The State of Robotics Ethics Education: A WIP Site Analysis

Yifei Zhu, Colorado School of Mines

I'm a PhD candidate in robotics at the Colorado School of Mines. I have an interdisciplinary focus on human–robot interaction, where I use mixed-methods approaches to design robot interaction and communication. I also study how emerging technologies such as robots are designed, deployed, and understood within broader social contexts.

Dr. Alison J Kerr, Colorado School of Mines

Alison J. Kerr has a doctoral degree in Industrial-Organizational Psychology from The University of Tulsa. Dr. Kerr's research interests include training development and evaluation as explored across a variety of academic disciplines and organizational se

Dr. Tom Williams, Colorado School of Mines

Tom Williams is an Associate Professor of Computer Science at the Colorado School of Mines, Director of the MIRRORLab, and author of Degrees of Freedom: On Robotics and Social Justice (2025).

Tom earned joint PhDs in Computer Science and Cognitive Science from Tufts University, and is an internationally recognized scholar of Human-Robot Interaction whose work examines cognitive, social, and moral dimensions of Human-Robot Interaction.

Tom is the winner of Early Career awards from the National Science Foundation, the Air Force Office of Scientific Research, and NASA.

Dr. Juan C. Lucena, Colorado School of Mines

Juan Lucena is Professor and Director of Humanitarian Engineering Undergraduate Programs at the Colorado School of Mines (CSM). Juan obtained a Ph.D. in Science and Technology Studies (STS) from Virginia Tech and a MS in STS and BS in Mechanical and Aeronautical Engineering fro

Dr. Katie Winkle, Uppsala University

Katie Winkle is an assistant professor at the Department for Information Technology at Uppsala University. She previously held a Digital Futures postdoctoral fellowship at KTH Royal Institute of Technology and completed her PhD in Robotics and Autonomous Systems at the Bristol Robotics Laboratory. Her research sits at the intersection of robotics, design, and the social sciences to tackle technical and societal challenges relating to human-machine interaction. Her award-winning work on feminist human-robot interaction has gained significant attention within the field and is helping to define new, critical directions of research on the design of robots and their interaction behaviours.

Tiera Tanksley, University of California, Los Angeles

Dr. Tiera Tanksley is a Senior Researcher in education and information studies at UCLA's Center for Resilience and Digital Justice. Her scholarship, which theorizes a critical race technology theory (CRTT) in education, extends conventional education research to include socio-technical and techno-structural analyses of AI and EdTech. Specifically, her research examines anti-Blackness as "the default setting" and "organizing logic" of both schools and school-based technologies, and analyzes the socio-emotional, mental health and academic ramifications of algorithmic racism in the lives and schooling experiences of Black youth. Her work simultaneously recognizes Black youth as digital activists and civic agitators, and examines the complex ways they subvert, resist and rewrite algorithmically biased technologies to produce more just and joyous digital experiences for Communities of Color. In 2020, Dr. Tanksley founded the Race, Abolition and Artificial Intelligence summer program - a critical science and technology program that prepares young people to have more critical, agentic and algorithmically-conscious relationships with digital technologies that they encounter both within and beyond the classroom context.

The State of Robotics Ethics Education: A WIP Site Analysis

Abstract
Robotics is a rapidly emerging field, yet robotics education remains relatively underexplored. As robots become increasingly integrated into communities, there is an urgent need to embed social justice principles into robotics education. To achieve this, it is critical to first understand the current state of robotics education, including student demographics, instructional practices, and existing approaches to social justice integration. This work-in-progress paper examines three case sites that represent diverse geographical contexts, student populations, and instructional approaches. Each site incorporates social justice principles into robotics to varying degrees and through different methods. This paper presents a step in site analysis that illuminates key dimensions of robotics education practice. Our findings provide a reference for researchers and educators seeking to integrate social justice into robotics education, and serve as the first step for planned subsequent refinement of our work on social justice-centered robotics curricula design.

1. Background and Introduction

Robotics is a new and emerging field. Industrial robots are working in manufacturing alongside human workers to assist with tasks [1], [2]. Educational robots are assisting teachers and students in classrooms [3], [4]. Service robots are taking care of repetitive tasks in settings from restaurants to personal homes [5], [6]. Robots are deployed in therapy and healthcare, where they interact with people in need of medical or therapeutic care [7], [8]. Such large-scale and diverse robot deployment leads to the need for well-rounded roboticists who can contribute to the diverse and profound impact. As such, robotics is an incredibly important area of education and training. However, despite its potential for great impact on communities, robotics and robotics education is still relatively under-explored, and the literature on robotics education is also relatively nascent. Thus, our interdisciplinary and inter-institutional research team is aiming to contribute to research on the current state of robotics education and on supporting the development of more resources to help develop future roboticists. Recognizing the potential impact the deployment of robots into society, we will ultimately be focusing specifically on areas that will help ensure these robots align with community goals and needs and can uphold ethical and social justice priorities. We regard both ethics and social justice with equal but different importance, seeing that ethics can be the guiding principles that steer everyday praxis for roboticists, while social justice principles are necessary for ensuring that the field of robotics aligns with pro-social goals that serve to enhance equity and the well-being of society.

In taking on this challenge to contribute to robotics education insights, curricula development, and resource deployment that can help instill ethics and social justice principles in the next generation of roboticists, we recognize there are a number of initial challenges. First, we recognize that even identifying what should be included in ethics and social justice integrated curricula will require attention to the vast array of diverse socio-technical elements involved [9], [10]. Even when a robust understanding of an ethical and social justice framework is identified, there is additionally the need to design and tailor developmental curricula to specific learners and institutional contexts [11]. While our team has already begun constructing a framework of robotics for social justice, taking into account consideration and concerns from other fields, we recognize that in addition to creating an ideal for what should be done, it is important to first get an understanding of what currently exists. Furthermore, to best customize a framework of robotics social justice education, a foundational understanding of the audiences that engage with robotics social justice education needs to be understood. This Work In Progress (WIP) paper seeks to create a foundation for our research and ongoing efforts to enhance robotics ethics and social justice education by detailing three sites that we focus on for our ongoing research, social justice framework refinement, and formative curriculum development and implementation. We provide this foundational documentation to serve as a starting point for more robust educational needs analysis that we are conducting in this next year. We also share work to encourage our engineering education peers and robotics community to also consider their own educational contexts and what their robotics and technology programs may need when it comes to further enhancing education opportunities especially with respect to ethics and social justice integration. Additionally, we invite others who may also want to contribute to our collective understanding of what is currently being done and what more could be needed.

2. Approach

This WIP is a part of a larger mixed-method study. In Phase I of the study, we construct theoretical framework through engineering-education informed workshops with the research team and consulting faculty. In planned Phase II, we will validate and further refine the framework by conducting education needs analysis to investigate the degree of adherence between our theoretical framework and educator needs and goals. In Phase III, we will create, implement, and assess robotics ethics and social justice education approaches into robotics classrooms. Phase I of the study has recently concluded so this foundational site analysis serves as a first step of Phase II by helping our projects and other researchers in identifying the important dimensions of a site in order to plan out the education needs analysis.

To conduct our site analysis, we analyzed project meeting recordings from Phase I involving instructors at various educational sites and public program information and materials. The objective of this review and analysis what to synthesize the key characteristics of different robotics education contexts, which involved documenting key features such as instructional structure, student demographics, and how social justice topics were positioned or discussed. Below, we synthesize key characteristics of the three sites included in this case study analysis.

Before presenting the summary our results, let us briefly describe our three sites.

3. Site Analysis

3.1 Site Descriptions

We sought out to include a diverse range of geographical locations and student demographics. All three sites involve robotics classes that currently incorporate social justice principles, albeit to different degrees and with different approaches. As such, to establish a better and preliminary understanding of the different dimensions of robotics education environments and institutional contexts, we aim to create a foundation for our research by examining the three sites that we will be working with in our current research. The three sites that we are exploring all host courses that are explicitly labeled robotics or involve highly relevant topics to robotics (such as technology design, algorithms, community-based research, etc.), and the three instructors who design, teach, and manage the courses all incorporate ethics and justice into their classes. The three sites offer different types of student demographics. Below, we describe each site. A summary of these characteristics is also available in Table 1

Dimension	Site A	Site B	Site C
Power Orientation	Explicit aim is not to oppress students.	Not explicitly discussed, but likely emphasizes not oppressing students.	Focus on understanding and surviving systems while also challenging them.
Goal of Classroom	Similar goals across contexts.	Similar goals across contexts (implicit).	Similar goals across contexts.
Technological & Social Preparation	Higher emphasis on social context and flexibility.	Preparation through both technological and social forms of education.	Strong existing student consciousness of social and technological issues.
Instructor	Unknown / variable.	Technical instructors may not always be trained in ethics or power analysis.	Unknown; varies widely.
Student	Students from various backgrounds that connect to robot design	Students experience and carry power in technical programs.	Many students enter with highly diverse trajectories, often not pursuing STEM long-term.
Identity & Trajectory in STEM	Greater flexibility in student pathways.	Students often feel pressure: "You are going to be an engineer, or you are out."	STEM trajectories are less linear; identity formation is fluid.
Political & Social Orientation	Affirmative action is illegal; university cannot explicitly correct inequities.	Ethics courses often seen as "less important."	Students already very socially conscious; discussions happen naturally.

Table 1: Comparison of educational, social, and power-oriented dimensions across three instructional contexts

3.1.1 Site A

Site A is a public research university in Europe. Here we focus on undergraduate students and the specific robotics curriculum offered through the Human-Machine Interaction program. Approximately 1500 students belong to this program. In this group of students, 65% of the students are male, 35% of the students are female. The faculty divides as 20% female and 80% male. The specific robotics course under investigation typically has 50 students enrolled for each offering. The goal of the particular course is to allow students to complete interdisciplinary projects and to further their understanding of intersectional technology; thus, sometimes classes involve real stakeholders. The main format of class sessions is lecture, discussions plus group assignments.

3.1.2 Site B

Site B is a public STEM research university in the Western United States. The primary focus at the institution are earth science and engineering, as the majority of the students pursue engineering majors. At this site, the robotics program is aimed at the graduate student level and offered primarily through the Computer Science department and an interdisciplinary robotics program. This program has approximately 1500 students, which includes both graduate and undergraduate students. In this group of students, 68% are male, 32% are female. In this program, 59% of the faculty are male and 41% are female. The specific robotics courses typically has 30-50 students enrolled for each offering. The courses are focused on robotics ethics and society integration. The goal of the particular courses is to allow students to learn about different Human-robot interaction topics and to gain practical skills in both robot design and robotic research. The main format of class session is lecture, discussions plus laboratory works where students engage in both research design and robot programming and design.

3.1.3 Site C

Site C is a computer science-focused program associated with a public research university in California. While associated with higher education, this particular program is focuses on the K-12 students. We will be examining a summer program that aims to include mainly high school students of color, and the program generally see even gender split. The class size is usually 20-25, many students in the program do not have a formal background in computer science, and are first-generation students. The goal of the program is to integrate students' lived experience and coursework in the form of discussions, peer learning, and strong mentorship from prior students. The goal of the particular summer class is to help students gain skills to critically examine how technology can shape social justice. The course format includes lecture, discussions, and final projects that showcase their proposed technical solution to a problem of their choice. After the class, many students go on to pursue non-STEM careers.

3.2 Examination of Site Characteristics and Implications

The set of site characteristics presented above serves as a first step in examining ethics and social justice–centered robotics education. As an exploratory first step, this analysis surfaces key institutional, demographic, and pedagogical dimensions that contribute to how social justice is facilitated or con- strained in practice. We take an opportunity here to examine the ways in which these 3 sites represent a valuable range and variation of student demographics and institutional and program contexts. First, we highlight the strengths and limitations that we see in our site representation. Then we briefly examine how the wide range of student demographics and pedagogical approaches highlights distinct institutional cultures.

3.2.1 Strength

We explicitly sought to have a broad approach to the level of education and age of students for our consideration. Having access to educational programs at the K-12, Undergraduate, and Graduate levels sets us up to collect ample information about various student needs and educational approaches. While not all works focus explicitly on robotics, the collection includes a balanced mix of domain-specific and more general contributions, including both robotics and social justice.

3.2.2 Limitations

Although the participating institutions exhibit comparable faculty gender ratios, additional faculty characteristics may warrant further consideration. Relatedly, demographic variables such as racial and ethnic representation were not explicitly captured in the present analysis. While the institutions collectively reflect a broad range of backgrounds, the primary comparisons in this study occur between institutional groups rather than within them, limiting the interpretability of such demographic variation. Moreover, although the institutions of focus demonstrate substantial differences at the institutional level, the specific programs and courses examined may be less representative when analyses are constrained to smaller class enrollments. Finally, geopolitical affiliations were not systematically included in this study and are therefore only briefly acknowledged, despite their potential relevance to institutional context and educational practice.

3.2.3 Some additional considerations

As our overarching project is on the integration of ethics and social justice into robotics curricula, we also highlight that these three sites illustrate a range of opportunities for integrating social justice principles into robotics education. For example, Site A integrates social justice implicitly through interdisciplinary project-based work and stakeholder engagement, Site C centers justice explicitly by grounding technical projects in students' lived experiences and critical discussions of power and inequality. This site analysis also shows how ethics and justice emerge in robotics classrooms across different geographical and political contexts, for example, while ethics-related courses may not be prioritized at Site B, Site C sees students who are often very aware of issues around equity.

In summary, while we do think these sites provide a variety of technology and robotics educational approaches, we still recognize that they represent only a small part of the broader range of robotics learning environments, institutional contexts, and educational needs, opportunities, and challenges.

4. Discussion and Future Directions

The set of site characteristics presented above serves as a first step in examining ethics and social justice–centered robotics education. As an exploratory first step, this analysis surfaces key institutional, demographic, and pedagogical dimensions that contribute to how social justice is facilitated or constrained in practice. These insights will directly inform the design of our subsequent Phase II semi-structured interviews with robotics instructors and program leaders, as well as focus groups with current robotics students. By identifying which dimensions are relevant, appropriate, and context sensitive across different educational settings, we can better target our next approaches to collecting data on the current state and subsequent needs. Without this analysis, interview protocols may risk being irrelevant or imprecise to educators' lived experiences and instructional realities. As such, this work provides a foundation for rigorous subsequent needs assessment and supports the development of interview protocols that can more accurately capture educators' goals, challenges, and opportunities for integrating social justice into robotics education.

While this paper is simply meant to provide an overview of three focus sites for our future work, we believe it is important to disseminate this work in order to engage the broader robotics ethics education community in our work. As we engage with our continuing research project, our next steps will be to conduct a more thorough Educational Needs Assessment which will center around two major questions (1) What formats of robotics educational approaches already exist?, (2) In what ways do the robotics education programs incorporate ethics and social justice considerations in the instruction?, and (3) What more is needed for these programs to ensure that the next roboticists are prepared to incorporate ethics and social justice considerations in all of their future work? We will be aiming our next efforts on gathering insights and evidence from these three sites, but we recognize that despite our best efforts to identify a set of sites that represents a diverse range of potential educators and learners, we inevitably will fall short of a complete understanding of the full need when it comes to robotics ethics education. That being said, we invite other robotics educators and ethics education researchers to engage with our work so that we may have a greater impact with our own case findings. Thus, this analysis lays crucial groundwork for the next phase of our mixed-method study. The dimensions surfaced through this site analysis directly inform our upcoming educator interviews and training needs assessment, guiding explorations of where current practices are. Ultimately, this work serves as an initial map that guides deeper inquiry into how robotics education can more equitably prepare the next generation of roboticists. Thus, we conclude with an invitation for engagement with our work and furthering the scope of the robotics education sites that can be examined or potentially benefit from our ongoing research on the need for and approaches to robotics ethics and social justice education.

5. Acknowledgment

This work was supported by NSF grant SBE-2418199.

References

[1] L. Liu, F. Guo, Z. Zou, and V. G. Duffy, "Application, development and future opportunities of collaborative robots (cobots) in manufacturing: A literature review," *International Journal of Human–Computer Interaction*, vol. 40, no. 4, pp. 915–932, 2024.

[2] L. Sanneman, C. Fourie, J. A. Shah, *et al.*, "The state of industrial robotics: Emerging technologies, challenges, and key research directions," *Foundations and Trends® in Robotics*, vol. 8, no. 3, pp. 225–306, 2021.

[3] N. Atman Uslu, G. Ö. Yavuz, and Y. Kocak Usluel, "A systematic review study on educational robotics and robots," *Interactive Learning Environments*, vol. 31, no. 9, pp. 5874–5898, 2023.

[4] L. P. E. Toh, A. Causo, P.-W. Tzuo, I.-M. Chen, and S. H. Yeo, "A review on the use of robots in education and young children," *Journal of Educational Technology & Society*, vol. 19, no. 2, pp. 148–163, 2016.

[5] S. Ivanov and C. Webster, "Restaurants and robots: Public preferences for robot food and beverage services," *Journal of Tourism Futures*, vol. 9, no. 2, pp. 229–239, 2023.

[6] H. Balcha, P. Rauffet, G. Wagari, and C. Buche, "A review on human-robot trust in home service robots," *ACM Transactions on Human-Robot Interaction*, 2025.

[7] A. Khan and Y. Anwar, "Robots in healthcare: A survey," in *Science and Information Conference*, Springer, 2019, pp. 280–292.

[8] J.-J. Cabibihan, H. Javed, M. Ang Jr, and S. M. Aljunied, "Why robots? a survey on the roles and benefits of social robots in the therapy of children with autism," *International journal of social robotics*, vol. 5, no. 4, pp. 593–618, 2013.

[9] J. A. Leydens and J. C. Lucena, *Engineering justice: Transforming engineering education and practice*. John Wiley & Sons, 2017.

[10] J. C. Lucena and J. A. Leydens, "From sacred cow to dairy cow: Challenges and opportunities in integrating of social justice in engineering science courses," in *2015 ASEE Annual Conference & Exposition*, 2015, pp. 26–806.

[11] D. A. Martin, E. Conlon, and B. Bowe, "A multi-level review of engineering ethics education: Towards a socio-technical orientation of engineering education for ethics," *Science and Engineering Ethics*, vol. 27, no. 5, p. 60, 2021.