Responsible Innovation in Designing AI for Education: Attending to the “How,” the “for What,” the “for Whom,” and the “with Whom” in a Rapidly Growing Field

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Growth of Investment and Interest in AI in Education

Since 2022, private sector investments have grown, market researchers expect them to grow to more than $26B by 2030.

Areas include: tutoring, lesson planning, mining student information systems for data to inform interventions

The biggest investments are focused in the area of **personalization.**

Educators Are Confronting AI as an Arrival Technology

“In contrast to adopted technologies, **“arrival technologies”** bypass the planning, assessment, policy-making, and professional learning that have historically (if imperfectly) accompanied previous generations of technology integration….

Educators Are Confronting AI as an ‘Arrival Technology’

Some prior innovations could be classified, at least partially, as arrival technologies – students brought their personal calculators to math class in the 20th century; mobile phones brought the internet into some classrooms before intentional adoption – but generative **AI represents a step change in both the velocity and nature of technology arrival.** In less than a year, nearly every internet-connected computing device suddenly had access to dramatic new capacities.

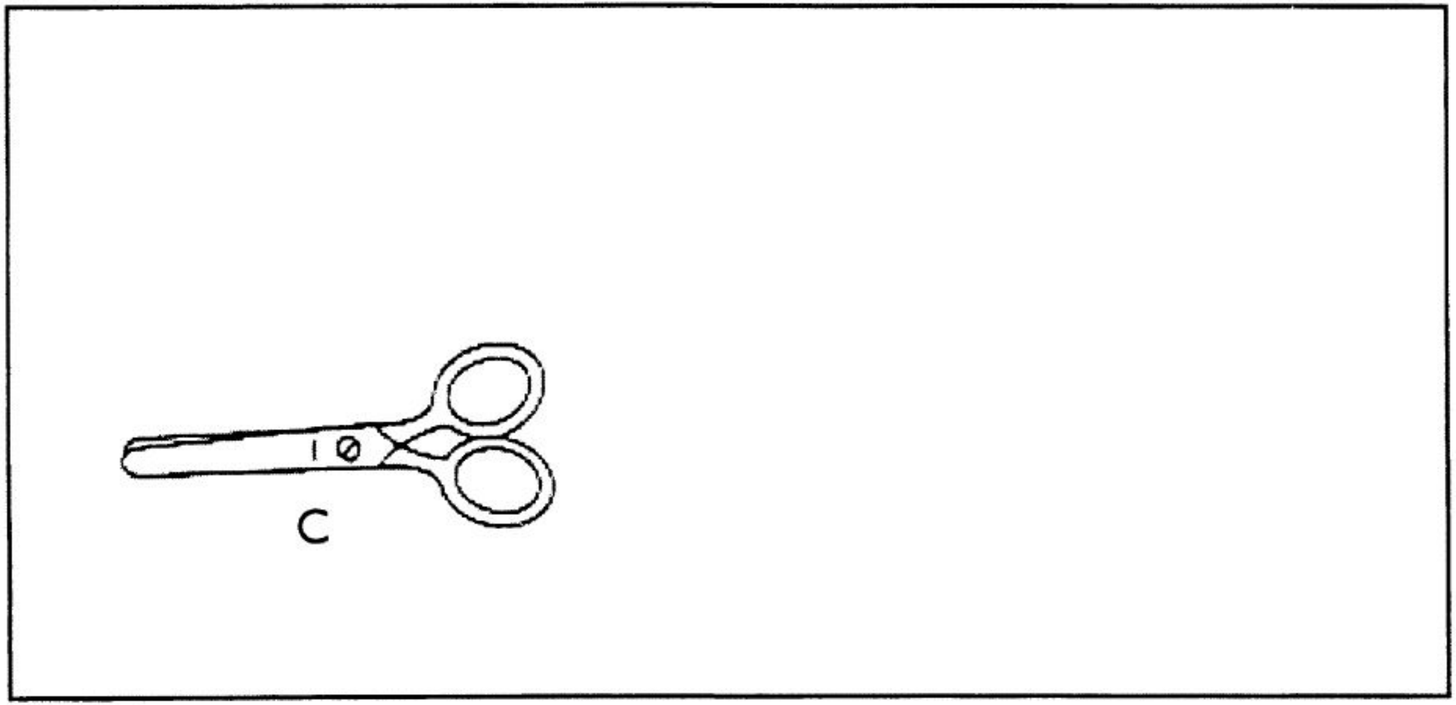
- Justin Reich

As Scholars…

Now is a critical time to ask questions about AI in education::

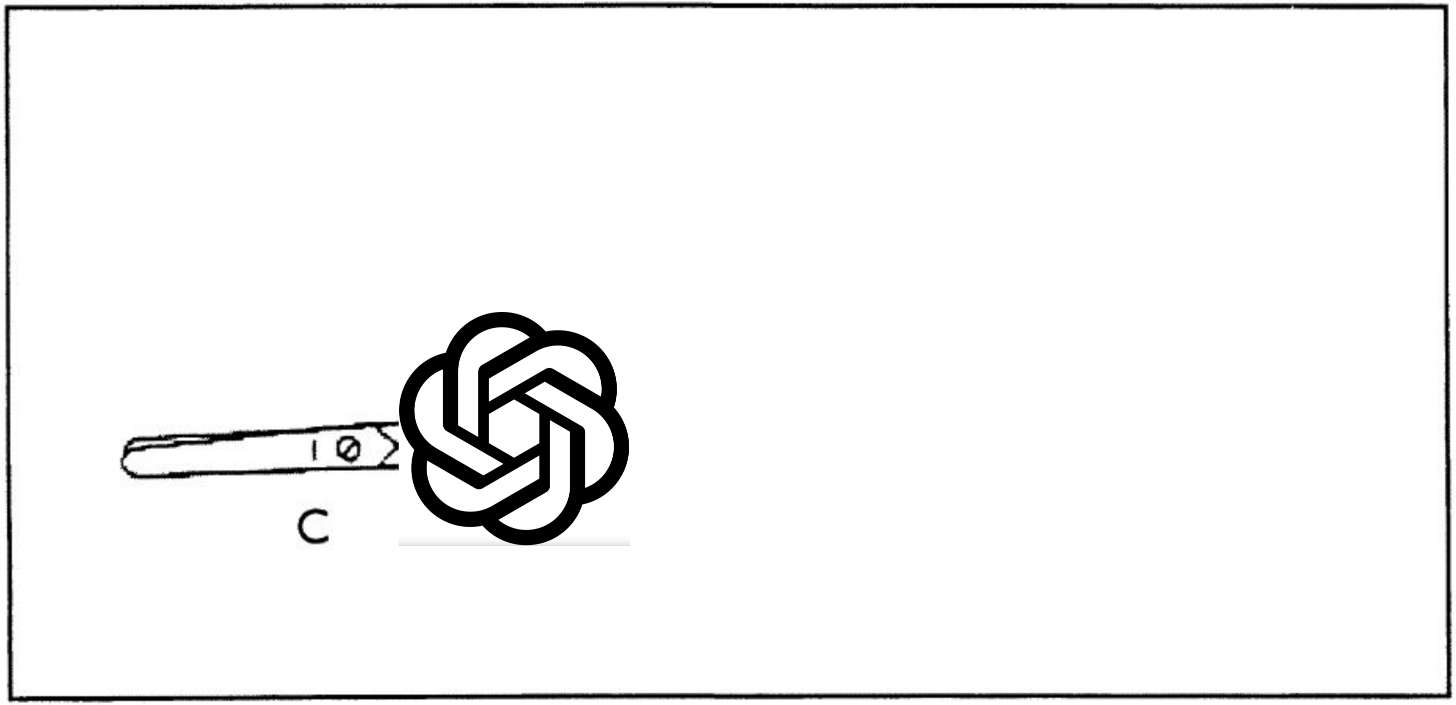
- What ought to be the **ends or goals** for AI in education?
- What **theories of learning** should inform their development?
- **Who needs to be at the table** to settle on these ends and shape the tools used in classrooms?
- **How** should **AI tools be designed**?

Presenting Contrasting Cases



Bransford & Schwartz, 1998

Presenting Contrasting Cases



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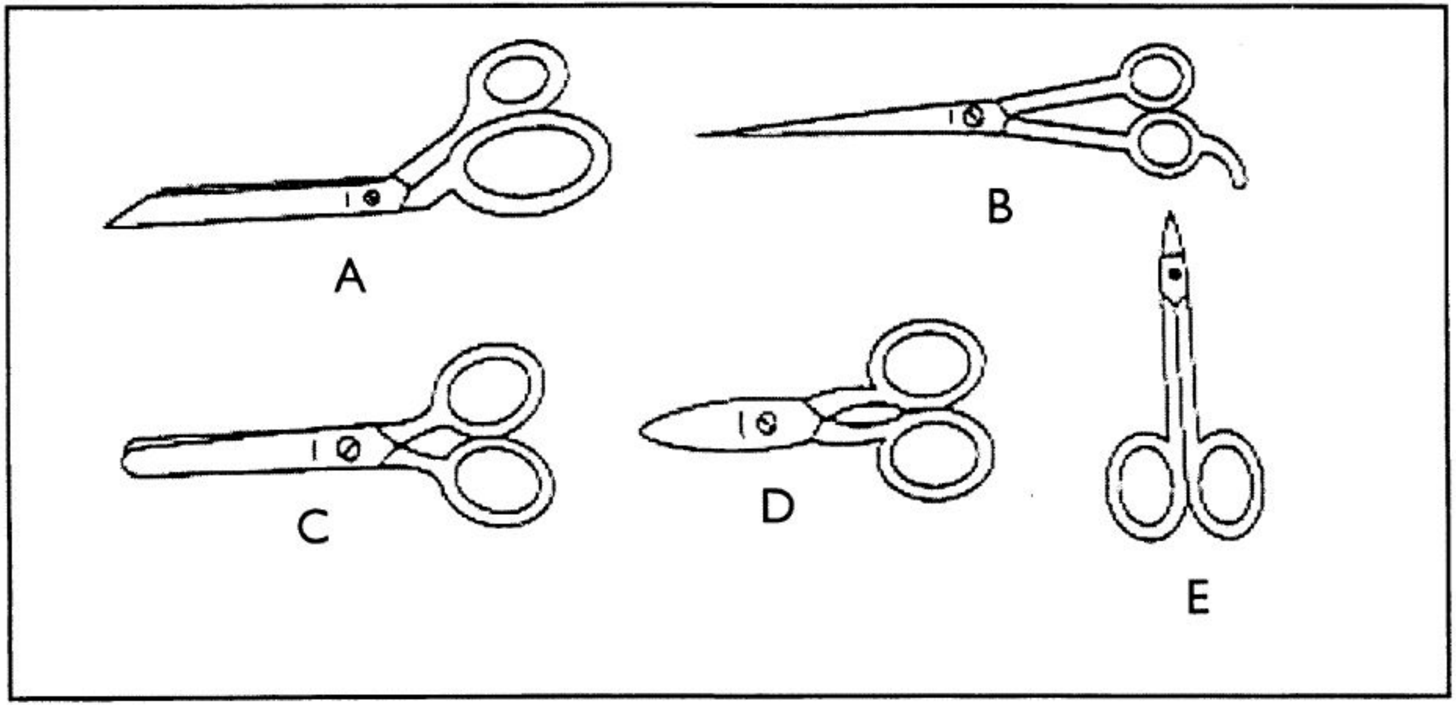
Presenting Contrasting Cases



Bransford & Schwartz, 1998

AI in Education: 50 Years of Scholarship

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INTELLIGENT TUTORING SYSTEMS

How Computers Achieve Learning Gains that Rival Human Tutors

Sidney K. D'Mello and Art Graesser

Tutor: When you turn on the computer, how is the operating system first activated and loaded into RAM? [main question]
Learner: *When the computer is turned on a file is automatically booted up.*
Tutor: Anything else? [this is a pump for more information]
Learner: *This file contains the operating system.*
Tutor: What about storage? [this is a hint]
Learner: *The operating system is then read into RAM and activated.*
Tutor: Right. The CPU executes instructions in ROM, which helps the operating system to start. [after giving positive feedback, there is an assertion]
Learner: *After being read from ROM the OS is activated.*
Tutor: Right. Let's review what we've just gone over. The operating..... [summary after positive feedback]

Consider the above excerpt of a one-on-one tutorial dialog between a student and a tutor on the topic of computer literacy. As the example illustrates, the tutor understands what the learner is saying by analyzing the conversation occurring in natural language. Not only does the tutor interpret the learner's responses in terms of the underlying discourse (e.g., identifying questions from the learner's contributions), the tutor also comprehends them with respect to the domain content (e.g., the OS is read into RAM and not vice versa). The tutor executes appropriate dialog moves to keep the conversation on track and eke out information from the learner as the two collaboratively construct a response to the main question. Perhaps what is less obvious is that each tutorial dialog is unique – the tutor keeps track of what the student knows and uses this information to make fine-grained adaptations tailored to the student. Taken together, the tutor exhibits some characteristics of intelligence.

Would you be surprised to learn that the tutor in this case is a computer (called AutoTutor) that simulates one-on-one human tutoring sessions? What if we told you that it and other intelligent tutoring systems (ITSs) produce learning gains that rival human tutors? Herein lies the promise of ITSs. One-on-one human tutoring is one of the most effective ways to promote learning (Nickow et al., 2020) and has been identified as a promising approach to alleviate pandemic-related learning loss (Stavely, 2022), but is difficult to scale (Kraft & Falken, 2021). Though they can be expensive to develop upfront, ITSs have much lower deployment cost

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Fig. 1 Children interacting with the Intelligent Science Station in the Guided-Discovery condition, where they make predictions, observe results, and provide explanations with interactive feedback from an AI system that can see the results of their experiments. Children's engagement can be seen in a supplementary video

Source: Yannier et al 2020

The Promise of Personalized Learning from ITSes

Development of Tutors Has Followed an R-to-P Model

Research-Design-Development-Use paradigm (Peurach et al., 2019):

- focused on **translating research into practice,** rather than on establishing a reciprocal relationship between research and practice
- an underlying aim is to develop and bring better research-based principles for learning to inform debates about the **means** of supporting learning (Koedinger et al., 2012)

Alternate Learning Goals We Can Draw On

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The Role of Collaboration, Computer Use, Learning Environments, and Supporting Strategies in CSCL: A Meta-Analysis

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This meta-analysis synthesizes research findings on the effects of computer-supported collaborative learning (CSCL) based on its three main elements: (1) the collaboration per se, (2) the use of computers, and (3) the use of extra learning environments or tools, or supporting strategies in CSCL. In this analysis, 425 empirical studies published between 2000 and 2016 were extracted and coded, and these generated the following findings. First, the collaboration had significant positive effects on knowledge gain (ES [effect size] = 0.42), skill acquisition (ES = 0.64), and student perceptions (ES = 0.38) in computer-based learning conditions. Second, computer use led to positive effects on knowledge gain (ES = 0.45), skill acquisition (ES = 0.53), student perceptions (ES = 0.51), group task performance (ES = 0.89), and social interaction (ES = 0.57) in collaborative learning contexts. Third, the use of extra learning environments or tools produced a medium effect for knowledge gain (ES = 0.55), and supporting strategies resulted in an ES of 0.38 for knowledge gain. Several study features were analyzed as potential moderators.

KEYWORDS: computer-supported collaborative learning, CSCL, meta-analysis, learning environment or tool, supporting strategy

Group awareness tools are intended to help students monitor and/or coordinate collaborative activities.

Cognitive: Provide information about other members’ knowledge

Social: Provide information who is contributing and how people are interacting

Flourishing as a Goal for Learning with AI

A vision centered on *collaborative flourishing* focuses on supporting learning how to co-construct knowledge using disciplinary practices and 21st century skills across domains (D'Mello et al., 2024).

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SPECIAL TOPIC ARTICLE

From learning optimization to learner flourishing: Reimagining AI in Education at the Institute for Student-AI Teaming (iSAT)

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Flourishing as a Goal for Learning with AI

A way of **living together**, "of being and doing, of realizing one's potential and helping others to do the same…of living with integrity even in challenging circumstances" (Su, 2021, p. 10)

It is **collective**, not individual, and depends in part on the circumstances where we find ourselves (Willen et al., 2022).

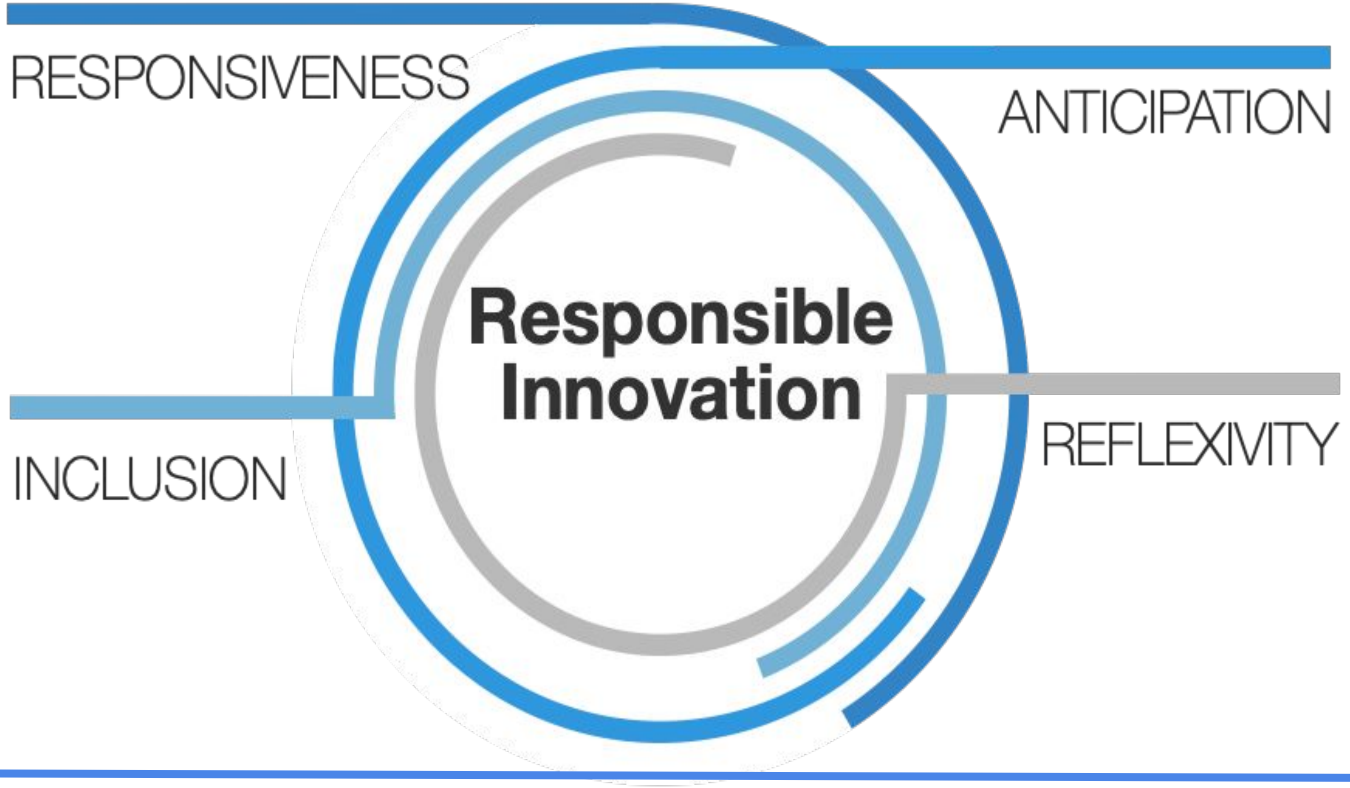
Alternate Approaches to Design

Participatory design (Ehn, 1992; Muller & Kuhn, 1993; Bang & Vossoughi, 2016)

- Design charrettes
- Prototyping
- Rapid testing and refinement

Research-practice partnerships (Farrell et al., 2021)

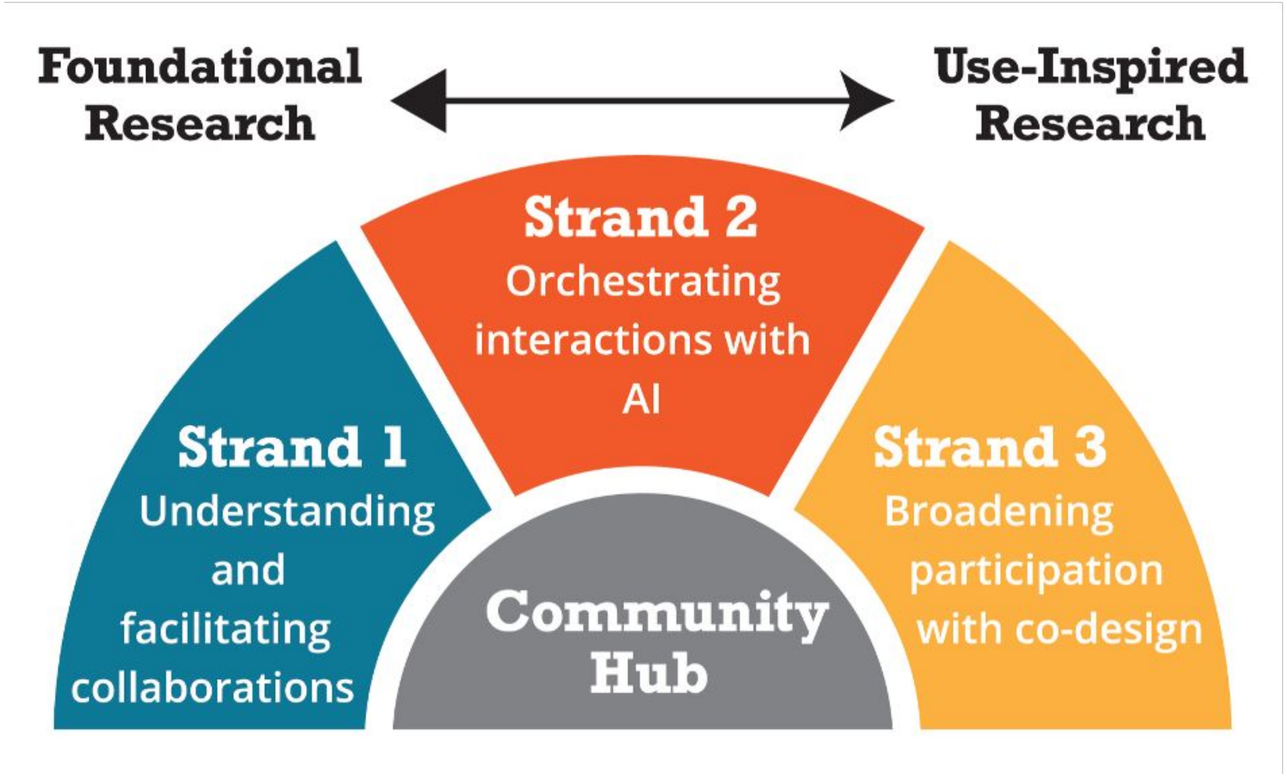
- Enable long-term involvement that attends to infrastructural demands, policy constraints
- Allow for multiple forms of engagement over life of the development process



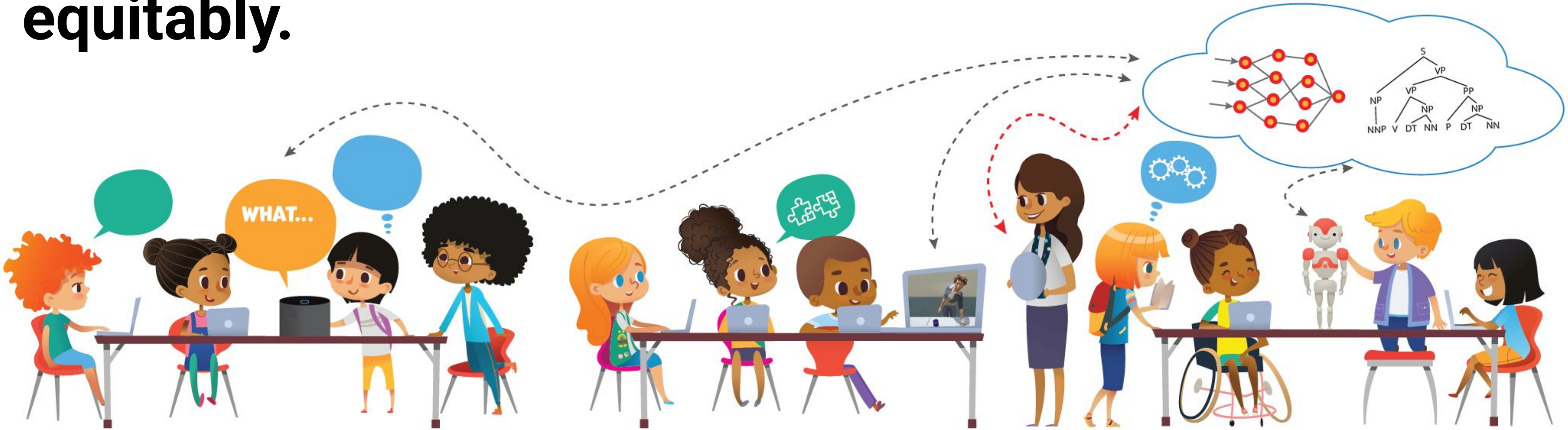
“taking care of the future through collective stewardship of science and innovation in the present” (Stilgoe et al., 2013, p. 24) **and with attention to history and protecting dignity**

Institute for Student-AI Teaming (iSAT)

iSAT’s Organization



High level conjecture: AI can serve as a social, collaborative partner helping students and teachers to work and learn more **effectively, engagingly, and equitably.**



Technical Challenge: Understanding multiparty, multimodal dialogue in real time in noisy learning environments

The Community Builder (CoBi)

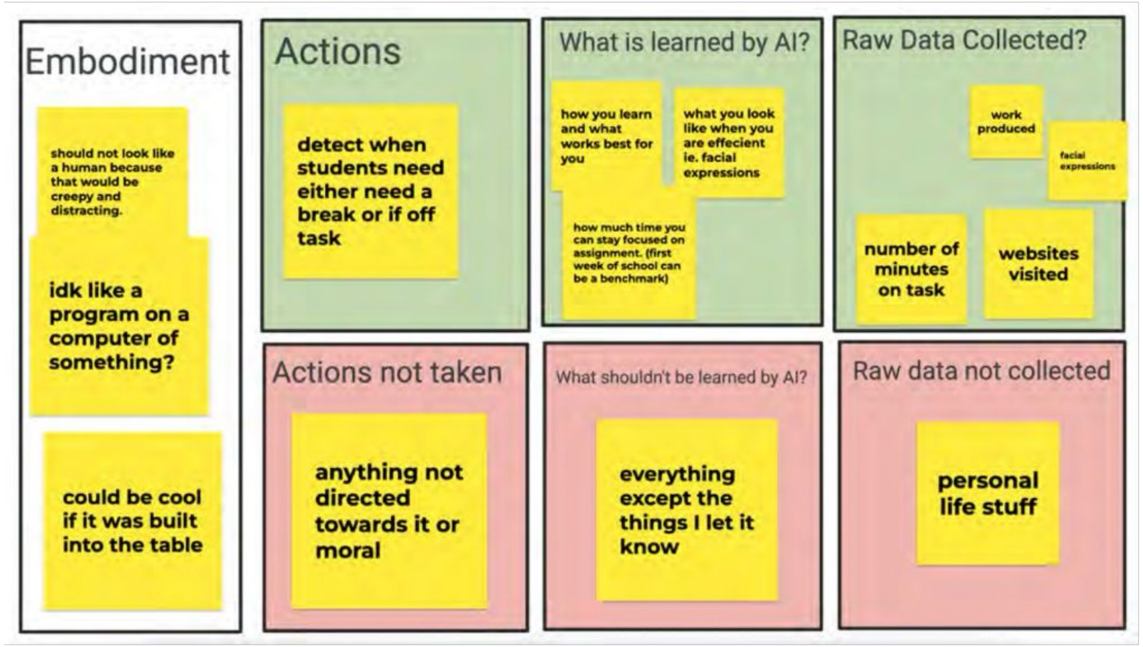
One of two **AI partners** we have designed and tested in classrooms aimed at supporting collaboration in iSAT

CoBi is a **group awareness tool** that (1) listens into small group collaborative work and (2) provides feedback at the class level with respect to a set of community agreements students have defined within some existing categories

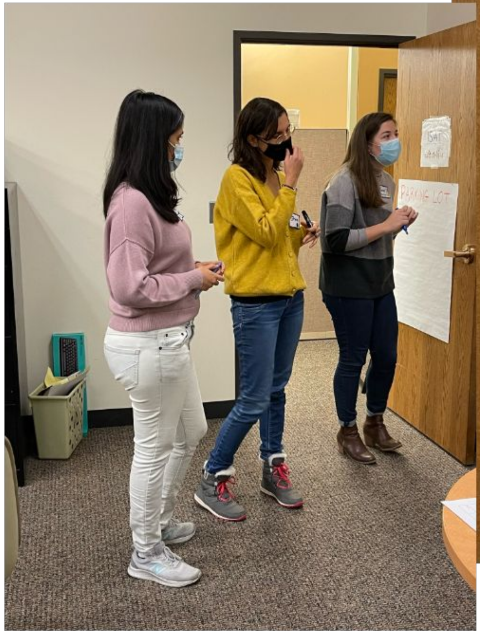
How Does the Community Builder AI Partner Work?

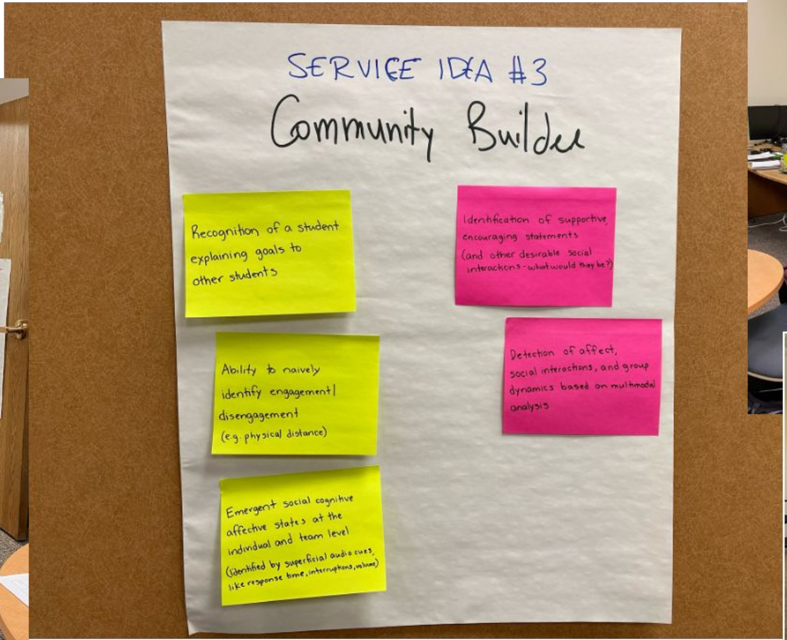
We Didn’t Start Here…

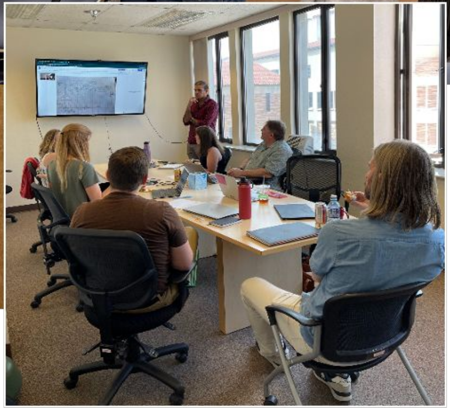
Learning Futures Workshop: Challenging Our Ideas



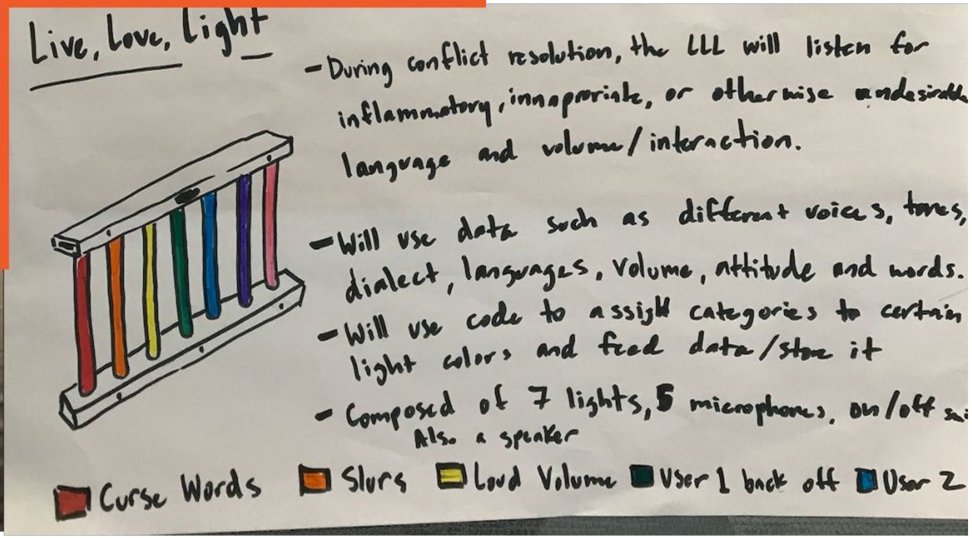
Design Sprint with Students



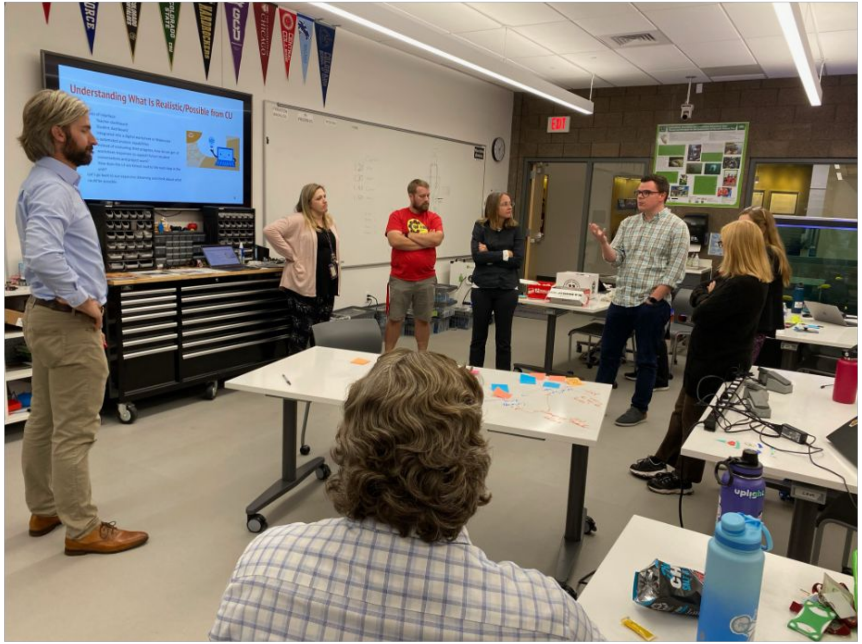




A Second Learning Futures Workshop



Further Engagement with Educators: Building Routines



OpenSciEd Community Agreements

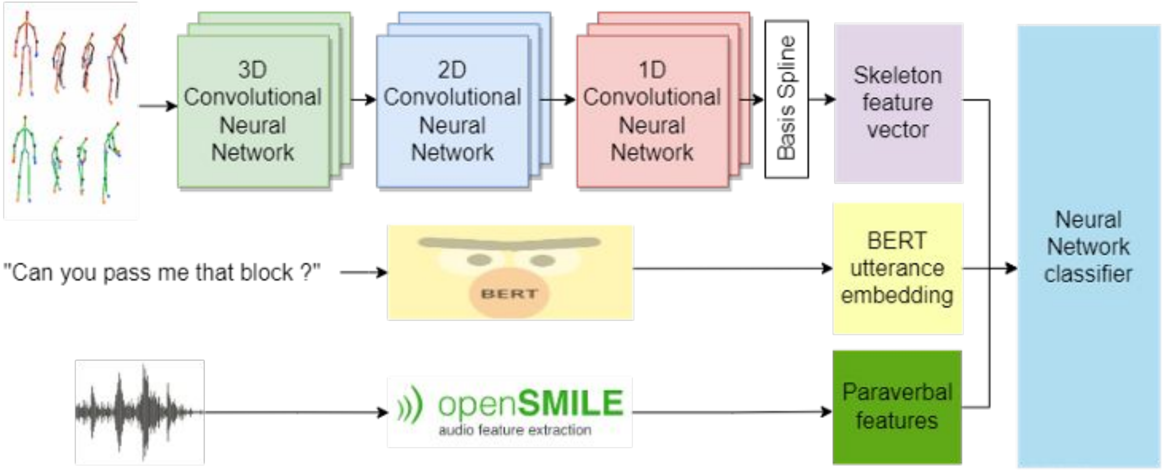
OpenSciEd

These agreements are introduced in the first unit of each course and referenced throughout the following units.

Community Agreements	
Respectful Our classroom is a safe space to share.	• We provide each other with support and encouragement. • We share our time to talk. We do this by giving others time to think and share. • We critique the *ideas* we are working with but not the *people* we are working with.
Equitable Everyone's participation and ideas are valuable.	• We monitor our own time spent talking. • We encourage others' voices whom we have not heard from yet. • We recognize and value that people think, share, and represent their ideas in different ways.
Committed to our community We learn together.	• We come prepared to work toward a common goal. • We share our own thinking to help us all learn. • We listen carefully and ask questions to help us understand everyone's ideas. • We speak clearly and loud enough so everyone can hear.
Moving our science thinking forward We work to figure things out.	• We use and build on other's ideas. • We use evidence to support our ideas, ask for evidence from others, and suggest ways to get additional evidence. • We are open to changing our minds. • We challenge ourselves to think in new ways.

 June 2019

Technical Advances Enabling Classroom Testing of an AI Partner



GAZE												
Joint Visual Attention (looking at a common tool): B=Blocks; L=Laptop			Individual attention (Looking at individual tools / materials)			Looking at other student (which may include the speaker)			Look away (outside group)			H
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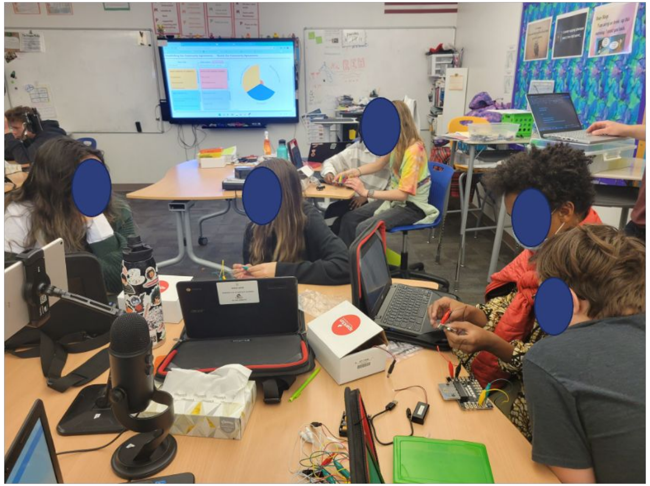
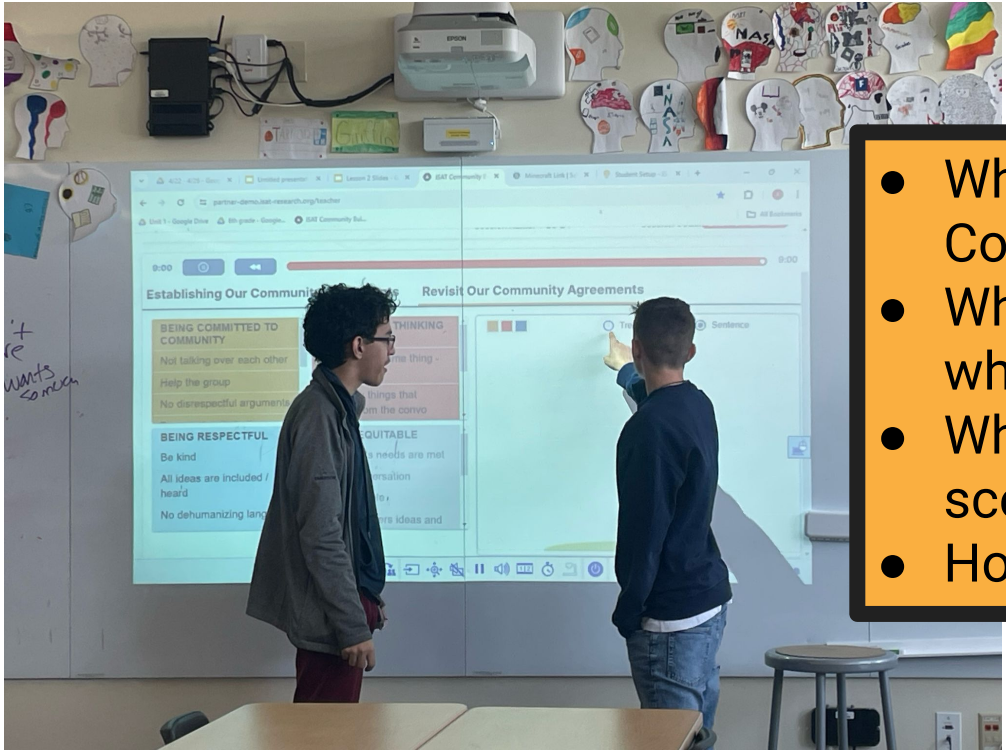


Integrating with Curricular Units: Speculative World Building

Example:
Moderating Online Games Unit

Students explore different ways to moderate communities and, along the way, learn how AI has been used (with varying degrees of success) to moderate communities to make them places where people can be themselves and feel like they belong.

Students Continue to Have a Say



- What kind of moderation is CoBi?
- What is it detecting? With what accuracy?
- What is it doing “behind the scenes”?
- How can we make it better?

How Our Approach Might Support Flourishing

Learning to work together in activities where they **feel respected**, are **treated well**, and **contribute** their ideas to solving meaningful problems of how we live together.

Participatory design, professional learning, and enactment support serve as their own **humanizing environments** where people's ideas are taken seriously and embodied in designs.

How Will We Know If CoBi Supports Collaboration?

Currently we are in the middle of a quasi-experimental study in two school districts to test the efficacy of CoBi in supporting collaboration.

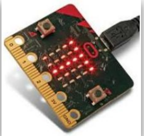
Human and Automatic Coding	Self-report Measures
Collaborative Problem Solving Skills (CPS; Sun et al 2020) Community Agreements Communicative influence	Resource interdependence Positive group interdependence Valuing collaboration and heterogeneity in collaboration Perceptions of adherence to community agreements

Conditions for the AI Supporting Collaboration

CoBi

Teacher Facilitation

Curriculum



Support students in understanding, critiquing, and building ethical A.I.

Student experiences + learning

Reflecting on the *How*: External and Internal Boundary Spanning

External	Internal
Support for ongoing adaptation of materials Responsiveness to classroom realities that arise	Transforming insights from LFWs to prototypes to working partners Backcasting to enable researchers responsible for technical advances to explore possibilities for vision

Thank You!

EXTRA SLIDES (for Q and A)

Addressing Issue of Noisy Classrooms

We experimented with multiple microphones, ultimately settling on Yeti Blue as producing highest Word Accuracy Rates for ASR

- We have gotten WER rate for ASR using Whisper large model to around 0.34

Internal studies have found many issues pertain to automatic transcription missing phrases or words, rather than mistaking them (Bradford et al., 2022)

Generalizability of Models

We've tested generalizability of models for categorizing speech into three community agreement categories (respectful, moving our thinking forward, committed to community with verbal with data from Minecraft Hour of Code, Physics playground:

- Models trained with Sensor Immersion data showed good generalizability to other domains and settings (Transfer Rates: 0.46-0.85)
- Potential robustness across diverse educational contexts
- Models suffered in instances with domain-specific verbiage:
- "okay so next time you want to start from the top so that it swings you can hit control right click and it will delete" (Physics, Committed to the Community)

Embodying Responsible Innovation