Co-designing AI Education Curriculum with Cross-Disciplinary High School Teachers

Benjamin Xie,[1] Parth Sarin,[*1] Jacob Wolf,[*2] Raycelle C. C. Garcia,[1] Victoria Delaney,[1] Isabel Sieh,[1] Anika Fuloria,[1] Deepak Varuvel Dennison,[1] Christine Bywater,[1] Victor R. Lee[1]

[1]Stanford University
[2]Harvard University
benjixie@stanford.edu, psarin@stanford.edu, jwolf@g.harvard.edu, raycellegarcia@stanford.edu, vldocherty@stanford.edu, isabelrs@stanford.edu, afuloria@stanford.edu, deepakvd@stanford.edu, cbywater@stanford.edu, vrlee@stanford.edu

Abstract

High school teachers from many disciplines have growing interests in teaching about artificial intelligence (AI). This cross-disciplinary interest reflects the prevalence of AI tools across society, such as Generative AI tools built upon Large Language Models (LLM). However, high school classes are unique and complex environments, led by teachers with limited time and resources with priorities that vary by class and the students they serve. Therefore, developing curricula about AI for classes that span many disciplines (e.g. history, art, math) must involve centering the expertise of cross-disciplinary teachers. In this study, we conducted five collaborative curricular co-design sessions with eight teachers who taught high school humanities and STEM classes. We sought to understand how teachers considered AI when it was taught in art, math, and social studies contexts, as well as opportunities and challenges they identified with incorporating AI tools into their instruction. We found that teachers considered technical skills and ethical debates around AI, opportunities for "dual exploration" between AI and disciplinary learning, and limitations of AI tools as supporting engagement and reflection but also potentially distracting. We interpreted our findings relative to co-designing adaptable AI curricula to support teaching about and with AI across high school disciplines.

Introduction

K-12 teachers' interests in incorporating learning about and with artificial intelligence (AI) into their classes have recently grown with publicly available AI tools such as ChatGPT (Impact Research 2023). While dedicated stand-alone instruction and computer science (CS) class integration have important merits (Alvarez et al. 2022; Druga, Otero, and Ko 2022), integrating AI education into in other subject areas can also provide unique benefits (Tedre et al. 2021; Lee and Perret 2022). These include situating understandings in disciplinary practices and broader reach beyond CS classes. Furthermore, educators from many disciplines have growing interest in and questions on teaching about AI (Jiang, Lee, and Rosenberg 2022; Sanusi, Oyelere, and Omidiora 2022).

One approach could be to focus on professional learning experiences to help secondary school teachers learn more about AI and use that increased content knowledge understanding to develop their own new lessons for their classrooms (Lee and Perret 2022; Sentance et al. 2023). However, high school teachers are often limited in time to learn about latest AI advances and develop new materials that integrate AI education into their instructional material. Developing full curricula that completely address and cover AI topics would require robust content knowledge. Curriculum adoption would need to negotiate many contingencies that are often variable, such as block scheduling, different academic term lengths, and larger school initiatives. Given these constraints, we explored modular curricular resources and short units about AI as they relate to disciplines that teachers can and are encouraged to adapt as they see fit.

We build off of prior work in AI education, such as defining key ideas (Sentance 2022; Long and Magerko 2020) and co-designing learning experiences (Long, Blunt, and Magerko 2021; Lin and Van Brummelen 2021), to investigate questions on designing adaptable cross-disciplinary curricular resources. We conducted five co-design sessions with eight teachers from different disciplines to investigate the following research questions: **RQ1**: How do high school teachers across multiple disciplines consider AI when it is taught in art, math, and social studies contexts? **RQ2**: What opportunities and challenges do high school teachers recognize with using AI tools to advance disciplinary learning objectives in classroom instruction?

This research paper contributes a formative, empirical evaluation of cross-disciplinary teachers' perspectives on learning with and about AI to inform the design of AI curriculum that engages with disparate subject areas.

Related Work: AI Edu & Curriculum Design

Reviews of prior AI curricula (Druga, Otero, and Ko 2022) and ML education research (Sanusi et al. 2023) identified that while some AI curriculum focused specifically on AI ethics and sociotechnical systems (Krakowski et al. 2022; Alvarez et al. 2022), most did not engage with the social and ethical implications of AI and ML. White researchers typically do not engage teachers in the AI curriculum co-design process (Song et al. 2023), interviews with 12 high school teachers in Africa identified that teachers felt their involvement in the curriculum co-design process of resources

[*]These authors contributed equally.

Copyright © 2024, Association for the Advancement of Artificial Intelligence (www.aaai.org). All rights reserved.

could support contextually situating the curriculum (Sanusi, Oyelere, and Omidiora 2022).

Prior work has divergent perspectives on the connections between CS programming and AI. Norouzi, Chaturvedi, and Rutledge (2020) conducted a month-long ML and NLP class with high school students, finding that introducing basic programming concepts was essential to teaching the AI topics. However, Tedre et al. (2021) suggested that integrating AI into K-12 computing education required "abandoning the belief that rule-based 'traditional' programming is a central aspect and building block in developing next generation computational thinking." Song et al. (2022) found that an AI curriculum for K-12 schools in China increased computational thinking in students, providing evidence to support connections between AI and computational thinking.

Prior work investigated AI curricula beyond CS and programming. These cross-disciplinary AI curricula have involved focusing on creative, human-centered aspects of AI (Guerzhoy et al. 2022). For example, Kumar and Worsley (2023) used AI to track and provide feedback with athletic drills, Touretzky and Gardner-McCune (2023) taught students to use phonological, syntactic, semantic, and cultural knowledge to teach about speech cognition AI, Chao et al. (2023) worked with unstructured text data to understand language in an English language arts (ELA) class, and Ali, Kumar, and Breazeal (2023) developed a card game that simulated AI audits to teach K-12 AI literacy.

Prior work with co-design of AI curriculum found benefits to engaging teachers from different disciplines. A prior study on co-design of integrated AI curriculum with K-12 teachers found that teachers required additional scaffolding in the curriculum to facilitate ethics and data discussions and valued learner engagement, collaboration, and reflection (Lin and Van Brummelen 2021). While this workshop engaged with teachers from disciplines including English Language Arts (ELA), CS, and history, they did not investigate cross-disciplinary discourse. Walsh et al. (2023) found that ELA teachers with minimal AI experience were able to adapt an AI ethics curriculum, suggesting that AI knowledge is not a pre-requisite for curricular co-design. This paper explores cross-disciplinary discourse amongst teachers with varying prior knowledge about AI to identify trends and tensions related to AI across disciplines.

From these prior studies and reviews, we can say that co-design of K-12 AI curriculum can benefit from engagement from teachers from different disciplines (Lin and Van Brummelen 2021; Walsh et al. 2023), should considering AI not only from a technical perspective, but also from ethical and socio-technical ones as well (Druga, Otero, and Ko 2022; Sanusi et al. 2023). Doing so can involve expanding decoupling AI from programming (Tedre et al. 2021), potentially promoting cross-disciplinary learning with and about AI.

Study Design

This project deploys a dual-purpose model of co-design. On the one hand, co-design is a powerful way to generate new ideas in ways that are ideally inclusive and more balanced with respect to who participates in key design practices (Costanza-Chock 2020). In addition to cultivating long-term partnerships and equitable relationships, the tangible and iterative products should serve the needs and interests of the group - in this case, teachers - who will be using the resulting artifacts or resources in their ongoing practice. That is, a better designed artifact should result.

A second use of co-design that is emerging in the learning sciences literature is as a space for its own data generation. Similar to interviews, observations, and focus groups, co-design can have rich interactions worthy of their own examination for understanding more about process, values, and judgments (Severance et al. 2016; Penuel et al. 2022).

The emerging model for this second use of co-design involves structuring co-design to encourage idea sharing and discussion, rather than independent creation of prototypes or anonymous written feedback. It also requires that recordings, field notes, and artifacts be intentionally collected for the subsequent review with an eye toward learning more about either the co-design process or about complex matters represented in participants' statements and comments. With this in mind, our co-design sessions were recorded and transcribed for their own analysis so that further analysis of participants' discourse and interactions.

We originally recruited high school teachers from multiple geographic regions of the United States who taught different subject areas. Of the 13 high school teachers who began the co-design sessions, four dropped out due to time constraints and one did not return their consent form. We report findings for the remaining eight teachers who completed all five co-design sessions and returned consent forms. Table 1 summarizes information about the teacher participants and describes the participant ID structure. We refer to participants with they/them pronouns for anonymity.

We received Institutional Review Board (IRB) approval for this study, which was conducted entirely in English. We compensated each teacher $900 for participating in a total of six hour long co-design sessions with up to one hour spent on preparation or follow-up for each session (10-15 hours total). We analyzed the first five co-design sessions for this study, as the sixth session was beyond the scope of this study.

Co-Design Sessions with 8 High School Teachers

When designing these co-design sessions, we followed principles of Research-Practice Partnerships that foster joint work through power and knowledge sharing and mutual engagement across multiple boundaries (Penuel et al. 2015). This involved using appropriate language and also validating a breadth of interactions. Firstly, we considered teachers as experts, aligning with principles of design justice (Costanza-Chock 2020). This involved us referring to teachers as "partners" and as members of a shared "team." Secondly, we sought to develop a common language amongst teachers, avoiding potentially unfamiliar jargon such as "co-design."

We conducted our virtual, collaborative co-design sessions so teachers could openly engage in multiple ways. We conducted co-design sessions over Zoom to enable teacher connections across different regions. All participants engaged in group sessions except for C-Econ-1, who participated individually with a member of the research team for all of their sessions due to scheduling constraints. At least

Table 1: Description of teacher participants' classes, schools, and students served. Participant IDs have the following structure: {school type: P for public, T for technical, C for charter}-{a subject taught}-{1 if Title I, 0 otherwise}. "Title I" denotes that $\geq 35\%$ of students experience poverty.

ID	subjects taught	school type	predominant student demographic
P-CS-0	web dev., augmented reality	public	white
P-Soc-1	social studies	public (Title I)	Hispanic
T-CS-0	game dev., animation, digital media	public (technical)	white
P-Stat-0	AP Stats, AP CS	public	Hispanic, Asian
C-ELA-1	English, AP Capstone	charter (Title I)	Hispanic
C-Econ-1	economics, IT	charter (Title I)	Black/ African-American
C-Eng-1	engineering	charter (Title I)	Latinx
C-Art-1	art, English	(same as C-Eng-1)	

one member of the research team facilitated each session, which typically involved a brief introduction, spending most of the time split into smaller breakout groups of 2-3 teachers (which were also facilitated by a member of the research team), and then coming back together to share and reflect at the end. Each breakout group typically centered around a shared, digital artifact that we encouraged but did not require teachers to contribute to, such as digital interactive whiteboard (Jamboard) or an editable collaborative document (Google Doc). This enabled teachers to interact in different ways, with some teachers speaking more (e.g. C-ELA-1, T-CS-0), others writing more (e.g. C-Eng-1, P-Soc-1), and others "bridging" spoken and written discourse by asking questions or calling attention to something that was written down. The members of the research team facilitated by keeping track of time, catalyzing discussions as necessary, helping bridge spoken and written discourse as necessary, and providing opportunities for teachers who have spoken less to do so.

We conducted these five co-design sessions across the span of four months (Nov 2022 - Mar 2023), enabling us to adapt their structure in response to teachers' feedback. A key adaptation we made was in support of fostering more teacher agency in the co-design process in Session 3-5 by providing resources and letting teachers develop their own lesson plans rather than have them provide feedback on existing lessons (Session 2). During this time, OpenAI made public ChatGPT (text generation tool built upon GPT-3 at the time) and DALL·E-2 (image generation tool built on GPT-3) gained public attention. This resulted in a greater focus on these Generative AI tools in Sessions 3-5.

Session 1: Curriculum The goals of the first session were to build relationships and familiarity between teachers and with the research team, articulate criteria for curricular resources, and identify how teachers could adapt curricular resources to meet the needs of different students and teachers. Most of the time was spent with teachers in small groups contributing to digital interactive whiteboards (Google Jamboard) responses to the following questions: 1) What types of resources do you use most in the classroom? 2) What types of resources or platforms do you ask your students to interact with outside of the classroom? 3) What types of resources do you consult most when developing a lesson?

Session 2: AI & You The goals of the second sessions were to understand how teachers interpret curricular resources and adapt resources to fit their own needs. We had teachers review two sets of resources that we developed relating to everyday experiences with AI.

The first unit taught students to identify examples of AI in their day-to-day life, articulate "where" the AI was in everyday examples, apply a framework to decompose applications of AI into the data that's used in the model and the people who are affected by the model, and hypothesize about behaviors that they engage in online that might be tracked by companies and used to train algorithms. This unit was broken up into two lessons around central quesitons. The first was *Where is AI in the world around me*? It included a video for students to consider where AI exists in their everyday lives (Verge Science 2018), accompanying worksheets and discussion prompts, as well as resources to help teacher prepare (Marr 2019). The second lesson focused on the question of *How does that algorithm work*? It centered around a human and data-centric AI framework we developed that considered inputs, outputs, and impact to direct and indirect stakeholders. It then asked students to apply it to Amazon's use of AI (Selyukh 2018).

The second unit taught about the qualitative aspects of Apple's FaceID technology by asking students to take a critical stance on its popular uses. This lesson taught students to critically discuss uses of FaceID and technologies that use machine learning in everyday life; discuss how users' data are shared, distributed, and used in the creation of new technologies; and consider users' rights to their own data: what is the status quo, and what are potential changes that ought to be made. These objectives aligned with skills in AP Statistics. Materials included interactive tools (YR Media's Interactive Team 2020) and articles to help students better understand facial recognition.

Session 3: AI & Art The third session asked teachers to outline a lesson plan around a key question relating to Generative AI and art after reviewing resources we provided.

The first question was *How do generative AI algorithms work*? The learning objectives were for students to be able to explain how AI algorithms are able to generate content that is based on, but not identical to, the content they were trained on; describe the effects that training data and their potential biases have on generative models; and evaluate how realistic modern generative AI models can be and where they still have room for improvement. P-CS-0 and P-Stat-0 reviewed resources including DALL·E prompt guidelines (dallery.gallery 2023), a video describing how AI image generation worked (Computerphile 2022), and an article on whether DALL·E art was borrowed or stolen (Cooper 2022).

The second question was *How can generative AI algorithms complement artistic practice*? The learning objectives were for students to be able to identify precise routines in their artistic and writing practice where generative AI algorithms can be used to strengthen their work; evaluate how helpful current AI systems can be and decide whether or not to incorporate algorithms more into their practice; and articulate the ways in which AI algorithms would need to improve in order to become a stronger, more ethical part of their practice. C-Art-1, T-CS-0, as well as C-Econ-1 in a separate session, considered resources including how to use DALL·E to make variations of hand-drawn sketches (MrStormUMA 2023), DALL·E prompt guidelines (dallery.gallery 2023), a link to ChatGPT, an AI generated children's book (Kessler 2022), and an article on ChatGPT for grading (Alonso 2022). After C-Art-1 mentioned intellectual property concerns on AI generated art, T-CS-0 added an article on a related class-action lawsuit (Lang 2023).

The final question was *What do generative AI algorithms mean for the future of creativity*? The learning objectives were to have student be able to use generative AI models to generate text-based or image-based ideas for creative passions they may have; debate the ethical implications of expanding the definition of "creativity" to include work created by generative AI models; and brainstorm ways in which artistic AI could grow. C-ELA-1 and P-Soc-1 considered resources including tools for text generation with GPT-3, image generation with DALL·E, and music generation with examples (Agostinelli et al. 2023).

Session 4: AI & Math Similar in structure to Session 3, we asked teacher to outline a lesson plan around key questions about AI and math after reviewing a set of resources.

The first question was *What is data, and what makes for a "good" data set*? The learning objectives were to have students be able to describe how computers interpret human-facing information as data; characterize features of a dataset; identify and describe factors that could make a dataset biased; and explore and explain societal consequences of modeling with a biased dataset. P-Soc-1, C-ELA-1, and C-Art-1 considered articles and interactive tools relating to image data (Conlen and Hohman 2018; YR Media's Interactive Team 2020), audio data (Allen et al. 2019), and features and bias in datasets (People + AI Research a,b,c).

The second question was *How does an AI algorithm use math to learn*? The learning objectives were to have students be able to identify where mathematics is used in the process of an AI making predictions; apply the overall training process to a real-world dataset; and critique the training using mathematical evidence. P-CS-0, C-Eng-1, and T-CS-0, as well as C-Econ-1 in a separate session, considered resources related to the role of math (e.g. mean squared error) in prediction (statisticsfun 2012) and training a model.

Session 5: AI & Society Similar to Sessions 3 and 4, we asked teachers to outline a lesson a plan around questions regarding AI and society after reviewing a set of resources.

The first question was *How do people interact with algorithms*? The learning objectives were to have students be able to identify, discuss, and analyze how society interacts with algorithms in practice and identify and situate themselves within narratives for how AI can be used to support flourishing in society. C-ELA-1 and P-Soc-1 considered case studies on AI in juvenile sentencing (Richardson and Schultz, Jason M Southerland, Vincent 2019), family services (Santhanam 2016; Ho and Burke 2023), and social media (Stanford 2022). They also considered an article relating to explainable AI (Rudin and Radin 2019) and a simulation of AI and hiring (Csapo et al. 2019).

The second question was *How and why are algorithms discriminatory*? The learning objectives were to teach students to describe how AI algorithms can perpetuate discrimination and inequality; classify kinds of algorithmic harm and construct a framework for dealing with AI harm; and synthesize ideas for dealing with algorithmic discrimination and propose and debate new solutions. P-CS-0 and C-Econ-1 in separate sessions considered resources on representation in image datasets (Wiggers 2020; Buolamwini 2018, 2016), AI in family services (Ho and Burke 2023), AI to draw congressional districts (Coldewey 2020), and AI in criminal sentencing (Angwin et al. 2016; Corbett-Davies et al. 2016).

Analysis Plan: Thematic Analysis of Interviews

We conducted a thematic analysis on the co-design session (Braun and Clarke 2006; Bowen 2006) recordings and transcripts for the 8 participants who consented to the study, about 13 hours of data. Immediately after each co-design session, attending researchers debriefed to discuss observations that served as initial sensitizing concepts (Bowen 2006): Teachers' disciplines and backgrounds, teachers considerations of student perspectives, and teachers' prior AI experiences. Two researchers then conducted the thematic analysis. Both had formal training in qualitative methods, with one also having five years of experience conducting thematic analysis. They independently open-coded one recording and accompanying transcript for each session, with all participants included in at least one of the recordings (about 5.5 hours, or 40% of the data). They then met to discuss their codes, collaboratively developing affinity maps for each co-design session that they developed into a codebook they then applied to the remainder of the data:

(1) Curriculum Development: How teachers *evaluated* whether to use curricular resources in their class, *adapted* these resources, considered the *timeliness* or *structure* of the resources. (2) Learning about AI: *Learning objectives* and *discipline-specific* connections related to AI. (3) Learning with AI (Using AI in the class): *Roles* of AI in classes (to augment a learning experience, augment capabilities, as an alternative) as well as their potential *limitations*. (4) Context and constraints: *Teachers' real-world constraints*, *grade level*, *school context*, *broader context*, and teachers' *prior*

knowledge, experiences, and preparation (KEP). (5) Perspectives on Students: Teachers' perspectives on *students' prior KEP*; *interests and engagement*; and *safety*

Results

In this section, we report themes and select quotations relating to our research questions: (1) How teachers consider teaching AI, and (2) what opportunities and challenges they identify with using AI in their classes.

RQ1: How teachers consider AI

Perceived Dichotomy between Technical Skills & Ethics Teachers tended to consider AI from technical and ethical perspectives, often considering the discipline they teach to determine which perspective is more relevant.

Teaching **AI from a technical perspective** appealed to C-Eng-1 for their engineering class. After discussing differences in engineering and ELA classes with C-ELA-1, C-Eng-1 connected AI to engineering by considering universal systems, while also acknowledging how this technical emphasis may be less relevant to ELA:

> C-Eng-1: *"you can sort of think about [AI] is a universal system....In my engineering class, we do a whole unit on universal system. And then we just 'input/output' a lot during the whole thing. So I guess it's in context of what you're trying to bring [AI] into. So for [English Language Arts], it would be like, the learning objectives are a little different. I like this lesson, because... they're learning the technical things... And less about, like, 'how to make an argument' or 'what ethics are.' "*

Even P-Stat-0, an experienced CS teachers who taught ML in their AP CS class, acknowledged gaps in their technical understanding of Generative AI: After learning about real time media generation with DALL·E and how to structure prompts in Session 3 (AI & Art), they saw connections between teaching about classifiers and Generative AI that a video explanation could help make possible:

> P-Stat-0: *" Transformers are complicated, and I don't know if I understand at a deep level how they work. But I was interested in having the framing be something like, 'okay, so you had an experience with the guts of classifiers. Has anybody heard of Generative AI?'... And then I'd have some videos queued. I'd not seen before like the real time generation like that. But that was really really cool. So maybe that one, and maybe some other ones to get a concrete illustration of like, what does that word generative mean here. And then the the goal of the lesson is going to be let's compare and contrast what we already know about classifiers, and what these generative algorithms are like... in terms of their structure, how they're trained, what you train them with, and then they're especially their use cases. "*

They emphasized that their reading of a prior IEEE article informed them to consider not just use cases of AI tools, but also potential misuse cases. These ethical considerations were already incorporated into their class for classifiers, and they wanted to extend this consideration to Generative AI tools as well. Finally, they and P-CS-0 agreed that the video explanation (Computerphile 2022) was helpful, but they wanted to ensure students engaged with at a level deeper than being able to "parrot" the information back.

When considering **AI from ethical perspectives**, C-ELA-1 sought to go beyond students discussing ethical dilemmas and instead have them use evidence to structure arguments for debates to align with English Language Arts (ELA) class. In Session 2: AI & You, C-ELA-1 compared the learning objectives of the units on AI in everyday life and on ethical considerations of FaceID, which included an interactive demo involving erasing features on your face (YR Media's Interactive Team 2020). While they found the interactive demonstration interesting, they found the ethics-related learning objectives unsatisfactory, especially when compared to the more "practical" skills taught in the AI in everyday life unit:

> C-ELA-1: *" To me, what's fun is [that] kids are going to want to try to break it. Like that's the whole point right? Like where's the breaking point of the technology? So that to me is Erase Your Face, but I think it's that's going in an ethical direction. And the other one [unit] is going in more of a practical one, like, what does this actually do and then the data use and misuse like I feel like it's trying to teach 'this is what AI is' and then bring up all the sort of ethical questions around it. Not that that's a bad thing to do. I'm just kind of not sure what the goal is... And maybe I missed some objectives, like key takeaways: 'we really only scratched the surface.' That's not a takeaway. That's a comment. The lesson objectives: 'critically discussed the use of face ID,' that doesn't feel like a really compelling objective to me. 'How users data are shared.' Okay, yes, I feel like that's helpful. 'Users rights to your own data.' Yes, helpful and important, but this is just discuss and consider. What are the skills or the actions that students are gonna be able to take away, come away with here? Because I'm not really happy with these objectives."*

After discussion with C-Eng-1 and T-CS-0 getting students to think about AI beyond a good/evil dichotomy, C-ELA-1 wanted their ELA students to debate instead of discuss the ethics of facial recognition better aligned with class expectations of using evidence to make to build an argument.

Teachers still wanted to ensure they were prepared to teach about AI from ethical perspectives. When asked in Session 5, "if there is a topic in this discussion of AI and society that you, as teachers, would absolutely want to stay away from," P-Soc-1 felt that there was no topic they would avoid, but wanted to ensure that they were prepared to teach about the social impacts of AI:

> P-Soc-1: *"It's never that I would shy away from doing it. I just want to know how I could best do it. Like, who should I collaborate with? What are the resources that are available? I won't pick it up if I don't feel confident that I'm gonna do it right. "*

Symbiosis w/ AI and Disciplinary Learning As shown in the previous section, teachers considered different framings of AI that were relevant to their respective disciplinary goals. P-Soc-1 and C-ELA-1 went beyond that to identify **"dual exploration" opportunities** where use of AI could support learning about disciplinary frameworks, and applying disciplinary frameworks to AI generated media supported creative and analytical thinking about AI.

To engage with the lack of historical context with AI art, P-Soc-1 considered applying the OPCVL (Origin, Purpose, Content, Values, Limitations) framework (Boyd-Thomas) for analyzing historical documents from their class:

> P-Soc-1: *"[AI generated art] is missing the author, and that's where our sourcing skill is. Because [history students] practice what we call OPCVL. So where is it coming from? Who wrote it? When did they make it? What what*

is their purpose of doing this? What is the message they're trying to convey limits and value and values, like in their perspective. [For example,] if there were men representing women in this painting, then what is the limit? What are their values?... I think that's what I'm going to call as the 'sourcing'."

Upon hearing this, C-ELA-1 considered "dual exploration," or investigating AI generated media with the ELA framework of SOAPSTone (Speaker, Occasion, Audience, Purpose, Subject, Tone), a series of questions for analyzing or planning compositions (Morse):

> C-ELA-1: *"I'm wondering for that thinking piece that you just did, if we could set up an opportunity for students to make that visible. So to ask them the question: If we take these processes that we already do... for me in English, it would be SOAPSTone... to say, how does this standard lens that we apply to a text or a piece of art, or whatever it is, How is that different? In what ways does that lens still fit something that is created by AI? And what ways does it fall short? What's missing?... I think that would be a dual exploration where it would one, help students understand the guiding principle of the skill, and it would also help students do some creative thinking or analytical thinking about what is AI, and where does it come from?"*

RQ2: Opportunities & Challenges using AI Tools

Roles of AI Tools C-Econ-1 was one of many teachers who saw **AI tools as augmentative** to their students' creative skills. After using ChatGPT for the first time to output a business plan, C-Econ-1 felt that it could take their ideas and better convey them as a professional business plan:

> C-Econ-1: *" I like this first objective, 'identify precise routines in their artistic and writing practice where generative AI algorithms can be used to strengthen their work.' So the way I would... use generative AI [would be] assisting me on how to word my business plan. This is the idea I'm trying to convey. But what's a more professional way to convey that [idea] to a group of investors, because often you know the way we talk just sitting there talking right now is not how you're going to talk if you're talking to a bank [or] private equity firm, for trying to get money for your business... you're gonna want to have it more professionally written... When I look at the objectives, that one stands out where we can use AI algorithms... to strengthen their work. I'm looking at that work as the business plan. How can this algorithm can assist me in writing a more professional business plan? "*

After this exploration, they felt that their business & economics students could be the source of "creativity" for their assignment relating to developing a business plan, with ChatGPT as a "tool" to help them communicate their ideas as a professional business plan.

Whereas C-Econ-1 saw AI as complementing student skills, P-CS-0 considered **AI tools as enabling students to do something they otherwise could not**. After reviewing guidelines on prompt engineering for DALL·E (dallery.gallery 2023), P-CS-0 saw DALL·E as a tool to help students create shareable art regardless of their artistic skills:

> P-CS-0: *"I like that there was that prompt book. So have them actually learn how to create a cool piece of art, and then we could have like a competition or something, and hang their pieces in the hallway. So everyone can say, 'hey? I created this,' because not everyone's an artist. But I look at [DALL·E] as a tool to help them create art."*

They then proposed learning about how AI generated art worked by breaking up a longer video (Computerphile 2022) into smaller chunks with discussion and check-in questions in between. Finally, students would read the articles on whether AI generated art is borrowed or stolen (Cooper 2022), conduct further research, and then have a debate.

Engaging with the limitations of AI Tools Most teachers discussed the limitations of existing AI tools. As previously stated, C-ELA-1 felt students were going to try to "break" the facial recognition tool from Section 2. In a separate session, P-Soc-1 felt that students' tendencies to find the breaking point of tools may distract from learning experiences.

T-CS-0 saw **limitations of AI tools as a discussion opportunity**. In Session 3 (AI & Art), T-CS-0 and C-Art-1 discussed how generative AI could complement artistic practices. They discussed how known limitations with media generated from DALL·E , such as anatomical issues (e.g. correct number of fingers), could impact learning experiences. After reviewing resources related to DALL·E and using the tool, T-CS-0 proposed using DALL·E to generate different poses for students to sketch. They then proposed a discussion with students on the ethical implications of creating and distributing sketches of a non-existent compared to a real person. C-Art-1 then raised their concerns about how DALL·E had issues producing anatomically correct pictures (e.g. incorrect number of fingers), and how that could impact learning experiences. T-CS-0 considered the scope of limitations as a discussion opportunity:

> T-CS-0: *"That's the discussion I want to have is [AI generated art] even close? And then to hit 'ways in which AI algorithms would need to improve in order to become stronger.' I think we just like you know, figure that out. [For example,] hands have got to be better. Anatomy's got to be better. This is not going to be a good resource until X, Y, and Z."*

Following this, C-Art-1 felt that their art students could explore **limitations of DALL·E for reflection on its affordances**:

> C-Art-1: *" I actually anticipate if a lot of them try [DALL·E], they would be bugged by the slight things that would be off about the AI [art]. Like 'why can't it give me a perfect picture,' and it's like 'well, it only has so much data to work with.' I think I would really like them to reflect on that process, right? Like, 'okay, I'm gonna try this. Seems really cool. Seems interesting. I'm going to generate some pictures. None of these pictures are great. I don't like any of them. I'm just gonna do it myself,' right? Some kids might come to that conclusion, whereas some kids might be like 'oh, yeah, this is awesome! This is great. I don't have to draw this, and now I already have an idea, and I could just copy it,' and that's fine, too. But I think at the end of the day, what I want them to do is like. 'How was this useful to you? Where was it easier? Where was it more difficult?' Reflect on that. Maybe AI Generative art is more useful in certain contexts, and maybe less than others, and just have them kind of grapple with that throughout the lesson."*

C-Art-1 would then refer to the resources on prompt engineering for DALL·E and expressed concerns relating to how Generative AI art tools' **sensitivity to prompts could hinder students artistic capacities**, proposing instead to have students draw without it to begin with:

> C-Art-1: *" I think one of the big allures of AI art is that it is very easy. It's very easy, but at the same time it's not right, because you have to get really precise with the prompts, and I don't think a lot of my kids would know that. I think I would like them to get started with like actually drawing it*

themselves first, so they don't get bogged down with trying to find the perfect wording and then get really frustrated and be like oh, 'I can't create what I want to create, because I don't have the words for it,' So I think I would like them to start with their own work, so they know that they have, like all other resources, and not just this one machine. "

Discussion

In this study, we conducted five co-design sessions with eight high school teachers who taught STEM (CS, engineering) to humanities (social studies, English language arts/ELA, art, economics) classes. Related to teaching about AI, we found that participants considered AI from both technical and ethical perspectives, with the importance of each perspective varying by discipline. Two humanities teachers identified ways for "dual exploration" where students could apply discipline-specific analytic frameworks to AI generated art to think more critically about the frameworks as well as about AI. Related to teaching with AI tools, we found that teachers considered AI tools as complementary to students' skills as well as capable of enabling students to do something they otherwise could not. Teachers framed limitations of AI tools as discussion or reflection opportunities, as well as potential distractions. In this section, we consider different ways to interpret our findings.

Limitations and Threats to Validity

One way to interpret these findings is that our qualitative analysis of a small sample size invalidates our findings. As with other qualitative studies, notions of *objectivity*, *truth*, and *generalizability* do not necessarily apply (Locke 2019). Instead, we should consider the credibility, richness, and recoverability of this study (Locke 2019; Holwell 2004; Tracy 2010), treating the results of our coding effort as organizations of claims about data rather than as quantitative data in and of itself (Hammer and Berland 2014). As a result, we did not report code frequencies, instead focusing on representative descriptions of the themes observed within our data.

Another limitation to consider is that we recruited teachers that authors had some prior relationship with. Four teachers had previously been participants in other studies with a researcher, one teacher had taken a class taught by that same researcher, and two teachers were from a high school that another researcher volunteered at. This could have led to Social Desirability Bias (Grimm 2010). This bias is a trade-off we made to establish trusting relationships with teachers to partner with. We tried to alleviate this by reiterating norms of openness and agency and also separating researchers from teachers they had prior relationships with.

A threat to validity is that this research was conducted in a Western, educated, industrialized, rich and democratic (W.E.I.R.D.) societal context. While this is common amongst neighboring research communities (Blanchard 2012; Linxen et al. 2021), most of the world is not W.E.I.R.D. (Henrich, Heine, and Norenzayan 2010). Most teachers in our study did work at Title I schools serving Black, Hispanic, and Latinx students (see Table 1). Nevertheless, we acknowledge this bias to create space for future work in less W.E.I.R.D. contexts.

Implications and Future Work

Another way to interpret these findings is that we must make technical and ethical perspectives of AI more compatible with different disciplines. Teachers found these perspectives in tension at times, with an engineering teacher more interested in low-level technical details and an English teacher more interested developing arguments related to the ethics of AI. This false dichotomy may be from how prior work has discussed and taught AI, with AI curricula often neglecting to consider ethical and social impacts (Druga, Otero, and Ko 2022) despite teachers' interests in incorporating these perspectives (Sanusi et al. 2023). Future work can explore how to integrate these perspectives in ways that are compatible to different disciplines. This could involve decoupling AI from rules-based programming (Tedre et al. 2021) or using micro/macro ethics framings from engineering education to consider ethical dilemmas at different levels (Herkert 2005).

Yet another way to interpret these findings is that we must prepare teachers to teach about AI from technical and ethical perspectives. Participating teachers' experiences with AI ranged from passing conversational knowledge to knowledge of ML (but not Generative AI), and all found ways to meaningfully contribute to the co-design sessions. However, even experienced CS and engineering teachers identified that there were crucial gaps in their technical knowledge of AI, and an experienced history teacher identified gaps in their knowledge when discussing the societal impacts of AI. Furthermore, knowledge to contribute to co-design sessions is not the same as knowledge to teach about AI. An English teacher who had previously taught CS (C-ELA-1) tried implementing curriculum from Session 2 (AI & You) into their ELA class, only to conclude "I'm not sure what I'm talking about sometimes!" Teachers typically lack opportunities to learn about AI (Lee and Perret 2022), substantiating the concerns of teachers in our study. Future work can explore how to prepare teachers to teach about AI from different perspectives, especially for teachers beyond CS.

A final interpretation is that there are opportunities to design for "dual exploration" of disciplinary learning alongside learning about AI and its limitations. History and ELA teachers identified how students could try to apply their disciplinary analytical frameworks to AI generated content to think analytically about both the authority of the AI outputs and the applicability of the frameworks. However, teachers also identified that using imperfect AI tools in class presented challenges (e.g. distracting from learning objectives) as well as opportunities for students (e.g. to reflect on affordances of AI tools relative to their own skills and other tools). Explainability and bias will be challenges with AI for the foreseeable future. AI Education researchers may be able to overcome these challenges and embed learning about AI across disciplines by leveraging curricular co-design to guide the development of these sociotechnical learning experiences. By partnering with teachers throughout the design process, we can realize learning experiences where teachers have relevant preparation to teach about AI using AI tools to support disciplinary learning and/or student reflection, while also ensuring students' safety and agency given the unpredictable nature and biases of AI tools.

Acknowledgments

This material is based upon work supported by Stanford Digital Education, Stanford Institute for Human-Centered Artificial Intelligence (HAI), Stanford Accelerator for Learning, and the McCoy Family Center for Ethics in Society as part of the Stanford Classroom-Ready Resources About AI For Teaching (CRAFT) initiative. We thank the teachers who co-designed curriculum with us.

References

Agostinelli, A.; Denk, T. I.; Borsos, Z.; Engel, J.; Verzetti, M.; Caillon, A.; Huang, Q.; Jansen, A.; Roberts, A.; Tagliasacchi, M.; Sharifi, M.; Zeghidour, N.; and Frank, C. 2023. MusicLM: Generating Music From Text.

Ali, S.; Kumar, V.; and Breazeal, C. 2023. AI Audit: A Card Game to Reflect on Everyday AI Systems. *AAAI*, 37(13).

Allen, A.; Harvey, M.; Clark, C.; Lewandowski, A.; and Rothenberg, D. 2019. Pattern Radio: Whale Songs.

Alonso, N. M. 2022. DALL-E Copies My Hand Drawings.

Alvarez, L.; Gransbury, I.; Cateté, V.; Barnes, T.; Ledéczi, Á.; and Grover, S. 2022. A Socially Relevant Focused AI Curriculum Designed for Female High School Students. *AAAI*, 36(11): 12698–12705.

Angwin, J.; Larson, J.; Kirchner, L.; and Mattu, S. 2016. Machine Bias. https://www.propublica.org/article/machine-bias-risk-assessments-in-criminal-sentencing.

Blanchard, E. G. 2012. On the WEIRD Nature of ITS/AIED Conferences. In *Intelligent Tutoring Systems*, 280–285. Springer Berlin Heidelberg.

Bowen, G. A. 2006. Grounded Theory and Sensitizing Concepts. *International Journal of Qualitative Methods*, 5(3).

Boyd-Thomas, D. ???? How to Tackle the OPCVL Question for IB History.

Braun, V.; and Clarke, V. 2006. Using thematic analysis in psychology. *Qualitative research in psychology*, 3(2).

Buolamwini, J. 2016. The Coded Gaze: Unmasking Algorithmic Bias.

Buolamwini, J. 2018. Gender Shades. http://gendershades.org/overview.html. Accessed: 2023-2-8.

Chao, J.; Ellis, R.; Jiang, S.; Rosé, C.; Finzer, W.; Tatar, C.; Fiacco, J.; and Wiedemann, K. 2023. Exploring Artificial Intelligence in English Language Arts with StoryQ. *AAAI*, 37(13): 15999–16003.

Coldewey, D. 2020. AI-drawn voting districts could help stamp out gerrymandering. *TechCrunch*.

Computerphile. 2022. How AI Image Generators Work (Stable Diffusion / Dall-E) - Computerphile.

Conlen, M.; and Hohman, F. 2018. The Beginner's Guide to Dimensionality Reduction. https://dimensionality-reduction-293e465c2a3443e8941b016d.vercel.app/.

Cooper, D. 2022. Is DALL-E's art borrowed or stolen? https://www.engadget.com/dall-e-generative-ai-tracking-data-privacy-160034656.html?guccounter=1.

Corbett-Davies, S.; Pierson, E.; Feller, A.; and Goel, S. 2016. A computer program used for bail and sentencing decisions was labeled biased against blacks. It's actually not that clear. *The Washington Post*.

Costanza-Chock, S. 2020. *Design Justice: Community-Led Practices to Build the Worlds We Need*. MIT Press.

Csapo, G.; Kim, J.; Klasinc, M.; and ElKattan, A. 2019. Survival of the Best Fit. https://www.survivalofthebestfit.com/game/. Accessed: 2023-2-8.

dallery.gallery. 2023. The DALL-E 2 prompt book. https://pitch.com/v/tmd33y/6fb6f14b-10ef-48f3-a597-d4af7aa1c9c6. Accessed: 2023-1-4.

Druga, S.; Otero, N.; and Ko, A. J. 2022. The Landscape of Teaching Resources for AI Education. In *27th ACM Conference on on Innovation and Technology in Computer Science Education Vol. 1*, 96–102. New York, NY, USA: ACM.

Grimm, P. 2010. Social Desirability Bias. In Sheth, J.; and Malhotra, N., eds., *Wiley International Encyclopedia of Marketing*, volume 50, 537. Chichester, UK: John Wiley & Sons, Ltd. ISBN 9781405161787, 9781444316568.

Guerzhoy, M.; Neumann, M.; Johnson*, E.; Johnson, D.; Chai, H.; Garijo, D.; Lyu, Z.; and MacLellan, C. J. 2022. EAAI-22 Blue Sky Ideas in Artificial Intelligence Education from the AAAI/ACM SIGAI New and Future AI Educator Program. *AI Matters*, 8(2): 16–21.

Hammer, D.; and Berland, L. K. 2014. Confusing Claims for Data: A Critique of Common Practices for Presenting Qualitative Research on Learning. *Journal of the Learning Sciences*, 23(1): 37–46.

Henrich, J.; Heine, S. J.; and Norenzayan, A. 2010. Most people are not WEIRD. *Nature*, 466(7302): 29.

Herkert, J. R. 2005. Ways of thinking about and teaching ethical problem solving: Microethics and macroethics in engineering. *Science and Engineering Ethics*, 11: 373–385.

Ho, S.; and Burke, G. 2023. An AI tool may flag parents with disabilities and take their children away. It could be coming to Northampton County. *Morning Call*.

Holwell, S. 2004. Themes, Iteration, and Recoverability in Action Research. In Kaplan, B.; Truex, D. P.; Wastell, D.; Wood-Harper, A. T.; and DeGross, J. I., eds., *Information Systems Research: Relevant Theory and Informed Practice*, 353–362. Boston, MA: Springer US. ISBN 9781402080951.

Impact Research. 2023. Teachers and Students Embrace ChatGPT for Education. Technical report, Walton Family Foundation.

Jiang, S.; Lee, V. R.; and Rosenberg, J. M. 2022. Data science education across the disciplines: Underexamined opportunities for K-12 innovation. *British Journal of Educational Technology*, 53(2): 1073–1079.

Kessler, A. 2022. Children's Book Generated With ChatGPT & Midjourney. https://80.lv/articles/children-s-book-generated-with-chatgpt-midjourney/. Accessed: 2023-1-8.

Krakowski, A.; Greenwald, E.; Hurt, T.; Nonnecke, B.; and Cannady, M. 2022. Authentic Integration of Ethics and AI through Sociotechnical, Problem-Based Learning. *AAAI*, 36(11): 12774–12782.

Kumar, V.; and Worsley, M. 2023. Scratch for Sports: Athletic Drills as a Platform for Experiencing, Understanding, and Developing AI-Driven Apps. *AAAI*, 37(13).

Lang, J. 2023. Class-Action Lawsuit Filed Against Stability AI, Midjourney, DeviantArt. *Cartoon Brew*.

Lee, I.; and Perret, B. 2022. Preparing High School Teachers to Integrate AI Methods into STEM Classrooms. *AAAI*.

Lin, P.; and Van Brummelen, J. 2021. Engaging Teachers to Co-Design Integrated AI Curriculum for K-12 Classrooms. In *CHI Conference on Human Factors in Computing Systems*, CHI '21. New York, NY, USA: ACM.

Linxen, S.; Sturm, C.; Brühlmann, F.; Cassau, V.; Opwis, K.; and Reinecke, K. 2021. How WEIRD is CHI? In *CHI Conference on Human Factors in Computing Systems*, number Article 143 in CHI '21, 1–14. New York, NY, USA: ACM.

Locke, L. A. 2019. Typical Areas of Confusion for Students New to Qualitative Research. In Strunk, K. K.; and Locke, L. A., eds., *Research Methods for Social Justice and Equity in Education*, 117–123. Springer.

Long, D.; Blunt, T.; and Magerko, B. 2021. Co-Designing AI Literacy Exhibits for Informal Learning Spaces. CSCW '21. ACM.

Long, D.; and Magerko, B. 2020. What is AI Literacy? Competencies and Design Considerations. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, CHI '20, 1–16. New York, NY, USA: ACM.

Marr, B. 2019. The 10 Best Examples Of How AI Is Already Used In Our Everyday Life. *Forbes Magazine*.

Morse, O. ???? SOAPSTone: A Strategy for Reading and Writing.

MrStormUMA. 2023. Using ChatGPT to grade essays and give detailed feedback: For Teachers.

Norouzi, N.; Chaturvedi, S.; and Rutledge, M. 2020. Lessons Learned from Teaching Machine Learning and Natural Language Processing to High School Students. *AAAI*, 34(09): 13397–13403.

Penuel, W. R.; Allen, A.-R.; Coburn, C. E.; and Farrell, C. 2015. Conceptualizing Research–Practice Partnerships as Joint Work at Boundaries. *Journal of Education for Students Placed at Risk (JESPAR)*, 20(1-2): 182–197.

Penuel, W. R.; Allen, A.-R.; Henson, K.; Campanella, M.; Patton, R.; Rademaker, K.; Reed, W.; Watkins, D.; Wingert, K.; Reiser, B.; and Zivic, A. 2022. Learning Practical Design Knowledge through Co-Designing Storyline Science Curriculum Units. *Cognition and Instruction*, 40(1): 148–170.

People + AI Research. ????a. coco_captions. https://knowyourdata-tfds.withgoogle.com/.

People + AI Research. ????b. Datasets Have Worldviews. https://pair.withgoogle.com/explorables/dataset-worldviews/. Accessed: 2023-9-8.

People + AI Research. ????c. Explore datasets in Know Your Data. https://knowyourdata-tfds.withgoogle.com/.

Richardson, R.; and Schultz, Jason M Southerland, Vincent. 2019. Litigating Algorithms 2019 US Report: New Challenges to Government Use of Algorithmic Decision Systems. Technical report, AI Now Institute.

Rudin, C.; and Radin, J. 2019. Why are we using black box models in AI when we don't need to? A lesson from an explainable AI competition. *1.2*, 1(2).

Santhanam, L. 2016. Can big data save these children? https://www.pbs.org/newshour/nation/can-big-data-save-these-children. Accessed: 2023-2-8.

Sanusi, I. T.; Oyelere, S. S.; and Omidiora, J. O. 2022. Exploring teachers' preconceptions of teaching machine learning in high school: A preliminary insight from Africa. *Computers and Education Open*, 3: 100072.

Sanusi, I. T.; Oyelere, S. S.; Vartiainen, H.; Suhonen, J.; and Tukiainen, M. 2023. A systematic review of teaching and learning machine learning in K-12 education. *Education and Information Technologies*, 28(5): 5967–5997.

Selyukh, A. 2018. Optimized Prime: How AI And Anticipation Power Amazon's 1-Hour Deliveries. *NPR*.

Sentance, S. 2022. The AI4K12 project: Big ideas for AI education. https://www.raspberrypi.org/blog/ai-education-ai4k12-big-ideas-ai-thinking/. Accessed: 2023-9-1.

Sentance, S.; Barendsen, E.; Howard, N. R.; and Schulte, C. 2023. *Computer Science Education: Perspectives on Teaching and Learning in School*. Bloomsbury Publishing.

Severance, S.; Penuel, W. R.; Sumner, T.; and Leary, H. 2016. Organizing for Teacher Agency in Curricular Co-Design. *Journal of the Learning Sciences*, 25(4): 531–564.

Song, J.; Yu, J.; Yan, L.; Zhang, L.; Liu, B.; Zhang, Y.; and Lu, Y. 2023. Develop AI Teaching and Learning Resources for Compulsory Education in China. *AAAI*, 37(13).

Song, J.; Zhang, L.; Yu, J.; Peng, Y.; Ma, A.; and Lu, Y. 2022. Paving the Way for Novices: How to Teach AI for K-12 Education in China. *AAAI*, 36(11).

Stanford, C. 2022. Angèle Christin: "Algorithms in Practice".

statisticsfun. 2012. Standard Error of the Estimate used in Regression Analysis (Mean Square Error).

Tedre, M.; Toivonen, T.; Kahila, J.; Vartiainen, H.; Valtonen, T.; Jormanainen, I.; and Pears, A. 2021. Teaching Machine Learning in K–12 Classroom: Pedagogical and Technological Trajectories for Artificial Intelligence Education. *IEEE Access*, 9: 110558–110572.

Touretzky, D. S.; and Gardner-McCune, C. 2023. Guiding Students to Investigate What Google Speech Recognition Knows about Language. *AAAI*, 37(13): 16040–16047.

Tracy, S. J. 2010. Qualitative Quality: Eight "Big-Tent" Criteria for Excellent Qualitative Research. *Qualitative inquiry: QI*, 16(10): 837–851.

Verge Science. 2018. What the world looks like to an algorithm.

Walsh, B.; Dalton, B.; Forsyth, S.; and Yeh, T. 2023. Literacy and STEM Teachers Adapt AI Ethics Curriculum. *AAAI*, 37(13): 16048–16055.

Wiggers, K. 2020. Researchers show that computer vision algorithms pretrained on ImageNet exhibit multiple, distressing biases.

YR Media's Interactive Team. 2020. Erase Your Face. https://interactive.yr.media/erase-your-face/.