Science/Technology Education in Church-Related Colleges and Universities

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STS: A New Opportunity For Our Re-Integration of Christian Concern Into American Academic Life

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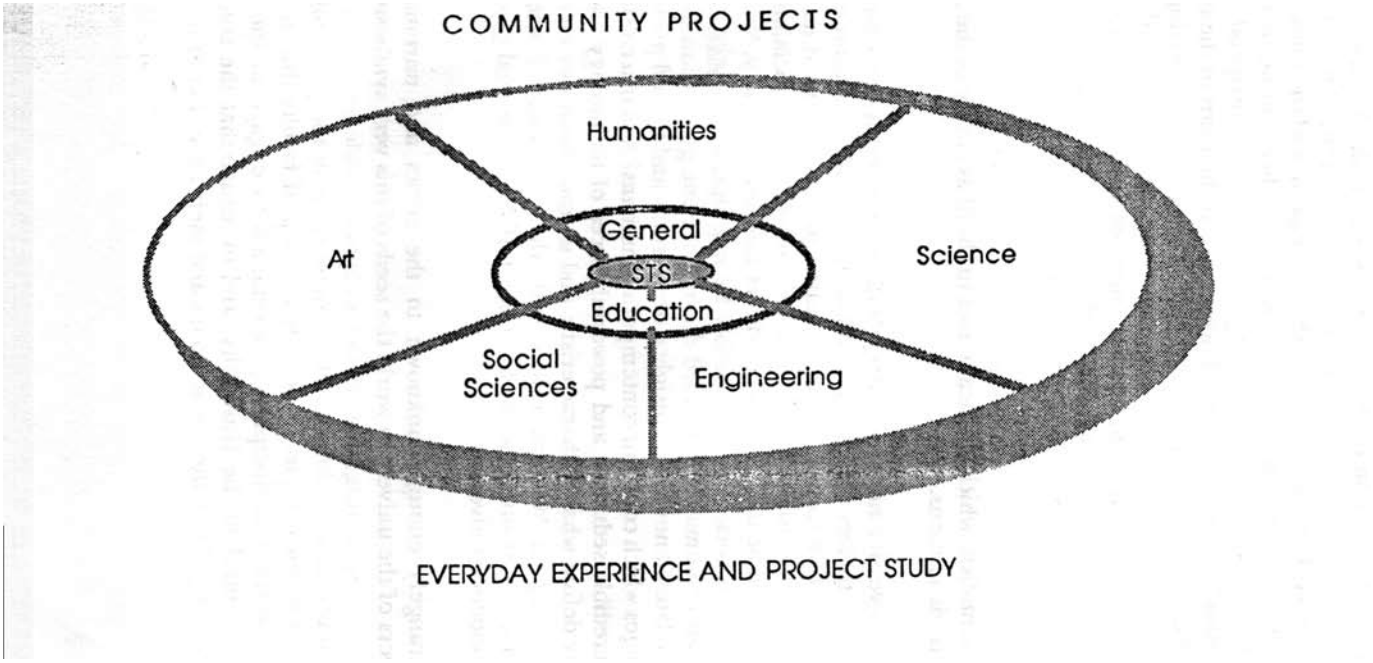
STS New Star On The Academic Horizon

For good or ill a new subject matter field is inexorably elbowing its way into American and world academia. The field is called in most places, Science, Technology and Society (STS); sometimes the word Values is included in the title in some combination. STS claims to be both the only necessary and sufficient education **in** and **about** science and technology which **every** citizen needs. Of course, it is not sufficient for professional scientists/engineers (2-5% of the population) nor for non-technical managers and leaders of our technological world (10-15%) but for the rest (80-85%) STS is the necessary and probably sufficient contact with the world of Science and Technology.

STS is unapologetically interdisciplinary, syncretist, general rather than specialized, broad rather than deep. STS stands foursquare against the dominant reductionist paradigm, borrowed from bad science, that specialization-ad-infinitum is the only way to "progress" in any field. It boldly claims that right brain rationale, and contextual understanding, visualization and conceptualization, are at least as important as left brain, isolated, linear, mathematical, more and more narrowly specialized approaches to knowledge.

In an educational world where the thinking professionals (probably more so in a small university or college) recognize that the pendulum has started to swing away from the excesses of specialization and fragmentation, the faculty have become more receptive to new integrative concepts, among which STS pre-empts the unique central space (See Fig. 1).



No wonder then that between 1500 and 2000 colleges are teaching at least one course which is clearly within STS and probably a third or a quarter are keeping up in some way on "STS" as the largest emerging field within

American higher education. About 100 formal programs of one kind or another -- departments, interdisciplinary programs, undergraduate or graduate majors, minors, etc., are now in place. The unifying forces of STS-curricula have spread to the K-12 system. Many states or provinces require STS, many will introduce it over the next few years. Hundreds of schools today teach STS in the U.S., Canada, Britain, Holland, etc., and the number will be in tens of thousands in the next decade.

Now how does this situation for STS relate to the needs and special opportunities of the church-related colleges and universities?

STS: Its Role In The University

STS is the reinvention of the University within the Multi-versity. Clark Kerr long ago described the transmogrification of the University into the Multi-versity. But the accuracy of this description and the impact that the reality behind the description has had on higher education has never been fully acknowledged. The *fact* is that the centripetal forces of "unification" of knowledge which were once at the heart of the institution called the University have been routed. The victorious centrifugal forces in the contemporary research university are: increasingly narrow disciplinary specialization; the absurdity of the continuously running research funding *NO* play, the explosion of relative ignorance (often mistitled the explosion of knowledge); the continued whining by the most affluent (the scientists) about obsolete equipment (last year's model) when they haven't had a day to think or reflect all year; and the institutional fundamentalism which has academics in thrall as surely as the Ayatollah controls his minions.

The multi-versity survives, indeed William Bennett is certainly accurate in saying it thrives, *financially*. And that, of course, is reason enough to resist any action to pay serious attention to at least one of its principal functions -- the unifying function. Discovering and proclaiming great unities should be the University's direct function in society. Which other institution in society could possibly be appropriate to *unite* the grand traditions of humankind handed down from one generation to the next with the latest knowledge, insights, deep truths and indeed problems and challenges which confront contemporary humans? And in a culture where the incredibly seductive and powerful forces of technology and science literally define what is characteristic and unique about our own culture, the unifying of Western values with the meanings of science and technology must surely be the focal point of the intellectual *raison d'être* of the modern university.

Yet strangely enough, unknown to the critics and unremarked by observers of the university world the seeds of this very synthesis we seek are already sprouting, not in the unapproachable refined air of the research universities alone but throughout the educational establishment. STS on a major campus is typically a group of faculty drawn from the widest spectrum of disciplines, determined to engage in the dialogue which is central to the University, and to assure that the students are exposed not *only* to the Great Books and their ideas, but to the possible connection between the Symposium and Special Relativity, and the contact between the Bible (as the religious guideline Bloom would have) and bioethics. General education, presumably, is the place where unification could be done. The spate of general education reforms is testimony to the universal awareness that, instead, on most campuses general education remains a pork barrel for the distribution of large enrollment "service" courses. For the first time, in STS, a set of integrative principles has emerged which forms an intellectual core for much of general education (see Figure 1) decisively different from the "course distribution" of a Chinese restaurant dinner. It is the genuine fusion of ideas, knowledge and values which counters the fissioning of knowledge over the last century. Moreover, this integrative style also helps, by contagion, to render more porous the walls between the higher reaches of the disciplines.

It is perhaps not an unreasonable projection to see the development of integrative general education with STS at its core as the emergence -- finally -- of the University within the multi-versity it can no longer supplant. In my view the only realistic scenario by which we can reinvent the University -- integrated, interdisciplinary, general -- alongside the other units of the multi-versity -- differentiating, disciplinary, and specialized -- is through the fledgling STS movement.

Insofar as Cardinal Newman was concerned with the "Idea" of the university, no responsible church educator can remain ignorant of or indeed engaged [sic] in this movement, precisely because it is the first time that the biggest questions, i.e., the religious questions of values, human and ultimate are raised now legitimately, indeed centrally on the campus. For the church to remain disengaged from the STS movement may sign the death warrant for any significant *academic* involvement for the next century. This is a uniquely suitable and legitimate entry point, *there may simply be no other*.

Supplement

The Origin of STS and The Return of the Prodigal Son

J. Robert Oppenheimer, speaking at the Bicentennial of the Princeton Theological Seminary, said `I cannot imagine modern science without the culture of Western Europe. And the culture of Western Europe could not exist without its Judaeo-Christian roots.' Many years earlier Carl Friedrich von Weizsäcker, the world's leading scientist-theologian, in his Gifford Lectures published as the `The History of Nature,' has developed this same theme in a more scholarly way: that modern science is rooted in the Judaeo-Christian tradition. Elsewhere I have used the `Parable of the Prodigious (and prodigal) Son' to describe the relation of the parent Western Christian culture to its offspring, modern Science and Technology. This powerful progeny has left behind the parent's household, and rejected its constraining values as surely as the Prodigal Son indulged himself in `riotous (i.e., unconstrained by extrinsic values) living.' The modern enterprise of Science and Technology in turn has been at great pains to establish and maintain its `autonomy' from values -- an absurd and futile effort. Yet after the Galileo affair we, in the Church, can hardly blame S and T for being thus God-shy! Moreover we have, as yet in the Church, no loving parent accepting, welcoming and thereby earning the right to share its wisdom with this prodigious prodigal.

And yet today, something has clearly gone awry in the Technological Eden. And whatever it is, it will not be easily fixed. And slowly it has begun to sink into the Western consciousness. First came the modern prophets of the Technological Society: Einstein, Weizsäcker, Ellul, Mumford, Weisskopf who have cried out, as clearly as did Jeremiah or Hosea or Amos, against the headlong autonomous rush of Technology into everywhere at the same time at maximum speed. The problem worsens yearly. The population explosion, environmental crisis, resource shortages, the Damoclean sword of nuclear war. Today even the universities, bastions of we-tooism, we hear of it and in their scholastic tones an uncertain trumpet has sounded. Three events played major roles in laying the groundwork for the emergence of STS: Rachel Carson and the `environmental movement'; the anomie at the root of the shortlived student revolts of the late sixties; the realization of the enormity of the threat of nuclear war. `STS' is the response by a thoughtful minority to an analysis of where we are as a world and how we got there. Indeed, the tide has turned so far, that among *those who have studied the STS issues* in depth there is general agreement that, to put it with Jacques Ellul's bluntness, S and T *are* now out of human control. Yet all agree that somehow they must be re-integrated into Society (read Culture, Values, `Church'), if we are to have even a chance to restore the balance of power in the Global Village.

This relatively sudden recognition all over the world of the profundity of S and T's impact upon us, this `megatrend,' is the historical origin of the STS movement. The world of academic leadership has come to a gradual realization that the fundamental proposition that Society had control of S, and (thence of) T, was fatally flawed. Science and Technology are not merely another set of watertight disciplines on the campus. Out there in the real world there was a drama brewing, something more real than any TV spectacular, which could be titled `Clash of the Titans -- Tradition vs Technology.' Occasional stray sniper's bullets had telegraphed the message -- a Karen Quinlan story, a Love Canal incident. Sometimes a veritable barrage told us we were in a real war, as in the Iranian revolution where a nation revolted against the `modernization' of S and T and opted to re-submit itself to the draconian hegemony of religion. Even with the `sanctum sanctorum,' there was trouble: 50 Nobelists and over half the members of the National Academy of Sciences urged the President of the U.S. to stop his Star Wars program even though it carried generous bribes to the science community. At least some of the `prodigal' sons had realized their

mistakes. Today `STS' is still a movement just trying to burst out of academia. In Troeltsch's terminology it is a sect type, not a church type movement. It is a golden opportunity for an amazing array of concerned citizens to contribute to, interact with, support, network with, all others in an effort to establish a radically different balance of power between religious traditions and the technological Trojan horse seductively presented at our gates. It is a propitious time for university chaplains, whose work surely *can* lie astride both worlds, to enter the lists.

What Is STS?

The Megatrend In Education

Science, Technology and Society (STS) has become the fastest growing subject matter field in the halls of academia both in the U.S., and in Britain -- and more recently in other countries. Moreover, it has sprung up simultaneously in dozens of places: it is not organized, there is no STS-society, no government agency pushing it. Yet it grows: it is truly a megatrend.

Integrative General Education

STS is general education for a technological society. It differs in a significant way from other components of general education in that it is the capstone rather than the foundation. STS is `integrative' of the wide spectrum of increasingly discrete subjects and courses to which a student is exposed. It shows linkages, helps patterns to emerge, develops meanings out of the whole. For a student or adult to be functionally literate in contemporary society she or he must have acquired -- by one means or another -- the rudiments of what is included under STS. In other words, STS is the only meaningful way to describe the content of technological literacy. Indeed given the nature of the world in which one lives it would, perhaps, not be too grandiose to claim that STS is the core content of citizen education in every major country.

One does not need to document the awareness of the great difficulties which arose in the early decades of this century as the seamless robe of `higher education' was divided even further into narrower and increasingly insular departments and disciplines. This fissiparous tendency can be linked perhaps to the reductionism inherent in `science.' The writer has made the case elsewhere that another fundamental cause lay simply in the explosion of the amount of `knowledge' easily available via books and journals, etc., in any one field, compared to the fixed negentropic capability of the human brain.

Whatever the cause, the fact was undeniable that to an increasing extent even the educated world was becoming bimodal. One small (1-5%) component consisting of those who understood the arcane language of science and technology and the others who were either alternately enchanted or amused by the `output' of this minority or alarmed and bemused by the same. When C.P. Snow wrote the Two Cultures the momentum driving the divergence between the cultures was already so great, that its intellectual argument had little impact on the academic world. A much more significant work, Jacques Ellul's *La Technique* had waited ten years to be translated into English and it received widespread attention only when history caught up with it in the late sixties and early seventies. From the romantic paeans of praise, and downright worship of technology characterizing the mid-sixties, the developed world in five to ten years switched to recognizing Technology as the `enemy.' What had intervened were the `student movements' in Europe, Rachel Carson, the Vietnam war, Fritz Schumacher and Small is beautiful and towards the end the Oil Crisis, and the *Limits to Growth* (See box for examples). The wave of `anti-technology' sentiment is hardly a decade long when another swing of the pendulum seems to be in the making, new technological saviors being sold under every brand name from computer literacy to high-tech to Star Wars.

In our fragmented world, we all need some `glue' to hold the pieces together. Today science and technology are major forces shaping our environment, workplaces, and lives. STS provides the most thoroughly developed integrative framework to enable students to understand the many factors at work in the world, and to integrate the many intellectual skills and problem-solving routines they are acquiring in their university studies.

All of the `excellence reports' recently prepared by blue-ribbon panels of leaders in education, industry and government call attention to the need for integrative education in general, and education which integrates an understanding of science and technology with the rest of life. (See the following box for examples).

A New Area of Interdisciplinary Study

STS is the prototype of the new academic fields, all struggling to establish themselves in a hostile university atmosphere totally controlled by departments. STS is, of course, quintessentially interdisciplinary, attempting to link together a large fraction of all the departments on a campus. STS works towards an understanding of science and technology in the context of society.

STS brings together scientists, engineers and technologists, social scientists, humanists, and members of professional and pre-professional faculties. Through face to face discussions and tutorials, faculty members can at least make an `honest effort' to keep up with the significance of developments outside their own fields which often have a profound relevance for their own. Humanists can gain perspectives on the whole range of technologies which they use daily -- steel, highways, sewer systems. STS helps de-mystify all the sexy names like supercomputers, lasers and the bio-technologies. Scientists and technologists can learn STS involves insights from literally every discipline on campus, and the typical STS faculty is composed of representatives from the same wide spectrum of disciplines.

Changing Views On S/T

These two quotations, both by distinguished, articulate spokespersons for the American body politic, illustrate the rapidity of change in society's attitudes to S/T.

`Yesterday, most of mankind could look forward only to a life that would be `nasty, brutish and short,' on the verge of privation in good years, starving when the harvests failed. Now wheat pours out of our ears. We swim in milk. We are threatened with vegetable and fruit surpluses and even, in some happy years, wine glut as well. Water, man's precious resource, will be captured from the oceans by desalinization; nuclear power promises unlimited energy; the rocket, unlimited speed; electronics, unlimited technical control. All the old locks of scarcity have been sprung, the prisons flung open. From the first stone tool to the cell which snaps a camera shutter on the far side of the moon, the stride of man's abundance is all but imaginable -- and yet it is here.

`This is the basic miracle of modern technology. This is why it is, in a real sense, a magic wand which gives us what we desire. Don't let us miss the miracle by underestimating this fabulous new tool. We can have what we want. This is the astonishing fact of the modern scientific and technological economy. This is the triumph we hail today. This is the new instrument of human betterment that is at our hand if we are ready to take it up.'

Gov. Adlai Stevenson, 196

`I find that one of the great challenges of the future will be to differentiate what science and technology can do from what it cannot do. That will be the problem. Their promise is great. They can and will continue to make dramatic breakthroughs in field after field. They can continue to significantly improve the human condition but I fear that people have too much faith in their miracles and that the cornucopia of the benefits of sciences can seriously excuse, postpone and delay some public policy considerations that we must soon institute.'*

Gov. Richard Lamm of Colorado, 1977

**I disagree. I side with the small minority of distinguished scientists who believe that most of the major impacts affecting the masses are behind us.*

Three Metaphors About STS

1. STS: The Essential Glue in College Education

`Glue Not Included'

Go to your local five-and-ten-cent store and buy yourself one of those kits to build a `model car.' Take out the plastic bits -- the wheels, panels, chassis, engine -- and spread them out on the table, and get ready to put them together. Stop! You need something else to hold the whole structure together. You forgot to read the outside label on the box. It says: `Glue not included.'

If you have finished an American college (or high school) education you are exactly in the position just described. You have been given all the pieces: engine (math), door panels (English), fenders (social studies), windows (science), and so on. Each one a different color (neatly packaged into a course) but there was nothing to hold it together, and precious little instruction on how it all fits. The glue of making a whole (education) out of the parts (courses) is definitely not provided in the education which 99 percent of Americans receive.

So what is the missing glue in our education?

It is the study of science and technology in relation to society. STS is the new acronym for the most significant change since the war in what is taught on campus.

2. STS: The Best Topsoil for Nurturing Citizenship

The Latin root of the word education is educare (<u>not</u> educere) which is best translated as `to nurture'. STS is the soil which nurtures the full variety of `good' citizens from scientists to humanists, poets to theologians to engineers.

3. Pyramid not Flagpole

U.S. Science education has been unconscionably concerned only with reproducing scientists and engineers, neglecting the `science education' of the 99% who support that science and engineering. The U.S. S/T enterprise finds itself like a shaky flagpole in hostile winds of a technologically illiterate society. Instead the world should be building a stable pyramid of increasingly more technically trained citizens, based, critiqued and supported by the technologically literate masses, made possible by introducing STS throughout the curriculum.

STS On The Campus Today

The emergence of Science, Technology and Society as a recognizable academic unit on the campus both in America and in Europe remains a remarkable phenomenon. It was a genuine grass-roots phenomenon, nucleated in the atmosphere of crisis in the air of the student upheavals but is sustained by the deep concern and teaching overloads of faculty committed to the field. We have already noted that if anything qualifies to be called a `megatrend' as defined by Naisbitt the emergence of STS in college education certainly does. STS as a field of pedagogy and study certainly encompasses a wider range of disciplines than any predecessor `interdisciplinary' field. The record of U.S. higher education in coping with such interdisciplinary fields is dismal [1] and STS presents

1. R. Roy, "Interdisciplinary Science on Campus – The Elusive Dream," Chem. And Engg. News 55 (35), 28-40 (1977)

a unique case in more ways than one. It has been driven from the bottom-up with a wide base of faculty support yet it has had to try to find a place in the academic sun without any major funding aimed at a national objective (as was the case for `Materials Science' or `Environmental Sciences') all the while attempting to integrate knowledge across a much wider spectrum.

In 1989 we are 15 years past the point where a large percentage of these STS `programs' -- ranging from colleges and formal departments to a group of two or three courses listed in the catalogue were put into operation. At the midpoint in this decade a Congressional committee made a survey of the status of these programs and in 1976-77 the NSF sponsored Cornell survey [2]was conducted. Since then the climate in American universities has changed rather sharply, and as a result newcomers to the STS academic marketplaces are sure to be substantially affected. In 1983, while on sabbatical at the Brookings Institution, it was decided to conduct a simple survey to determine the status of this interdisciplinary field then. This survey was limited to the United States.

The American Scene

The Cornell study by Heitowit, Epstein and Steinberg showed that in round numbers some 1000 colleges give one or more courses in what we would, today, subsume under `STS'. That number can only have gone up, and as we will describe below, STS is now reaching into the secondary schools. The Brooking survey [3] found some 50 (out of a possible total of about 60) colleges and universities which have formal academic unit specifically dealing with STS or one of its component parts. We estimate that another 100 are examining options on how to institutionalize STS on campus.

These programs break down into clusters which reflect the emphasis (or origin) of the program: genuine interdisciplinary, public policy related, humanities related. The paper [3] provides other useful information on the faculty members and disciplines in each program. From these data one could conclude that the reality of STS in the U.S. is that it is at one and the same time an umbrella term for a syncretic discipline covering a wide spectrum, while it is also used to describe smaller subsets such as science policy, history of science, etc. Thus while science policy is a part of STS, STS cannot be equated with science policy or bioethics or other subsets. Of course in many cases STS programs have grown up around early efforts in one of these areas. In other cases the presence of more narrowly focused programs may have inhibited the growth of a full-range STS program. The following five areas emerge as rational subsets of the field.

- Humanities, History, Philosophy of Science/Technology.
- Engineering/Technology/Science and Public Policy
- Environmental values, issues, policy
- STS by/for Engineers and Scientists
- Interdisciplinary STS covering the entire field.

2. E. D. Heitowit, Epstein and Steinberg, Editors and Compilers. "Science, Technology and Society: A Guide to the Field," Program of Science, Technology and Society, Cornell University (1977)

3 R. Roy and J. Lerner, "The Status of STS Activities at U.S. Universities, "Bull. Sci. Tech. Soc. 3, 417-432 (1983).

In programs emphasizing any of the above (except the last named) the composition of the faculty reflects the emphasis and is often not interdisciplinary at all. The last set consists of the genuinely interdisciplinary faculties and these programs represent the STS experiment in general or interdisciplinary education in its present form. The MIT STS - `College' is clearly an attempt to create an umbrella for already-existing major programs in the sub-areas of STS.

The data on the size of the programs presented are new and surprising. The largest programs serve some 1000 students per year; many universities offering upwards of 10-20 courses. Yet only one dozen institutions offer undergraduate and just over a dozen graduate degrees in STS. Effort levels angle downward from 15 person-years to token support for an `office.' It is noteworthy that some of the late-comers to the field, e.g., Duke University and Virginia Tech appear among the largest programs.

Administrative issues have been probed both by recording the status and reporting channel for each program, as well as by recording whether the assignment of personnel is through the program office itself, or whether the latter only coordinates the faculty provided by various departments. We find that only six programs are full-fledged departments within a college or graduate school. In many ways these programs are the most stable since they fit the relatively rigid constraints or academic administration. On the other hand it is difficult for such programs to be truly interdisciplinary, and this is reflected in the faculty make-up. The interdisciplinary programs typically report directly to the central administration but what is gained in a more appropriate STS faculty is lost in size and control of budgets.

The power of the purse is certainly not an index of the success or value of the program. It is on the other hand, an indicator of that institution's commitment to the STS field, and probably a measure of the stability of the program on the campus.

At the time the Brookings survey was completed the subjective comments from the University academic community were not optimistic with regard to expansion and future penetration into American academic life. Since then, however, a major change has occurred in the national climate for science education and technological literacy, as noted above. It is because of **this emphasis** that the future of STS (as the primary vehicle for technological literacy) as a major factor in academia is assured.

Newest Development: Technological Literacy And STS In Schools

While a few U.S. universities (Penn State, Cornell, SUNY Stony Brook, Stanford) started up the STS field the British and Dutch have moved far ahead in expanding STS courses into the high schools and elementary schools. In the U.K., with its long tradition of social criticism of science, the approach grew steadily. The Science in a Social Context Project (SISCON), an inter-university program, got underway in 1973 and set itself the admirable task of preparing teaching materials at college level, freely available to all comers. Indeed by 1980 the British had already jumped ahead in starting to introduce such materials into the high school curriculum and public examination system. Research groups in one or other aspect of STS, notably at Sussex, Edinburgh and Manchester became well established. With a time lag of a few years, similar developments spread to Australia. Canada came later but is now introducing a TV link between universities in eight provinces to maximize the return on their efforts. Europe has not been slow in making its mark: Lund in Sweden; in West Germany Ulm and Kiel, the latter producing excellent high school programs, come to mind. Holland, with its long tradition of close internal collaboration between universities and readiness to work with its neighbors has formed European Associations for STS. And there is much activity, both established and growing, elsewhere in Europe. The developing world, with very rare exceptions such as one or two individuals and groups in India, has been slow to follow and has not yet started to formalize efforts in STS. Somewhat surprisingly, there are several individuals and groups in the USSR (such as V.V. Nalimov in the Mathematics Institute of the Moscow State University) and in Eastern Europe who

are writing and working in the field, but this is probably far from affecting the education of the masses. Nalimov's books [4] are of especial interest to all those concerned with religious values, which he treats more explicitly than most western authors.

The Route to Technological Literacy

The critical, evaluative science of STS is as significant a *technological* advance as any other technology. The STS experts claim that thinking clearly and systematically about science and technology today is as essential - - *more* essential -- to any society as biotechnology or robotics or any other catchword.

One is tempted to think of STS, then, as the content of what is so often called technological literacy.

In the U.S. since early 1983 the crisis in `math and science' education became the subject of intense public and administrative interest. Half-a-dozen major reports were written in 2-3 years. Without exception they advocate integrative education and some version of STS. See the following `boxes' for quotes. From an insoluble crisis in March 1983, the media have already wrested a victory over illiteracy by 1985. Would that it were that easy!! From Reagan's literally `zero-ing out' all expenditure in science education in the NSF, the House and then the Senate has passed a bill for $925 million for `science education.' But will, or can, more money eradicate the problem?

Add up, if you will, the cost of all the solutions that have been proposed to curb the decline in math and science education. Dr. Gregg Edwards, formerly of the Science Education Directorate at the National Science Foundation, estimated the sum to be $150 billion. President Reagan is sure to hold back or rescind the Congress' law. Since any allocation will be a trivial portion of the $150 billion, we will clearly have to be innovative in *how* we use the new funds. Are there such new options? Unfortunately, the university world, which sets educational priorities for the country, resists genuine innovations as much as any conservative board of directors or entrenched union.

For the last 30 years, the leaders of academic science and engineering have treated the problem of technological illiteracy with what amounts to benign neglect. In recent months, however, the problem has attracted nationwide attention, and the educational community will no doubt respond to the half-billion federal dollars being dangled out there for `science education.' The crucial question that every policy and school board or university president must ask is: science education for whom? Is this crisis merely a way of saying that we have shortages of computer scientists and electrical engineers? Or is it an epidemic affecting the entire population? For whom shall we design the cure-- the roughly one percent who become professional scientists, engineers, or doctors?

No, I submit that while this may be the group that most scientists and engineers think of first -- as we did after Sputnik -- it is not what the public and Congress have in mind. No further proof is needed of congressional intent than the `horror stories' that have been cited in testimony to win the passage of recent bills to improve math and science education. The tellers of these stories invariably focus on the problem of *math and science illiteracy in the general population*, and they offer alarming comparisons with other countries to drive the point home.

4. V.V. Nalimov, Realms of the Unconscious: The Enchanted Frontier, ISI Press, Philadelphia (1982); Faces of Science, ISI Press, Philadelphia (1981).

All Recent National Reports On Education At Every Level From K-Grad School Stress Two Themes: 'Integration' and 'Societal Connection'

"Involvement In Learning: Realizing The Potential Of American Higher Education (1984)."
Study Group On Conditions Of Excellence In American Higher Education

- *Liberal education requirements should be expanded and reinvigorated to ensure that students and faculty* ***integrate knowledge from various disciplines*** *(emphasis added).*
- *A 'principal aim' of liberal education is `the* ***ability to integrate*** *what is learned in different disciplines,' and hence that reform must be based on `collaboration among faculty from different departments,' which will `establish specific* ***integrative mechanisms.'***

'Educating Americans For The Twenty-first Century' (October 1983) Final Report:
National Science Board Commission On Pre-college Education In Mathematics, Science, and Technology

- *(For Science in grades 7 and 8) A beginning understanding of the integration of the natural sciences, social sciences, and mathematics; familiarity in* ***integrating technologies with experiences in the sciences*** *(emphasis added).*
- *(Secondary Biology) Understanding biologically based* ***personal and social problems*** *and issues such as health, nutrition, environmental management, and human adaptation; ability to resolve problems and issues in a* ***biosocial context involving value or ethical considerations*** *(emphasis added).*
- *(Computer Science) General understanding of the problems and issues confronting both individuals and society as a whole in the use of computers,* ***including social and ethical effects of computers; the ethics involved in computer automation*** *(emphasis added).*
- *'The greater the degree to which all the Sciences and Technology can be* ***integrated*** *in new curricular approaches, the broader the understanding in* ***these*** *fields will be.'*
- *Urges educators to take advantage of the `numerous opportunities to demonstrate the* ***interdependence of human knowledge,*** *and encourage students to apply the skills and concepts from one discipline in seeking solutions in the others.'*

National Science Board Conference On Goals For Science And Technology Education
Grades K-12 (April, 1983)

- *Science curriculum grades 9-11 will be '****structured around the interactions of science and technology with the whole society,'*** *with instruction centered around problems that `****integrate knowledge****' from engineering, physics, biology, earth science, and applied mathematics.*
- ***'Integration of Science, Technology****, and Applied Mathematics' throughout basic education.*
- *A curriculum 'organized around* ***problem-solving skills, real life issues, and personal and community decision making.'***

National Science Teacher Association Recommends Unanimously That

Emphasis on science-related societal issues

- *Elementary level: a minimum of percent of science instruction should be directed toward science-related societal issues.*
- *Middle/junior high school level: a minimum of 15 percent of science instruction should be directed toward science-related societal issues.*
- *Senior high school level: a minimum of 2 percent of science instruction should be directed toward science-related societal issues.*

The Northeastern Association Of Graduate Schools,
A Group Of 80 Graduate Institutions From Maryland To Maine,
Also Recommends Interaction, Interdisciplinarity

- *The adoption of a cohesive minor for doctoral students* ***would stress linkages*** *among disciplines.*
- *A* ***new interdisciplinary seminar*** *focusing on the process rather than the products of inquiry.*
- *A* ***didactic short course*** *focusing on the* ***ethical, governmental, and legal forces that shape and influence research and scholarship*** *(=STS).*

It is true that in sheer number of hours, the average student in the United States is exposed to one-fifth to one-third as many hours in science and math as her or his counterpart in Western Europe or Japan. Out of 17,000 school districts in this country, well over half have an inadequate staff to cover math, science and technology. And while the Soviet Union has 123,000 physics teachers, the United States has 10,000. Even more striking is the technological illiteracy of college seniors who have already had required science and math courses. According to a National Science Foundation study reported in *Daedalus,* Spring 1983, the vast majority of seniors still can't solve a simple word-problem after four years of college. Given the extent of this problem, we in the science and education community would betray the country if we focused once again on just creating more or `better' scientists and engineers. The goal this time should be math and science education for all.

Those who are closest to the problem -- the nation's secondary-school science teachers -- have pointed to one solution. In a position paper adopted unanimously in 1982, the National Science Teachers Association claims that the biggest gap in high school science education is not in physics, biology or even computer manipulation -- but in the relationship of science and technology to society. Science, technology and society (STS) programs would focus, for example, on technology's relationship to the food-population seesaw, the consequences of genetic engineering, or the effect of computer automation on jobs.

Only by teaching science and technology in this context can we truly expect the American public to become interested in these subjects. By studying acid rain, not only does a citizen become informed about a major policy issue, but she (or he) learns what pH means and how bases neutralize acids. At The Pennsylvania State University, discussing the issues of nuclear war and nuclear power has helped our philosophy and English majors grasp the principles of fission in a way that their required science courses in high school and college were never able to. Science teaching has long followed the more elitist European model of teaching pure science first with very little reference to technology. We must turn this sequence around by focusing on experience and teaching technology first, science thereafter.

In implementing what amounts to a basic restructuring of science education in the United States, there are major hurdles to overcome. The first and perhaps most serious is that there is no constituency fighting for institutional

reform or the dollars with which to launch STS programs at secondary schools and college campuses. While there is, for instance, an established (and powerful) physics community fighting for financial support of physics research and education, there is no entrenched group of scholars fighting in the interests of STS.

Academic Politics Of STS

This paper has, so far, presented the case for the importance of STS as recognized universally, and the response in the college and pre-college institutions. It also documents the sharp flattening out of the growth curve in the number of STS programs in colleges. The intellectual merits of integrative education, linking both high school and college students' learnings in science and technology to their cultural and citizen responsibilities, are widely touted as proved in our quotations. Yet in a period of financial stringency STS has not attained the status it clearly should have as an indispensable, if small, part of every student's education. Indeed, it is remarkable that *not a single major institution* has as yet *required* a single STS course of every student. Yet typically, virtually every student is required to take three or four courses *in* `science' (usually a totally fragmented set of astronomy, biology, geology, etc.) which studies of science literacy show, are not retained at all. The institutional barriers to innovation are so great in a university, and the incentives for success in institutional change so miniscule, that it is not surprising to find that a new field like STS is having a hard time in the academic jungle.

'Para-educational' institutions such as the chaplaincy can therefore play a critical role in making common cause with well-thought-through changes. Indeed the Church in its `pioneer' mode -- as the agent of change -- must learn to make common cause with the change-agents present within secular society.

The absolutely needed continuous evolution of the curriculum to meet the needs of a changing society are universally stymied by the faculty for the same simple reason that change is so often blocked in all sectors of society: the fear that change may cost those presently in charge prestige, power or even jobs. The total `student credit hours' in any university curriculum is essentially fixed. Hence changing courses is a zero-sum game. If subject or department A gets more courses, departments B or C *must* lose courses, and so on. STS must make room for itself, essentially as a replacement for part of science, part of the humanities, and part of the social sciences.

STS programs on all campuses collaborate vigorously with other groups -- environmental concern, anti-nuclear war, joblessness, etc. But it is important that friendly groups work to assure the appropriate and permanent institutionalization of the STS program and its courses, otherwise the quality of the faculty and its programs will suffer. The following section will help the reader understand better what arguments can be used and the context in which students and faculty can be benefited.

Which Students Will Benefit?

All students require assistance in integrating their learning and tailoring it to their specific goals in the vocational, social, and personal dimensions of their lives. Three types of students as they perceive themselves can see the relevance of STS.

The first type is the `high achiever' aiming at participation in professional life, through employment in one of the major corporations or in State and Federal government. It goes without saying that such students will need a high level of scientific and technical knowledge. The addition of STS to their training will give them a special sensitivity to the social dimensions of science and technology and hence an edge in gaining leadership positions.

A second type of student has a high level of community commitment, and seeks to provide assistance and service to people in their urban/rural communities. Minority communities, among others, are often the victims of technologies, such as asbestos, lead paint, and air and water pollution. STS will prepare students with sufficient science and technology literacy and social awareness to be effective in such roles as policy analysts, community advocates, and change agents.

A third type of student has had poor experiences in mathematics and science education. They now shy away from learning about science and technology because they fear failure in this area. STS education can help to address this problem in two ways. First, it places science and technology content in learning contexts where students feel safe and comfortable, and where some basic concepts can be taught without arousing fear. Second, by relating these concepts to the social and personal concerns of these learners, STS can bring about an increase in their motivation to take the next step -- to try a course they might otherwise have avoided.

STS courses -- as we have had data for 15 years -- also serve to raise levels of awareness and responsibility for the problems now faced by people around the world. Many students place a high priority on personal goals (personal achievement in terms of income, prestigious employment, and possessions) because they cannot really see how the complex world works, especially how they could make a difference. STS education, by helping students to learn these complex factors and their interaction, and by showing how an individual can make a difference, can play an important role in effectively directing the energies of students to community and even global concerns. By doing so, it serves the goal of `enlargement' in the best sense.

STS 'Programs': How One Is Started

An STS `program' typically consists of one or more `core' courses, and a group of courses (many already on the books) which are suitable for cross listing as STS courses. Although there are variations to suit the needs and traditions of different institutions, there is a typical pattern to an STS program.

First, a core faculty is identified. These faculty members are chosen because of their current interests and plans for teaching and research. They are selected from a wide spectrum of fields and departments in the institutions. Through some form of staff development program, these individuals share their common knowledge and their individual strengths. College- or university-wide STS seminars, often involving non-faculty, are excellent ways of getting started, and bringing in outside talent, to stimulate interest. Eventually a `set' of STS courses will emerge on the books and then comes the difficult part: getting the administration to identify a structure, a leader, and a faculty to set the program goals.

The Science Community - Divided Like Gaul Into Three Parts

Let's face it, it is the very nature of science itself which has landed us in the pickle we're in -- of a nation of tourists in their native land. Reductionist science leads inexorably to narrower and narrower specialization as the totally false `requirement' to be at the frontier in one's field. Thus scientists and engineers ignored society. What of the rest of society? Illiterate in their own mother tongue the citizens wander around on the surface of their own culture. But who should have taught them the language of S/T? Why, the scientists and technologists (and engineers), of course. But they were too busy specializing and hence they left the job to a specialty corps called science-teachers. And all this led to the fissioning of the community into three very separate blocks with very separate cultures -- scientists, engineers and teachers. Moreover, the world has a grossly incorrect view of the relationship of these three communities to each other.

Science-Theology: Technology-Religion

The distinction made at the end of the last paragraph between the communities of scientists and engineers finds an exact parallel in the religious community. Good theology does not lead to good religion any more than science leads to religion. Orthodoxy is not orthopraxis. Yet obviously in a complex world the world turns to the religious community for the guidance of the great religious traditions on what they *ought* to do. But acid rain issues and genetic engineering are not referred to in the Bible, Talmud or Koran. Here too the fundmentalist makes the error that I attribute to my own science community: thinking that the tree of (traditional) theology can lead to the fruit of good religion. It cannot. Theology and religion interact but are not of the same genus. What we must do -- just as the best contemporary science is *one* tool in making technological innovation -- is to utilize old *and new* theological insights to address a new religious (ethical) problem.

We have a plethora of new moral and ethical issues caused by violent change in the human situation. There will no doubt be the temptation to bring the traditional religious values to bear on the new problems, unorthodox (I introduce the term deliberately) problems. Growing up as a young Christian child in the syncretic culture of India, I often heard the smiling comment: `If the Christians lose a cow, they search for it in the Bible.' There is too much truth in that quip and much relevance to our subject of Science, Technology and Traditional Religious Values. I am on record as interpreting and reinforcing Lord (C.P.) Snow and Robert Heilbroner as saying that the ONLY possible way to manage technology is to bring it under the hegemony of a religious worldview and the power of religious conviction. Yet the religion of a Jerry Falwell or an Ayatollah Khomeni will not do. To use the parallelism of technology and science, just as some new technology utilizes some new scientific advance whether $e = mc^2$ to build a bomb, or the transistor action to build big computer chips, so useful religion guiding orthopraxis, needs to draw on *new theological* insights. These, I deeply regret to say, are totally absent from the traditional theological sources -- perhaps appropriately so. But there *are* a very few seminal *lay*-theologians who have contributed enormously to this task. Whitehead is valuable and relatively well known to theologians but he lays only a foundation. All the new important work is European. Carl Friedrich von Weizsäcker[5] is the dean of the scientific theologians: his works *The History of Nature* and *The Relevance of Science* are required reading. Sir Alistair Hardy's [5] *The Biology of God*, Konrad Lorenz and Sir John Eccles' [5] two books, address the newer biologically-connected issues. From the social science perspective, Jacques Ellul (*The Technological Society*, etc., etc.) and Ivan Illich (*Medical Nemesis*) represent the very best examples of how Christian insight helps shape one's critique of technology at the very deepest level. Their criticisms have proved to be profound and profoundly right, precisely because they are based on the very deep insights of faith into nature and human nature.

Over the last few years I have addressed the task of developing a new evolving Christian *theology* which absorbs the insights of Science and Technology. My own Hibbert Lectures, published under the title *Experimenting with Truth*, starts with an attempt to deal with the question of `God-language' and the images and meaning associated with the word. I summarize below the principal theses.

1. That a Christian pan-en-theist -- the Beyond in the midst of everything -- is the only conceivable meaning one can attribute to God *which is consistent with our scientific weltanschauung* and which can form a meeting ground for all religions.

2. That the Either/Or of much Western religious thought must give way to a greater degree of Both/And.

3. That the profound role of Chance -- established as an absolute in nature -- in individual lives and society can be very creatively interpreted as `God's' interventionist agent in human society. Everything else is done via or by human beings.

4. That Doing the Truth is an essential component of Truth.

5. I present the unique view that science and religion are related as detailed description of the *parts*, to the fuzzy big picture of the *whole* -- a matter of focus and perspective.

I cite these only to illustrate the kind of thinking in modern theology which the religious and STS communities must develop in order to be able to attack the problem of how religion addresses a technological issue. I am sure that in the next few years a sophisticated set of `axioms' will emerge: will these be the new Creed? I only assert their absolute necessity to any fruitful dialogue between campus chaplains and the academic STS community.

In return I juxtapose my own evolving attempt at what may well be the cognate STS axioms. The list below may be regarded as *one* statement of the most general laws of STS. Just as Newton's laws, and the laws of thermodynamics and quantum mechanics rule the physical world, these STS `laws' -- qualitative but laws no less -- govern the interaction of Society with the world of S and T.

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5. These books are largely taken from the prestigious Gifford or Hibbert Lectures, where a high proportion of the selected lecturers have recently been scientists. Many are Nobel prize winners.

In my book *Experimenting with Truth*, I give a simple yet novel answer to this perennial student question. Science and religion differ in their focus on life. Science is only, and I mean rigorously only, concerned with detail. Its method is *only* valid when it is reductionist, isolating and examining in detail one tiny point. Conversely Religion is properly concerned only -- equally rigorously only -- with the whole, the big picture. Whenever religion gets involved with detail -- when does life start, prescribing dietary or detailed behavioral laws -- the picture will necessarily be out of focus.

The Seven Axioms of STS

1. *The SYSTEM as a concept is a description of reality: the ECOSYSTEM of nature and the TECHNOLOGICAL SYSTEM as the matrix of all modern human endeavor. Personal human values reflected in `society', are a major force in the system, but are subject to the system's operation.*
2. *The TIME-CONSTANTS for different physical and social phenomena are fixed, but vary enormously from one another, complicating the system.*
3. *TRADE-OFFS are absolutes in all human decisions. Every technology has costs and benefits, and these are unequally distributed in space (i.e., between regions or nations) and time (e.g., between generations) and between sectors of one society.*
4. *There will be UNEXPECTED SIDE-EFFECTS to any technological change because of*
   (a) CHANCE
   (b) The CHAOS factor in complex systems
5. *SIMPLEXITY of concept must be held in tension with the COMPLEXITY of reality.*
6. *BEING-and-DOING or THEORY-and-PRACTICE are the ying and yang of all STS learning; experimenting with truth is unavoidable.*
7. *ALTRUISM, the cardinal ethical principle of the great traditions, is equally paramount for optimizing the technological system.*

STS and the Church-On-Campus

The thesis I advanced in the introduction is that the nascent *academic field* offers a missionary opportunity for campus chaplains. Clearly even if a chaplain has an undergraduate degree in physics or philosophy he/she very soon finds that he/she does not -- indeed cannot -- participate in the professional life of the discipline. The only discipline in which a chaplain may have academic entre is religious studies, but even that is not *always* very welcoming.

STS is a subject matter field which is the `technical approach' to life and society's problems which is professionally accessible to the chaplaincy. Moreover, the chaplain can -- if she or he becomes competent in STS -- bring his or her own specialization in value to the party.

STS has another attitude in common with the chaplaincy -- the bias towards acting on decisions. Here too there can be excellent two-way exchange and enrichment. The Church in the last couple of decades has been caught unprepared with `technologically' naive policy recommendations -- simply for lack of contact with the S/T policy personnel. Even today not only the Church but the large fraction of the policy establishment fails to understand the role of R and D in determining what happens 20 years hence. R and D is the engine running the 100-car long train. Most of us hear, write and read about the tank cars full of MIC, or the Japanese cars on the piggybacked trucks, or the dining car with the shrimp from Sri-Lanka and tomatoes from Mexico, or the caboose of acid rain,

all the while the engine dragging us into the future is OUT OF SIGHT. Why? Because *RESEARCH POLICY* is unintelligible to the lay person. In my new book *lost at the Frontier: U.S. Science and Technology Policy Adrift* co-authored with Deborah Shapley, a science writer, we have tried to show -- principally in industrial policy areas, how bad *R and D* policy has led the U.S. to the brink of disaster.

Surely any chaplaincy worth its name should be able to relate the faith to these issues with the degree of professional competence available to the STS community. The “simplexity” of the gospel call to love must be interpreted into the complexity of social decisions soaked with S/T and predetermined by the R/D of the last decade. Jesus sure didn’t promise anyone a rose garden or a simple gospel -- I recall something about “This ye should have done but not neglected the other also.” Yes to gospel and to STS.

What can the chaplains who pay the entry fee of becoming thoroughly informed on STS contribute to the academics? Most urgently they need to call the latter to account to rethink their own values vis-a-vis their own work and profession. STS is a platform for calling such re-examination of the values of science and of the scientists as individuals. In the last box I set down my own response to this challenge: a worthy set of goals to guide world-wide science and scientists.

Science/Technology Education in Church-Related Colleges and Universities		
ID	**Article Title**	**Author**
BK022-001	Table of Contents	
BK022-002	Foreword	Father Robert Brungs, SJ
BK022-003	Keynote Address	J. A. Panuska, SJ
BK022-004	Reflection: Imaginative Learning in Theology, Science and Technology	J. Cross, C. Ford, G. Magill
BK022-005	A Pilot Study of the Present Condition of Undergraduate Science and Technology Education in Church-Related Colleges as Perceived by Department Chairpersons	Charles E. Ford
BK022-006	Feasibility of Developing Adequate Natural Science Programs in a Church-Related School	J. Richard Chase
BK022-007	Why Church-Related Institutions Should Be Involved in Science/ Technology Education	Sr. Rosemary Connell, CSJ
BK022-008	Science and Technology in Jesuit Education	Robert A. Brungs, SJ
BK022-009	Science/Technology Education: An Administrative Perspective	James Bundschuh
BK022-010	The Ideal and Reality of Science Education in Catholic Colleges and Universities	Thaddeus J. Burch, SJ
BK022-011	In What Ways Can Science/Technology Education Enrich the More General Liberal Arts Emphasis of Many Church-Related Schools?	Sr. Mary Virginia Orna, OSU and Sr. Angelice Seibert, OSU
BK022-012	The Role and Importance of Research and Publication in Church-Related Schools	James W. Skehan, SJ
BK022-013	Developments in Science/Technology/Society Curricula at the Secondary Level and How Colleges Can Connect and Continue	Marie Sherman
BK022-014	STS: A New Opportunity for the Re-Integration of Christian Concern into American Academic Life	Rustum Roy
BK022-015	Session 1: Discussion after Keynote	
BK022-016	Session 2: General Discussion	
BK022-017	Session 3: General Discussion	
BK022-018	Session 4: General Discussion	
BK022-019	Session 5: Small Group Reports	
BK022-020	Session 6: General Discussion	
BK022-021	Session 7: General Discussion	