Impact.AI
Democratizing AI through K-12 Artificial Intelligence Education

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Abstract

Today’s artificial intelligence (AI) technologies are changing how many people play, work, learn, and govern themselves. This rapid technological change is already having significant effects on individuals’ lives and opportunities. Thus, researchers, educators, and government leaders must consider how to prepare a diverse citizenry to thrive in the emerging age of AI, for example through outreach initiatives like grade school AI curricula. We propose to develop AI curricula and educational platforms that support K-12 students in fostering identities as technosocial change agents while they learn about AI. First, we introduce a new AI literacy framework, Impact.AI, that covers the AI concepts, practices, and perspectives that align with a technosocial change agent identity. This framework will inform the development of middle school AI curricula that empower students to become conscious consumers, ethical engineers, and informed advocates of AI. Next, we will develop AI education tools that facilitate students’ learning about AI as they work on AI projects. These tools will provide technical scaffolding, encourage creativity, and guide reflection. Finally, we will bring together these two strands of work to evaluate how well these artifacts improve learning outcomes and students’ attitudes toward AI. As AI becomes increasingly prevalent in everyday life, it is important that all people have the opportunity to both understand and shape the technology.

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Introduction

“We have this AI in the district where my school is, ShotSpotter. They put microphones all over the city listening for gunshots then reporting them to the police. The problem is, sometimes there’s a loud sound, like a car backfiring, and all of a sudden police swarm a neighborhood. Then it’s a tense situation with police in a life or death situation, looking for a gun where there isn’t one, and people having no idea what’s going on... I want my students to learn about that stuff, like how it works. I feel like with this [AI curriculum], they could learn and maybe try to build something better.”

- Paraphrased from a conversation with Chicago public school teacher

From voice personal assistants to government decision-making algorithms, artificial intelligence (AI) is increasingly involved in how people work, play, learn, and govern themselves. However, many people are unaware of the extent to which AI is used in their daily lives and have limited understanding of how it works (Gallup and Northeastern University, 2019). This lack of awareness about AI is likely to put individuals at risk of rights violations like manipulation, discrimination, and privacy encroachment (McReynolds, et al., 2017; O’Neil, 2017).

Furthermore, researchers and organizations have identified concerns about how the lack of oversight and diversity in the field of AI has led to systems that disproportionately harm the most vulnerable members of society (Benjamin, 2019; Bolukbasi et al., 2016; Buolamwini and Gebru, 2018; Eubanks, 2018; Noble, 2018). Although access to CS education is expanding, participation from historically marginalized groups continues to lag (Code.org et al., 2022). To ensure that a diverse citizenry can thrive in the emerging age of AI, we must think about how we create opportunities for everyone to participate in this field.

I propose to develop AI literacy artifacts that help prepare a diverse citizenry to become technosocial change agents in an AI-powered society. This term comes from work on culturally responsive-sustaining computing pedagogy and involves creating learning environments that empower students to explore and reimagine technology, society, and themselves (Scott et al., 2015). The first artifact of this dissertation is an AI literacy framework that outlines the AI knowledge and perspectives that align with a technosocial change agent identity. This framework will inform the creation of AI curricula for middle school classrooms. The second artifact will be an AI-enabled programming platform that scaffolds students' technical skills, creativity, and self-regulated learning.

I will evaluate this work by analyzing the effectiveness of the artifacts in classrooms. At the middle school level, teachers have curricular flexibility, and students are academically prepared to implement interesting AI projects for social good. We are centering students with identities that are underrepresented in tech (specifically female and other gender minorities, Black, non-white Hispanics, and students from low-income socioeconomic backgrounds) to create a positive educational opportunity for groups of students that have been historically underserved by the U.S. education system.
Contributions

This work will contribute to AI literacy, AI education (defined as AI systems developed to support education), and AI for social good. The contributions to AI literacy include the design of an AI literacy framework and AI curricula that prepare learners to become technosocial change agents. The curricula will be free, publicly available resources that educators can adapt to their needs. The contributions to AI education are a new AI programming platform with integrated scaffolds for technical skills, creativity, and reflection. Finally, for the field of AI for social good, we will curate a collection of community-centered AI projects developed by students primarily from groups that are marginalized by and excluded from the tech industry.

Related Work

![Diagram of Five Big Ideas in AI]

Figure 1: The Five Big Ideas in AI as proposed by Touretzky et al., 2019.

K-12 AI Literacy

In recent years, researchers have put forth two significant frameworks for K-12 AI literacy: a blue sky paper on the Five Big Ideas from Touretzky et al. (2019) and a paper defining AI literacy by Long and Magerko (2020). Touretzky et al. (2019) focus on the AI concepts that all K-12 students should learn to be empowered as consumers and future contributors to AI. They framed them as Five Big Ideas in AI: (1) Perception, (2) Representation & Reasoning, (3) Learning, (4) Human-AI Interaction, and (5) Societal Impact. Long and Magerko (2020) synthesized 17 AI
competencies that non-technical learners should master to become AI literate. The competencies include what AI is, what it can do, how it works, and how students can use AI properly. Their work also includes considerations for the design of AI curricula and educational artifacts. Overall, both frameworks outline a vision for the knowledge and skills that everyone should possess to be effective users of AI (Touretzky et al., 2019; Long and Mageenko, 2020).

In a systematic review of sixty K-12 AI curricula, we observed trends in the AI content that educators typically teach. Most of the curricula were short, informal learning opportunities focusing on one topic or Big Idea in AI. Many researchers have noted that Machine Learning (Big Idea #3) is the most frequently covered topic, often at the expense of other areas of AI (Ng et al., 2021; Sanusi et al., 2021). Societal Impact and Ethics (Big Idea #5) was covered in fewer than a third of the curricula despite its expressed importance in the Five Big Ideas framework. For AI skills, learning to build AI artifacts was emphasized over learning to analyze AI systems or communicate about AI. Most curricula taught students to construct AI using block-based programming languages like Snap!, Scratch, or AppInventor with AI extensions. There need to be more tools and platforms that help students analyze and communicate about AI. Finally, the most taught AI perspectives were related to digital literacy, with little focus on critical digital literacy or students’ identities relative to technology. Critical discussions about identity and society only came up in curricula with a dedicated diversity, equity, and inclusivity (DEI) focus (Zhou et al., 2020; Ng et al., 2021). These trends in the design of AI curricula demonstrate a solid foundation of work that we can build upon and important areas we still need to address.

Beyond knowledge and skills, AI literacy frameworks should also cover critical perspectives about AI’s role in society and learners’ potential roles in shaping technology. Emphasizing topics like ethics, social impact, and justice in AI will be necessary if the field is ever going to stop perpetuating systems of harm (Buolamwini & Gebru, 2018; Eubanks, 2018; Noble, 2018; O’Neil, 2016). In university courses, Skirpan et al. (2018) concluded that when students learn ethics throughout a computer science course, they finish the course with a better grasp of the implications of technology than if ethics is taught at the end of a course or in a different course altogether. At the K-12 level, we advocate for building AI curricula that “embed ethics” in technical lessons to engage students in discussing sociopolitical issues as they learn about the technological affordances (DiPaola et al., 2020; Payne, 2020; Williams et al. 2022).

AI literacy frameworks should also explicitly address DEI in AI by incorporating culturally responsive-sustaining pedagogies (CRPs). CRPs recognize that students must develop academic knowledge, cultural competence, and critical consciousness to become efficacious agents for change in an inequitable society (Ladson-Billings, 2014; Scott et al., 2015; Lee and Soep, 2016; Madkins, et al., 2019). Although existing AI frameworks allude to the importance of inclusivity, none directly tackles the challenges that historically marginalized students face. The Machine Learning Education Framework created by Lao (2020) is the best example of an AI literacy framework that considers learners’ identities. It emphasizes that learners should build self-efficacy and develop identities as ML-engaged citizens. However, the ML Education Framework focuses on machine learning, not all AI topics, and is for post-secondary learners.

By building on CRPs and the ML Education Framework, we aim to create rigorous programs that enable students to use their AI knowledge to address authentic and meaningful problems. In particular, we will build on Culturally Responsive Computing. Culturally Responsive Computing is a specific CRP that
outlines five tenets to aid students in their identity formation as technosocial change agents who take meaningful action to transform society using technology (Scott et al., 2015).

AI Education Platforms

A large portion of work in K-12 AI literacy involves the development of novice-friendly platforms that aid learning. Ng et al. (2021) and Sanusi et al. (2021) reviewed the educational tools used in K-12 AI curricula, including hardware, software, intelligent agents, robots, and unplugged learning activities. Many tools are for AI prototyping, signifying a common tendency toward hands-on learning and empowering students to become producers, not just consumers, of AI (Ng et al., 2021). These interactive tools make different parts of AI development more accessible to students. Plus, they take input from users' webcams, microphones, voice assistants, or computer files to encourage personalization. Usability in the classroom is an important design consideration for the tools. Online tools such as the Teachable Machine, Cognimates, Machine Learning for Kids, LearningML, and our RAISE Playground have made it easier for students to train AI models without needing high-end hardware or extensive setup (Carney et al., 2020; Druga, 2018; Rodriguez-García et al., 2020; Jordan et al., 2021).

Although K-12 AI curricula often leverage digital platforms to teach AI concepts, less effort has gone into building AI-powered tools to teach AI. There is much potential to build on existing AI education tools for language arts, engineering, math, and computer science education that scaffold both technical and metacognitive skills. For AI literacy, three critical areas to support students are through technical scaffolding, creativity, and guided reflection. First, technical scaffolding tools, like a tool we developed called LevelUp, can help students get real-time help as they develop new AI skills. LevelUp is an automatic assessment tool that grades students' text classification projects as they work (Reddy et al., 2022). Next, creativity scaffolding tools like socially assistive robots have helped human creators brainstorm and explore new ideas (Gordon et al., 2015; Kahn et al., 2016; Ali et al., 2021). This support drives learners to stay motivated as they tackle new challenges. Finally, robots have also guided users in reflecting on and connecting their previous experiences to new tasks (Jung et al., 2014; Kahn et al., 2016). Reflection helped users deepen and generalize their understanding of what they were doing. We hope to holistically support learners as they work on creative AI projects by incorporating these kinds of AI-powered scaffolds into AI curricula.

Proposed Work

AI Literacy Framework

The Impact.AI framework seeks to equip students to use AI to transform society. Learning to be technosocial change agents means that students become conscientious consumers, ethical engineers, and informed advocates who view AI as a tool to transform society. The framework also directly confronts issues of inclusion by centering students who have been historically marginalized in the field of technology. The framework covers the knowledge and perspectives students should possess as technosocial change agents, broken down into three areas: content, practices, and perspectives. Brennan and Resnick’s (2012) concepts, practices, and perspectives framework for K-12 computational thinking education inspired this structure.
AI "concepts" are the set of knowledge that AI practitioners engage with as they do their work. We define AI concepts based on the Five Big Ideas plus background knowledge about AI, and interdisciplinary topics (e.g., biological science, data science, math) (Touretzky et al., 2019). Covering every AI concept is unlikely to be feasible due to classroom time constraints. However, within a topic educators should strive to cover key vocabulary, different approaches, applications, capabilities, and limitations. We also advocate for embedding ethics and societal impact in every lesson. Embedding ethics means contextualizing technical information in its broader impact and engaging students in ongoing discussions in the field of AI (Williams et al., 2022).

AI "practices" are the skills that AI practitioners employ in their work. The three subcategories of AI practices are the construction of AI, analysis of AI, and communication about AI. AI construction skills are prevalent in prior work, with many curricula providing tools for AI prototyping. Students should be able to determine whether an AI system can solve a problem then engage in a human-centered AI development process (i.e., empathize, define, ideate, prototype, test, reflect) to build functional AI systems. Analysis and communication appeared less often, though they are essential AI skills. To prepare students to critically examine the societal consequences of technology, analyzing and communicating about AI must be more central in AI literacy. For analyzing AI, students should be able to use field-recognized methods to evaluate systems and their impact on key stakeholders. For communicating about AI, students should be able to use a variety of styles to collaborate with interdisciplinary audiences. Within each subcategory of AI practices, students should be exposed to multiple tools and a range of different AI problems, including problems they independently develop.

AI "perspectives" are the beliefs about technology and self that individuals realize as they engage with AI. The subcategories of AI perspectives are 21st century citizenship and identity and social awareness. 21st century citizenship covers students' beliefs about technology's role in shaping society and society's role in shaping technology. Students should be able to use their AI knowledge to understand AI artifacts, advocate for systems that dismantle oppression, and integrate socially beneficial AI into their lives. They
must have a nuanced view of AI's potential and recognize that different people have important roles to play in shaping technology. Finally, students should cultivate a positive self-image as AI creators and activists. This perspective derives directly from the Culturally Responsive Computing framework developed by Scott et al. (2015) and is especially important for students from groups that have been historically marginalized by the field of computing. Students should develop a sense of self-efficacy with regard to AI. They should feel empowered both to use AI as individual creators and as community activists. All students should feel empowered by AI curricula and excited to engage with AI as consumers, engineers, and advocates.

Middle School AI Curricula

One goal of the Impact.AI framework is to inspire the design of K-12 AI curricula. We are developing two middle school AI curricula that cover chatbots and self-driving vehicles. We chose these two topics to match partner schools' interests and expand the coverage of AI topics provided by the MIT Personal Robots Group. Tables 1 and 2 display each curriculum's specific learning objectives regarding AI concepts, practices, and perspectives.

Curriculum 1 – Dr. O’Bott: Chatbots for Mental Health

Today's chatbots and voice personal assistants are more pervasive, persuasive, and alluring than ever. These AI-enabled assistants are not only highly capable, but also designed to seem trustworthy and lifelike. In this curriculum, students explore the affordances of chatbots, how they work, and how they impact people positively and negatively. Students will explore topics like agent persona design, user interface design, and intent recognition with machine learning through hands-on programming activities. They will also explore and debate critical ethical considerations in the design of AI agents, like accessibility, manipulation, and privacy. By the end of the curriculum, students will take all they have learned to design a well-being intervention with AI agents for personal use or their communities.
Table 1: Concepts, Practices, and Perspectives Covered in Dr. O’Bott

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Practices</th>
<th>Perspectives</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Background</strong></td>
<td><strong>Constructing AI</strong></td>
<td><strong>21st Century Citizenship</strong></td>
</tr>
<tr>
<td>Definition of AI, examples of</td>
<td>Scoping AI problems, human-centered AI</td>
<td>Recognizing AI in daily life, imagining uses for AI, exploring different perspectives about AI, disparities in access to mental health and well-being resources</td>
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<tr>
<td>AI, capabilities and limitations</td>
<td>development, programming and</td>
<td></td>
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<td>of natural communication with AI</td>
<td>computational thinking, user</td>
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<td>interface design</td>
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<td><strong>Big Idea #4 Natural Communication:</strong></td>
<td></td>
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<tr>
<td>Definition of AI agents, intro to</td>
<td>Analyzing AI Stakeholder analysis, getting user feedback</td>
<td>Identity and Social Awareness</td>
</tr>
<tr>
<td>AI capabilities that contribute to</td>
<td>User-facing warnings, presentation skills, debate</td>
<td>Inventor personal strengths, connecting AI knowledge to community issues</td>
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<tr>
<td>natural communication, chatbots for well-being</td>
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<tr>
<td><strong>Big Idea #5 Ethics and Societal Impact</strong></td>
<td></td>
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<tr>
<td>Potential benefits and harms of AI agents, design considerations for AI agents, AI bias</td>
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<tr>
<td><strong>Curriculum 2 – Red Light, Green Light: Self-Driving Cars</strong></td>
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<td>Self-driving cars are one of the most popular and futuristic examples of AI that is within reach today. Although fully autonomous vehicles are not currently on the streets, many problem-solving algorithms that power self-driving cars are present in everyday technologies. In this curriculum, students learn about AI decision-making, modeling real-world phenomena, AI fairness metrics, and present-day examples of AI problem-solvers. In the societal impact and ethics modules, students learn how algorithms have perpetuated or mitigated disparities in communities’ access to resources. At the end of the curriculum, students will share a mobile, autonomous AI system they designed to address an algorithmic bias issue.</td>
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Table 2: Concepts, Practices, and Perspectives Covered in Red Light, Green Light

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<tr>
<th>Concepts</th>
<th>Practices</th>
<th>Perspectives</th>
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</thead>
<tbody>
<tr>
<td><strong>Background</strong>&lt;br&gt;Definition of AI, examples of AI, human vs. AI decision-making</td>
<td><strong>Constructing AI</strong>&lt;br&gt;Scoping AI problems, human-centered AI development, programming and computational thinking</td>
<td><strong>21st Century Citizenship</strong>&lt;br&gt;Recognizing AI in daily life, exploring different ways to solve problems, disparities in access to social services</td>
</tr>
<tr>
<td><strong>Big Idea #2</strong>&lt;br&gt;Definitions of representation and reasoning, mapping, path planning, search algorithms, applications of decision-making AI</td>
<td><strong>Analyzing AI</strong>&lt;br&gt;Stakeholder analysis, impact analysis, evaluation metrics</td>
<td><strong>Identity and Social Awareness</strong>&lt;br&gt;Inventorying community resources and strengths, digital activism</td>
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<tr>
<td><strong>Big Idea #5</strong>&lt;br&gt;Design considerations for AI decision-makers, AI bias, measuring the impact of AI systems</td>
<td><strong>Communicating About AI</strong>&lt;br&gt;Awareness campaigns, presentation skills, communicating with data visualization</td>
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*AI Platforms for AI Curricula*

Both curricula include hands-on programming activities that leverage the RAISE Playground, a block-based programming platform for building creative AI projects. We built this platform on top of the open-source Scratch Blocks code repository\(^1\). The AI extensions in the RAISE playground make it easy for beginning programmers to create dialogue flows, control robots, train supervised machine learning models, create maps, and implement path-planning algorithms. The entire platform runs in the browser and does not require installation, account, or payment – making setup easy.

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\(^1\) Scratch Blocks code repository, [https://github.com/LLK/](https://github.com/LLK/)
Both curricula also leverage physical robots that promote student engagement through embodied interaction. The chatbot curriculum uses a social robot called Jibo. It is a consumer social robot with an expressive screen/face, an expressive voice, automatic speech recognition, physical movement, and an LED ring. Jibo is used for socially assistive robotics research in applications ranging from education to therapy. The self-driving vehicle curriculum uses a commercial micro:bit robot that includes peripherals like push buttons, a 25-LED array, two RGB LED headlights, a piezo buzzer, a distance sensor, two line sensors, and two motors. These robots can use line-following algorithms to navigate maps.

AI Education Tools

Despite the numerous resources available for K-12 computer science education, access to training and supplemental materials remain significant obstacles in K-12 AI literacy. We aim to facilitate effective teaching and learning by creating AI-based education tools. Integrating automatic scaffolding tools into our AI programming platform will enhance student learning and allow us to help students when they get stuck.

The goal of the technical scaffolding tool is to reinforce students' knowledge as they work on projects. We built an automatic scaffolding tool called LevelUp that evaluates the technical quality of students' projects as they work. LevelUp contains a rubric with a handful of crucial items programmers should consider when building supervised machine learning models (Reddy et al., 2022). The tool automatically scores students' projects as they work, then students can see a list of things they have done well and what they might do to improve. This continuous feedback gives just-in-time reinforcement of the skills students are currently learning. We have already built and evaluated this tool for supervised machine learning projects. We will expand it to cover dialogue flow and path-planning algorithms.

The goal of the creative scaffolding tool is to encourage students to extend their ideas and experiment with new ones. We will build a tool that gives visual feedback on creativity and recommends new things
to try. Building on Scratch's Coding Cards\(^2\), we have curated short code snippets incorporating different blocks and features within the RAISE Playground. For each topic (e.g., machine learning), there will be 7 - 10 associated coding cards that feature various types and levels of challenges for students to explore. Code snippets will appear in a pop-up tutorial window on the screen. The window will suggest different snippets based on a project's content, with easier and more relevant ideas displayed first. When a student's project includes code that is similar to a snippet, they receive a corresponding leaf on their "Creativi-tree," indicating their progress. Within one project, this visualization will make it easy for students to note their accomplishments. Across projects, the visualization can help identify trends in students' work. Students can use this information in concert with code snippets to guide their exploration. This tool is in progress and will be evaluated before we integrate it into a curriculum.

The goal of the reflective scaffolding tool is to strengthen students' self-regulated learning by providing some structure for them. Before students work on projects, they can check out finished examples. Then, they will be asked to reflect on their personal interests and skills to set meaningful goals for their work. Some of these goals can be automatically tracked, like those in the technical and creative scaffolding tools. Other goals can be manually checked off, like asking for feedback from a particular person. This information is stored with projects, so students can continue to come back to them. At the end of working time, students can use the goal-setting tool to acknowledge their accomplishments and reflect on new interests and future goals. This tool is in progress and will be evaluated before we integrate it into a curriculum.

**Research Questions**

I will evaluate the curricula and artifacts developed using scientific research studies in middle school classrooms. Through the completion of this dissertation, we hope to answer the following research questions:

1. How effective are the automatic scaffolding tools in supporting technical complexity and creativity in students' AI projects?
2. How effective are the Impact.AI curricula in supporting technical AI knowledge gain?
3. How effective are the Impact.AI curricula in promoting students' self-efficacy, sense of belonging, and identity as technosocial change agents?

Data collection for this dissertation will involve both lab and classroom studies. We will use smaller lab studies to answer research question 1. In these more focused studies, we can make more controlled measurements of the effectiveness of the scaffolding tools. We will use larger classroom studies to answer research questions 2 and 3 in a practical classroom setting.

Participants
In the smaller lab studies, we will gather 30+ participants with little to no experience in computer science or AI. Participants will complete the user study individually with a researcher. For the larger classroom studies, we will recruit 2-4 middle school teachers, ideally from Title 1 middle schools in the United States, and train them to conduct an Impact.AI curriculum in the classroom. We will ask teachers to recruit middle school (ages 11 to 14) students from their classrooms to participate in the workshops. Students will have the option to participate in the workshop whether they consent to data collection or not.

Before studies begin, the protocols will be reviewed and approved by the Institutional Review Board at the Massachusetts Institute of Technology. All participants will be informed that they are participating in a research study to evaluate and refine educational materials for AI literacy. Students and their parents who agree to participate in the study will sign consent forms before participating in the study. Teachers participating in the study will review and sign consent forms that permit us to use their data. Teacher and student participants will reserve the right to withdraw from the study at any point.

Data Collection and Methodology
To measure the extent to which our study can be generalized to different populations, we will collect demographic information about the schools, students, and teachers that we work with. Specifically, the students’ age, whether their gender is underrepresented in tech, whether their race is underrepresented in tech, and the amount of prior experience in computer science they have. For teachers, we will collect the number of years they have spent teaching, the number of years they have spent teaching STEM/computing, and whether their race and gender is underrepresented in tech. For the school we will report each school’s Title 1 status, overall demographics, and number of computer science courses.

Lab Studies
Quantitative assessments:
1. Pre-Post AI concept and skill assessment
   We will use a modified version of the AI Concept Inventory developed by Zhang et al., (2022). The AI Concept Inventory has six scales that measure students’ understanding of general AI concepts, logic systems, machine learning, supervised learning, neural networks, and generative adversarial networks. We will use the general AI scale from this inventory and then add additional questions related to whichever topic (e.g., chatbots or self-driving cars) is directly relevant to the study.
   On the post-assessments, we will ask self-assessment questions about their comfortability with skills related to constructing AI.
2. Project topic and skill inventory
   We will use a modified version of Lao’s (2020) analysis of project themes and approaches. This analysis includes describing students’ final projects by their theme, how students came up with the project, and the AI concepts and practices demonstrated in the project.

Qualitative assessments:
1. Thematic analysis of post-study responses to open-ended questions
The procedure we will follow for the lab studies is as follows:
1. We will recruit participants and assign them to an experimental condition such that we can balance the gender, age, and amount of previous computing experience in each group.
2. Participants will complete the AI concept and skill pre-assessment.
3. Participants will receive instructions on how to complete a creative programming project on the RAISE playground. The instructions will include resources participants can use to practice target skills (i.e., creativity or reflection).
4. Participants will have 15-20 minutes to work on a creative programming project. Participants in the test condition will have access to the automatic scaffolding tool.
5. Participants will submit their first projects and complete the AI concept and skill post-assessment.
6. Participants will have another 15-20 minutes to work on a second creative programming project. This time, the conditions will switch and the control group will get access to the automatic scaffolding tool while the test group will be restricted.
7. Participants will submit their second projects and complete a final post-study interview on their experiences.

To answer research question 1 (How effective are the automatic scaffolding tools in supporting technical complexity and creativity in students’ AI projects?), we will create achievement metrics from the project topic and skill inventory to compare the two groups. We expect that, when students have access to the automatic scaffolding tool, their projects will receive higher project achievement scores and there will be more variety in their project topics. We will also compare groups’ pre-post scores on the concept and skill assessment to verify that differences in project scores are due to the tool rather than differences in understanding. The post-study interviews will help us understand what factors contributed to students’ success from their point-of-view.

*Classroom Studies*

Quantitative assessments:
1. Extended Pre-Post AI concept and skill assessment
   Similar to the lab studies, we will use a modified version of the AI Concept Inventory developed by Zhang et al., (2022). We will use the first three AI Concept Inventory scales (general AI, logic systems, and machine learning) then add additional questions to assess concepts related to chatbots and self-driving cars.
   On the post-assessment, once students have been exposed to AI practices, we will ask self-assessment questions about their comfortability with skills related to constructing, communicating about, and analyzing AI.
2. Pre-Post Attitudes toward AI questionnaire
   We will use a modified version of the Attitudes Toward AI Survey developed by Zhang et al., (2022). The Attitudes toward AI survey contains 5-Likert scale questions about science motivation, attitudes toward science, and AI anxiety. To these items, we will add questions from Lao’s (2020) survey on self-efficacy.
3. Final project topic and skill inventory
   Similar to the lab studies, we will use a modified version of Lao’s (2020) analysis of project
   themes and approaches. We will use Lao’ full analysis plus two items about the relevance of the
   project to social justice themes explored in the curriculum and the projects’ scope (e.g. personal,
   local, specific group, regional, global).

Qualitative assessments:
1. Thematic analysis of post-workshop responses to open-ended questions

The procedure we will follow for the classroom studies is as follows:
1. We will recruit and train teachers to deliver a complete version of an Impact.AI curriculum.
   Teachers will complete a pre-interview.
2. Before instruction begins, students will complete the AI concept and skill pre-assessment and the
   Attitudes toward AI pre-questionnaire.
3. As students complete the curriculum, we will collect their written work and programming at the
   end of each session. We will also collect written (slides or reports) and recorded versions of
   students’ final presentations.
4. At the end of the workshop, students will complete the AI concept and skill post-assessment and
   Attitudes toward AI post-questionnaire. This will include an optional feedback survey.
5. Teachers will complete a final post-study interview on their experiences with the curricula.

To answer research question 2 (How effective are the Impact.AI curricula in supporting technical AI
knowledge gain?), we will analyze data from the AI Concept and Skill Assessment, final project topic and
skill inventory, and final project achievement rubric. We expect that students’ understanding of AI
concepts and grasp of AI skills will improve significantly. The skills that students say they grasp should
be reflected in their achievement scores on the final projects. We will use multivariate analysis to
understand which concepts and skills are more difficult for students to grasp, and to compare performance
across classrooms. Finally, we will use students’ responses to open-ended responses to understand how
the curriculum and learning environment contributed to their achievements.

To answer research question 3 (How effective are the Impact.AI curricula in promoting students’
self-efficacy, sense of belonging, and identity as technosocial change agents?), we will compare students’
scores on the Attitudes Toward AI Questionnaire. We expect that students’ scores will significantly
increase on all scales, indicating higher interest and sense of self-efficacy in AI. We will use students’
responses to open-ended responses to better understand their questionnaire responses.
Timeline and Resources

We can conduct lab studies using space and resources provided by MIT. We are recruiting participants for these studies by partnering with educational organizations that work with RAISE. For the final study, we are building connections with teachers and organizations in the greater Boston area, particularly the Dearborn STEM Academy. We are actively looking for funding sources to provide robots and support staff for conducting the study.
References