The Role of the Liberal Arts in Undergraduate Robotics Education

By Matt Zucker

Robotics falls at the intersection of engineering, computer science, math, physics, and cognitive science. As robots become ubiquitous in society, they impact our everyday lives in both more frequent and more significant ways. In contrast to siloed approaches that establish robotics under the sole purview of a single academic department, framing undergraduate robotics education in a liberal arts context is not just an effective way to make connections among disparate areas of inquiry—it is a necessary step toward making better and more responsible roboticians.

Given the multidisciplinary nature of an undergraduate robotics course, it is tempting to require prerequisite courses in circuits, programming, or mechanics. However, permissive requirements admit a broader range of students, each with his or her own interests and expertise. Connections to sciences beyond physics and math abound: consider biologically inspired swarm robotics and artificial muscle actuators or the tools and concepts from psychology that inform human–robot interaction. Ideally, engineering students taking robotics can share their foundational knowledge with nonengineers while benefiting in turn from other perspectives.

Open-ended assignments and self-directed projects are great ways to allow such specialization to flourish, while in-class presentations develop communications skills and empower students to educate peers about topics that inspire them.

A holistic robotics education should expose students to the history of technology. At Swarthmore College, where the majority of students taking Mobile Robotics are engineering or computer science majors, I often start the course with a timeline of key points in robotics and artificial intelligence (AI), beginning in 1920 with playwright Karel Čapek’s coining of the word robot as we use it today. In tracing the evolution of the field, I highlight the sometimes student division between the connectionist and symbolic camps of AI, concluding with the successful integration of the once-dueling approaches in DeepMind’s 2016 AlphaGo system.

For many students, this is the first time that they grapple with the notion that STEM topics they may have previously seen as objective or neutral are, in fact, immersed in ideological debate and influenced by trends in both the research community and society at large. Going forward, I hope to invite guest lecturers versed in science and technology studies to frame robotics in the larger context of technological developments in the 20th and 21st centuries.

Although most engineering courses can host conversations about the social
impacts of technology, the impact of robotics is especially salient and consequential in ways that students can readily relate to. In my classroom, we have discussed questions about the degree of responsibility of rank-and-file engineers in the 2018 Uber autonomous vehicle testing fatality in Arizona. We have also debated the impact of automation on disparate sectors of the economy, raising the question of how society values the output of laborers in industries ranging from mining to driving to manufacturing, drawing on ideas from sociology, economics, and political science. The point is not to arrive at correct answers but to engage students to think beyond whether they can build a system and consider what happens once it is built.

Conversations in the robotics classroom can range further into the philosophical. For example, in some years, I introduce students to the concept of emergent behavior through a thought experiment from Valentino Braitenberg’s *Vehicles: Experiments in Synthetic Psychology*. Simulations of Braitenberg vehicles demonstrate that simple excitatory or inhibitory connections between sensors and motors can generate a variety of apparently goal-directed, intentional behaviors. After reading Braitenberg and interacting with the simulation, students engage in debate about the nature of intelligence: Is it in the eye of the beholder, or is it an intrinsic property of systems?

As engineering educators, we must help students transcend a narrow technical viewpoint and develop into well-rounded citizens whose skills will outlast ephemeral trends in robotics and AI. We can achieve this goal by explicitly considering the broader impacts of robotics in society and studying the questions that underpin the relationship between robotics and cognitive science. At every type of undergraduate institution—not just small colleges, such as Swarthmore—instructors should be empowered to point out the deep connections among the disparate fields that inform robotics as a discipline as well as to frame robotics itself as a liberal art.

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