

NARRATIVE EXPOSITION OF STS COURSE OBJECTIVES

For the benefit of Santa Clara faculty who are developing, or thinking about developing *Science, Technology and Society* courses for the new core, this document defines each of the three course objectives for STS and describes general pedagogical approaches to meeting these objectives, along with examples of such approaches in various disciplines.

Proposals for STS core courses should describe how that course will satisfy the three STS objectives for student achievement, and how such achievement will be assessed. With regard to each of the objectives, a course proposal should (a) identify and describe those exercises, units, or themes that the instructor believes will be particularly successful in modeling/encouraging student achievement of the objective, and (b) how someone looking at the course products could tell how well this goal was achieved in the case of any given student.

Finally, in order to ensure that STS courses provide students with substantial exposure to both the scientific/technological and the social dimensions of their subject matter, the STS Faculty Core Committee developed the following rule of thumb: a minimum of 30% of the course content should address the scientific/technological dimension, and a minimum of 30% of the course content should address the social dimension, each taught at a level appropriate for the expected student audience. Ideally, these dimensions will be integrated within the course rather than treated separately, and thus the FCC does not regard precise quantitative assessments of such percentages as feasible; however, the minimums reflect the overarching aim of the STS component: a true intellectual union of these perspectives in the minds of our students.

Course Objective #1

Students will demonstrate a more comprehensive appreciation of the complex relationship between science and/or technology and society.

Definition: Our first objective is to teach students that science, technology and society are not three separate islands, but that they mutually interpenetrate: social changes precipitate scientific and technological changes and vice versa.

General Approaches: This objective entails that one step towards helping our students become fully engaged citizens is to have them be able to pick up a newspaper or a popular science or technology journal and be aware of social, technical or scientific dimensions that are critical to understanding the development and are not included; and to know where they might go to pick up the whole picture.

Coursework should help students recognize that science, technology and society are, and have always been, fundamentally inter-related dimensions of human existence and help them integrate their understanding of these three regions of human activity.

Example: There are many ways to play this out in different disciplines. We will give just one example covering climate change from different disciplinary angles.

A historian teaching a climate change course might want to look at the history of the relationship between peoples and climate change over the past several thousand years (the desertification of Africa; the little Ice Age in the early 1800s when the Thames froze over) and so forth. So they would learn that climate change is an ongoing phenomenon. They should learn about the evidence for anthropogenic climate change dating from the Industrial Revolution. They should understand enough of the science to be able to follow debates around natural variation (Milankovich cycles; the role of volcanic eruptions and so forth) as opposed to change caused by our activities. They should learn about scientific changes on this issue – in the 1970s the consensus prediction was for an imminent Ice Age. And they should learn about the politicization of climate change science over the past ten to twenty years. A cognate course in an engineering school might look at the various technical fixes that have been proposed: giant mirrors in space, increasing the albedo of the ocean by dispersing reflective sheets, burying carbon dioxide far below the surface and so forth. However, to work in the new core, such a course might also cover an exploration of the trade-off between lifestyle changes (polluting less) and technical solutions. They might look at how ‘clean technology’ is developing now – and how some countries have embraced this as an economic boon and others continue to push for, say, the use of coal-fired plants. A science class could look at the various modalities for measuring climate change (tree rings, ice cores, the importance of isotope variations and so forth). However, it could also look at the ways in which the rules of scientific evidence have been deployed politically on both sides of the equation by believers and unbelievers.

Course Objective #2

Students will acquire a better understanding of the methods and process of scientific inquiry and how science and technology advance through such processes.

Definition: Expresses the need for students to acquire a greater capacity for understanding how scientific inquiry and/or technology actually progress.

General Approaches: Develop a course containing content that helps students develop a greater capacity for understanding basic scientific/technological methodologies, concepts, principles, standards, and techniques.

Examples: A course offered in philosophy, history or another area of the humanities might meet the objective by presenting students with one or more case studies taken from the history of science in which the evolution of a particular theory or scientific concept is analyzed; this might include examining the theoretical or experimental background used to select and define the specific research problem or question; the specific patterns of scientific reasoning (deductive, inductive or abductive) used to advance the discovery; the specific techniques used for data collection and analysis, the stages by which the scientists arrived at their conclusions, and/or how the validity of those conclusions was

ultimately confirmed by the research community. For example, one might teach a course in evolutionary theory that explored the conceptual difficulties in dealing with non-experimental, non-predictive science. In a history class, attention would be paid to the development of the theory in the context of changes in geology early in the twentieth century, the development of statistical tools and their value, and finally the synthesis between evolutionary theory and genetics.

A course taught in the natural sciences or engineering might meet this objective by focusing on a particular scientific discovery, development or sub-discipline and examining: the underlying scientific principles; the ideas that were revised, replaced or removed as understanding grew; and the scientific techniques used and developed that provided the tools for the discoveries. The theoretical and quantitative components of this treatment may be analyzed on a deeper level than would be the case in a humanities STS course, in accordance with the skills and background knowledge of the expected student audience. A canonical case here would be the move from a Newtonian to an Einsteinian world view—one could discuss this through reading Thomas Kuhn on the structure of scientific revolutions and the role of anomalies in science (which could be covered in an exploration of the emergence of quantum theory and general relativity).

Alternately, a natural sciences or engineering STS course might meet this objective by looking at a particular technology and examining: the mechanical or other physical principles presupposed by its design; the constituent physical parts of the technology and the means of their interaction; the nature of the energy sources relied upon; various quantitative methods and empirical techniques used in the design, fabrication and testing phases, and the prior technologies it draws from, improves upon, or replaces. For example, one could look at the development of the transistor, understanding why they are more useful than vacuum tubes, why it was so applicable to different industries, principles of integrated circuit design (especially the role of Boolean logic) and difficulties balancing heat budgets with chip size. The same types of technological content might be treated in a humanities STS course, but again, the theoretical or mechanical principles and quantitative methods may be analyzed on a deeper level in a course in the natural sciences or engineering, in accordance with the skills and background knowledge of the student audience.

Course Objective #3

Students will develop and employ critical and independent thinking skills in the analysis of the social impact of science and technology, and how science and technology are themselves impacted by the needs and demands of society.

Definition: This objective concerns a range of cognitive habits and abilities that foster the ability to move beyond the confines of current conventional thinking and/or one's own background assumptions and prejudices, and to move in directions that are fruitful because they further illuminate the world and/or suggest constructive avenues of response to challenges.

General Approaches: Critical thinking skills extend beyond memorization and other passive learning techniques and involve the ability to *use* information actively and effectively. Although many approaches for STS courses would allow students to practice and enhance the above habits of mind, several can be highlighted as particularly appropriate. A course might lead students to closely follow the science in a case that illustrates the process through which, and consequences with which, a change occurred in accepted scientific thinking. Students could work to identify the initial scientific assumptions; the aims and values that shaped the selection of the problem and methods for attempting its solution; or how social, economic and/or political conditions may have impacted the work. Students might be asked to critically assess the way in which scientists and their peer community assessed their own progress; and/or the resultant consequences for society—both anticipated and unanticipated—of their achievements. Another course might analyze the “before/after” social transformation that occurred as a result of the introduction of a new technology. Students might work to identify the social, economic and engineering considerations that guided the design process; to discern and critically assess the merits of various assumptions about the needs and desires of the society or culture for which the technology was being developed; to compare the actual effects of the introduction of that technology with what was expected and to assess its overall contribution to human flourishing; or in the case of an emerging technology, to identify the various factors and contingencies that will collectively determine its impact on society. Students could also be asked to rigorously explore alternative ways that technology could work to better enhance social/community/organizational life, or ways that particular societies/institutions might be modified in order to constructively adapt to changing technological conditions.

Examples: A course on robotics and society might require that students practice critical and independent thinking by identifying the relevant socioeconomic facts, cultural priorities and presuppositions, human needs and values that created the initial impetus for robotic technology, as well as those currently shaping its development. Demonstrating more advanced critical faculties might involve reflecting upon the relationship between robotic technology and various notions of the ‘good life’, and determining how the benefits and costs of robotic technology might be distributed among different social and economic groups and institutions. The course might also involve the students anticipating future developments in robotics and assessing the social impact and ethical import of such developments. Finally, reasoned conclusions might be drawn about the social desirability of various possible outcomes, and sound strategies for societies, institutions and individuals to employ in constructively guiding and adapting to future developments in robotic technology could be identified.

A course on biotechnology and society might look at the structuring of the biotech industry and the role of publicly funded research. The stress here would be in identifying how and why certain scientific breakthroughs occur and others don’t (for example, biocontrol is languishing at the expense of biotech in part because of different economic models). While exploring specific scientific developments (stem cell research, crop biotechnology, cloning) it could look at the role of public debate about these issues. Material from scientists, public policy makers and activists would be looked at in order to see what use – rhetorical and factual – they were making of scientific findings.