to run out. It could take just a few short decades to run out of fossil fuels.

Explanation (low)

The ideas of environmentally friendly energy and renewable energy are no the same thing. You can have environmentally friendly, non renewable energy, and you can have renewable energy that is terrible for the environment. There is a lot of overlap but they're different ideas.

Cognitive conflict

In what ways did students engage in theory building with public sources?

Improve Refining in Baotou, Mongolia?
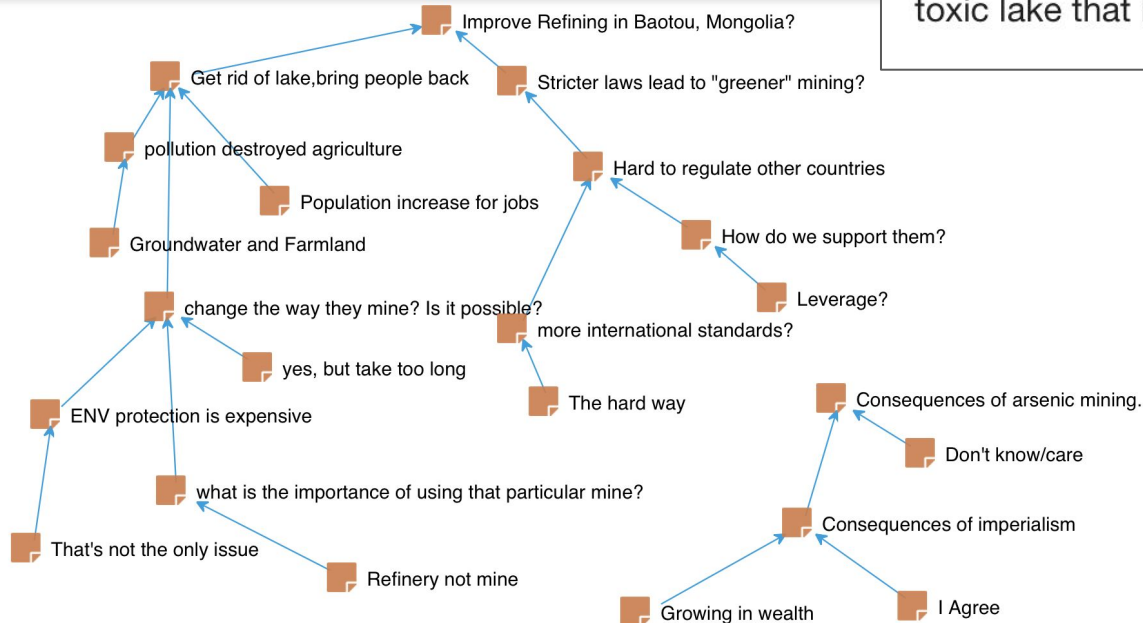
How can we (I need a method to)... - Improve refining in Boatou, Mongolia, so it doesn't result in a toxic lake that hurts farming and the local community.-

Improve Refining in Baotou, Mongolia?

Get rid of lake,bring people back

Stricter laws lead to "greener" mining?

pollution destroyed agriculture

Population increase for jobs

Hard to regulate other countries

Groundwater and Farmland

How do we support them?

change the way they mine? Is it possible?

Leverage?

yes, but take too long

more international standards?

ENV protection is expensive

The hard way

Consequences of arsenic mining.

what is the importance of using that particular mine?

Don't know/care

That's not the only issue

Consequences of imperialism

Refinery not mine

Growing in wealth

I Agree

In what ways did students engage in theory building with public sources?

Improve Refining in Baotou, Mongolia?

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Don't know/care

Refinery not mine

Consequences of imperialism

Growing in wealth

I Agree

It is hard to get anything we say here to affect people in other countries where this is happening. We already have laws keeping this stuff from happening here, it just doesn't affect anybody other places.

How can we (I need a method to)... - give our support to the people in countriwes with less mining restiction? What can we do to support their needs, whatever that may be? -

In what ways was consequentiality reflected in student knowledge building?

Consequentiality of learning
(Hall & Jurow, 2015; Birmingham et al., 2017; Philip & Sengupta, 2021)

- Relate to self
- Care for people, communities, society, and nature
- Critique practices in society
- Look for actions and solutions

> You may not have heard of Baotou, but the mines and factories here help to keep our modern lives ticking. It is one of the world's biggest suppliers of "rare earth" minerals.

Mining is killing the environment and community in Baotou, yet modern society justifies this by being supplied their "essential" technology.

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> In general, mining techniques become much more environmentally sensitive when efficiency is improved because less waste is produced. However, even greater

green mining techniques exist, but require extreme mine efficiency, causing less waste.

The types of mines can affects how "green" it is, but the bottom line is that efficiency is the important part in making a ming "greener." Efficiency = a better mine for the environment.

My theory... - Capitalism/imperialism is all about the growth of wealth, not about the protection of human rights and human lives. -

Key takeaways

- Growing epistemic thinking
- Increasingly sophisticated rhetorical references to sources
- More advanced theory building moves
- Students criss-crossed complex information landscape while reasoning about socio-scientific issues

3. Collaborating with generative AI in knowledge building

Chen, B., Zhu, X., & Díaz del Castillo H., F. (2023). Integrating generative AI in knowledge building. *Computers and Education: Artificial Intelligence, 5*, 100184. https://doi.org/10.1016/j.caeai.2023.100184

Goals:

- Augmenting student creative work with ChatGPT

- Facilitating students' AI literacy

- Seeking to redesign knowledge building environments

Context:

- A high-school class about World Religions course

- One teacher (Mr. F) and 10 high school students from Bogota, Colombia

- Students were expected to examine various religions in the world and develop religious literacy

Design

- **Co-design partnership between the teacher and researchers**

- **Situate ChatGPT in Knowledge-Creating Dialogue Moves:**
  - Problem definition
  - New ideas
  - Promisingness evaluation
  - Meta-dialogue
  - Comparison
  - Critical discourse
  - Higher-level ideas

  (Bereiter & Scardamalia, 2017)

Two phases of using ChatGPT in the class:

- Exploring the problem space (Pattern 1)
- Generating knowledge for the final essay through collaborative discourse (Pattern 2)

Design Pattern 1
Student   ChatGPT

Knowledge-Creating Dialogue Moves

Problem definition

New ideas

Promisingness evaluation

Meta-dialogue

Comparison

Critical discourse

Higher-level ideas

Design Pattern 2
Student   ChatGPT
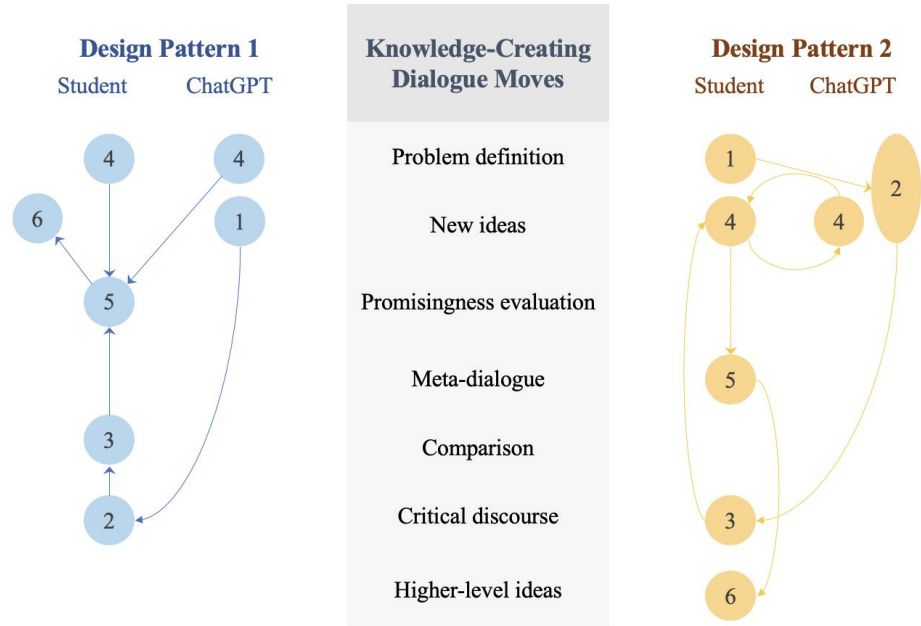
Note. Numbers indicate the steps within each design pattern.

The Use of ChatGPT in Class:

- The goal was "to support learning and knowledge creation" - quote from the syllabus
- The teacher dedicated class time to introducing, discussing, and tinkering with ChatGPT

Example ChatGPT Prompts Designed by Mr. F.

Mr.F used ChatGPT to create a sample essay for the students to read and reflect on	Mr. F invited students to converse with ChatGPT with a steering prompt
Essay Generation Prompt (Mr. F. gave ChatGPT 3.5 the same prompt he gave the students, without any tailoring for the A.I.) Write a brief essay that is no more than 600 words long including titles and inline references, but not the bibliography. Your essay should address the following issues based on the readings and discussions we have had in class so far, and it must include complete in-line and bibliographic references to the authoritative sources. You must include the readings addressed in class along with any other sources you use. The sources are: … Key questions and issues to address in your essay: What is religion (and what is not)? What are the big ideas of religion (those topics or key areas that many religions have in common and we would to address to understand them)? What are some key questions about these big ideas that you are most interested in? As with any paper, yours should include a title, introduction, body, conclusion and bibliography.	Steering Prompt You are a teaching assistant in a high school-level introduction to world religions course. Students have read chapters in the book "God Is Not One" by Stephen Prothero about specific religions and they have done some independent research online. They will ask you questions to advance their understanding of class topics and their own questions. Answer following this protocol strictly: 1. Provide a brief answer in accessible language for 16-18 year olds, assuming knowledge of themes touched on by Prothero in his book. 2. Highlight disagreements or different points of view on the issue that bring nuance to the discussion. 3. Follow-up with a question that may help the learners understand nuances and complexities of the issue discussed. Are you ready for a question?

Research Questions

1. In what ways did students incorporate ChatGPT in their knowledge building?

2. To what extent was students' AI literacy enhanced, and how?

Data source

- **Primary data**: semi-structured interviews with 10 students (in groups of 2 or 4)

- **Secondary data**:
  - Student writing and artifacts generated from KF and Miro
  - Teaching planning docs and reflective journals

Data Analysis

- **Interview data**: iterative coding processing
  - Coding scheme:
    - ***Use AI in Knowledge Building***: utility, process, challenge, coping strategy
    - ***AI Literacy***: mechanism, strength, weakness, risk, societal implications, human-AI relationship

    (Bearman & Ajjawi, 2023; Laupichler et al., 2023; Long & Magerko, 2020; UNESCO, 2023)

- Leveraged secondary data to triangulate with the interview results

Results: Knowledge Building *with* ChatGPT

Utility of ChatGPT
- Information search
- Accomplishing mundane learning tasks, such as grammar check
- Supporting knowledge building especially in offering inspirations, generating new ideas, and promoting collaboration

Processes of Using ChatGPT
- Integrating ChatGPT in writing and discussion processes
- Most students imposed limits, some fully relied on it
- Navigating challenges for prompt engineering
- "Fact-check" & proper citation

Results: Students' AI Literacy

Mechanisms of ChatGPT

- All students recognized ChatGPT as an AI technology

- The majority had a rudimentary understanding

  - ChatGPT queries a database of sources in real-time
  - OpenAI developers uploaded files to the database

- A few students delved deeper: computer algorithms powering it & safeguard mechanisms put in place to filter out harmful information.

Results: Students' AI Literacy

Strengths:

- Interpreting user prompts
- Retrieving information efficiently
- Offering quick and clear responses
- Students perceived the information provided by ChatGPT to be rich and diverse, representing different "facts" that inspired them to generate new ideas
- Students appreciated how ChatGPT's responses were akin to those from a human

Weakness:

- Output quality: inaccurate or dated information, "black box"
- Limited cognitive capabilities

Results: Students' AI Literacy

Risk and Societal Implications:

- **In school:** potential abuse of AI in school settings, especially for students who might not have the opportunities to learn and understand how to use AI properly.

- **Beyond schoolwork:** Combined impact of AI and social media on their generation, such as cyber violence and misinformation

- **Bias:** ChatGPT is **not** biased because of the AI's strict role in responding solely to prompts without any feelings or opinions.

Relationship with ChatGPT:

- A valuable **tool** that greatly supported their learning processes.

- Primary source for **information**.

- Not overly depend on it and preferred to **set a limit** on their usage.

- Most students did **not fully trust** AI.

Takeaways

- Student understanding and AI literacy developed in tandem

- The use of ChatGPT made learning *harder*, instead of easier, as mindful engagement was needed

- Students took high-level responsibility in the long process

- The teacher was a co-learner of ChatGPT and played an instrumental role in guiding students' use of ChatGPT

Summary

Studies	Epistemic agency	Information sources	Technological support	Pedagogical support
Study 1 (2015)	Finding promising ideas	Student ideas	Promising Ideas tool	Iterative cycles of idea refinement
Study 2 (2020)	Traversing idea landscapes to build knowledge	Public sources	IdeaMagnets tool	Cycles of problem finding, sensemaking, theory building
Study 3 (2023)	Collaborating with GenAI	ChatGPT outputs	ChatGPT	Patterized student-AI interaction for knowledge creation

Epistemic Agency in Shifting Socio-Technical Contexts
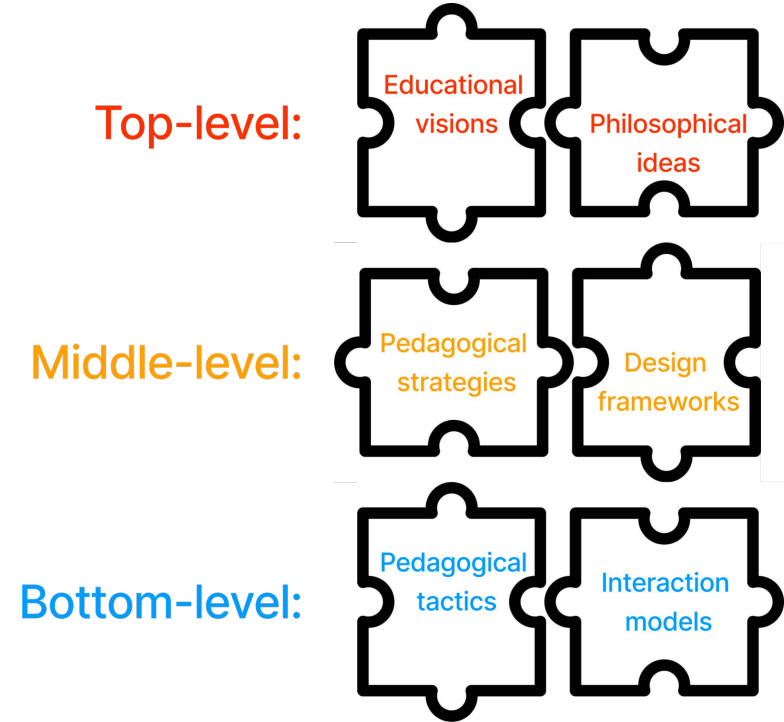
Learning analytics for epistemic agency

- How to retain human agency when designing and implementing learning analytics?
- How to move towards integrated, process-oriented analytics?
- How to come up with design trade-offs to meet various goals?

(Chen & Zhang, 2016)

- Design the right thing, design things right
  - Co-design
  - Value-sensitive design

- Teachers as "barefoot analytics developers"

Epistemic agency in the world of genAI

- The boundary between human and machine agency is more fluid than ever.

- Map out design spaces to avoid mindlessly giving up human epistemic agency (aka. epistemic hijacking)

Chen, B. (2024, June). *Towards a Design Space for AI Support in Knowledge-Building Classrooms*. OSF Preprints.

Top-level:

Educational visions

Philosophical ideas

Middle-level:

Pedagogical strategies

Design frameworks

Bottom-level:

Pedagogical tactics

Interaction models

unlock human potential via new learning **infrastructures** that respect, reinforce, and restore human epistemic agency

Thanks

Any questions?

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