A Human-Centric Approach towards Equity and Inclusion in AI Education

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Abstract

Artificial Intelligence (AI) has become pervasive in modern lives, with AI generative tools driving further transformation. However, a notable issue persists: the underrepresentation of females and individuals from ethnic and racial minorities in the tech industry. Despite generally positive attitudes toward technology among young students, this enthusiasm often does not extend to aspirations for careers in the field. To address this disparity, many schools in the United States are now offering computer science and AI courses at the high school level. Nevertheless, students from underrepresented groups often feel disconnected from these subjects, leading to low enrollment rates. Research underscores that students' career aspirations are solidified between the ages of 10-14 yrs, highlighting the importance of engaging them with computer science and computing skills during this formative period. Leveraging the Bourdieusian concept of social capital, this paper proposes educational interventions tailored for elementary schools. By nurturing students' technical social capital, these interventions aim to foster an inclusive ecosystem from an early age, when aspirations are taking shape. Ultimately, the goal is to enhance the accessibility of computer science education and related skills, empowering young students from underrepresented groups to pursue higher studies and careers in computer science and AI fields.

Introduction

Artificial intelligence (AI) has become a major catalyst in driving the next revolution and has continually made headlines, with a lot of public interest in generative AI. This revolution has brought with it new jobs and business opportunities that have changed our everyday lives and the way we work. The advancement of technology and its pervasiveness has highlighted the importance of incorporating AI education at the school level.

Despite recognizing the importance of AI we see disparities in the participation in the professional workforce in the field of AI and computer science (CS). Individuals identifying themselves as Black, African American, Hispanic, Latinx, American Indian, Alaska Native, or members of other indigenous groups and girls are underrepresented in computing fields. These underrepresented groups miss out on several high paying employment opportunities and chances to contribute to the field besides the nation facing shortage of CS workforce.

One of the efforts suggested towards addressing race and gender disparities in AI is to draw more women and ethnic minorities into the industry and offer AI courses for school going students encouraging girls and students from ethnic and racial minorities to consider a career in AI while at school. This paper is an attempt at proposing interventions that could be carried out in the existing elementary school system to motivate young children to participate in AI learning, based on Bourdieu's concept of social capital.

Research Context and Literature Review

Technology workforce has shown an increase of 3.2% in 2022 from the previous year and accounts for 4% of total employment in the United States (State of Tech workforce report 2023). According to the same report, women comprise 26% and Black/African American and Hispanic/Latino workers each represent 8% of tech occupations.

The World Economic Forum report (2023) has shown that about 78% of global professionals with AI skills are male, while a study by the AI Now Institute of New York University showed that over 80% of AI professors are men. Furthermore, only 2–4% of researchers at major AI firms are Black, and 3–6% are Latino (West, Whittaker and Crawford 2019). According to AI index annual report (Zhang et al. 2021), women comprise about 16% of tenure-track faculty at computer science departments of top universities in the US, African Americans and Hispanics constitute 2.4% and 3.2 % respectively of US resident Ph.D. candidates in AI. These figures point to gender and race inequities in the technological landscape. The disparities are not just the matter of technological exclusion, but they also amplify the existing socio-economic inequalities. According to Krupiy (2020) unequal access to AI can skew its development, leading to AI processes that "fail to reflect the lived experiences of individuals and as a result to undermine the protection of human diversity".

The long-term outlook for diversity in tech workforce is closely tied to representation in computing and computer science related subjects in schools and universities. According to 2023 State of Computer Science Education report (Code.org, CSTA and ECEP Alliance 2023), in the United States only 8 states have CS as high school graduation requirement. Twenty-seven states require schools to teach CS where it is offered either as an elective or extracurricular activities. Thus, access to CS has been uneven across the student population. Students missing out on using/learning AI in schools are missing out on potential avenues for learning collaboration, communication and technical skills which are important skills for college and career readiness (National Research Council 2012).

Recognizing the importance of CS and the rise of AI as well as other emerging technologies, K-12 leaders have expressed a desire to broaden access to CS in schools, even in the elementary grades (Waterman, Goldsmith and Pasquale 2020). Teaching AI refers to the "process of educating individuals on how to understand and utilize AI technologies" (Rizvi, Waite, and Sentance 2023). It includes teaching students about the underlying principles of AI, how to program AI systems, and how to design and develop AI applications.

If we zoom into the areas where CS education has not been accessible in school, we see a disturbing trend. According to 2021 State of computer science education report (Code.org, CSTA, and ECEP Alliance 2021), urban and rural schools are less likely to offer CS courses than suburban schools in the United States. Districts with a high percentage of economically disadvantaged students are less likely to offer CS courses. It is also observed that Black and Hispanic students do not feel a "sense of belonging" and hence are less likely to go to schools that offer CS related subjects. Faircloth and Hamm (2005) in their study have indicated that perceived ethnic-based discrimination is one of several indicators of a young person's sense of belonging. Although AI holds promise for the future, technological development and accessibility are biased against disadvantaged groups. There is a strong recommendation in the report to ensure efforts are directed towards making CS subjects accessible to an underrepresented population.

Research studies around the globe have indicated that young students generally have a positive attitude towards technology and associate it with products and this attitude changes when students are around 14 years of age (Ardies, Maeyer and Gijbels 2013). Even though young students think positively about technology but their opinions on technology education and careers are not particularly positive (Mehrotra et al. 2003; Ardies et al. 2013). Girls are less interested in technology and technological careers; this interest also declines faster than for boys. Often this lack of enthusiasm in technical careers is a result of students' experiences of technology at school and at home (Lindahl 2007). Persistent "low aspirations [of girls] in science and technology is not due to the lack of interest in subjects rather there is a 'doing' and 'being' divide that exists among the youth" (Archer et al. 2020) -I like doing computer science but I do not want to be working as computer science professional. In short, there is a discrepancy between attitudes and aspirations.

Some factors that hinder the translation of students' attitudes to aspirations include, educational practices, dominant representation of technology and science, educational gatekeeping, sense of belonging, parental characteristics (educational and professional background, economic resources), self-identity (Archer et al. 2020, Ardies et al. 2015). For example: Birhane and Guest (2020) and Hicks (2013) found in their studies that AI and technology are perceived as unsafe for women and racial minorities. Computer Scientists in media and books are often portrayed as white or Asian males that are lone "geniuses or nerds" with no other hobbies. These largely inaccurate and unrelatable images and stereotypes about CS lead women and minorities to question their aptitudes and abilities to engage with (fit for) the subject further demotivating them to take up its formal study. Science and technology related educational qualifications, understanding, knowledge and interest in the subject, and social contacts/networks with people or groups that are involved in scientific and technological endeavors are some factors that are known to have a positive impact on students' career as aspirations.

Thus, the lack of diversity in AI and related professional space is not by mere chance or unwillingness of underrepresented groups to be a part of computing workforce rather there are deeper social and educational factors working that prevent women and underrepresented ethnic minorities to enter the profession and remain within it for long time. There is a need to broaden all students' access to high-quality AI education.

Conceptual Framework

Research literature has pointed that AI and CS-career aspirations in adolescence are one of the primary determinants of pursuing a higher degree and entering AI related profession (Archer et al. 2020; Tai et al. 2006). In this paper we aim to address the challenge of diversity faced in AI and CS workforce from the vantage point of school education. The interventions we suggest can be implemented at the upper elementary and middle school level. Directing the efforts at adolescence will not only strengthen CS and AI educational and career pathways of young students including girls and students from ethnic and racial minority groups but will also make the CS and AI fields more productive, inclusive and collaborative.

We propose two interventions in this paper based on the concept of 'social capital' (Bourdieu 1977, 1986). Social capital is defined as a resource, whether instrumental, informational or emotional, available to an individual based on group membership, relationships, networks of influence, and support. Such membership gives individuals access to resources and collective understanding. Students' social capital is derived from families, peers, school context, teachers and professional networks and experiences and affects their academic achievement and career trajectories (Mishra 2020; Ryan 2017; Saw 2020). In short, social capital theory implies that those with larger and stronger networks, relationships and interpersonal trust excel at achieving their goals (in this case CS and AI related educational and professional goals). This outcome is possible through resources made available by connections (Madda 2023).

In the context of CS and AI education, social capital comprises resources such as information, availability of tools (hardware, software, computing devices etc), and emotional support that students can access through their social networks that can promote students' educational and career outcomes. In the existing school system, there are ample opportunities where underrepresented groups can be provided opportunities for social capital development.

Ferguson (2021) defines technical social capital as "the total of the supportive resources embedded in social networks of individuals in the technology field that students can employ to successfully navigate technology-related education and career pathways. This encompasses information, emotional support, embodied assets, material and financial resources." One of the ways in which students can gain technical social capital students is to provide them access to items outside of their everyday technical experience. For example: schools can acquire resources that are not available at students' home, such as trained teachers, equipment (bots, computers, software etc) needed for engaging in AI tasks. These resources constitute students' social capital. Elucidating the importance of tech social capital for underrepresented minorities, Ferguson (2021) has argued that young, underrepresented Black and Latinx students need tech social capital to gain entry and advance in the tech field. In short, to get students, particularly girls and marginalized groups to participate in technological activities from an early age, efforts must be made to enhance/broaden their technical social capital.

The Bourdieusian concept of social capital provides us with a framework that has the potential for integrating and promoting women and underrepresented ethnic groups in the field of CS and AI. The interventions suggested in this paper are drawn from the perspective of enhancing students' social capital and can be implemented within the context of the existing school system. The interventions aim at broadening the participation and access to AI related courses at the elementary and middle school level.

Proposed Interventions Based on the Concept of Social Capital

The interventions proposed in this paper aim to address the disparity in participation in computer science and AI courses among students from underrepresented groups. These interventions focus on leveraging existing social networks and resources to create an inclusive environment conducive to the development of technical skills and aspirations for careers in technology.

Culturally Responsive Non-Formal Learning Contexts

To make AI education inclusive, meaningful and appropriate it must respond to the social and cultural background of its participants. Non-formal learning environments provide a fertile avenue where AI education could be introduced to elementary school children in a culturally responsive way. Cultural responsiveness is an approach which "recognizes the importance of using learners' cultural tools, resources, or experience as their strengths to empower and enable their learning" (Villegas 1991). Non-formal learning refers to a kind of learning which is relatively systematic and (but not necessarily) pre-planned, with a clear intention on the part of the learner and teacher to accomplish a particular learning task (Combs and Ahmed 1974). The aim of teaching AI in the space of culturally responsive non-formal education is to generate and sustain interest in AI related subjects and careers. This approach has been found to be helpful for STEM majors (Adams, Gupta and Cotumaccio 2014).

Non-formal learning environments (such as after school AI clubs or AI camps) provide an opportunity for students to tinker with ideas, figuring out problems that relate to their real world and working collaboratively with peers and mentors. Non-formal learning environment (as opposed to formal classrooms) provides a 'low pressure setting', without the consequences of grades and assessments, in which students could get time and space to cognitively struggle with AI concepts and build on them as a hobby, which is personally relevant for them. Such meaningful engagements help underrepresented groups improve their sense of belonging and interest.

In addition to providing an appropriate setting where students could get hands-on experience with AI, it is also recommended that students in upper elementary and middle school be engaged in AI tasks as students' aspirations are unlikely to change dramatically beyond 14 years of age. Research evidence points to the 10–14 age period as being a critical time during which aspirations are formed (Tai et al.

2006, Lindahl 2007, Archer et al. 2012, 2013). At present in the United States CS related subjects are offered at high school.

In non-formal settings, teachers, knowledgeable peers, coaches are "institutional agents" and can help develop students' social capital. In the program Code Next as Madda (2023) reports, access to coaches (technical experts) who guided students through their projects were the resources that helped build students' technical social capital. In the program these coaches often shared students' racial and ethnic identities and brought with them education and tech experience. Thus, mentors form an indispensable part of building students' technical social capital.

Peers also perform the role of "institutional agents" for one another. With regular opportunities to work with a variety of members of the learning community, students grow their social networks and mediate changes in their social capital. Over time they became "aware of the opportunities these experiences afford[ed] them" as they continue to explore and engage in the AI landscape (Habig et al. 2020).

Non-formal learning environments in AI learning for example could possibly introduce a broad-based approach to AI and CS, spanning across disciplines with culturally relevant themes, where students can be involved in collaborative projects. Culturally responsive non-formal learning approach would also help to eliminate stereotypes associated with AI and CS and may appeal to a broader audience, including girls and students from ethnic minorities (Saw 2020).

Thus, introducing AI in non-formal, culturally responsive learning environments helps in building participants' social capital (Kuchynka et al. 2021) where participants are welcomed and supported. Ferguson (2021) reiterates that by providing "supportive" resources students can expand their agency, thus enabling them to create tech social capital. According to Reinking and Martin (2018), "getting out of textbook into the messiness, controlled chaos and problem solving... engages girls at a higher level." Museums·and science summer camps have been shown to benefit students' science learning outcomes (Habig et al. 2020; Afterschool Alliance 2016) and we expect it have similar outcomes for AI learning.

Teacher Professional Development

As mentioned earlier, teachers play an important role in shaping students' interests, aspirations, and attitudes. Despite the influence of innovations and technological revolution in the teaching and learning processes, the role of teachers in the classroom continues to impact students' learning in profound ways.

There is increasing evidence that professional development training provided to the teachers is not effective and the student outcomes or participation has not improved much over the years in technology related programs (Smith 2011; Archer et al. 2020). In the context of CS and AI education, professional development programs are even more important. The changing nature of programing language and advances in technology necessitate more frequent update in teachers' knowledge and practices. Professional development programs that provide subject content knowledge are therefore crucial for the teachers (Khreisat, Sharma, and Sinha 2023), however they have certain limitations. CS and AI teachers need to go beyond teaching subject content and have expressed a need for support that can help them connect theory and practice in contemporary classrooms, with changing mindsets of students and shifts in societal structures, values and resources (Hennessy and Davies 2019).

For professional development programs to remain effective, the programs must include a component that will help teachers connect with students in their classrooms as their collaborator in the learning process. CS and AI teachers must be able to help students develop confidence in computing skills and foster their sense of connection and belonging to the larger tech community.

To bring about a change in student diversity in CS and AI programs and make them inclusive, teachers must be trained in pedagogical practices that are more humanistic. One such practice towards being inclusive is the teacher taking up the role of a facilitator and mentor, as opposed to transmitter of knowledge. Teachers often need to intentionally facilitate relationships between themselves and their students and among the students, to support the growth of closer relationships and thus nurturing a community of learners and building students' social capital.

This change in teachers' role from being a transmitter to a facilitator will help construct a collaborative classroom with meaningful connections where students feel accepted and encouraged to try out new ideas and co-construct knowledge (Farber and Penny 2020). These cognitive/affective bonds unilaterally enhance all strong ties among those working together in class (Ferguson 2021).

However, a change in teacher role requires a change in mindset and teachers must be helped to make this crucial shift (Chee, Mehrotra, and Ong 2014). Ultimately the students may receive crucial support for success in education and career paths.

Proposed Implementation of the Intervention in Elementary Classroom

There are many opportunities for higher education, high school, and middle school students to learn about AI in a technology class, or a robotics club, or as an after-school activity, using readily available, curated, curriculum resources (AI4K12 2020, AI4ALL 2024; AI education Initiative at MIT 2020; Code.org 2023). Elementary students on the other hand have very few resources, although recently, curricula and frameworks for these younger students have been proposed and developed (AI4K12 2020; Sinha, Evans, and Carbo 2023). To implement the interventions in K-5 Elementary Classrooms, we propose non-formal learning environments such as after-school AI clubs or summer camps. Computational thinking is recognized as a key skill set for all 21st century learners, and in these clubs or camps, K-5 students will get an opportunity to learn such skills to eventually build real-world applications related to social justice, climate change, and environmental causes – which are very meaningful and relevant specially for girls and marginalized groups. One way to make these projects fun for our K-5 students and improve their sense of belonging and interest is to start with unplugged activities to learn about AI and come up with ideas to solve simple problems. Teachers and mentors can then help them use tactile and personal mobile devices to tinker further with these ideas, to figure out problems that relate to the real-world and to work collaboratively with their peers to seek solutions. Unplugged (screen-free) activities can use educational floor robots such as Bee-Bots® (TTS Group 2023) and KIBO (KinderLabs Robotics 2023) for example, and once the students have a basic understanding, they can use a rule-based programming language such as Calyspo (Visionary Machines LLC 2017) to learn about intelligent robots and interact with them. Bee-Bot (TTS Group 2023) is a great tool for teaching control, directional language, and programming. Thinking with KIBO (KinderLabs Robotics 2023) is a curriculum (based on KIBO – a hands-on, screen-free robot kit) introducing early elementary age children to the core concepts of AI. The Calypso (Visionary Machines LLC 2017) curriculum provides a framework for reasoning about programs. Students learn to program a robot's movement and actions, predict its behavior, diagnose problems when things go wrong, and write programs of their own.

Hands-on, active learning can be facilitated using affordable physical devices such as the micro:bit (Micro:bit Educational Foundation 2016). This device is used by millions of young people worldwide to get hands-on with computer science and technology. Microsoft, one of the founding partners of the Micro:bit educational foundation, recently introduced the FarmBeats for Students program (Microsoft Educator Center 2024). Through this program, students build a garden monitoring system and learn about AI, data analysis, and the Internet of Things (IoT). Using an affordable micro:bit-based hardware kit with curated curriculum and activities that are designed to give students hands-on experience in precision agriculture, students learn the impact of modern tools and the opportunities within agriculture. FarmBeats for Students can be run using any device with a web browser, making it easily accessible for everyone. Students gather data through sensors and then analyze that data to get insights and make decisions. Finally, students build a machine learning model to identify garden pests and predict nutrient imbalances in their plants. Programs such as FarmBeats have the potential to connect with students from rural and agricultural backgrounds.

Another way to increase AI awareness and empower elementary students to hone their creative and programming skills is to teach them to "program" without any programming knowledge or experience. Students learn to create mobile applications (apps) for smartphones and tablets using a web browser and either a connected phone or emulator – without writing a single line of code. MIT App Inventor (Massachusetts Institute of Technology 2012) enables you to develop such apps and is an intuitive, visual programming environment that allows everyone (even children) to build fully functional apps for smartphones and tablets. Those new to MIT App Inventor can have a simple first app up and running in less than 30 minutes. The blocks-based tool facilitates the creation of complex, high-impact apps in significantly less time than traditional programming environments. The MIT App Inventor project seeks to democratize software development by empowering all people to move from technology consumption to technology creation. Other ways to kindle the creative spirit in elementary students is to have students create their own apps using free applications such as Scratch (Scratch Foundation and MIT Media Lab 2007) and ScratchJr (Scratch Foundation and DevTech Research Group at Boston College 2014). Scratch, an educational tool, is a high-level block-based visual programming language aimed primarily at children ages 8 to 16. Elementary students can learn about AI, train a machine learning model, and interface with it using Scratch (Sinha, Evans, and Carbo 2023). ScratchJr is also a visual programming language but designed to introduce programming skills to children ages 5–7. The app is considered an introductory programming language and is available as a free app for iOS, Android, and Chromebook.

Many states in the US are committed to ensuring their students have access to high-quality education in computer science, and New Jersey, as part of its Expanding Access to Computer Science: Professional Learning Grants, created CS Hubs throughout the state to provide high-quality professional learning for educators and resources for school districts to increase computer science opportunities for their students (Khreisat, Sharma, and Sinha 2023). Such CS hubs prepare and support teachers and are thus essential to expanding access to CS education. We envision these hubs to include AI topics and train our elementary school teachers to bring AI education to their classrooms.

Having higher education and high school students participate as mentors in teaching the elementary students in non-formal learning environments will create opportunities and avenues for all students (even those with special needs) to enhance their computational and AI skills. Elementary students can benefit tremendously from after-school programs which focus on computer science and AI. AI professionals and other industry partners from different sectors such as: healthcare, pharmaceutical, business, retail, finance, education, publishing, entertainment, and technology, can visit elementary classrooms as invited speakers and spark the elementary students' interests in technology-related fields. Leaning on outreach and extra-curricular programs; curated, standards-based, and accessible AI curriculum; and well-trained teachers and mentors, we hope to support all students including those with special needs, language hurdles, and even very young students.

Conclusion

AI education has the potential to ensure that all students irrespective of their race, ethnicity, gender, geographical location have access to the tools and knowledge required for developing skills for the 21st century skills (Kelly 2022). The disparities in access between different genders and ethnic groups highlight crucial challenges such as widening skill gap, biased AI systems, economic inequality besides ethical concerns. Ensuring that the benefits of AI are not reserved for a privileged few, regardless of their gender, race and socio-economic background, the universal offering of AI and ML courses is a long-term strategy. We believe that interventions grounded in a sociocultural framework, with students at the center, would be practical to implement within the existing elementary school systems in the United States and would support building an inclusive ecosystem at an early age when attitudes and aspirations are being shaped. Diversity and inclusion in AI promote social justice and drive sustainable development. The interventions mentioned in this paper are suggestions that need to be tried out in real school settings.

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