Science, Technology, and Catholic Identity in the Education of Professionals

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The reception of Ex corde ecclesiae *has been uneven across the disciplines, with scant interest in distinctly Catholic pedagogies outside of the humanities. This essay argues that Catholic universities can distinguish themselves by how they present science and technology in their curriculum by drawing from the interdisciplinary field of "science, technology & society," or STS. We argue that discussions about Catholic identity, science, and human values can and should extend into the curriculum while simultaneously safeguarding academic freedom, and that this can readily be done in professional schools, such as law and engineering. We outline the contributions that STS as a field could offer Catholic higher education. We discuss how teaching science and technologies as social forces can provide the intellectual and reflective space necessary for critical reflection on their moral dimensions, in society and in the emerging professional lives of students. We argue that STS can help Catholic universities express the Catholic tradition of linking knowledge and wisdom, and thus has the potential to advance the distinctly Catholic character of universities. To substantiate our claims, we present three examples of STS in Catholic higher education curriculum: undergraduate core curriculum, law school instruction, and frugal innovation in engineering education.*

Introduction: The Value Commitments of a University

> We must ask ourselves whether both science and religion will contribute to the integration of human culture or to its fragmentation. It is a single choice, and it confronts us all…Simple neutrality is no longer acceptable. (John Paul II, 1988)

The release of *Ex corde ecclesiae* (ECE) by Pope John Paul II in 1990 marked a threshold in discussions of the distinct characteristics of Catholic higher education. ECE articulated an expansive vision for

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Catholic universities, and elaborated specific roles and responsibilities for various parties in fulfilling their distinctly Catholic mission (Morey & Piderit, 2006). Some smaller Catholic schools welcomed the document and proudly proclaimed their Catholic identity, but many—especially larger Catholic universities that depend upon external research funding—expressed concern about the potential erosion of institutional autonomy and academic freedom (D'Souza, 2002; Dosen, 2000; Janosik, 1999). Some administrators and faculty questioned the value of a distinctly Catholic identity, and whether the vision of ECE could be compatible with the culture of American higher education.

With respect to the meaning(s) of distinctly Catholic higher education, there is substantial agreement that "because reason and faith are ultimately related in the Catholic tradition, every part of a Catholic School's curriculum should be informed in some way by philosophical, ethical, and theological perspectives" (Heft, 2010, p. 10). The presentation of faith and reason as linked is generally done in undergraduate theology and philosophy courses, where it has been said that "the Catholic School is free to teach whatever, and however, it deems best" (Lawler, 1950, p. 53). And in the rest of the humanities curriculum, integration of Catholic values is at least easily imaginable; for example, in "the study of history, the presence, forms, and vitality of various religions are studied as an integral part of the human story" (Heft, 2010, p. 10). Thus nearly all Catholic university websites promise an education influenced by Catholic traditions, teachings, or values; and their respective departments of mission typically hold workshops to help faculty integrate Catholic social teaching. There is controversy, to be sure: (1) concerns over academic freedom (Thiessen, 2001); (2) accusations that some "elite Catholic schools are sadly lost" to secular models of education (Weigel, 2007); and (3) whether an emphasis on values, and not Catholic values, is sufficient to advance Catholic identity (Orsy, 1987).

Resistance to ECE has focused on Part II, "General Norms;" however, its positive vision of the contributions of Catholic universities to the well-being of society, elaborated in Part I, "Identity and Mission," has received less attention. Critics of ECE have failed to engage the broader philosophical propositions of Part I: how universities are to provide service to society, pastoral ministry, cultural dialogue, and evangelization. Generally speaking, it is remarkable how little consideration has been devoted to any distinctly Catholic approach to pedagogy outside of religious studies, philosophy, and the humanities. Substantially less attention has been devoted to fostering Catholic identity at the graduate level (Hellwig, 2000). Of course, some efforts have reached beyond the humanities to integrate Catholic values into professional training. In Catholic legal education, successes have been reported concerning many Catholic legal scholars in law schools who integrate "Catholic social and intellectual thought into the mainstream of American legal education" (Mengler, 2010). And while we focus in this article on science education in law and engineering, and not medical training, "the Christian vision of the human person will fundamentally shape the care given the sick, the poor, and especially the dying" (Heft, 2010, p. 10).

This essay argues that Catholic universities, drawing from the classic Catholic understanding of the integral relationship of knowledge and wisdom, can distinguish themselves by how they present science and technology in their curriculum and research. This is not to suggest that the content of natural science be different at Catholic universities than at other schools. Rather, it argues that Catholic universities should engage science and technology as social forces within society that have significant cultural and ethical implications, and that society shapes the trajectory of their development. The interdisciplinary field of "science, technology & society," or STS, provides a particularly suitable framework for exploring the dynamic interaction of science and technology and society. Briefly, STS is an interdisciplinary field of inquiry focused on the social and cultural aspects of the scientific enterprise, including, for example, the authority structures of scientific institutions, the rhetorical practices identifiable in scientific texts, the economic pressures that influence science, the ethical implications of technology, and the social values embedded in scientific practice.

Furthermore, this essay argues that the distinctly Catholic approach to knowledge within the Catholic intellectual tradition (Hellwig, 2000) should find expression in how universities operating within this tradition present the relationships between science, technology, human society, and moral values. This broader conceptual framework can and should be applied to the content and structure of curriculum while simultaneously safeguarding academic freedom, and that this can readily be done in professional schools, such as law, engineering, and medicine. This essay argues that STS tools can enhance the critical thinking skills of students, promote critical reflection on the mutual influence of science and human values (such as Catholic social teaching), and advance a distinctly Catholic approach to educating professionals by instilling a sense of vocation, calling, or moral purpose. We do not argue that the STS model itself necessarily fosters Catholic identity, or that teaching STS necessarily prompts students to reflect on their own vocation and life purpose. Rather, STS opens up a broader conceptual framework for considering the social dimensions of science and technology, in other words, the social relations that give rise to science and technology and the social implications thereof. It is this presentation of social choices that can stimulate students to consider moral options that they might take individually or in a profession, in a pedagogical situation where they might otherwise not recognize the existence of ethical or vocational choices.

We begin, in section II, with a discussion of how teaching science and technology as social forces can foster Catholic identity. Calling into question the received wisdom that science is necessarily in conflict with religion (Mahner & Bunge, 1996), we argue that science and technology cannot exist but within a cultural context, and that STS tools can provide the interdisciplinary analytical framework to interpret how science and religion are related through culture. We describe the congruence of STS with classic Catholic formulations of knowledge and wisdom, and highlight how the STS framework can facilitate moral assessment of science and technology in society.

In section III, we attempt to summarize briefly the history and influence of STS–even though there are numerous STS programs, centers, and faculty in universities throughout the nation (and world), some readers may only be vaguely familiar with STS. For example, STS is often viewed as a critique of, or attack upon, science, which is misleading but resulted in the so-called science wars—an academic skirmish supposedly between those with total faith in science as the (only) source of objective knowledge, and those social constructivists who labeled every advance in science as a merely rhetorical or ideological accomplishment. Neither position in this trite narrative is attractive or compelling, and we hope to provide a fairer summation of an important controversy. The reason for our interest in STS, however, is not simply to argue that it has academic value, but rather that STS should be of particular interest for Catholic higher education, especially for the training of the professions that will inevitably shape the social context and consequences of science and technology development. Following our introduction of STS, we go on to argue that professional training requires an understanding of the role of values in the practice of science—how they appear in purportedly value-free science, and how the actual practice of science shapes values and has social consequences. Moreover, we emphasize the special responsibility that Catholic institutions of higher education have to prepare professionals who can think critically about science as they take on leadership positions in society. Actually, we are astonished at how many university students believe in value-free science and are unaware of the implications of STS research (Campbell, 2005). While conversations about

Catholic values may perhaps be taking place somewhat spontaneously in the humanities, STS-themed courses for professional schools offer a new opportunity for a distinctly Catholic perspective, especially at the graduate level.

Section IV presents three examples of STS applications for Catholic higher education curriculum: (1) STS as an undergraduate core requirement, (2) STS in the law school, and (3) engineering technology development for underserved communities. These pedagogical examples, to varying degrees, invite students to consider moral and vocational choices around society's use of science and technology. We conclude that the field of STS holds out the promise of assisting Catholic higher education in its mission by making visible the fundamental role of culture in shaping science and technology as social forces with the potential to promote the good. This analytical framework can serve as a robust foundation for helping Catholic higher education fulfill the moral vision of ECE.

A Counterintuitive Approach: Facilitating Catholic Identity by Teaching Science and Technology as Social Forces

The "conflict thesis" asserting the inevitable "warfare" between science and religion, dating back more than a century (White, 1896), remains popular among the public and some scientists. Putatively justified by the "Galileo affair," this approach presumes science as a way of knowing superior to any other. On the other hand, some American Christians today express suspicion of science and scientists. The inevitability of conflict has been broadly rejected by philosophers and historians of science as inadequate to explain how human beings have actually related the fields of science and religion (Dixon, 2005). These types of ideological assumptions—that science and religion must exist in conflict, or that they cannot possibly have anything to say to each other—are incompatible with a Catholic philosophy of knowledge. Briefly, leading scholars studying science and religion have identified four recurring approaches: conflict, independence (or contrast), dialogue (or contact), and integration (or confirmation) (Barbour, 2000; Haught, 1995).

As a former professor of philosophy, Pope John Paul II was deeply interested in the contemporary dialogue of faith and reason, and the relationship between science and culture. His understanding of the relationship between science and religion might be best described as a blend of the "dialogue" and "integration" approaches: "Science can purify religion from error and superstition; religion can purify science from idolatry and false absolutes. Each can draw the other into a wider world, a world in which both can flourish" (John Paul II, 1988). He affirmed that the Church erred in the case of Galileo, and he extended the Catholic teaching tradition, dating at least back to Vatican II, of insisting on the intellectual autonomy of science and theology, the so-called principle of noninterference (Hayes, 2001):

> [T]he church does not propose that science should become religion or religion science. On the contrary, unity always presupposes the diversity and integrity of its elements…both religion and science must preserve their autonomy and their distinctiveness. Religion is not founded on science nor is science an extension of religion. Each should possess its own principles, its pattern of procedures, its diversities of interpretation and its own conclusions. (John Paul II, 1988)

This principle broadly applies to the dialogue of faith and reason across the academic disciplines.

ECE also insisted that the intellectual autonomy of disciplines must be combined with active multidimensional dialogue between Christian thought and the modern sciences (ECE 46). In the vision of ECE, dialogue between faith, culture, and knowledge of all types—especially the sciences—is central to the mission of Catholic higher education. ECE articulates an epistemological dimension to the dialogue with the sciences, but also ethical and cultural dimensions. Thus, theologians and the Church can never impose a view on scientists, but conversely, scientists and those who develop technologies have the duty to recognize the implications of their discoveries and inventions on human culture:

> Science develops best when its concepts and conclusions are integrated into the broader human culture and its concerns for ultimate meaning and value. Scientists cannot, therefore, hold themselves entirely aloof from the sorts of issues dealt with by philosophers and theologians. By devoting to these issues something of the energy and care they give to their research in science, they can help others realize more fully the human potentialities of their discoveries. (John Paul II, 1988)

ECE's proposal that human culture serve as the context for dialogue between scientists, theologians, philosophers, and ethicists is remarkably compatible with core theoretical principles of STS.

The field of STS arose, in part, to investigate the social power of scientists, the truth claims made by scientists, and the social implications of technology development (Baglio, 1999). Indeed, many of the scholars who pioneered the field rejected the idealized presentation of science as value-free, a notion common in scholarship of a prior generation. The disciplinary *tributaries* to STS include: (1) the history of science, where the influences of social contexts are identified, (2) anthropological inquiry, insofar as a laboratory might be observed by an outsider to identify its social practices, (3) cultural studies, as a project to identify empowered and disempowered discourses, (4) the philosophy of science, as a study of the assumptions and presuppositions that ground scientific inquiry, and (5) the fields of science and engineering, to the extent that scientists and technologists seek to understand the social implications of their work. Teaching STS is not the same as teaching the principles of one of the natural sciences, but any group of natural scientists can be studied as a social phenomenon or community of practitioners adopting particular experimental conventions, reward frameworks, consensus-building techniques for overcoming controversies, and linguistic preferences.

STS investigates the cultural contexts in which scientific and technological development occur, as well as the cultural values that alternatively encourage, support, and interfere with the directions, progress, and failures of science and technology. This is highly appropriate for informing the education of professionals, because of their potential power and autonomy in society. Critical thinking about how science and technology actually function within society is therefore essential to the mission of Catholic higher education in the modern world. American Catholic universities, especially those with professional schools, have special opportunities and obligations to teach how science is used in society, and they can better fulfill these by deploying the analytical tools of STS. The thrust of ECE suggests the importance of training professionals who use science to understand what science and technology actually are: how they function as ethically laden forces within society, and how they could advance a more just and sustainable world. In this framework, the development and application of science and technology could be evaluated in light of a Catholic social vision of human culture and its authentic development, including the dignity of the human person, the common good, and stewardship of the Earth.

Scientists have at times presented science as deterministic, or as John Paul II said, in terms of false absolutes. The STS framework provides the intellectual and reflective space for students to evaluate critically the moral dimensions of how science, technology, and society are related. It is this presentation of social choices that can prompt students to consider moral options available to them, individually or socially, where in other pedagogical situations, this ethical dimension might be ignored or excluded. The more open frame of STS makes possible the dialogue between the sciences and broader human culture and questions of ultimate meaning. The STS framework can help a Catholic university accommodate and engage the broader cognitive, intellectual, and philosophical issues raised by contemporary science and technology. The field of STS does not, by itself, provide this integration. STS does, however, offer a conceptual framework that makes possible an integrative approach to knowledge, wisdom, and moral praxis in contemporary society. As Monika Hellwig (2000) asserts, a key distinguishing feature of the Catholic intellectual tradition is the desire to integrate knowledge with practical wisdom for living of one's life. STS can enhance the integration of science and technology into the Catholic approach to knowledge and learning.

STS: Articulating Social Values, Science, and Technology

While the sociology of science has never been viewed as an integral part of the natural sciences, some of its earliest efforts—which can be called the "first wave" of STS and include the work of sociologist Robert Merton—were "aimed at understanding, explaining, and effectively reinforcing the success of the sciences, rather than questioning their basis" (Collins & Evans, 2002, p. 239). But from the early 1970s to the present, a "second wave of STS re-conceptualized [science] as a social activity" (p. 239), and began to focus on the cultural, institutional, and rhetorical aspects of the scientific enterprise. For example, drawing upon anthropological models of inquiry, some sociologists of science visited laboratories to observe what scientists do and say, as if visiting a foreign tribe to discern how the "natives" produced their "culture."

> They found many practices that seemed to share more with daily life outside the lab than with the strict edicts governing knowledge in science, such as universality, objectivity, or reproducibility. Measurement might be based on a very unclear consensus. Techniques might be developed in local settings and depend upon local materials and practices …The establishment of findings in the laboratory as facts accepted by the wider scientific community might turn out to be in large part a social process…of gaining credibility. (Martin, 1994, p. 6)

As more and more social and cultural aspects of science were identified (not in the official texts and self-understandings of scientists, but through observational studies and interviews), STS as a field took various "turns"—(1) away "from the Kuhnian predilections for science as theory-driven (i.e., observation is always theory-laden or biased by theoretical presuppositions)" (Rheinberger, 1999, p. 285), and (2) toward science as a cultural production, a practice, involving not only theory but narratives and rhetoric, negotiation and interpretation, linguistic conventions, and discursive strategies. Concerned that this "semiotic" turn might seem to be a reduction of scientific achievement to rhetorical force, Timothy Lenoir remarked that the "emphasis on practice in recent science studies has included material as well as symbolic culture," calling attention to the "materiality beyond" the texts of science (Lenoir, 1999, p. 291). Thus Bruno Latour's so-called naturalist turn in STS emphasized that

> scientific facts are indeed constructed [but] they cannot be reduced to the social dimension because this dimension is populated by objects mobilized to construct it...The ozone hole is too social and too narrated to be truly natural; the strategy of industrial firms…is too full of chemical reactions to be reduced to power and interest; the discourse of the exosphere is too real and too social to boil down to meaning effects. Is it our fault if the networks are simultaneously real, like nature, narrated, like discourse, and collective, like society? (Latour, 1996, p. 6)

One goal of the STS project is to show that the social contexts, institutionalized credentialing processes, contested representations, consensus-building techniques, rhetorical moves, theoretical commitments, and experimental conventions of science are not external or expendable *influences*, but actually *constitute* scientific practice.

The significance of STS as an intellectual project is that its identifications of the social, institutional, and rhetorical aspects of science are conventionally not part of the natural sciences—neither the self-understanding of scientists, nor the treatises and journal articles they read and discuss, are oriented to the cultural aspects of science. Because social, economic, or political values and interests are not supposed to influence or be a part of science, the "first wave" of STS was characterized as a "sociology of error:"

> False belief could be directly explained through a "social fact" (personality, prejudice and so on) disrupting the proper operation of scientific norms...Put simply, in this view of science, the facts themselves determine truth, while error is explained by processes of a psychological or social nature. (Potter, 1996, p. 19)

Even after the second wave, when those who idealize science (as a matter solely of theory/data/conclusion) were faced with evidence of institutional gate-keeping, dominant theoretical paradigms, methodological preferences, experimental conventions, negotiation strategies, consensus-building activities, and governing linguistic structures, these "social" *factors* could all be set aside (and ignored) as useful supports that are not part of science itself. For STS scholars, however, the entire process of scientific progress appeared to be social at every stage—not only were there theoretical presuppositions and communal expectations at the hypothesis stage, but also standards as to what is worth doing (or worth funding) and what is allowable in terms of general cultural values or government policy; at the testing stage, there were discursive regimes, governing metaphors, rhetoric and persuasion, and institutional gate-keeping in terms of granting credentials and selecting what to publish. And even the best science, in terms of rigorous methodology, can involve political and economic interests and pressures—they do not always signal an error. The notion that science and society are mutually constituting goes beyond the sociology of error.

In David Hess's account, our theories and assumptions, which are shaped by what we have the ability to observe and what we expect to observe, are the "outcomes of discussions and controversies in which social negotiation is critical" (Hess, 1995, p. 3). Hess then confirms that he is not suggesting that observations have nothing to do with reality—only that "observations are simultaneously socially shaped and representative of" a real natural world (p. 3). Alongside observations, our "decisions on appropriate methods, criteria for establishing replication, statistical measures, and so on are shaped by rhetoric, network politics, disciplinary cultures, gender socialization patterns, and so on" (p. 3). The social aspects of science are therefore neither dispensable nor merely external.

For our purposes, we are particularly interested in the social values that appear even in competent, respected science. For Ian Hacking,

> it is patently obvious that which questions get asked, taken seriously, investigated, funded, reported, analyzed, and so forth is the result of social processes, human interaction, and current interests. Very few detailed questions are asked about the most widespread tropical diseases because there is no money in it for drug companies. (Hacking, 2000, p. S69)

And yet, the social context is not merely economic, since some

> problems are especially significant…partly because of the history of research [in the field], partly because of what it is…possible to do, and partly because of the practical consequences of certain terms of inquiry when applied to the problems of certain kinds of societies. (Kitcher, 1998, p. 37)

Thus it may be "artificial and indeed impossible …to distinguish between intrinsic and extrinsic interest," between "strictly scientific determinations and strictly social determinations" (Bourdieu, 1999, pp. 32-33), because a

> scientist strives to do research which he considers important. But intrinsic satisfaction and interest are not his only reasons...The scientist wants his work to be not only interesting to himself but also important to others. (Rief, 1961)

Valuation within the scientific community, and within society at large, is at issue in all science.

One of the interesting subdisciplines that developed alongside the cultural study of science (i.e., STS's study of science *as* a culture) is "literature and science." Literary images of science can be studied to identify popular sentiment—Mary Shelley's *Frankenstein* is often mentioned as reflecting a fear of scientists as amoral and dangerous (Haynes, 1994), which fear is reflected in numerous other historical and contemporary books and movies, particularly horror and science fiction films (Tudor, 1989). Even as societal trust and confidence in science is also apparent, there is nevertheless an ongoing concern that science and scientists should be ethically restrained. The term ELSI has become popular to signify attention to the ethical, legal, and social implications of science. While ELSI is often associated with "downstream" efforts to restrain science, after its discoveries and advancements, STS has shifted the gaze "upstream," into the laboratory, such that scientific discoveries and advancements can be coproduced alongside nonscientists (e.g., ethicists, lawyers, social theorists). A recent example has been discussed by anthropologist Paul Rabinow, who worked with the synthetic biology laboratory at Berkeley and who proposed a collaboration between biologists and engineers, on the one hand, and "ethicists, anthropologists, political scientists, administrators, foundation and government funders, students, and so on" (Rabinow, 2009). While we are somewhat critical of Rabinow's failure to mention STS (perhaps due to public relations), and his corresponding implication that there were no ethical values in the lab prior to the arrival of his team of nonscientists,

> Rabinow's project might be a new model for [STS]–critically examine existing structures, recognize resistance (and try to overcome it), collaborate to develop ameliorative goals, and build ethical consensus, all from the inside. Take control of the social, institutional, and rhetorical reins of the scientific enterprise, and share in its successes–that would be more power than the anthropologist of science-in-action ever has. (Caudill, 2009, p. 439)

In the end, Rabinow considered his experiment unsuccessful, but not a failure, and he hopes to modify and improve the "experiment" to make some "scientific progress" (Rabinow, Gaymon, & Stavrianakis, 2009, pp. 478-479).

In our own "experiment," we highlight the potential of STS insights in Catholic higher education, particularly with respect to identifying opportunities for integrating and teaching Catholic values outside the undergraduate humanities. The specific aspects of STS that we draw on and emphasize include reflection on (1) the value inquiries initiating scientific research (What is worth doing/funding?), (2) the cultural values directing science (What is allowable?), and (3) the social evaluation of the results of science (What are the moral implications of technology development?). And we are not simply interested in the importance of a discourse concerning values in higher education; rather, we emphasize the relevance and availability of distinctly Catholic values to our students: What is worth doing/funding in light of the *common good*? What is allowable in light of the *dignity of the human person*? And what are the implications of technology development in light of the *moral obligation to address the needs of the poor and promote stewardship of the earth*? In the next section, we offer three examples based on our experiences as faculty members at Catholic universities.

Teaching STS Makes Visible the Cultural Context and Ethical Implications of Science and Technology

> Catholic teaching should have a place, if appropriate to the subject matter, in the various disciplines in the university. Students should be provided with adequate instruction on professional ethics and moral issues related to their profession and the secular disciplines. (United States Conference of Bishops, 1999)

Contemporary society is shaped by science and technology to such a profound degree that to be an effective leader, one must understand, engage, and shape social, scientific, and technical forces. However, the structure of most university curricula functions to compartmentalize science, technology, and society, as if they were three separate and distinct domains of human experience, rather than understanding them as mutually interpenetrating and reciprocally shaping each other. Students majoring in the arts and humanities may view science and technology simply as aspects of society they can passively consume or reject, while students in the natural sciences or engineering may be content with thinking about their laboratory work in isolation, seemingly disregarding the social conditions that shape their work and its broader societal impacts. These narrow perspectives inhibit the more complex and critical thinking students need in order to capably and responsibly shape our human future. This section presents three case studies of deploying STS to redress these problems and to advance the distinctly Catholic character of higher education at Santa Clara University (SCU) and Villanova University. The first case reports an initiative to teach all undergraduates the basic vocabulary and critical thinking skills to understand science and technology as social forces, and the impact of human values on their development. The second two cases present examples of teaching STS in professional schools: law and engineering. These cases are by no means comprehensive, but they help justify our assertion that teaching STS, especially to professionals, can help universities make progress toward the vision of Catholic education in ECE.

STS as an Undergraduate Core Curriculum Requirement

Informed by its Jesuit tradition (Currie, 2011), Santa Clara University summarizes its mission as preparing leaders of competence, conscience, and compassion. Many alumni work in the technology industries of Silicon Valley, whether graduating from engineering or business schools, or from arts and sciences. The 1988 undergraduate core curriculum instituted a technology requirement—innovative at the time, but in practice it merely required students to demonstrate the ability to use computing technology. Thus, science majors "learned science," and in other courses "learned how to use technology."

In 2005, the university began preparations for a new undergraduate core curriculum. The committee charged with these preparations determined that students in the natural sciences and engineering majors were developing strong scientific and technological skills, but that there was a need to help them develop the ability to think critically about the social implications of science and technology. Conversely, among other students, there is a certain "science-phobia," a resistance to learning about science, even by students who use personal technologies hourly. The committee proposed an STS approach to address these dual concerns. In 2007, the SCU faculty approved a new undergraduate core with a STS requirement:

> Many of the most important choices that students will make in their lifetimes will concern whether and how they, their employers, and their government should develop, adopt, and regulate scientific and technological innovations. To make informed decisions, students will need to grasp scientific and technological developments, how they emerge, and their social impact. (Proposal, 2007, p. 20)

The purpose of STS in the core is to help students develop a more critical understanding of how science and technology actually operate in society, and to develop into responsible citizens and leaders in a scientific and technological complex world. These general learning goals were translated into specific learning objectives that would be used to evaluate new syllabi to fulfill the new core curriculum requirements:

1. Recognize and articulate the complexity of the relationship between science and/or technology and society.
2. Comprehend the relevant science and/or technology and explain how science and/or technology advance through the processes of inquiry and experiment.
3. Analyze and evaluate the social impact of science and/or technology and how science and/or technology are themselves impacted by the

needs and demands of society.

These learning objectives reflect the desire that students learn about the mutual influences of science, technology, and society; the developmental processes of science and technology; and the social implications of these developments. The STS requirement is best taught at the junior level, since it builds upon foundational collegiate level material presented in introductory natural and social science classes. Faculty from virtually all departments developed new syllabi or redesigned old "technology course" syllabi for approval under these criteria. Learning objectives 1 and 3 were challenging for some natural science faculty to fulfill, and learning objective 2 required some social science and humanities faculty to teach more about the development of science and technology than they had typically done.

Santa Clara University (SCU) created the Center for Science, Technology and Society ("the center") in 1998 as one of three centers of distinction to advance its Jesuit Catholic identity. Partially in response to ECE, the university established this center, along with others dedicated to applied ethics and to Jesuit education, to express the university's values and to link the campus with local and global communities of interest. When the undergraduate core curriculum implemented the STS requirement, the center played a leadership role in faculty development and new course creation.

Several departments developed numerous new courses to fulfill this requirement. Some departments (e.g., anthropology, biology, environmental studies, and public health science) have demonstrated relatively more interest in interdisciplinary teaching. Sample classes include:

1. Sociology 49—Computers, Internet & Society
2. Biology/Environmental Studies 135—Biofuels: Sustainable Energy for the Future?
3. Communication 164A—Race, Gender & Public Health
4. Operation Management Information Systems 34—Science, Information Technology, Business and Society

Engineering students, however, do not fulfill the STS learning objectives in the same way as do other undergraduates. Learning objective 2, requiring comprehension of the developmental character of science and technology, is necessarily fulfilled by many required science courses. However, firms hiring our graduates have emphasized the critical importance of communication skills. Thus, engineering students are not required to take a dedicated STS course, but learning objectives 1 and 3 are embedded in a required first-year introduction to engineering and an upper-division technical writing course, as well as the senior capstone research projects.

SCU is one of very few schools with a STS requirement of all undergraduates, and the only Catholic university to do so. This component of the core invites students to comprehend the conditions under which science and technology arise, and their varied impacts on society. This is more likely to result in a realistic and sophisticated understanding of these social forces. In addition, it has focused the attention of a subset of faculty across multiple disciplines on STS approaches and methodologies in their research.

This requirement does not fulfill the philosophical vision held out by ECE. It does not require teaching the ethical implications of technology, nor does it, on its own, provide the basis for a dialogue between theology and science. However, it does open up pedagogical possibilities for evaluating the social influences on and social impacts of science and technology, and raise practical epistemological questions about the nature of human knowing and its relationship to other forms of human experience. Thus, as an undergraduate requirement within the core curriculum, it fosters conditions under which Catholic social teaching principles can be considered in dialogue with science and technology development. However, concurrent with the campus-wide deliberations about the new STS requirement, faculty transformed the undergraduate "combined sciences" major into a "public health science" major. This provides a broad, interdisciplinary framework for understanding how medical sciences can address the needs of those unable to access health care institutions, with a special attention to communicable diseases afflicting the poor, marginalized, and underserved. Public health science is the practical application of medical science for the common good. The design of this major reflects the broader evolution of thinking across the campus, and the desire to link science with social justice issues, and thus advance a distinctly Jesuit approach to health science.

STS in the Law School Curriculum

The notion of integrating Catholic social teaching into the law school curriculum seems to be an easy case—legal education is concerned generally with justice and the rights and the responsibilities of citizens, and it is not difficult to see law practice as a vocation or calling with a moral purpose to serve clients. Family law, labor and employment law, and poverty law come to mind as natural candidates for integration. There is, however, resistance to the idea of teaching religion in law school, because the primary goal of legal education is to produce lawyers trained in law, everyone's law! Nevertheless, all law students are required to take a course in professional ethics, and while the core materials of that course are the rules of professional conduct, those rules (1) are not presented as exhaustive, (2) acknowledge that an attorney is guided by other moral sensibilities, and (3) imply that "professionalism" is a broader notion (or "calling") above and beyond the minimalistic rules. It is not unusual for law professors to supplement coverage of the rules with broader ethical reflections, including philosophical materials on ethics or justice, literary (or filmic) representatives of good and bad lawyers, or religious materials such as, in Catholic law schools, introductions to Catholic Social Teaching. Law students who view their legal education in pragmatic terms may not appreciate such "soft" materials, since most of them seem to feel that they are morally "formed" prior to law school, but the connection of moral values to law practice is neither invisible nor difficult to establish.

On the other hand, in courses that focus on the use of science and scientific expertise in law, including evidence (which includes scientific evidence as a topic among many other topics), advanced trial advocacy (which may include scientific expertise, but may only cover lay testimony), various administrative law courses (including product, pharmaceutical, and environmental regulation), and a general law and science course (an offering growing in popularity due to the importance of expert testimony in litigation and in agency contexts), the connection between science and social values is not initially self-evident. Indeed, most law students inherit an idealized image of science as a value-free arbiter of legal controversies. Unfortunately, many judges also share a fairly idealized image of science, which can lead to injustice in the results of litigation. By "idealize," we mean the tendency to see science as completely different from law, where law is viewed as a highly social, institutional, contested, and rhetorical enterprise, and science, by contrast, is objective, universal, and therefore somewhat above culture and its values, biases, and interests.

Students in science-related law courses should at least be introduced to the argument that judges who idealize science have a propensity toward two types of (oddly inconsistent) errors (Caudill & LaRue, 2006). First, a judge may be too strict and fail to recognize that expertise does not always rely on objective measurement, and that science typically involves probability, uncertainty, and alternative explanatory models. That is, such a judge may reject the testimony of a good expert who concedes that science at its best is often tentative, contradictory, and probabilistic; faced with alternate explanatory models by two experts in conflict, such a judge will likely try to figure out which scientist is a charlatan and which is delivering truth. A more sophisticated explanation of such a conflict, based on STS, might be that science is based on reasonable beliefs and is subject to internal disagreements, and that pragmatic concerns and limitations affect scientific evaluations. Economic factors may also be at work, when the expert for one side, say a chemical company in a toxic tort suit, or a prosecutor with access to a crime lab, has control of more data and studies than a plaintiff or criminal defendant. Questions of economic injustice arise easily in this context.

The second error that idealizing judges make, perhaps unsurprisingly, is to be too gullible in the face of an expert who claims certainty, and who is admitted to testify solely on the basis of credentials and general acceptance of the testimony in previous lawsuits, even if that deference is not earned by methodological rigor. The recent (and ongoing) crisis in forensic science supports the concern that many of the forensic "science" identification methods relied on by prosecutors and judges lack any real scientific basis. STS insights can go a long way in explaining how the *social* authority of science can outrun the actual scientific credibility of "legal" or "courtroom" science. The idealization of science affects not only some judges, but also those serving on the jury who defer quickly to a forensic scientist, without regard to the broader standards of the scientific community. Injustice can result in the name of science.

Turning briefly to the policy-making context, there is a substantial literature concerning the influence of political and economic interests at the level of expertise in regulation. Health, safety, and environmental advocates accuse industry of interfering with good science by attacking it as inadequate to justify regulations:

> Manufacturing uncertainly and promoting inappropriate criteria for assessing the quality of evidence...are central elements of a strategy for opposing regulation, impeding discussion of values and societal priorities, and closing out input from those whose health and quality of life are impacted by regulatory decisions. (Hoppin & Clapp, 2005, p. S8)

Claims of too much uncertainty, and promotion of unreasonably high standards of evidence, are examples of strategic idealizations of science, because they suggest that good science avoids tentative conclusions, consensual assumptions, and the need for further research. Industry is also regularly accused of funding studies that support the safety of its products, implying that the resulting scientific conclusions are interested, not objective. (This, too, is an idealization of science, as if inevitable motivations, funding, and research expectations are markers of bad science; fraud, of course, *is* a marker of bad science.)

From the side of industry, activists are likewise accused of politicizing science. For example, a recent *Wall Street Journal* editorial claimed that Agriculture Secretary Tom Vilsack, in a "jaw-dropping" move, had

> invited activists and biotech critics to shape the agency's regulatory decision on a biotech product. If the precedent stands, it could permanently politicize a system that is supposed to be based on science. (*Wall Street Journal*, 2010)

Vilsack suggested, the editorialist explained, "that science itself is subjective, and that he could have three different groups bring him three different supposedly scientific opinions" on the risks of the product, which was unthinkable to the editorialist. The first study submitted, it seems, was *science*, the answer, and any studies by "activists" were merely "supposedly scientific opinions." Without entering that debate, our point is that the use of science in agency proceedings is not black and white, clear and simple, science versus politics. Politics is in the eyes of the beholder, and the STS tradition helps explain how social and political values get intertwined when science enters the political realm.

The more interesting question is: What social values are driving these debates putatively about science? The identification of social values (hidden in idealized accounts of science) is an important part of the literature associated with STS. Once students get beyond the illusion of science as involving no values, interests, funding sources, uncertainty, or assumptions, then they can begin the critical task of deciding which values, interests, funding sources, uncertainties, and assumptions are, respectively, useful, illegitimate (because they interfere with good science), suspicious, acceptable, or ethical. Values are only irrelevant if one holds an idealized conception of the scientific enterprise. Because values are relevant in science, questions arise in legal processes and institutions (that *listen* to science) about protecting the poor and vulnerable, stewardship of creation, and the need for a healthy community.

Here is the opportunity for, or link to, Catholic higher education. Science in legal contexts (including science-based law and decision making) is not a neutral ground where nature and facts simply speak and we listen and record data. Rather, science is a field of controversy, with options to decide how much risk is appropriate, when do we know enough to regulate, and who will protect the vulnerable when the voices of the powerful are loudest? Catholic legal education is already attuned to law practice as a calling to public service, as a vocation with a purpose—many law students already imagine giving their talents to represent a client who cannot afford an attorney, or to mediate a dispute toward fairness. The significance of integrating STS into Catholic legal education is to extend the notions of public service, purpose, and moral agency into the field of law and science. Instead of viewing science and technology as producing inevitable results (without regard to human culture), students can be taught that there is room for conscience, moral imagination, and overcoming economic injustice in the fields of science and technology, whether in environmental protection, pollution abatement, public health initiatives, pharmaceutical regulation, or even evaluation of the quality of courtroom expertise. Classroom conversations about justice for all, human dignity, the common good, and stewardship of the earth need not be viewed as dispensable add-ons at a Catholic law school, but are actually central to the discourse of legal processes and institutions.

Frugal Innovation: Engineering as Applied STS for the Common Good

The mission of SCU's Center for Science, Technology, and Society (the center) is to accelerate global, innovation-based entrepreneurship in service to humanity. It works closely with an international network of entrepreneurs pursuing social goals (e.g., the United Nation's Millennium Development Goals). Social entrepreneurs create businesses to achieve social goals, such as water and energy services, education, and microfinance (Bornstein & Davis, 2010; Elkington & Hartigan, 2008). The center's signature program, the Global Social Benefit Incubator (GSBI), was launched in 2002. It recruits social entrepreneurs from around the world and helps them scale up their enterprises to meet the needs of the poorest world populations. These social enterprises are creating markets that can provide, at an affordable price, essential goods and services to very poor communities.

In partnership with the School of Engineering, the center launched the

Frugal Innovation Lab in 2010 to develop accessible, affordable, and appropriate technologies for emerging markets. This built upon a graduate STS minor offered by the School of Engineering. Frugal innovation is a technology development paradigm linking engineers and social entrepreneurs to address the basic economic needs of communities living in extreme poverty. Frugal innovation differs from conventional product development because it begins with the question: How can the needs of extremely poor communities be met using novel business enterprises and simple, rugged, affordable technologies? Frugal innovation takes seriously the design constraints present in the lives of people living in underserved communities, such as no grid power system; no water distribution or sanitation systems; inconsistent transportation systems; and erratic employment and household incomes. Thus, frugal innovation addresses the goals of all three pillars of sustainable development: environmental protection, economic development, and social equity. When frugal innovations are combined with social entrepreneurship strategies, genuine progress toward sustainability goals is possible at the community and regional scale.

The physical space of the Frugal Innovation Laboratory has been designed to foster faculty-student collaborative research on specific projects, while the Frugal Innovation program has provided funding. The Frugal Innovation Lab—usually in partnership with Silicon Valley technology research laboratories, social entrepreneurs, or international development organizations—researches and develops technologies to address the same types of human needs as the GSBI:

1. *Clean energy*: renewable forms of energy generation and distribution for communities without access to an electrical grid power, for example, with portable solar lanterns and village-scale micro-grids (Aron, Kayser, Liautaud, & Nowlan, 2009).
2. *Clean water*: purification, distribution, rapid assessment, and waste disposal technologies for communities without water systems, for example, with community-based reverse osmosis water treatment plants, and technologies based on mobile phones to assess water purity (Hammond , Koch, & Noguera, 2009).
3. *Public health*: public health information and management, for example, using cell phones to verify the veracity of pharmaceutical labels and telemedicine clinics in remote villages (Sandhu, 2011).

Technologies developed for the US market fail in these types of social environments. Innovation in this context requires understanding the "base of the pyramid" market and environmental conditions in the developing world (Prahalad & Hammond, 2002). Silicon Valley firms are quite aware of the market potential in the developing world, and are looking to hire engineers who can develop technologies for use in underserved communities.

The principles of frugal innovation are taught as units within the first-year introduction to engineering and other undergraduate courses; as dedicated technical electives for undergraduates; as a dimension of senior engineering design research projects; in public health science classes; and in a dedicated sequence of graduate engineering courses. These courses present the key features of frugal innovation, such as rugged design, affordability, simplification, renewability, and reliance on local materials and manufacturing. Three graduate engineering courses have been particularly popular:

1. Engineering 336. Engineering for the Developing World.
2. Engineering 338. Mobile Applications and Instrumentation for Emerging Markets.
3. Engineering 340. Clean Energy for the Developing World.

A new course titled Innovation, Design and Spirituality integrates the social, human, ethical, aesthetic, and creative dimensions of frugal innovation for graduate engineering students. This course emphasizes the "why" and the "who" of frugal innovation: Why and how should engineers address the technology needs of economically marginalized communities? And who are the kinds of engineers that are able to create frugal innovation strategies? These types of questions prompt students to address their own vocation, or life purpose. Readings and class discussions investigate the nature of innovation through the lenses of social justice, spirituality, vocation, the creative arts, and engineering.

The Frugal Innovation Lab and associated curriculum prompt students to develop technological problem-solving skills under conditions of poverty, but equally important is its challenge to reflect upon how they might place their skills at the service of the human family. Frugal Innovation requires students to understand the profession of engineering within a much broader social context: a global society in which more than a billion people live in extreme poverty in critical need of technology solutions. Although this is of genuine interest only to a minority of engineering students, those who are attracted find frugal innovation a very compelling paradigm. The profession of engineering is thus tacitly presented as having ethical duties to foster a more authentic form of human development, as articulated by Pope Benedict XVI in the social encyclical, *Caritas in veritate* (Benedict XVI, 2009). The Frugal Innovation paradigm integrates human need into the engineering design process, and thus integrates a discernment process (whether named or not) into the pedagogy itself. The educational experience of frugal innovation facilitates the linkage, whether explicit or tacit, of social need and technology development. In other words, it structures the learning experience as a practical and technical exercise in moral imagination (Johnson, 1993), for it invites students to consider how they might use their gifts in service to the poor and underserved, and asks engineering students to bring a broader framework of moral concerns to their own professional decisions.

Conclusion: Teaching Science to Foster the Moral Imagination of Professionals

> Nothing seems easier for the philosophical mind than to delineate an abstract ideal to be sought after by a school; and nothing seems harder–judging from the rarity of its appearance–than to show the correlation of such an ideal program with the actual work of education. (Lawler, 1959, p. 31)

Science and technology are powerful forces within society, and the professions are powerful, in part, because they deploy them. At the same time, human values have shaped the practice of science and the development of technologies. These are more than epistemological assertions. Millions of professionals of all kinds work at the intersection of science, technology, and society on a daily basis. The education of professionals can shape professionals' understanding of how these forces are related—or can tacitly present them as unrelated.

This article has proposed that the interdisciplinary field of STS can assist Catholic higher education institutions in advancing their distinctly Catholic mission. The STS framework does not necessarily foster Catholic identity, and teaching STS does not necessarily prompt students to reflect on their own vocation and life purpose. However, teaching STS in the context of a Catholic university creates the pedagogical situation in which students can bring what they are learning about ethical reasoning and moral imagination to bear on how society makes choices about science and technology, and how they in turn might use and advance science and technology in their own professional lives.

Catholic universities can draw from the field of STS to extend their core commitments to linking knowledge and practical wisdom. This, in turn, can help universities fulfill the vision of ECE by foregrounding culture as a context for knowing, and for dialogue between disciplines within culture. Teaching STS is not appropriate for foundational natural science courses, but can be helpful in understanding the application of science and technology in most disciplines at the upper division level. More importantly, it is highly congruent with the mission of professional schools, such as law and engineering. We conclude that the field of STS holds out the promise of assisting Catholic higher education in its mission by making visible the fundamental role of culture in shaping science and technology as social forces with the potential to promote the good. This analytical framework can serve as a robust foundation for helping Catholic higher education fulfill the moral vision of ECE. There have been pilot assessments done of some elements of STS education at Santa Clara University, but these initiatives are too new to have been fully assessed. Any effort to assess STS education at a Catholic university should investigate how this might contribute to more integral student learning, reflecting a Catholic approach to the relationship of knowledge, wisdom, and vocational praxis.

By educating professionals in this way, Catholic higher education can provide greater service to society, for its graduates will be able to extend critical moral reasoning into social decisions affecting science and technology. The integration of STS into the curriculum of Catholic higher education can prompt students to exercise their moral imagination, and to creatively discern how their professional choices might result in ethically preferable outcomes (Johnson, 1993). Science and technology can thus be understood as social forces, but also as instruments with the potential for fostering a more just, sustainable, and ethical world.

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