

# For the Public Good: Incorporating Civic Science into Undergraduate STEM Education

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**Executive Summary:** Science and technology are ubiquitous aspects of modern life, and their importance reaches far beyond the laboratory and into the public square. Those with STEM training have a distinct opportunity and responsibility as civic participants to apply their training to promote the public good by engaging with the civic dimensions of science and technology. However, civic engagement is difficult to do well, and current undergraduate STEM education does not adequately train students in these critical skills. To improve STEM graduates' understanding of science and technology in broader societal contexts, enhance their science communication skills, and increase their civic engagement and competency, universities should adopt a civic science approach to STEM education. Drawing on an example from the Science and Technology and Society co-major program at Tufts University, **we recommend universities and STEM departments incorporate training in civic science into STEM education to prepare STEM graduates to engage more fully with the technical and political dimensions of democratic life.**

## I. Background

Science and technology are ubiquitous aspects of modern life, and their importance reaches far beyond the laboratory and into civic life. In recent years, we have seen how science and technology have come to the forefront of a seemingly endless array of public problems. From the existential threats of climate change and the COVID-19 pandemic, to concerns about data privacy and algorithmic bias, to developing sustainable energy agriculture, and infrastructure, and advances in artificial intelligence, automation, cybersecurity and biotechnology, there is no aspect of public life untouched by science and technology. As White House Office of Science and Technology Policy deputy director Alondra Nelson states, "science and technology now sit in the center of every policy and social issue" (Nelson and Kearny 2021).

Nelson's admonition recognizes that science and technology are not separate from the rest of society but are an integral part of a healthy, well-informed, and publicly accountable democracy. Those with STEM training have a distinctly important role to

play not only as skilled professionals in science and technology careers, but also as civic participants in democracy. It is imperative that universities equip STEM graduates with the critical skills needed to engage with the civic dimensions of science and technology to promote the public good.

The idea that science and technology are important for civic life is not new (Bush 1945; Polanyi 1964; Ravetz 1988; Gibbons 1999; Guston 2000; Douglas 2009). However, there has been a resurgence in attention to the "rightful place of science" and expertise in democracy (Sarewitz 2009; Crow et al. 2013; Grundman 2018; Douglas 2021). The 2017 March for Science (Ross et al. 2018; March for Science 2019), called for more scientists and engineers to run for public office (Bloudoff-Indelicato 2012; Coons 2017; Mervins 2018; Tormos-Aponte, Fickle, and Parker 2020), and the prevalence of rhetoric to "believe", "trust", or "follow" the science demonstrate a recurring instinct that science belongs in civic life (Biden 2020; Bourla 2021; Mak 2021; Oreskes 2021).

However, in recent years, precisely what the place of scientific expertise *should* be in public decision making has been contested across the political spectrum. For example, during the Trump administration, executive orders reduced resources for federal agencies that rely on scientific expertise (Waldman 2019; Popovich, Albeck-Ripka, and Pierre-Louis 2020) and President Trump himself doubted scientists' knowledge of climate change (Lemire et al. 2020). The Biden administration, however, has not been free of controversy regarding scientific expertise. For instance, the controversies surrounding ongoing changes to CDC guidelines for mask use, testing, and isolation periods during the pandemic (Huang 2021) and the disgraced resignation of former Science Advisor to the President Eric Lander (Thompson 2022) illustrate how the role of scientific expertise in civic life remains an area of contention. While such examples are not directly comparable in their consequences or causes, they do highlight how determinations of the "rightful" place of science is more than merely a change in political administration (Facher 2021; UCS 2021).

What is clear is that science and technology are deeply intertwined with critical civic issues with far-reaching effects. Such matters are not only important for STEM professionals to understand. They are consequential for all of us. It is therefore crucial that those educated in STEM disciplines also are trained to effectively engage civically.

However, engaging with the civic dimensions of science and technology is difficult to do well and requires specialized skills that are often absent in STEM education (Brownell, Price, and Steinman 2013; Simis et al. 2016). Likewise, engaging public audiences about science presents its own challenges for promoting trust in science (Wynne 2006). Yet, survey research suggests that the majority of scientists want to be more civically engaged, but few feel that they have the skills to do so effectively (Royal Society 2006; Besley, Oh, and Nisbet 2012; Besley et al. 2018). There is a need in STEM education for civic training that is not sufficiently met.

While the total number of STEM degrees awarded in the US continues to grow (NASEM 2018, 30), the 2020 US Census indicates more than two out of three

STEM graduates do not end up in STEM careers (Day and Martinez 2021). STEM education, therefore, trains more than future STEM professionals—it also trains professionals across many sectors of society who will nevertheless be civic participants in a world where science and technology are at the center of most every issue. STEM education should reflect the reality that, regardless of career path, STEM graduates have a distinct opportunity and responsibility to apply their training for the public good. **We propose that universities and STEM departments should incorporate training in civic science into STEM education to prepare STEM graduates to engage more fully with the technical and political dimensions of democratic life.**

## II. Policy recommendation: Incorporate civic science into STEM education

At its core, civic science is a commitment to the idea that scientists, engineers, and other STEM professionals can and should be more civically engaged because science has civic consequences, and the civic realm has consequences for science. Civic science aims to make scientific institutions more accountable to the public (Schmandt 1998; Bäckstrand 2003; Christopherson et al. 2021) and to reimagine the relationship between science and the public anchored in equity and civic responsibility (Walker and Daniels 2004; Fortun and Fortun 2005; Wylie et al. 2014; Garlick and Levine 2016; Dosemagen 2020). Therefore, STEM education must equip students to apply their distinct technical skill sets to solving public problems, both as STEM professionals and STEM-trained civic participants. Incorporating training in civic science into STEM education prepares students to better participate in civic life in three important ways.

### *i. Better understanding of science and technology in context*

Civic science education situates science and technology within a broader societal context. By incorporating key insights from the social sciences, and humanities—and from science and technology studies (STS) in particular—civic science shows how the ways we make scientific knowledge are intertwined with the ways we order society. (Callon 1984; Latour 1993; Jasanoff 2004). Science and technology both shape and are shaped by the social, cultural, and political institutions of modern democracies. Civic science equips STEM students

with a more nuanced approach to understanding problems in science and technology as not only technical ones, but also as social, political, and ethical problems. While STEM expertise is critical to addressing many public problems, civic science education emphasizes that expertise across a diversity of disciplines, communities, and experiences are needed to provide more complete solutions to societal problems.

#### *ii. Enhanced science communication skills*

Civic science education enhances STEM students' science communication skills by recognizing that civic action requires more than asserting facts alone. In addition to training in effective science communication (Seethaler et al. 2019), STEM students must be equipped to engage with the "messy, complex work of civic discourse" (Christopherson, Scheufele, and Smith. 2018, 48). As the crises of the COVID-19 pandemic have acutely demonstrated, civic engagement is a necessary component of incorporating scientific knowledge into public decision-making. For instance, a scientist whose task is to convince publics that mask-wearing is important, or that inoculation by vaccine is the best choice we have, will not be effective by merely appealing to more facts (Hornsey 2020) or relapsing into persistent deficit models of science communication (Wynne 2006; Simis et al. 2016). Instead, scientists must be "more effective 'bidirectional' communicators" (Christopherson, Scheufele, and Smith 2018, 49) that are attuned to the needs and values of diverse communities (Dietz 2013; Christopherson et al. 2021) and can "bridge the gap between the generation of scientific knowledge and the translation of that knowledge into meaningful civic action that impacts deliberations and decisions on policy and governance" (Garlick and Levine 2016).

#### *iii. Greater civic engagement and competency*

Research shows that exposure to civic science education helps students to connect their learning in STEM courses with their personal motivations and values, and increases their participation in civic life (Levy, Oliveira, and Harris. 2021). This may include acts of individual advocacy, membership in professional associations, or pursuing policy-related

careers. Similarly, experiences in civic science education may also improve STEM students' understanding of civic processes, like how laws are passed, budgets made, and policies enacted, while also developing analytical and participatory skills (Levy, Oliveira, and Harris. 2021). Civic science education empowers STEM graduates to become more engaged and competent civic participants who bring much-needed technical understanding to effectively address public problems.

### **III. A case study of civic science for STEM education at Tufts University**

In 2016, the Science, Technology, and Society (STS) program at Tufts University developed a co-major program that provides STEM undergraduates access to civic science training alongside their primary field of study. At Tufts, the STS co-major is not a standalone major but is always partnered with another major, typically in STEM. Undergraduate students use the co-major program to engage more fully with the relationships between STEM and civic life. Upon graduating, students receive degrees that reflect both their primary STEM degree and their STS co-major as distinct from students who complete only a STEM degree.<sup>1</sup>

The goal is for students to specify the types of civic relationships between science and society that students engage with more deeply. To do so, students can choose from three co-major tracks according to their areas of interest: Bodies, Health, and Medicine; Science and the State; or Math, Maps, and Modeling. For instance, one biology major with an interest in applications of computational systems biology may pursue the Math, Maps, and Modeling track while another biology major interested in policies regulating human genome research may favor the Science and the State track.

Within these tracks, students choose from sets of courses that directly complement their STEM coursework. Some co-major courses are cross-listed with already existing courses in anthropology, sociology, philosophy, history, and community health departments, as well as political science, classics, urban and environmental planning, and environmental studies. Other co-major courses are

<sup>1</sup>The STS program at Tufts University is not the only example of civic science work. Other universities have similar programs at the intersection of science and society. However, the co-major approach at Tufts is a distinct example of one way universities can apply institutional resources toward civic science into STEM education.

housed within STEM departments themselves, focusing on the interplay between science and society (e.g., a biology course on food systems and sustainability, or a computer science course on cybersecurity). As students take more technically-rigorous STEM courses alongside courses that are civically-rigorous, students learn to recognize how public problems are seldom strictly social or strictly scientific in nature. Rather, the STS co-major program prompts students to engage both their STEM training and civic science *in practice* together.

#### *i. Practical and institutional challenges*

Incorporating civic science into STEM education may also face practical and institutional challenges. The infrastructure necessary to support civic science training requires significant investments of time, money, and energy from faculty and university leaders. Likewise, there may be external pressures from university donors, state and local governments, or other funding bodies to not include civics as part of STEM curricula. It may also be difficult to create a unified educational experience across such varied departmental curricular requirements.

However, the co-major approach has several practical advantages that enable many institutions to use resources they already have to overcome those challenges. The co-major approach minimizes start-up costs by leveraging other departments, courses, and faculty already present at the university to incorporate civic science training into STEM education. It also does not require redesigning core STEM curriculum, which enables STEM course sequences to remain unaffected while offering parallel opportunities to engage with scientific and civic dimensions simultaneously. Finally, because the co-major is independent of the base STEM degree, it enables students from *any* STEM major program to cross-train in civic science.

While we have focused on a co-major model, there is no one-size fits all approach for civic science. The best approach for another university or department may include integrating civic science curricula into

core STEM courses, developing novel degree programs, or investing in extracurricular and professional development opportunities for STEM students to engage in civic issues. Though the resources available to develop co-major or similar programs will vary by university context, the advantage of this kind of approach to civic science is that it enables collaborations across traditional departmental boundaries, while maintaining disciplinary distinction between different kinds of expertise.

#### **IV. Conclusion**

Science and technology are integral to most every aspect of our social and political lives. STEM education, therefore, is crucial to the training of the next generation of STEM professionals and STEM-trained civic participants. However, current undergraduate STEM education does not sufficiently train students to effectively engage in civic issues around science and technology. Moreover, if STEM graduates are to become more effective “bidirectional communicators” between science and society, then STEM education must not only equip them with technical and communication skills, but also with an understanding of *the civic*. **We recommend that universities and STEM departments incorporate training in civic science as part of undergraduate STEM education**

While building civic science into STEM education will not be costless, staying the current course in STEM education is not costless either. Failing to prepare STEM graduates with the skills to use their scientific and technical training in a civic context is a dereliction of the responsibilities of science and higher education to prepare the next generation of STEM students for success in a technically and socially complex world. The goal of civic science in STEM education is not to merely check a “science and society” box or to make STEM graduates experts in everything. Rather, civic science aims to instill among STEM graduates an appreciation for the many kinds of expertise and knowledge needed to ensure that science and technology serve the public good.

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