Science, Society, and Self

An Undergraduate Course for Imparting Social Context to STEM

By Marcus Aldredge, Sunghee Lee, and Josh Klein

A formal pedagogical push emerged and later blossomed in designing integrated curriculum between STEM and non-STEM areas in secondary and higher education. A growing cadre of research identifies positive learning outcomes for students participating in an integrated curriculum who apply basic STEM knowledge to investigate social problems and justice issues within social contexts. Research indicates STEM students demonstrate fewer concerns with social issues, often placing a greater interest in the value of individualism. This article outlines a new, integrative course, Science, Society and Self, which was supported by a National Science Foundation grant to Iona College in the Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM) program. The Development of Excellence in Science through Intervention, Resilience, and Enrichment (DESIRE) program seeks to increase retention and graduation rates for economically disadvantaged and high-aptitude STEM majors. Skills important for success in STEM courses are reviewed, as are service-learning and policy applications. We also explore the intersections between nature of science (NOS) and sociological concepts. This culminates in distinguishing public science issues by connecting the intersections of human biographies, history, and societal structures through the sociological imagination, as conceived by C. Wright Mills.

The groundswell of support for an interdisciplinary approach to teaching science dates to the 1990s for elementary and secondary schools (Akins & Akerson, 2002). Adopted in 1996, the *National Science Education Standards* (*NSES*; National Research Council, 1996) outlined an inclusive set of standards for K–12 teaching and learning, with "Science in Social and Personal Perspectives" directly addressing the application of science to individual, community, and societal issues such as poverty, health, and the environment. Subsequently, the field saw more support for the integration of different natural sciences (e.g., physics, chemistry, and biology) in kindergarten through Grade 12 by building cross-curricular connections, "big picture" themes, and concept development (i.e., creative thinking, problem solving, the scientific method, methodological design; Nyckel, 2000).

Secondary education trends correspond with those in higher education. Interdisciplinary approaches to STEM pedagogy benefit students by helping them learn how to apply science to the social problems one encounters outside a laboratory or classroom (Lin et al., 2019). These applications include emphasizing social responsibilities, such as justice and sustainability, in the face of global issues. This trend calls for a "bottom up" approach supported by "top down" initiatives from university administration (Daempfle, 2013). The unintended and unanticipated consequences of scientific and technological innovations—such as human-induced pollution, waste, climate change, and the technology gap—need to be addressed using science and policy (Merton, 1936; Mitcham, 2005). This need offers a solid rationale for teaching students the importance of working toward significant cultural change in science, technology, engineering, and mathematics (STEM; Zandvoort et al., 2013). Research indicates that students in nonscience majors are more likely than STEM college students to strive toward goals of social change, social justice, and civic duties, though the numbers are higher among students of color (Garibay, 2015). Research indicates that STEM majors frequently value and idealize individualism, competition, and a more "laissez-faire attitude" when weighing the social impact of scientific research (Beckwidth & Huang, 2005). Convincing American students that science is trustworthy in an age of cynicism and unfettered skepticism is another key goal (Oreskes, 2019).

In this article, we discuss a course designed to use sociology to explore relatable social issues for freshmen STEM students. A National Science Foundation (NSF) awarded grant to Iona College in the Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM) program in fall 2016 supported the course's creation and implementation. One programmatic rationale is to augment the American workforce for a competitive global landscape in STEM fields. The grant funds scholarships for economically disadvantaged students with a high academic aptitude to help increase retention and graduation rates and increase workforce or graduate studies following degree completion. Iona College's program—Development of Excellence in Science through Intervention, Resilience, and Enrichment (DESIRE)—focuses on students majoring in computer science and chemistry (for now) and meeting other S-STEM prerequisites. Numerous reports, including from the World Economic Forum and the Organisation for Economic Co-operation and Development (OECD), confirm the lag in American students' preparedness compared with other countries and emphasize the importance of redressing these issues for future expansion in STEM jobs (Daempfle, 2013; World Economic Forum, 2016).

Course objectives

Housed in the Criminal Justice and Sociology Department at Iona College, the course Science, Self & Society is required for first-year DESIRE students to help them foster an interdisciplinary, integrative approach to science. This article represents the course's third and culminating run in 2020.

The course begins by having students read about and discuss reliable survival skills as a way to help science students succeed in college courses. In addition to covering and discussing vital skills for academic success in the sciences, the course introduces students to the connections between science and civic responsibility, service learning, and community activism. The course subsequently surveys pivotal contributions throughout the history of science and key foundational norms, ideals, and tenets of science. It is not an introduction to science and technology studies, science studies, or the sociology of science; rather, it follows a nature of science (NOS; Abd-El-Khalick & Lederman, 2000) approach that is integrated with foundational readings from sociology, popular social research on science and technology, and applications from everyday life. In the words of the syllabus, the course explores "sociological intersections of science, technology, society and the social self." Recognizing science as a human enterprise, the course investigates how individuals, social groups, and cultures intersect and influence the theories and methods of science and technology within social contexts.

Common learning objectives include addressing the cognitive skills of problem-solving, critical thinking, and creating cultural artifacts and forms of communication (Loudon, 2019). The course teaches students how to distinguish and use the scientific method to communicate and abate serious public science issues as active and socially conscious citizens. The course's student learning outcomes (SLOs) are as follows:

- SLO1: To identify important themes and examples of the impact of scientific discoveries upon society and in human lives
- SLO2: To articulate the foundations of scientific inquiry and the intersections between the sciences
- SLO3: To identify the long-term prospects, positive life-long outcomes, and responsibilities to oneself and society in entering a STEM field

Like similar multi- or interdisciplinary courses at other institutions (Farah & Montepare, 2019), the course SLOs match three of Iona College's core SLOs (Iona College, n.d.):

- Through engagement with "big questions" grounded in liberal arts, students will demonstrate an integrated knowledge of the meaning and complexities of the human experience and its relationship to the natural world.
- Through the participation in a cohesive and interdisciplinary core, students will demonstrate the capacity to synthesize and adapt knowledge, skills, and responsibilities to new settings, questions, and specialized studies.
- Through a comprehensive curricular experience that emphasizes the values of peace, justice, and service, as well as appreciation for human diversity, sustainability, and civic engagement, students will demonstrate the ability to apply a global perspective and the principles of ethical reasoning—human diversity and global perspective specifically.

The course is an elective for sociology minors and majors; fulfills the Diversity, Cross-Cultural and Global (DCCG) requirement; and is part of the Iona College, Identity—Persons, Societies & Cultures, Integrated Course Theme (ICT; Iona College, n.d.).

Course resources and organization

While the course's interdisciplinary nature is its strength, it may also be considered an impediment to constructing a consolidated set of resources. Finding a balance across the different objectives requires the use of many primary and secondary sources. Peter Daempfle's (2013) book *Good Science, Bad Science, Pseudoscience, and Just Plain Bunk: How to Tell the Difference* provides the content for 40% of the 15-week course. This text covers the basics of the nature of science and the history and philosophy of science and discusses applications in contemporary everyday life and modern threats and challenges to science. *What Every Science Student Should Know* (Bauer et al., 2016) foresees and prepares students for likely pitfalls and issues they will face as emerging students. The remainder of the course's readings are a collection of excerpts from books, popular science periodicals, academic journals, and reputable newspapers (see Table 1). The curriculum is built around the course title's trilogy of concepts: science, society, and self. Recognizing that these concepts do not exist in isolation, the organizing sections divide the intersections of these concepts as well as technology, an extension of and application to science.

Studying and using science

The course's introduction presents three key curricular objectives. The first section (SLO3) addresses the importance of learning reliable and beneficial educational practices that freshmen STEM (and others) majors need to succeed in collegiate courses, such as proactive study habits, improved note-taking skills, reduced test anxiety, and cultivation of relationships with professors, including by attending office hours to address issues of concern or clarification. The second section (SLO1 and SLO3) surveys the basics of service learning. Primary concepts such as community service, citizenship and global citizenship, civic capacity, and empathy are discussed. The section focuses on what constitutes being an active citizen, applying STEM solutions to real-world problems, balancing empathy with self-empowerment, and connecting scholarship with community improvement. The final introductory section (SLO1 and SLO2) begins by addressing the "great man theory" of science (Connor, 2005, p. 17). As seen in this excerpt from *A People's History of Science,* Connor (2005, p. 3) scrutinizes the traditional metanarrative of science by uplifting the overlooked contributions by workers, farmers, and the proletariat who have experimented with nature for thousands of years:

> *The geography and cartography of the Americas and the Pacific Ocean are founded on the knowledge of the native peoples. Captain John Smith acknowledged that his celebrated map of the Chesapeake Bay area "was had by information of the Savages" and Captain Cook's maps of the Pacific Islands were derived from information given to him by an indigenous navigator named Tupaia.*

These contributions by laypersons have long been overlooked in favor of the contributions of European icons in science, such as Nicolaus Copernicus, Galileo Galilei, Isaac Newton, and Robert Boyle. We return to these and other natural philosophers and scientists later in the semester.

Learning, understanding, and disseminating the nature of science

This section summarizes the general principles and nature of science. Each week, readings are assigned from *Good Science, Bad Science, Pseudoscience and Just Plain Bunk* (Daempfle, 2013). Scientific literacy is framed to encourage students to become "independent thinkers" and good citizens of democracies and to understand the value of STEM careers. Science is defined, as are crucial related concepts such as methodology, sample size, critical thinking, and reasoning. These concepts are taught in the context of the daunting challenges the American education system faces in overcoming STEM deficiencies. Argumentation and logical justification of beliefs are explored next. Within this framework, the key concepts of skepticism, persuasion, a balance between cooperation and competition, epistemology, realism, and relativism are covered and discussed. Daempfle (2013) provides tangible examples of science's triumphs, including the eventual dismissal of the 1950s controversy

TABLE 1

Course outline with weekly topics, sections, primary readings, and important concepts.

Table 1. Course Outline with Weekly Topics, Sections, Primary Readings and Important Concepts

Week	Weekly Topics	Topic Section	Primary Readings / Important Concepts
1	Introduction, Syllabus Review, Group Assignment	Studying & Using	Introduction / Great Man Theory of Science
2	Excelling in Science Courses & Service Learning	Science	Strategies for excelling in STEM courses / Service Learning, Civic Responsibility
3	What is Science & Argumentation		Chapters 1&2 (Daempfle) / Science, Skepticism, Reasoning, Epistemology, Positivism
4	Critical Thinking and Science in Media	Understanding Science	Chapters 4-6 (Daempfle) / Unifying Concepts, Rite of Passage, Critical Thinking, Instant Gratification
5	Scientific Progress and Problems		Chapters 7 & 10 (Daempfle) / Conformity, Pseudoscience, Cynicism, Bullshit and Truthiness
6	Fundamentals of the Social Self	Science & Self	The Self (Mead) & Identities, Social Roles, Social Structures, Institutions (Stryker)
7	Social Roles & the Body		Gender Equity and Role Models
8	Science as Vocation and Profession		"Science as Vocation" (Weber) & Gender/Culture on Research
9	Sociology of Science and Objectivity	Science & Society	"Normative Structure of Science" (Merton) / Scientific Objectivity
10	Science, Public, and Global Issues		"The Sociological Imagination" (Mills) / Public and Scientist's Views on Science
11	Science, Public, and Global Issues		Climate Change, Diversity, Economic Inequalities
12	Technology, Culture & Inequalities		Excerpt from Technopoly (Postman) /Digital Divide
13	Inequalities, Politics and Responsibilities	People Doing Science &	Chapters 8 & 9 (Daempfle) / "Do Artifacts have Politics" (Winner)
14	Science Fiction and Challenges to Science	Science doing People	Chapter 10 (Daempfle) / SiFi Innovation
15	Overcoming Problems of Science and Technology		Chapter 11 (Daempfle) & "How is Google Changing your Brain" (Wegner & Ward) / Space (Turkle)

*Note: Last names of authors for major works/readings are in parenthesis over fluoridation and the positive but unintended consequences of discovering ultrasound for German U-boat detections. A *New York Times* (Carroll, 2015) article about the genesis of and ongoing controversy about the science of human vaccinations exemplifies these challenges today.

The next section outlines the National Research Council's (1996) *National Science Education Standards*. The unifying concepts of science are identified, including evidence, models, explanation, evolution and equilibrium, and form and function (Daempfle, 2013). Yet, these concepts are left unlearned if students show no interest in science or leave college. The "leaky pipeline," or the enduring issue of losing students who initially show interest in science to other academic interests, is discussed, and data show that this issue impacts female students and students from minority backgrounds the most (Cole & Espinoza, 2011). Learning and fine-tuning cognitive strategies native to critical thinking, such as avoiding oversimplification or distinguishing relevant or irrelevant facts, are highlighted. We tangentially discuss five common logical fallacies (e.g., *ad hominem*, red herring, and poisoning the well) and view notorious social psychological studies (e.g., Solomon Ashe on conformity and Stanley Milgram's obedience to authority) whose findings exemplify (albeit sometimes with dubious ethics) the all-too-human pitfalls of unsharpened critical-thinking skills (MacFarlane et al., 1990). Learning and becoming aware of different types of cognitive biases (e.g., fundamental attribution error, confirmation bias, and anchoring bias) further support these concerns and the need for a heightened self-consciousness.

Subsequent chapters outline the media's profound and comprehensive power as shared communicational conduits for false and specious understandings of science and scientific studies. Mass, new, and social media explosions present more problems for scientific findings and discoveries, as they are often oversimplified and misrepresented. Similar issues are driven by the conflation of education with profit motive and entertainment, as well as a culture of instant gratification, all of which are infused into technology and educational pedagogies. These issues are further muddied by equal public recognition of and platforms for science and pseudoscience (e.g., astrology and astronomy are presented as commensurate sciences). Although they are perhaps meaningful to individuals, not all ontologies and epistemologies are accountable to the same paradigmatic rigor, methodologies, argumentation, and reasoning of science.

Science and self

The self is the smallest organizing concept in the course's trilogy of concepts. Notwithstanding the varied history of studying the human self, this course's two readings represent the pragmatist-symbolic interactionist tradition. George H. Mead (1934) conceived the self as a dynamic social construct in today's parlance—while shaped by the social world, the self has the agency to act back upon it. Sheldon Stryker (1980) continued this tradition by looking at how a social self is the structural basis of social identities, roles, interactions, structure, and institutions. These readings detail the complex processes and organizing patterns of human identity construction through the social environment, including social roles. Roles and identities connect human experiences, guide socialization, and influence social outcomes through shared communication, group identities, and culture. These primary sources are supplemented with a reading from *Science* (Bonetta, 2012) examining contemporary issues of gender equity in scientific fields. The readings build connections for students on how identities—as a woman, as a scientist, or both—influence other organizing practices, building blocks of society and internalized values and assumptions of the social world. Learning about how scientists hold and share a "reference group" (Kuhn, 1964) with other scientists helps future scientists see the importance of creating and sustaining associations with other professionals (Kim & Sinatra, 2018).

Science and society

The intersection between science and society is the critical intersection of the course. The literature in this section pulls from the sociology of science, cultural studies, and science and technology studies (STS) canons. The first three excerpts are from Max Weber's (1946) "Science as Vocation," Robert Merton's (1973) "The Normative Structure of Science," and Peter Daempfle's (2014) *Science and Society*. Daempfle's discussion surveys the interactions between society and science, focusing on ethical differences seen from social constructivist and positivist perspectives. Weber's analysis discusses the inward "calling" of science, also recognizing how the accepted rationality foundational to science influences common everyday interpretations of the world. Merton also focuses on this interaction, looking at the scientific community's orienting norms and practices. He argues that four norms guide a scientific ethos: communism (knowledge and scientific practices are owned by everyone), universalism (scientific merits supersede personal attributes), disinterestedness (personal gain is secondary to shared scientific goals), and organized skepticism (all claims are scrutinized). These are supplemented by a *New York Magazine* article (Singal, 2017) on the debate over scientific objectivity and Thomas Rodham's (2012) article

"On Bullshit and Truthiness," which defines and details Harry Frankfurt's (2005) and Stephen Colbert's concepts of bullshit and "truthiness," respectively. These two concepts get to the heart of how truth is increasingly evasive and challenged, making the scientific process of truth seeking more difficult in the face of social media.

The next reading, an excerpt from C. Wright Mills' (1959) *The Sociological Imagination*, represents a theoretical nexus of the course. Mills asks readers to explore the intersections of one's biography, society, and social history to best contextualize shared life's experiences and societal issues. Mills suggests that an elevated self-consciousness—conceived as the sociological imagination—allows holders to distinguish social problems (e.g., divorce, prejudice, drug abuse) as "public issues" in need of collective, intentional improvement by the public. This article is the basis for three additional articles used to exemplify this approach, including a Pew Research Center (2015) study that contrasted the perceptions of the American public and scientists on scientific issues and topics.

People doing science and science doing people

The concluding curricular section explores the dimensions of the dialectical relationships between science, human experiences, and technology. These two short subsections ask the reader to rethink how modern technology is increasingly encompassing and shaping how we think, formulate our identities, and interactions with others. The section begins with a reading on and discussion of professional ethics as guided by a code of conduct and scientific integrity with honesty as a core directive. Different types of violations are covered, including issues of plagiarism, scientific transparency, malicious intent and misuse of science, and the inevitable moral conflicts between human and natural laws.

The class reads excerpts from Neil Postman's Technopoly (1993) and Langdon Winner's (1980) classic article on technology, "Do Artifacts Have Politics?" These readings uncover the cultural and psychological influence of modern technology and its evolutionary changes and overall significance. They underscore power relations and unknown motives embedded in cultural artifacts and technology, exemplified by the unknown prejudices and bias influencing the rearrangement and design of the New York city road system by Robert Moses (Winner, 1980, p. 123). These exposed issues and concerns provoke questions about possible ethical mandates to monitor and control biases—conscious or unconscious—and practices of conduct in the applications of science in technological innovations. The final two readings encourage students to examine the impact of economic interests on science, as well as the prescience and aspirational sway that science fiction has on science. These readings scrutinize how technology is increasingly blurring the lines between the human mind and a collective digital consciousness and the spatial and interactional negotiation between humans and machines.

Course assessment and evaluations

A variety of instruments for assessing student learning outcomes are employed: tests, quizzes, online discussion boards, a group presentation, and a culminating paper. Using an online means of assessment presents an opportunity to experience and reflect firsthand on the socio-cultural implications of technology. For the group presentation, students are alphabetically assigned to groups to ensure greater group diversity. Each group is assigned the materials for a week. They summarize and integrate the readings into a chosen topic examining a public science issue (e.g., water pollution in communities, lead paint exposure, global pandemics, climate change, or dangers of pesticides/herbicides). According to *The Sociological Imagination* (Mills, 1959, p. 9), public issues are

> *matters that transcend these local environments of the individual and the range of his [sic] inner life. They have to do with the organization of many such milieux [sic] into the institutions of a historical society as a whole, with the ways in which various milieux overlap and interpenetrate to form larger of social and historical life. An issue is a public matter; some value cherished by publics is felt to be threatened ... often involves a crisis in institutional arrangements, and often too it involves what Marxists call "contradictions" or "antagonisms."*

A public science issue is an issue that science can pragmatically improve but where threatened cultural values present impediments to collective solutions. The public science issue is often an unintended consequence of past science and technological innovations. Each group presents on their approved topic via PowerPoint or Google slides for 15 to 20 minutes, followed by posing three online Blackboard questions to their classmates. Each group provides a novel service or policy program to the community to combat the issue. The final paper is similar to the group presentation but also asks the student to address how the issue connects with the course's trilogy (i.e., science, society, and self) and to define and integrate a minimum of two scientific concepts from readings in their analysis. An extra credit essay pertaining to an exhibition at the American Museum of Natural History in New York City, or any science museum, is optional.

The coronavirus (COVID-19)

pandemic unexpectedly disrupted the second half of the semester. All in-person meetings were suspended, forcing classes to be conducted exclusively online using synchronous Zoom presentations; virtual discussions; and asynchronous Blackboard quizzes, tests, and a concluding paper. Students remained engaged, with few absences and an impressive grade distribution for a regular semester. Final grades ranged from A to C+ (only two) with a class average (n = 10) of 85. The course and instructor were evaluated by students through a standardized, online end-of-semester SmartEvals. Participation in the evaluation process was voluntary, and 4 of the 10 students provided responses. The responses equaled or exceeded 3.5 (on a 4-point scale) for each question regarding the quality of the course and instructor. All but three of the 29 questions had a score of 3.75 or higher. In the qualitative responses, one student said, "The codification of things one may see every day has allowed me to look at problems with a new, clearer lens when thinking about society, science, and myself. I am also glad that service learning was discussed but not mandated; forcing 'charity' or 'service' ends up feeling like a hostage situation more than a legitimate good experience."

Summary

The goals of this course are guided by its genesis. Bridging the boundaries of disciplines—between the sciences and humanities—demonstrates the interconnectedness of knowledge (Gardner & Southerland, 1997; Kumar, 2001) and the need to apply the foundational tenets of science to address relevant societal issues. The instrumental, long-term goals of this course are to increase retention and graduation rates and the number of students from economically disadvantaged and historically marginalized backgrounds who enter STEM fields. The course is intended to enhance students' understandings to fan inspirational flames so they use their scientific aspirations and intellectual aptitudes for an interdisciplinary application of STEM in their community, nation, and global landscapes (Ozaktas, 2013).

Students demonstrate in their work and evaluations that—by using the sociological imagination to make connections between themselves, history, and society—they gain a stronger understanding of science and technology. In a culminating discussion, 70% of the students identified Rodham's (2012) article on bullshit and truthiness and Singal's (2017) article as the most insightful readings about the global COVID-19 pandemic. Helping people understand connections between themselves and public science issues lays the groundwork for change. To these students, this connection helps illuminate the "bullshit" increasingly plaguing American public discourse about science and exemplifies to the students the broader cultural mission of the specific curriculum and course.

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