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ABSTRACT

The papers in this volume represent a sampling of the perspectives shared at the 1996 National Technological Literacy Conference. The papers are divided into two sections. Section 1, "STS [science, technology, and society]: Philosophical and Sociological Perspectives," includes: (1) "Relevant Science: STS-Oriented Science Courses for All Students" (Art Hobson); (2) "Ethical and Political Dimensions of Technological Citizenship" (Andrew D. Zimmerman); (3) "The Objectives of Technology Education: A Philosophical Perspective" (Ahmad Zargari; Charles Patrick; Charles Coddington); (4) "Science Literacy Standards as Ethical Theories" (Barbara J. Reeves; Daniel R. Dunlap); and (5) "Writing Racial and Gender Equity into Science Classrooms" (L. Blasi). Section 2, "STS Education in K-12 Schools and Teacher Preparation Programs," contains: (1) "Rockefeller University's Science Outreach" (Bonnie Kaiser); (2) "Women and the Sciences at the Fieldston School: A Vertical Approach" (Barbara S. Silber; Tama K. Seife); (3) "The Cat in the Hat Comes Back" (Bernice Hauser); (4) "Bioethics Forum" (Donald R. Daugs); (5) "Science Sleuths: A Group Approach to Using Multi-Media" (Donald R. Daugs); (6) "Hands-on Science Education in Rural Pennsylvania" (Peter C. Stine); (7) "Effective, Energized Education--STS at its Best" (Carol A. Wilson); (8) "The Development of Students' HOCS [higher-order cognitive skills]--The Key to Progress in STES [science-technology-environment-society] Education" (Uri Zoller); and (9) "The Learning Cycle: A Vehicle for Change in Teacher Education" (Jane A. Berndt). A complete conference program follows the papers section. (EH)

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Arlington, VA

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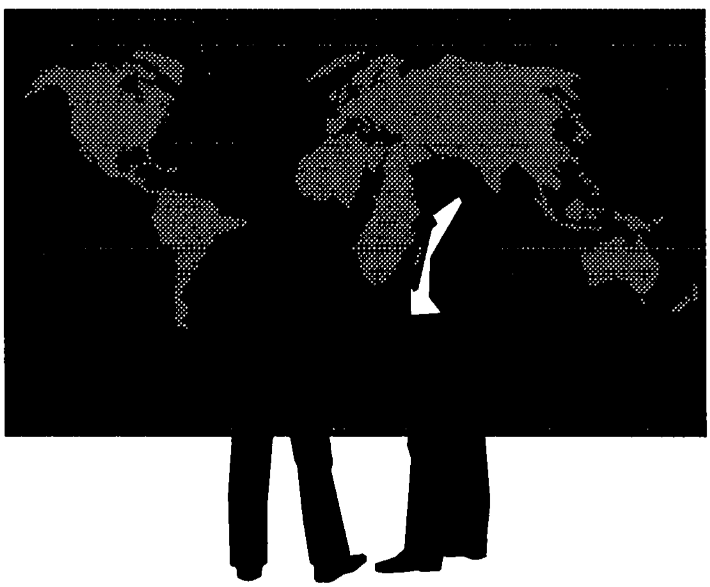

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Introduction

The National Association for Science, Technology and Society has been a national voice and international mover in the realm of science, technology and society (STS) education for ALL for more than a decade. The papers within this volume represent just a sampling of the perspectives shared at the Eleventh National Technological Literacy Conference held at the Crystal Gateway Marriott in Arlington, VA from February 8-11, 1996. This volume joins its companion volumes within the ERIC system as a fitting tribute to the strength and continuing vitality of the international STS movement. Proceedings of prior years can be found within ERIC under the following access numbers: (ED 388 558 - TLC 10), (ED 381 429 -TLC 9), (SO 024 866 - TLC 8), (ED 350 248 - TLC 7), (ED 339 671 - TLC 6), (ED 325 429 - TLC 5), and (ED 315 326 - TLC 4).

The 1997 conference is scheduled for March 6-9 on the campus of Worcester Polytechnic Institute in Worcester, MA. This venue represents a change in the annual meeting site of the National Association for Science, Technology and Society (NASTS). Additionally, the headquarters of NASTS has relocated to 765 Van Allen Hall, The University of Iowa, Iowa City, IA 52242-1478, (319)335-1192 after its many years within the STS program at The Pennsylvania State University. We wish NASTS well as it enters this new decade of STS promotion and education.

--- The Editors

RELEVANT SCIENCE:
STS-ORIENTED SCIENCE COURSES FOR ALL THE STUDENTS

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When talking to groups about science and society, I often begin by challenging the audience to call out significant global or national issues. We quickly amass a score of issues that might include overpopulation, AIDS, deforestation, nuclear weapons, global warming, poverty, famine, solid waste, acid rain, drugs, inner city decline, racism, abortion, crime, ozone depletion, air pollution, the economy, resource depletion, the automobile, religious fanaticism, war, species extinction.

Motivation for relevant science courses

Such a list holds many lessons. It suggests that each of us should work toward resolving some of these issues. For some, such a multitude of interlocking problems implies that the real issue is: survival (of the environment, of industrial democracy, of civilization). For science teachers, the list shows that it is hard to find a topic of national or international significance that does not relate importantly to science. Thus, students who want their life to make a difference should learn enough science to understand these issues.

It is an eye-opening exercise to ask: How many audience members have studied any of these topics in a high school science course? In a college science course? In a physics course? How many have had any science course that includes a serious discussion of perhaps the next century's dominant issue, global warming? How about ozone depletion? Nuclear weapons? Positive responses are usually sparse. Although most people have had several high school and college science courses, few of them dealt with any of these topics. Discussion often brings out complaints about previous science courses, and resolutions to urge teachers to deal with the science-related realities of our times.

The lesson, surely, is that science educators need to teach socially relevant science to all students in our public schools and colleges.

Reaching all the students

Topics such as overpopulation, nuclear weapons and global warming have a distinct STS ring about them. The STS community, and the science education community, need to think much bigger about their role in educating our society about such issues. We need to affect many more people! More generally, many more high school and college students need to become scientifically literate, and this science literacy needs to include societal topics like those on the preceding list. The point of this article is to provide some ideas that might help accomplish this task.

My field, physics, is the worst offender. Only 21% of our high school students take any kind of high school physics course, let alone a course that includes socially relevant topics (Schewe, 1994). It is depressing that only 20% of all elementary school science teachers have taken any college physics course, and only 35% took a college chemistry course (Goodwin, 1988). And a survey of 1800 college campuses indicates that only about 50% of the nations campuses offer any kind of physics course for non-scientists, and that many of these courses enroll only a few tens of students per year (Henderson, 1995). Thus, most physics departments care so little about nonscience students that they provide no education at all to the vast majority of such students.

The STS picture seems even worse than the general science picture, because it appears (at least from my own informal observations) that relatively few large STS-oriented courses are being taught. At any rate, I strongly suspect that even fewer high school and college students enroll in an STS-oriented physics course than enroll in a general physics course.

I believe that we can improve matters by (1) shifting the focus of both high school and introductory college science education toward broad-based science courses directed at nonscientists and scientists alike, and (2) providing relevance by including, in every general science course, such STS-related issues as the ones listed above. These two recommendations overlap and reinforce each other, especially in the sense that STS topics will go far toward enhancing general science courses for nonscientists.

Note that this is not a call for new specialized STS-type courses. Such specialized courses can be useful and educational in their own right, but I'm afraid that they will never get us to where we need to be nationally because they will be taken by too few students. To get where we need to go we must include societal topics in every general science course, especially those for nonscientists, because the science and the societal topics enhance each other and the societal topics provide the general interest and relevance that can enable us to reach nearly all of our high school and college students.

Is this really possible? I have some evidence that the answer is "yes."

An experiment in STS-physics

The liberal-arts physics course developed on my campus, along with the accompanying textbook (Hobson, 1995), is an experiement in the kind of science course described above. Physics 102 approaches physics as a human endeavor, in philosophical and social context. It includes such societal and cultural topics as scientific methodology, the interpretation of relativity and quantum theory, pseudoscience including creationism, the search for extraterrestrail intelligence, ozone depletion, global warming, technological risk, energy resources, nuclear power, and nuclear weapons. It is non-algebraic, but quantitative in the sense that it frequently uses numbers, proportionalities, graphs, powers of ten, probabilities and quantitative estimates.

Following the difficult task of obtaining approval from the university's conservative educational fathers, Physics 102 began in 1976 with 30 students per semester. Previously the physics department had offered a traditional physical science course, one with no "impure" (i.e., interdisciplinary) topics such as global warming, that students were avoiding in droves. By contrast with the fading traditional course, Physics 102 approximately doubled its enrollment every two years until, in 1982, it reached 220 per semester where it was forced to remain until 1995 because of competition for scarce teaching resources. Some 23% of our university's 9400 non-science undergraduates were then taking Physics 102 at some point during their college career. I regard it as a big mistake to have limited the course's growth during 1982-95. We were turning non-scientists away when they actually wanted to take a science course!

Finally, we expanded the experiment last year by enlarging the number of seats to 330 per semester, taught in two large sections. Not only did all 330 seats fill immediately, they filled faster than competing introductory courses such as geology, biology and astronomy.

This experiment underscores the science community's own responsibility for our failure to cure science illiteracy. The experiment indicates that students desire physics, but that most do not enroll in it merely because physicists have defaulted in the competition for these young minds. If we do not offer the courses, students cannot take them! And if we do not offer science courses that are socially and culturally relevant, students will remain scientifically illiterate about the science-related topics that really matter. They will regard our courses as pointless and thus avoid taking them.

We ignore these students at our peril. These students include the elementary education majors who will teach our sons and daughters, the journalism majors who will give our society its view of the world, the law and political science majors who will interpret our laws and who will be our elected officials, and the business majors who will oversee new technology development and hire our scientists and engineers. They include the parents of the next generation of college students. Anything that we do, or that we fail to do, to provide relevant science education for these students has a large future multiplier effect.

I suggest the following useful and reasonable goal for science and STS education: Biologists, geologists, chemists, and physicists on every campus should see to it that a large fraction, say 50%, of their non-science students completes a socially relevant general science course in their field. As another way of putting this, essentially every non-science student should graduate with two or more *socially and culturally relevant* general science courses under their belt.

Teaching global warming

I want to provide practical information on teaching just one particular STS-type topic, global warming, within a broader science course. Space prevents me from discussing more of the many such topics included in Physics 102 (see Hobson 1995). Although I will present global warming within the framework of a general physics course, this topic is rich in chemistry, geology and biology, and could just as well be taught in those introductory courses.

Topics such as global warming can be dangerous, because instructors and students can get wrapped up in these intriguing ideas and spend more time on them than had been planned. I try to restrict myself to a single 50-minute period on this topic. Here, I will only describe a few of the main points covered during that time, along with some useful references for further information, and refer to the course textbook (Hobson 1995) for details. This description will be presented in the form of suggestions to teachers.

Begin by presenting the relevant pure science. Review the chemical composition of the atmosphere, emphasizing the many trace gases (much less than 1%) such as ozone, water vapor and carbon dioxide, that have an important effect on life (Hobson 1995 Table 9.1). Review the electromagnetic spectrum, and the solar spectrum, emphasizing the dominant regions in the solar spectrum (IR, visible, UV).

Discuss the flow of solar energy as it is received and ultimately re-emitted by Earth. Describe this energy flow through a hypothetical Earth whose atmosphere lacks the greenhouse trace gases (Hobson 1995, Figure 9.18). The temperature of this hypothetical Earth would be -19°C, the temperature of the top of the real Earth's atmosphere. Next, describe the energy flow through the real Earth, with the greenhouse gases. The energy flow is now vastly different (Hobson 1995, Figure 9.19). There is now an "energy recycling" effect that is very large in energy terms. This recycling is the greenhouse effect, and it raises Earth's surface temperature by 33°C, to an average temperature of +14°C.

The greenhouse gases act like a small tail wagging a very large dog. These trace gases have an overwhelming effect in controlling the energy relationship between Earth and the sun. One of the most important greenhouse gases, CO_2, has increased by 29%, from 280 ppm to 360 ppm, during the industrial age. Without drastic action, such as a 50-80% reduction in annual anthropogenic CO_2 emissions, atmospheric CO_2 is expected to double sometime during the next century.

According to the UN's Intergovernmental Panel on Climate Change, such a doubling would increase Earth's average temperature by 1-3.5°C. Discuss the computer models of the atmosphere upon which such predictions are based. Before 1995, there was some descrepancy between the computer models and the observed data. For instance, the models were predicting that warming of about 1°C should have occurred by now, whereas the data shows that only about 0.5°C of warming has actually occurred. In 1995, global climate modelers discovered the importance of trace anthropogenic pollutants, especially the sulfur compounds. Now that these pollutants (which have an overall cooling effect) are included in the models, there is good agreement between the models and the data.

Present some of the data. The global average surface temperature since 1860 (Hobson 1995, Figure 9.21) is especially pertinant. As mentioned above, this record shows an 0.5°C warming, and agrees well with the models. A second revealing piece of data is the Antarctic ice core record, which reveals the CO_2 concentration and the temperature during the past 160,000 years (Hobson 1995, Figure 9.22). These records show a close correlation between CO_2 levels and temperatures; they show that the difference between an ice age and an interglacial warm period (such as today's) is only about 5°C, and they show that the CO_2 level has remained in the range 200-290 ppm during the past 160,000 years. The present level, 360 ppm, and a future doubled level, 560 ppm, are thus unprecedented during this time interval that extends back through the preceding interglacial period.

By this point in the discussion, students might be asking lots of questions. They will probably want to know about other predicted effects, other than higher temperatures. These effects include rising ocean levels (a 10-20 cm rise has already occurred), increased cloud cover, plankton blooms, spread of mosquitoes and other disease vectors, increases in malaria and other diseases, expansion of the tropical climates, a 550 km northward shift of midlatitude climate zones, extinctions of some tree species and northward shifts of others, loss of mountain glaciers, coastal flooding and resulting loss of land, stratospheric cooling, increases in high-latitude precipitation, excess warming at the poles, retreating polar ice, decreased Asian monsoons, and weather extremes such as heavy reainstorms, severe droughts, and excessive precipitation in the cool months. Enough of these "footprints" have already been observed that the Intergovernmental Panel on Climate Change and other observers agree that climate change has now been observed in the data. For further details see the bibliography below and Hobson (1995).

Students also want to know the sources of greenhouse gases, and how emissions can be reduced. The basic answer is: Fossil fuels are the primary source, and emissions can be reduced by conservation and lifestyle changes that reduce fossil fuel use. Of course, there are many other culprits such as chlorofluorocarbon gases, methane releases, and deforestation. Further details are available in the references.

An annotated bibliography on global warming.

Books:

- Gore, Al *Earth in the Balance: Ecology and the Human Spirit* (Houghton Mifflin Company, Boston, 1992). A thoughtful and broad discussion of the major environmental problems (global warming, ozone depletion, water, genetic diversity, etc.) and the related questions of the human spirit (politics, materialism, religion, etc.). The book has had significant input from many scientists and is solidly based in good science. Chapter 3 discusses the climate throughout history, and chapter 4 discusses ozone depletion and global warming.
- National Research Council, *Global Environmental Change: Understanding the Human Dimensions* (National Academy Press, Washington DC, 1992). A behavioral

and social science view of global environmental issues. Global warming and global ozone depletion are prominent topics.

- National Research Council, *Ozone Depletion, Greenhouse Gases, and Climate Change* (National Academy Press, Washington DC, 1989). Proceedings of a joint symposium. Eleven articles by F. Sherwood Rowland, Mario J. Molina, and others.
- Schneider, Stephen H., *Global Warming: Are We Entering the Greenhouse Century?* (Sierra Club Books, San Francisco, 1989). The author heads the Interdisciplinary Climate Systems group at the National Center for Atmospheric Research. Scientific and societal aspects of global warming. Also the history and the science of global ozone depletion, pp. 218-237.
- National Academy of Sciences et al, *Policy Implications of Greenhouse Warming* (National Academy Press, Washington DC, 1991). Overall findings of a study under the National Academy of Sciences. Topics include effects of the greenhouse gases, policy, adaptation, mitigation, conclusions, recommendations.
- U.S. Congress, Office of Technology Assessment, *Changing by Degrees: Steps to Reduce Greenhouse Gases* (U.S. Government Printing Office, Washington DC, 1991). This OTA study offers two possible mitigation plans: a tough plan yielding a 25% reduction in CO_2 emissions, and a moderate plan yielding a 20% increase in CO_2.
- David L. Greene and Danilo J. Santini, editors, *Transportation and Global Climate Change* (American Council for an Energy-Efficient Economy, Washington DC, 1993). Eleven articles on alternative transportation fuels and technologies.

Articles:

- *Science* magazine follows global warming developments closely. See especially 21 April 1995, pp. 363-4; 22 September 1995, pp. 1659 and 1667; 3 November 1995, p. 731; 8 December 1995, pp. 1565-7; 22 December 1995, pp. 1904 and 1922. The IPCC and others now agree that the data shows the fingerprints of global warming, and that the computer models are in good agreement with the observations. These articles describe the expected,.and observed, fingerprints.
- *Scientific American*, September 1992. The entire issue is devoted to "Managing planet Earth." See: "The changing atmosphere" by Thomas E. Graedel and Paul J. Crutzen, pp. 58-69, and "The Changing Climate" by Stephen H. Schneider, pp. 70-79.
- Union of Concerned Scientists, *World Scientists' Warning to Humanity* (UCS, 1993). A majority of the living Nobel Prize winners, and many other prominent scientists, have signed this statement. It states that "A great change in our stewardship of the earth--is required if--this planet is not to be irretrievably mutilated." Covers all aspects of the environment, emphasizing overpopulation. Available from UCS, 26 Church Street, Cambridge, MA 02238.
- Gordon J. Aubrecht, II, *The Physics Teacher,* March 1988, pp. 145-152. A straightforward presentation of the physics of global warming, suitable for undergraduate physics majors. Includes 49 references.
- Pavel Ya. Groisman et al, *Science,* 14 January 1994, pp. 198-200. The extent of snow cover over the non-tropical part of the Northern Hemisphere has declined by 10% during the past 20 years. The feedback from this is likely to cause significantly enhanced springtime greenhouse warming.
- *Science,* 29 October 1993, p. 648. In the long term, slowing or even stopping the *increase* of CO_2 doesn't help. Current trends will push CO_2 levels to 8 times normal by the 23rd century; holding fossil-fuel use to today's level puts that date off to the 27th century.
- F. Sherwood Rowland, *Science,* 11 June 1993, pp. 1571-1576. AAAS President's (and recent Nobel Prize Winner's) Lecture, on scientific communication, scientific literacy, pseudoscientific ideologues, ozone, and global warming.

- *Science,* 14 May 1993, pp. 890-892. The ice, mud, and coral records reveal abrupt climate shifts during the last ice age.
- D. Raynaud et al, *Science,* 12 February 1993, pp. 926-934. The ice record of greenhouse gases, during the past 150,000 years.
- Dean Roemmich, *Science,* 17 July 1992, pp. 373-375. Ocean warming and sea level rise. The top 100 m of ocean water rose by 0.8°C and by 0.9 mm/yr during the past 42 years.
- *Science,* 22 May 1992, pp. 1138-1147. Several articles on global change. The lead-in news article is entitled "Greenhouse science survives skeptics." Articles on the threat to world food supply, biodiversity, environmental technology, teaching and research.

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Biography

Art Hobson is Professor of Physics at the University of Arkansas, Fayetteville, AR 72701, ahobson@comp.uark.edu. He is the author of *Physics: Concepts and Connections* (Prentice Hall, 1995), a textbook for non-science students that reflects the ideas of this paper. From 1987 through 1995 he edited the quarterly *Physics and Society*, the newsletter of the American Physical Society's Forum on Physics and Society.

ETHICAL AND POLITICAL DIMENSIONS OF TECHNOLOGICAL CITIZENSHIP

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What does citizenship have to do with technology? By way of an answer it can be noted that within the context of large-scale complex technological systems, citizenship needs to be conceived in two ways. One of these has received a fair amount of attention; one has not. The first one concerns the ways in which various technologies enhance or diminish opportunities for the practice of citizenship as it is conventionally understood, that is, as a citizen of *real* (not "virtual") communities and civil jurisdictions. Much discussion has been directed, for example, toward the role of telecommunication technologies such as the Internet, electronic bulletin boards, electronic mailing lists, etc. in facilitating dialog, debate, and the transfer of information concerning political issues ranging from the most localized level to the global. Interestingly, such channels have raised issues of citizenship in their own right—what is now commonly referred to as *cyber*citizenship. Another of the more heavily pondered topics in STS(S) has been and continues to be the effect of expertise (and the presence of experts) as an inhibitor of broad-based participation in decision making situations which, although ostensibly open to public input, are in fact relatively closed due to their technical nature. Anyone who has ever attended a zoning hearing or a public utilities commission hearing is familiar with this scenario. Once the lawyers, planners, engineers, financial analysts, and other technical experts start talking, there's not much hope for anyone else—including a lot of elected officials.

While these areas are certainly worthy of the scholarly and practical attention they have received, considerably less attention has been given thus far to another conception of citizenship. It focuses on the opportunities available to various individuals and groups to exercise decision making power over some of the most basic choices that are made in a technological society such as ours: decisions about whether and how various technologies will be introduced into the society and, once introduced, how they will be permitted to revise the form and texture of everyday life. Perhaps this issue has received relatively little attention because, as one prominent scholar-activist has suggested, our technologically driven way of life has been constructed with our unknowing complicity: by conforming to the myriad specific rules and requirements that the totality of our technologies engender, we have taken "unconscious collective actions" that reflect "a failure to evolve institutions through which we could begin to act upon appropriate questions" (Sclove 1995, 5, 7). In short, we don't recognize such matters as dealing with fundamental issues of how the society is governed.

Armed with these insights, a panel was organized with the above title for the Eleventh National Technological Literacy Conference in Arlington, Virginia, in February 1996. There were three panelists who brought very different and interesting perspectives to the above question. Considering the conference theme, the panel was implicitly addressing the question, What does citizenship have to do with technological literacy? There is a saying that "there are no coincidences:" the existence of *literacy* is an essential prerequisite to any experience of full citizenship. The next question, though, is a bit more elusive: What is it important to be literate *about?* After first reviewing the panelists' presentations, I intend to explore some answers to that question in this paper. For now, let it be noted that if technological *literacy* is a matter deserving of attention, then so must be technological *citizenship.*

A New Bill of Rights?

Frank Connolly, a professor in the department of Computer Science Information Systems at American University, presented a proposed "Bill of Rights and Responsibilities for Electronic Learners" (American Association for Higher Education 1993). It is premised on an emerging "technological empowerment" of all members of the "electronic community of learners," be they students, faculty, staff, or institutions. It includes both *procedural* rights ("A citizen's access to computing and information resources shall not be denied or removed without just cause.") and *substantive* rights ("The right to access includes the right to appropriate training and tools required to effect access." and "All citizens of the electronic community of learners have ownership rights over their own intellectual works.").

Both individuals and institutions are also charged with certain responsibilities in this document ("Each citizen, as a member of the electronic community of learners, is responsible to all other citizens in that community: to respect and value the rights of privacy for all; to recognize and respect the diversity of the population and opinion in the community; to behave ethically; and to comply with legal restrictions regarding the use of information resources.").

A number of noteworthy things stand out about this document. An obvious one is its borrowing of the name "Bill of Rights," a choice which ambitiously invokes a standard—and, no doubt, certain expectations—which may be impossible to deliver. Nowhere, for example, is it indicated how (and by what beneficent institution) will the rights, some of which imply the massive distribution of computing benefits, be guaranteed. Nor is it established by what institutional mechanism will responsibilities be enforced. Nowhere is it specified, or even laid out in generalities, how power should be distributed—and balanced—among the key parties in order for its provisions to be applicable to all of them. Yet despite these shortcomings (some of which are clearly way beyond its scope), the document does a number of worthwhile things. For example, simply by articulating certain principles, it becomes available for all to see, consider, discuss, and debate. It delineates the *domain* within which rights are to be had, and by whom. And it makes clear that rights can only be enjoyed to the extent that there is an assumption of corresponding responsibilities, something the original Bill of Rights neglected, so that we must endlessly bicker, for example, over just how far the freedom of speech, or the right to bear arms, should go.

In a legalistic society, if agreements and arrangements are to be honored, they had better be meticulously detailed in a contract. In a *moral* society, if rights are to be recognized and responsibilities assumed, they had better be detailed as well. It is a way of ritualistically formalizing the commitments that members of a community are prepared to make—to themselves, to each other, and to the community itself. In his books and essays, Langdon Winner (1977, 1982, 1986) has often noted that technologies imply powerful social contracts governing how rules, roles, and relationships will proceed within each technological domain; making such things more explicit can only be a positive step. Among other things, it helps to demystify the meaning that technology has in our lives. Of course, making something explicit and formal can backfire: witness the fate of the conservative Republicans' *Contract with America*. Creating new social expectations, especially in a highly publicized way, is a risky enterprise: should there be a failure or inability to adequately meet them, widespread disaffection will tend to follow.

A Gender Perspective on How Technologies Are Introduced

What kinds of cultural and gender "baggage" are associated with how technologies are introduced—especially into the home? Tara McPherson, on the faculty of University of Southern California's Film School, provided an enlightening and poignantly humorous perspective to this question. Clearly, in a culture that has been, thus far, unable to rid itself of many of the longstanding vestiges of sexual exploitation, even new technologies will tend to find their way into people's lives following old established patterns.

In keeping with such patterns, females are frequently altogether absent (perhaps *excluded* is a more accurate word) from the initial introductions of new technologies. When they do appear, or in any event when these technologies are finally presented in a more feminine light, it is generally much later, when manufacturers become focused on the need to expand the ways of marketing the technology or its applications. But the difference involves far more than timing: it entails the deployment of images and themes that embody a stereotypically female outlook: love, romance, beauty, comfort, etc. Thus, only after the electrification of a majority of homes and the development of electric motors for industry had occurred did a significant campaign to "win" women to the wonders of electricity materialize, sometime in the 1920s. Such efforts, most prominent in female-oriented publications like *The Ladies' Home Journal*, concentrated on the home (women's "proper place"). An effortless press of a button or push of a plug into an outlet could summon forth perked coffee, toasted bread, a hot iron, or warm baby's milk—things to "make your days easier and your evenings brighter" (advertisement, ç 1925).

More recent technologies have followed this familiar—and *familial*—pattern. When touchtone dialing was being promoted, as Professor McPherson recounted, it was injected with the theme of romance: lovers, feverishly anxious to reach each other, now had a faster, more convenient method. As the computer found its way into people's homes (a good bit after it was introduced into the workplace), we began to see, in advertisements carried by female-oriented magazines, images of the entire family gathered around the family computer. What could make mother happier than something that would bring the family together?

Of course, as Professor McPherson reminded her audience, absent from this "feminized" picture are some starker images those of us who are sympathetic to the *real* feminist perspective would insist be included. For while the computer was being introduced into the home with all the fanfare about family values, women who worked *outside the home* were already well-acquainted with this device. For those who toiled at what are cleverly called "pink collar" jobs, the computer was an alien and onerous presence: it saved labor, and in saving labor eliminated jobs (and thereby inflicted pain and disruption on real families). Moreover—and this is just as true today as it was, say, fifteen years ago—it demanded the acquisition of vast and complex skills which, once mastered, were soon rendered obsolete by the rapidly changing landscape of hardware and software. In occupations involving data entry, as opposed to clerical-secretarial positions, the unrelenting pace of the work done at a visual display terminal was and is typically highly stressful, with supervisors able to track one's every move through the monitoring systems enabled by the centralized networks. This stress has produced new variants of "terminal" diseases.

The Home Power Movement

According to Jesse Tatum, who has studied the *home power movement* for a number of years, people who participate in the movement exhibit behavior "well beyond traditional images of technical or economic rationality" (Tatum 1995, 97). Having at some point rejected the prescription of what in this culture constitutes a "normal" lifestyle, these are people who "share strongly felt motives that have carried them far from traditional patterns of life" (93). Instead of living in cities, suburban communities, or even rural towns, they live—often in clustered enclaves or communities—in remote areas, particularly in the western parts of the United States. Although they are identified by how they use energy, for the most part relying on small-scale renewable energy technologies, there are for many of them much deeper and more encompassing rationale for why they are living this way: "[T]here is clear and recurring evidence of a desire to reshape the human relationships of community and traditional definitions of work roles and a desire to redefine relationships with the natural world" (93).

Tatum conducted his first close-up investigation of the movement in 1989, spanning home power communities in four western states: Idaho, Washington, Oregon, and California (California is reported to have more home power systems than any other state). His findings provided the centerpiece for recommendations he presented in his book *Energy Possibilities* (1995). At the time of the NASTS conference panel that is the subject of this article, he was preparing to revisit some of these communities and incorporate some new data with support from the National Science Foundation.

What makes the subjects of his investigation particularly noteworthy is that they have, in effect, declared their independence from the established energy order and its large-scale, centralized, and remotely managed technologies. In so doing, they have reclaimed control over many of the decisions that have had to be made about how their homes and communities would be designed and powered. In a society in which the numerous technical decisions necessary to negotiate daily life are perceived as increasingly irksome demands on our already-overburdened attention, we are only too glad to see these decisions removed from our purview; better to let the experts take care of such matters. So it comes as a perplexity—with a tug of uneasiness somewhere deep down inside—to learn that there are people who have consciously taken back responsibility for such matters, and where they cannot assert adequate responsibility for a technology, they are likely to disassociate themselves from it. "Yet," Tatum declares, "this is not a utopian movement. Self-sufficiency, for example, is pursued only to a modest degree and as a means to assure the independence necessary to a reshaping of patterns of life in the ways just mentioned" (93-94).

Such people appear to exhibit a level of participation in the decisions affecting the content of their daily lives which is extraordinary by most standards. In this regard, they engage in a form of citizenship which is, in important respects, far more evolved than that practiced by the population at large. But the question arises: Must one eschew participation in mainstream American life in order to assert a measure of control over how key choices and decisions are made with respect to the introduction, configuration, and use of the technologies that have come to dominate the shape and texture of daily life? Is there no "happy medium" where people can inhabit *mainstream* society while retaining appropriate *rights* and assuming appropriate *responsibilities* with respect to the making of such decisions?

I believe this *can* occur, although there is much preparation that will no doubt need to take place both before and during such a potentiality. Improved citizenship—and one's inclination to strive toward it—do not just happen; they must *develop*, a matter I shall return to shortly. But there is something additional we need as we prepare to embark on this endeavor: we need a language which will permit us to differentiate what we are striving to accomplish from existing conventions. This language need not contain entirely new words, but it will most likely require new ways of naming things and, quite possibly, the naming of new things.

Langdon Winner, more than any other thinker that comes to mind, has contributed to the development of this language. His genius has been to crystallize both our understanding and our way of naming what we and generations of ancestors before us have been witnessing: the emergence of a new *sociotechnical* order. As this order has unfolded, it has wrought new forms of governance, forms that prompt us to inquire, as Winner (1977) has urged, not only "Who governs?" but, equally important in a world full of technological artifacts and systems, "*What* governs?" With this have also come powerful new *social contracts*, implied expectations of what social benefits can be derived from each new technology, and what must be surrendered in return. Taken in its totality, we can sketch the outlines of what Winner (1986) has called the "technical constitution of society."

Citizenship Redefined

Clearly, there is a pressing need to contemplate and discuss the fate of citizenship in such a context. The idea of *technological citizenship* has emerged in recent literature and discussions within the field of science, technology, and society studies (Frankenfeld 1992, Zimmerman 1995). It seeks to fill the void created by the inadequacy of a language best suited to the patricians of an ancient Greek or Roman city-state, or even the gentlemen-farmers and plantation owners of a Jeffersonian democratic vision. This revised citizenship is concerned with the norms, values, rights, and obligations according to which lay citizens might participate in the governance of the sociotechnical order by, among other things, having a role in the decision making about specific technologies.

At this juncture, let us return to a question posed earlier: With regard to technology, what is it important to be literate *about?* In what follows, I shall attempt a brief answer, but let it be understood that this is the beginning of a discussion which I hope will continue for quite some time.

In the context of technological society, with all that this entails that has been alluded to above, it is simply and dangerously insufficient to define *literacy* in terms of basic skills—even if we include *computer literacy* within the rubric of basic skills in such a society (with which very few people would argue). For that matter, even going a step or two beyond by incorporating some notion of basic *scientific* literacy, is still flirting with disaster—democratically speaking—if it goes no further. If citizenship within this context is to have a meaning that reflects democratic principles and values, which in my view means that it must go well beyond merely being a "member" of the sociotechnical order, a participant-consumer of its outputs, or a victim (actual or potential) of its disasters, it simply must embody the kinds of rights and obligations that Philip J. Frankenfeld (1992) has identified. Among his list of rights he includes (465):

1. rights to knowledge or information;
2. rights to participation;
3. rights to guarantees of informed consent; and
4. rights to the limitation on the total amount of endangerment of collectivities and individuals.

As one of the key requirements to be entitled to such rights, Frankenfeld makes it clear that "[c]itizenship...is limited to those who are capable of informed consent and autonomous thought" (471). On the face of it, this is no radical break with orthodoxy: legal conceptions of citizenship nearly universally exclude those who, by virtue of their age (children), their conduct (criminals), or their level of functioning (the mentally incompetent), are not deemed to be morally responsible. But I contend (with the support of Frankenfeld's framework) that the capacity to grant or withhold informed consent and to engage in autonomous thought is still not enough to make one a fully qualified citizen: to be *capable* of informed consent is one thing; to *practice it* is quite another. In other words, many highly intelligent, mentally competent, law-abiding adults will probably not qualify as full-fledged citizens *in the moral sense*, simply because they don't do what they are capable of doing.

This probably sounds rather extreme and elitist. But consider the argument that for every right claimed, to be valid, there must be a corresponding obligation. Thus, in Frankenfeld's model, the right to knowledge and information is linked to the *obligation to learn and use knowledge* (473). The right to participate is linked to the *obligation to participate.* And the right to guarantees of informed consent is linked to the *obligation to exercise technological civic literacy and technological civic virtue.* It is true that one becomes a *moral agent* by having the capacity for autonomous thought. But one becomes *virtuous* by turning that thought into conscious action.

Does this mean that the vast majority of citizens should not participate in the governance of our society—that it's actually better to leave the decisions to the experts? No, I don't believe this, and I am certainly not advocating it. In fact, a compelling case can be made that both expert and lay citizen alike may be equally unqualified to govern. The reason has little to do with technical understanding or expertise, but much to do with the inclination to exercise reasoned judgment *from a morally autonomous position*, and then to act in a manner consistent with that judgment.

A clearer sense of the argument I am presenting here emerges from a specification of the last two obligations Frankenfeld identifies: *technological civic literacy* and *technological civic virtue*. In his view, technological civic literacy is the realization that the role technology plays in our collective life goes far beyond the fact that the numerous technologies and technological systems in our midst have greatly altered the way many things are done; it embraces a view of technology as both a source and form of governing power and social order. Following from this, technological civic virtue embodies two elements which, taken together, concretize the link between virtue and full citizenship: an understanding of the profound interconnectedness and interdependence of all things, and the resolve to act in the world with a full sense of the responsibility that such knowledge entails. As one thus contemplates taking an action (or participating in a decision) involving the use of technology, one is therefore keenly aware of "the potency of consequences that technology brings, and the implications of this interdependence for moral responsibility to avoid harm" (1992, 474). In ethical thought, avoiding harm *(nonmaleficence)* is the minimum acceptable course; doing good *(beneficence)* is even better. Acting so as to prevent harm, do good, *and* promote autonomy (not just one's own, but other people's as well) is what really makes one a virtuous citizen.

The suggestion is not that we must always act in some perfectly optimal rational-moral way. That would, no doubt, be humanly impossible (and if it *were* possible, I'm not sure how *human* it would be). Instead, its value is that it gives us something to strive toward, something to approach. Along the way, we expand our consciousness of the consequences of our choices for ourselves, for each other, and for the environment. It will sometimes cause us to reconsider choices we have made already, as well as those we are contemplating. It may even cause us to choose to resist, repeal, or reverse commitments to policies and other courses of action long since entered into.

Frankenfeld's formulation reflects the influence of one of the best known and most widely read political theorists in the United States, Robert Dahl. In the book *Controlling Nuclear Weapons* (1985) Dahl set out to determine what form of governing authority is best suited for the task of overseeing this formidable technology. To assist in this inquiry, he established the meaning of *political competence*. In his view, in order for people to be qualified to govern—that is, be politically competent—they must possess two more specific competencies: *technical competence* and *moral competence*. Technical competence, that quality possessed by technical experts, involves knowledge of the best means to achieve a given set of ends. But only moral competence endows its possessor with the capacity to recognize what ends are desirable and appropriate. And then it goes a step further: "Since," as Dahl wrote, "it would be utterly bootless if people only knew these ends but did not act to achieve them, they should also possess a strong disposition actually to seek those ends. This quality may be called by an old name: *virtue*" (25).

If neither technical experts nor lay citizens have any particular advantage with regard to moral competence, and if technical experts at least have the advantage of their expertise, then one is tempted to conclude that on the basis of this advantage alone, experts should govern. In deference to Plato, Dahl calls this arrangement a *guardianship*, and reminds his reader that this is a patently authoritarian form of rule. But aside from rejecting such an arrangement on the grounds that it is undemocratic, Dahl contends that "prudence and practical wisdom" will militate against a guardianship of technical experts because no system is perfect, and when mistakes get made, democratic systems are much more resilient and forgiving:

> It is true that a democratic regime runs the risk that the people will make mistakes. But the risk of mistakes exists in all regimes in the real world, and the worst blunders of this century have been made by leaders in nondemocratic regimes. Moreover, the opportunity to make mistakes is an opportunity to learn. Just as we reject paternalism in individual decisions because it prevents the development of our moral capacities, so too we should reject guardianship in public affairs because it will stunt the development of the moral capacities of an entire people. At its best, only the democratic vision can offer the hope, which guardianship can never do, that by engaging in governing themselves, all people, not merely a few, may learn to act as morally responsible human beings (51).

Desperately Seeking Citizenship: A Conclusion

I have considered elsewhere (Zimmerman 1995) the advisability of a strategy, such as the one advocated by Dahl, that depends on placing people in decision making situations with the expectation that this will, by itself, assure both a democratic process and the further moral development of participants. My conclusion is that neither goal is likely to be reached to the extent that participants bring with them authoritarian predispositions. If anything, such a well-intended strategy can backfire, *reproducing* authoritarian repressive modes, as at least some participants seek, consciously or unconsciously, to assert heavy-handed control over the process. When this occurs, there is no guarantee that the remaining participants will be sufficiently alert to this, or that they will have the collective will to counter it and restore the process to a democratic mode. The lesson here is that participants must come to the process having already developed a sufficient degree of moral maturity.

Then what *can* be expected to work? Short of providing long-term psychotherapy to every citizen (which has its own power-related problems), we need to devise growth-inducing experiences which can be made fun and challenging, and be widely available. Drawing on the wisdom of Lawrence Kohlberg (1973, 1981), Carol Gilligan (1982), and Paulo Freire ([1972] 1986), among others, I suggest allowing would-be participants (that is, lay citizens) to have carefully structured opportunities to engage in role-playing scenarios which simulate both decision making processes and decision makers. While there is never a guaranteed result, the advantage of such "dress rehearsals" is that they cause participants to examine their own attitudes, values, mindsets, behaviors, and the like, as well as those possessed by other people who fill other roles. In fact, it may have the most promising outcomes when people are asked to play roles which they have hitherto perceived as antagonistic to their own real positions. The insights which may be gained from such experiences afford participants the opportunity to reexamine their beliefs and attitudes, reconsider their positions, or even revise their behaviors. Such experiences tend, by their nature, to be "eye-opening" and mind-broadening, as they help people gain greater clarity about their own beliefs and attitudes in relation to others'. In other words, they can help people develop their *moral competence*, so that when they do become involved in real decision making situations where there are real (and, quite possibly, considerable) stakes, there is a greater chance that both the process and the outcome will more closely match democratic principles.

What I have conveniently omitted here, but addressed elsewhere (1995), is the "minor" point that the institutional and structural arrangements in which and through which decisions get made must obviously be conducive to broad-based participation. Dahl's conclusions about the undesirability of a guardianship of experts makes it clear that such arrangements are both undemocratic and counter-developmental. However, I am convinced that simply changing the structures of decision making, without bringing more fully developed players to the process, will only recreate the same undemocratic structures. The point being made here can perhaps be likened to a band of muscles that surround a part of the body: with proper training, as they are stretched and challenged they expand their capacity, just as they make the structure they occupy capable of things that it was hitherto incapable of. What we need to do, then, is to make a commitment to begin training our citizenship muscle.

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THE OBJECTIVES OF TECHNOLOGY EDUCATION: A PHILOSOPHICAL PERSPECTIVE

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Throughout history, technology has provided appropriate tools, techniques, and technical systems required to meet human needs for survival. If technical means and processes are appropriately developed and used to meet people's environmental and social needs, standards of living can be enhanced, health improved, and human potential for the creation of a better society strengthened (DeVore, 1987). Because we live in a technological age that is characterized by rapid change, it has become imperative that social issues be placed in an educational framework. The education needed to be culturally literate today requires a world view and an understanding of the practice elements of this culture (Bensen, 1995). However, the knowledge of where we have come from is essential to understanding where we are going. This article is an attempt to disclose the objectives of technology education and its evolution as a discipline.

Background

In order to understand the role of technology education in education in general, and higher education in particular, a close look at its philosophical perspectives and its emergence as a discipline and a profession seems inevitable. Chaplin (1980) stated that, "Technology has provided and can provide the knowledge, energy, and material necessary to solve the society's problems of ecological damage, occupational and social dislocations, hunger, threats to privacy, the feeling of political insignificance of the individual, population growth, poverty, and the depletion of the resources" (p. 44).

Exploring the evolution of educational philosophies in European countries and their impact on American industrial arts, Nelson (1981) argued that "at about the time that people from Europe were colonizing for the first time on the eastern shores of America, educational philosophy in Europe was shifting from humanism to realism" (p. 20). Humanism placed emphasis on the teaching of the classics, while realism focused on social institutions. The philosophy of European educational leaders and social reformers, such as Comenius, Pestalozzi, Froebel, Salomon, and Della Vos in the 18th and 19th centuries, was instrumental in forming industrial education programs in the United States (Nelson, 1981). Believing that the Russian system of manual training, which placed instruction in the mechanic arts on a pedagogical basis, is an important turning point in the history of manual training and industrial education, Bennett (1937) concluded that, "The Russian system of workshop instruction in the mechanics grew out of a great need for a better system of giving shop instruction as a part of technical education of students of college grade" (p. 46).

American educational leaders such as Frederick Bonser in the late 1800s and William E. Warner in the early 20th century played a major role in the development of manual training, industrial arts, and contemporary technology education (McCrory, 1987). The historical development of the college level industrial arts education programs at The Ohio State University, an early pioneer in these programs, has its roots in the manual training movement of the 1870s. Ezell (1982) found that "This movement, generally attributed to Calvin Woodward of Washington University, St. Louis, Missouri, went through many influences and changes before it became what is presently called industrial arts" (p. 83). This program's initial purpose was to prepare manual training teachers, but early in its development it changed to reflect an industrial arts orientation. Under the leadership of William E. Warner, a graduate program evolved that had a major impact on developments in the profession (McCrory, 1987).

The Purpose for Technology Education

In response to the changing needs of our technology-based society, technology education has emerged as a field of study. Although technology education does not have a monopoly on the study of our society, it has the responsibility to participate in solving social problems. The discipline of technology education has the distinct advantage of working in laboratories designed to work with the technical means that provides the perfect avenue for accomplishing the basic skills (Lauda, 1988).

Technology education leaders believed that education and technology can solve most societal problems by providing new information and designing programs based on new knowledge. A very important role of education in technology is to foster the concepts of technological change. In this regard, Chaplin (1980) argued that "Education in the future will be concerned with teaching how to live with change" (p. 53). Obviously, citizens of the future must be equipped with certain basic skills, a desire for life-long learning, and values which enable them to perpetuate the goals of a larger society (Lauda, 1988).

The fact that skill of hand is an advantage to its possessor goes back to the time when primitive humans taught their children all the craft they knew, and when the exceptionally skilled worker was regarded as possessing super-human power (Bennett, 1926). Bennett provided a historical analysis of the evolution of technology education from the appreciation of the value of hand-skill to the individual to contemporary technology education.

DeVore (1980) argued that "With the study of technology organized into a meaningful whole and placed with the humanities and sciences, the education and preparation of future citizens in an age of uncertainty, value conflicts, and limited resources is aided" (p. xii). Referring to changing goals of industrial arts from the 1820s through the 1980s, White (1990) stated, "This major shift in the conception and the purposes of industrial arts remains a hotly debated issue, but the transition to technology education continues" (p. 1). Reviewing the philosophical issues and shifting goals of manual arts training, industrial arts education, and technology education, it seems clear that the profession has been continuously improving in order to adequately respond to people's needs. However, the main focus of the discipline, meeting humankind's social needs, has remained unchanged.

Philosophical Perspective

According to Bonser and Moosman (1924), "The industrial arts are those occupations by which changes are made in the forms of materials...for educative purposes, industrial arts is a study of changes made by [human]" (p. 5). The study of industrial arts serves two distinct purposes: vocational and general educational. Bonser and Moosman maintained that:

> The vocational purpose is the study of an industry for the sake of developing skill and efficiency in producing in this particular industry. The general education purpose is to help one to become efficient in the selection, care, and use of the

products of industry, and to become intelligent and humane in the regulation or control of industrial production. (p. 6).

The founders' description of the study of industrial arts identifies five specific, though closely related, values and objectives. These objectives are: an economic purpose, an art or aesthetic purpose, a social purpose, a health purpose, and a recreational purpose. The discipline of technology education is deeply rooted in the thinking of educational leaders and social reformers who established and advocated reform movements for the improvement of educational programs.

The Social Efficiency Movement

During the late 1800s, the social efficiency movement emerged as a proponent of industrial education. Educational philosophy of social efficiency supported by Charles Prosser, David Snedden, and Edward Thorndike, among others, was based upon the foundation that industrial and social efficiency could be achieved through the introduction of the subject field into public schools (Herschbach, 1979). Business and industrial organizations supported industrial education, because they thought it was necessary for the United States' economic growth. Supporters argued that industrial education could provide the American workforce with skills required for functioning in a machine production age. A study conducted in the late 1800s found that a massive increase in the numbers of public school students during that period forced public schools to adapt curriculum offerings to meet the needs of children of the working class (Herschbach, 1979). Because many students were dropping out of school, some educators suggested that industrial education was needed to prepare youngsters for the world of work (McCrory, 1987).

The Social Settlement Movement

The social settlement movement was founded in Britain in the 1880s and was brought to the United States by Robert Woods, Stanton Coit, Vida Scudder, and Jane Addams. Movement members participated in political and social programs to alleviate poverty and improve the living environment of the poor. In addition, advocates believed that giving individuals work skills via industrial arts education would help reduce poverty and create an air of equal opportunity (Luetkemeyer, 1985). After studying the movement in England, the social settlement advocates returned to the United States and established similar organizations in major industrial cities. For instance, the first American settlement was established by Stanton Coit in New York City in 1886. The settlement that became the most famous, Hull House, was founded in Chicago in 1889 by two women: Jane Addams and Ellen Starr (Luetkemeyer, 1985).

Educational programs developed by social settlement workers to assist the poor had a great impact on industrial arts education in America. Social settlement workers actively engaged in various political, educational, and other social programs that were designed to change the environmental conditions considered to be the causes of poverty. They also advocated that the public schools should adopt this social service philosophy. This concept was assimilated by John Dewey as a part of his educational philosophy (Luetkemeyer, 1985, p. 102).

Dewey's Psychology of Occupations

McPherson (1979) revealed that "John Dewey had great influence on the thinking of Frederick Bonser. A close relationship can be seen between Dewey's psychology of occupations and Bonser's psychology of arts" (p. 20). Dewey's concept of socializing education brought about an integration between the individual and society. In this regard, Dewey (1915) wrote:

> We must conceive of work in wood and metal, of weaving, sewing, and cooking ...

> We must conceive of them as their social significance, as types of the processes by which society keeps itself going, as agencies for bringing home to the child some of the primal necessities of community life. . . through which the school itself shall be made a genuine form of active community life, instead of a place set apart in which to learn lessons. (p. 14)

The school, Dewey observed, was isolated from life itself. Dewey selected activities which were of interest to the children and at the same time possessed educational value (McPherson, 1979).

The Social Service Philosophy

Based on John Dewey's educational philosophy, Charles R. Richards and Frederick G. Bonser conceptualized their ideas on industrial arts within the social service philosophy (Luetkemeyer, 1985). The fact that after more than half a century industrial arts and technology education focused on the education and training of mainly less-advantaged groups of society, reflects the service philosophy upon which this field was founded. Educational reformers including, Snedden, Prosser, and Dewey, among others, all advocated an educational reform movement which believed that traditional schooling would have to give way to new approaches more relevant to changing socio-economic conditions. They condemned sterile, exclusively bookish education and all wanted to broaden the curriculum by including studies more appropriate to a scientific technological era (Wirth, 1983, p. 141).

McPherson (1979) pointed out that "The work of founders Frederick Bonser, John Dewey, James Russell, and Lois Mossman in the progressive education movement developed an educational philosophy in which industrial arts was a vital part" (p. 23). Dewey had examined the works of such European educational reformers as Rousseau, Pestalozzi, Froebel, and Herbart and was actively involved in the child study and Herbartian movements which were popular during this era (Luetkemeyer, 1985). According to Luetkemeyer (1982), "this evolutionary approach to the study of industries advocated that an understanding of the present industrial civilization could be accomplished through the study of primitive cultures, showing how the present had evolved from the past... Units of study were concentrated about primitive industries which had evolved from the fundamental human needs of food, clothing and shelter" (p. 66).

An in-depth look at the history of humankind shows that any development which altered the technological means also changed the modes of thinking and behavior in that society (DeVore, 1980). Clearly, the characteristics of people and societies are related to the nature of the technology they have developed and employed. Although in ancient times futurists relied heavily on mysticism as they consulted oracles or mystics, the ancient world's ideas influenced human thinking about the future, because they believed that the future was not predetermined and that humans could shape it (Lauda, 1979, p. 219).

Transition of Industrial Arts into Technology Education

Introducing a rationale for transition of industrial arts education into technology education, Lauda (1988) argued that "industrial arts education responded to the needs of an industrial society throughout the years" (p. 14). Technology education evolved to meet the needs of a technology-driven information society. As the needs of society change, the objectives of educational programs must also change, and this calls for reform. The evolution of technology education represents an appropriate response to contemporary and future social needs, and it too must be in a constant mode of responding to change (Lauda, 1988). Industrial arts education focused on career exploration and vocation, consumerism, and skill development. Industrial arts heavily emphasized the purpose of subject matter as prevocational study (White, 1990). In contrast, contemporary technology education places emphasis on the study of industry and technology, critical consumerism, and the development of intellectual processes and interpersonal behavioral skills (White, 1990).

A close look at the definitions presented by technology education leaders indicates that the goals of technology education are quite different from those of the industrial arts. In technology education, major program goals stress adaptive, critical thinking, problem-solving skills and development in all domains of learning, which are essential to the preparation of productive citizens in an information age. White (1990) maintained that, "these skills are fostered through both group and individual learning activities within a core curriculum based on communication, construction, manufacturing, and transportation systems" (p. 18). Technology education allows the student to investigate in many areas and makes the curriculum relevant to all students, regardless of their academic goals. Schools in a democratic society should focus on the development of the individual. The only possible way to achieve this important objective is to provide experiences that will evoke thinking, feeling, and acting responsibly (Jennings, 1984).

The everchanging nature of technology has mandates that technology education programs be constantly revised, updated, and developed. To accomplish this, in 1981, twenty one leaders in industrial arts and technology education met to discuss and unite opinions about the differences between curriculum content. The document created from this meeting, the Jackson's Mill Industrial Arts Curriculum Theory, identified four curriculum content areas: communication systems, construction systems, manufacturing systems and transportation systems. This curriculum model was rapidly adopted and is currently in use today (McCrory, 1987; Snyder and Hales, 1981).

Conclusion

In this review of the objectives of technology education and its evolution from manual training to industrial arts and contemporary technology education, it appears that there has always been a strong connection between social needs, liberal education, and professional training. The valuable research of pioneering scholars such as Russell, Bonser, Woodward, and Dewey, as well as the work of many contemporary proponents of the field, reflects these founders' concern and conviction that the main purpose of technology education is to serve individuals and society.

Clearly, the study of technology has been in existence in one form or another throughout time. The objectives of manual arts, industrial arts, and technology education have always focused on solving humankind's social and environmental problems. Yet, technological growth requires a great deal of responsibility. To meet the present and future needs of society, technology education should be able to help individuals acquire problem-solving, critical thinking, and decision-making skills.

The founders' purpose of manual training, industrial arts, or technology education was to provide opportunities for individuals to contribute to the well-being of society. To accomplish this, technology education curricula should focus on liberal education as well as technical-professional training. It is, indeed, dangerous to prepare technologists lacking liberal arts education. Those technically-competent individuals who may not find the opportunity to become technologically educated might not be able to adequately serve the objectives of technology education.

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SCIENCE LITERACY STANDARDS AS ETHICAL THEORIES

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John Dewey once said that if you want to get at someone's philosophy, look at his theory of education. Answering questions such as, What is the aim of education? or What beliefs, attitudes, and abilities are of greatest value? requires philosophical reflection. We are living in an era of science education reform, though many of us have heard this cry before. The new rhetoric comes under the rubric "science literacy standards." Theories of scientific literacy, in their various forms, constitute philosophies of education, specifically philosophies of science education.

Two documents mark the current landscape. The first to appear, the American Association for the Advancement of Science (AAAS)'s Benchmarks For Science Literacy (1993), followed the work which had spelled out the goals of the project in its title: Science for All Americans (Rutherford and Ahlgren 1989, 1990; hereafter SfAA). The fundamental premise of this book was to reduce the clutter of scientific facts or "content" in school science and focus on the "key concepts" which have "the greatest scientific and educational significance for scientific literacy" (SfAA, ix). Benchmarks specified the learning objectives to be acquired at various levels of K-12 education. The more recent document, representing an effort separate from that of the AAAS, the National Research Council's National Science Education Standards (1996), goes beyond merely specifying content or key concepts to address teaching and assessment.

The question we explore here is not the laudable goal of specifying what everyone should know about science in order to provide a scientifically literate citizenry; rather, the question here is, What are the theoretical, philosophical, sociological, and especially ethical underpinnings of this rhetoric? Furthermore, how do the various understandings which constitute STS square with this rhetoric?

We discern two quite different philosophies of education underpinning the reform rhetoric, to which we refer for simplicity's sake as positivist and pragmatist. In the remainder of this paper we will try to highlight the differences between them at the level of philosophy as well as theory and explore the consequences for practice of these two rather different outlooks.

Contemporary philosophy, which has been dominated until relatively recently by positivism and logical empiricism, holds that knowledge is found or discovered rather than made or constructed. "Hard facts" are uncovered and organized using the indubitable principles of a priori rationality. This understanding is the basis of traditional views about science. Scientific knowledge takes the form of universal, objective, and unambiguous statements of "Truth," such as laws, about the real world. It is easy to see why these philosophers concentrate on the correspondence of statements to the empirical world as the source of meaning and truth. If a statement is empirically meaningful, then it is also independent of the social or historical context in which it occurs. Thus knowledge on the positivist account is capable of being entirely abstracted from the contingent human discourse practices that disclose it. Moreover, this knowledge is capable of being formulated in technical language devoid of value judgments. Knowledge can be completely decontextualized. It is worth noting, however, that this claim to value neutrality is of course a value position (compare Rudner 1953).

Science for All Americans is quite explicit in its opening chapter about its realism, its universalism, its convergence theory of truth, and its faith in progress (SfAA, 3-8). It may seem at first that Science for All Americans rejects the total decontextualization of knowledge we just mentioned, since briefly at the beginning and much more fully in the "Habits of Mind" chapter toward the end it discusses the values that underlie and give character to science, technology, and mathematics, such as integrity, fairness, openness to new ideas, skepticism, and especially curiosity (SfAA, 9-13, 171-183, especially 173). But note that these are behavioral values of the human practitioners--and ideally of the scientifically literate--not values of the knowledge itself. The National Research Council Standards treat scientific knowledge similarly, although they seem more insistent that ethical issues can be embedded in the practice of science (NRC 1996, 200-203).

Pragmatists such as John Dewey on the other hand rejected such separations of values from facts or knowledge. All knowledge has values embedded in it because, for the whole-hearted pragmatist, the search for new knowledge is always undertaken in response to human needs, interests, or purposes. Neo-Deweyans refer to this as the "Human Eros," that is, our desire to live shared lives of expanding meaning and value (Alexander 1993). The concept of knowledge for its own sake is thus meaningless. We simply cannot reach a state of pure detached equanimity in which we have an undistorted view of reality. In contrast to the positivists, pragmatists treat theories and laws as tools or instruments for the practices of science, and scientific practices are tools for meeting evolving human needs, interests, and purposes. For science educators the relevant questions become, What needs, desires, and purposes will the science class fulfill for the student? What should science education enable the student to do? And what are the purposes and values of science education itself?

A hearty pragmatism such as Dewey's suggests answers to such questions, and we conceive of STS as following in the pragmatist tradition. Accordingly, we oppose efforts to decontextualize science and technology from society with its constituent beliefs, purposes, and values. While positivist philosophers of science (and science education) have focused on theory or universals, and while science teaching typically focuses on unifying principles or fundamental concepts, contemporary STS aims at overcoming theory-fact, theory-practice, or knowledge-value dualisms. Much contemporary STS holds a social constructivist view of the nature of science, as does the pragmatist tradition of John Dewey (Pickering 1992, 1995; Garrison 1995b, 1996).

When STS makes its way into the public school classroom, it is usually in the form of constructivist collaborative learning activities which center around the search for open-ended or pluralistic solutions to particular local predicaments which we deem at least in part to involve science and technology. It is these types of instructional activities which have promoted the use of just-in-time science content learning. Here the student does not begin with the abstract universals which have been dogmatically handed down, studying instances of these general laws and theories. Rather through problem solving, including such revered scientific methods as trial and error, the student constructs and chooses the tools, including conceptual tools as well as instruments of metal, glass, and silicon, which she finds most useful for her purposes. The tools of science and technology come to include much more than just laws and theories and, moreover, the student is better able to experience the extent to which scientific knowledge is culturally embedded. This is pedagogical pragmatism.

But what does pragmatist STS mean for curriculum reform efforts and science literacy? Pragmatism and STS alert us to the intimate intertwining of knowledge and values, especially in places and with materials positivists tend to consider value free, such as curriculum. Curriculum content can be distinguished analytically from pedagogy or instruction. "What" is taught and "how" one teaches have traditionally been treated wholly separately, as content versus form. For a pragmatist, however, this dualism cannot be maintained in any practice, certainly not in teaching. Student learning practices and the corresponding needs and desires they address cannot be divorced from the knowledge that is learned. Nor can teaching practices and the needs and desires they address be divorced from the knowledge that is taught and the evaluations that are performed. Since the means and ends of education emerge inseparably intertwined, curriculum must deal with both. (We will treat the ethical nature of instruction or pedagogy below.) Embedded in curriculum is an ethical stance precisely because curriculum defines, by virtue of what it includes and what it leaves out, what knowledge, attitudes, and actions are good or valued. Only partially concealed are questions of whose authority the prescription rests upon and whose interests it represents and serves. It may be ironic that the new focus on standards emphasizes "selecting and adapting curriculum" over "rigidly following curriculum" (NRC 1996, 52). It is not surprising, however, that the standards fail to face the problems with promoting common curriculum that were addressed after the NSF alphabet reforms of the 1950s and 1960s. A number of researchers at that time noted that, despite noble efforts to invoke common objectives, it was impossible to identify in practice a common curriculum. In short, the contextual contingencies in classrooms and school systems far outweighed commonalities across settings.

Both Benchmarks and the NRC Standards deny repeatedly that they offer curriculum, and they both emphasize the contingencies of classrooms. Nevertheless, the NRC Standards are self-conscious about their normative stance, explicitly stating that

> science education standards are criteria to judge quality: the quality of what students know and what they are able to do; the quality of the science programs that provide the opportunity for students to learn science; the quality of science teaching; the quality of the system that supports science teachers and programs; and the quality of assessment practices and policies. (NRC 1996, 12)

They recognize in a reflexive manner that they are normative, and that the values of a wide range of persons and institutions are involved in their successful implementation. There may be some reason for hope here, although the NRC Standards themselves raise the possibilities of "misappropriation" and "incorrect implementation."

The question of whose knowledge, values, and interests dominate the discourse comes to the fore when we ask STS questions about the sources of these standards. Perhaps both Benchmarks and the NRC Standards thought they could avoid the question of authority by denying prescribing curriculum and leaving "selection and adaptation" to local groups. Yet Science for All Americans is explicit: Project 2061 emerged from the scientific community itself, which may be presumed to have interests in the content, form, and implementation of its recommended standards (SfAA xiv-xv). In the lists of the categories of those participating in the development of Science for All Americans "educators" always appear last: this certainly gives the impression of a hierarchical power structure and the expectation of deference to technocratic expertise (SfAA, xvii). The NRC Standards offer a different impression: the list of the kinds of people involved in their development begins with "teachers, school administrators, parents," and ends with "college faculty and administrators, scientists, engineers, and government officials" (NRC 1996, 3).

Pedagogy incorporates an additional ethical stance, about what kinds of teachers and learners are valued. The pragmatist view regards teaching as an ethical act that should involve moral perception of the unique needs and desires of each student and the singularity of the particular teaching situation (Simpson and Garrison 1995; Garrison 1995a). The teacher and the curriculum should explicitly address the unique position of the student as knower and learner (Reeves and Ney 1992, 1993; Koch 1996).

It appears that the NRC Standards implicitly recognize this commonly "devalued" aspect of teaching, and they are quite pluralistic. However, such concerns are quite marginal in Science for All Americans and Benchmarks. These tend to reproduce in the student the scientist as disembodied mind, while traditional instructional, bureaucratic, and technocratic models of education, based philosophically on the positivistic fact/value distinction, ignore or deny the uniqueness of the particular teaching situation entirely. As to an ethical stance toward teachers, the NRC Standards in general urge both the institutional and the professional empowerment of teachers, as those who are in the best position to recognize the needs and potentials of their students.

The heart of this discussion concerns the danger of assuming that values and ethical positions are not involved in matters of curriculum and pedagogy. Another danger of which educators are keenly aware follows directly. If, as pragmatists suggest, knowledge is always sought or gained for the sake of doing something, and, as STSers suggest, knowledge is constructed with reference to the particular local practices and contexts in which it is produced and reproduced, then purpose and desire--those of the student, the teacher, society--become central to educational practice. It is for such reasons that Dewey insisted that education should be conducted through (not for) the occupations.

Now, given that implemented science literacy standards often take as essential to their aims the measurement or assessment of their working definition of scientific literacy, these standards authorize certain practices while leaving others contingent. Assessment is a technology which has values embedded in it and in its employment. If the practices which are authorized by the standards projects, or by state boards presumably seeking accountability, include assessment according to standardized measures, then these must become in part the aim of the student. These in turn constrain or even prescribe teaching practices, favoring those which enable students to achieve high test scores. What is important here is that, according to a pragmatic epistemology, the knowledge that is learned is that which the learning practices enable the student to do or perform. Practices concerning the taking of tests, therefore, call for particular kinds of attitudes and values and particular kinds of knowing. Students have little intrinsic interest in such learning. It is not valuable in itself; it only has exchange value. It can be traded for college admission and later for a job. But, as we said earlier, teachers already know this: they call it teaching to the test. In such situations teachers and students have to view curriculum and pedagogy as means separated from ends. Teachers and students themselves soon become means separated from ends, and that is immoral. The NRC Standards, to their credit, recommend a wide variety of forms of assessment, recognizing the different learning styles and strengths of different students. The relations of means and ends in the assessment of science literacy makes the ethical dimensions crucial.

Another danger of scientific literacy standards is the danger of preaching a view of science shown to be inadequate by recent research in history and philosophy of science (HPS) and science and technology studies (also STS). Benchmarks and the NRC Standards both seem to maintain the position that there are overarching unifying principles of science, understood as unitary, beyond those of the specific disciplines. However, HPS and STS have to a large extent given up on the old positivist unity of the sciences program, or the search for criteria demarcating science from nonscience. If the search for such unifying principles is futile, then what sense should we make of scientific literacy writ large? If we wish to encourage the student to look beyond the content of science into the realm of scientific practices, then scientific literacy begins to look like multiple scientific literacies which no single person possesses. The danger of the outmoded view is that science will continue to be reserved exclusively for the science lesson, and this means, for example, that few connections will be made to history in general, to literature, or to social and political life as considered in social studies.

Most importantly, the danger of scientific literacy standards which are based on an outmoded view of science is that they make the learning about science into a technical matter of mere replication of assessable facts and concepts. Such an approach does not encourage the student to understand that learning is an ongoing act of continuing creation of and reflective appraisal of knowledge and values, in which we participate in and out of school, during schooling and all life long. Thus, such literacy standards point to measures which are of little worth to teachers and of even less to students.

Does this mean that we now have to give up the prospect of purposeful science education reform? If by that one means a single, unitary summation of educational goals, then our answer is yes, partly for the pragmatist STS reasons given above and partly because imposing monolithic values is dangerous to our pluralistic democracy. But if by that one means the prospect of students' better realizing their unique potentials to act, create, and value, then our answer is no, and we urge further exploration of the kind suggested above.

In summary, we want to re-emphasize some trenchant ethical questions:

- Do the goals of STS fly in the face of those of science literacy standards?
- What kinds of knowledge, attitudes, and values, and what kinds of teaching and learning are advocated by scientific literacy standard reforms? What kinds of people do the literacy standards envision creating?

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Writing Racial and Gender Equity into Science Classrooms

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Realizing that an increased emphasis on communication skills in science classrooms has consequences for scientific professions, and also considering the potential impact that appealing to a variety of learning styles can have on gender and racial equity in the sciences, I want to propose a change: writing should become a teaching and learning technique used in science classrooms. This change would not mean that teachers merely spend more time explaining how to write a research report, but would require that writing assume a heuristic role in the classroom. The difference is articulated by V.A. Howard who suggests that "too much emphasis has been placed on writing as communication and not enough on writing as articulation'" (Howard cited in Rivard, 1994, p. 970). By incorporating writing into the curriculum teachers can challenge students to connect concepts and develop a sense of their own intellectual skills as well as see themselves as part of an intellectual community.

Instead of limiting ourselves to technical writing courses that teach conventional stylistics, but do not always exercise the skills associated with critical thought, scientists can use writing in more comprehensive ways. Before we examine applications and consequences of incorporating heuristic writing in science curricula, we can first see that writing does have advantages over speaking in the classroom. Drawing from Lev Vygotsky and M. M. Bakhtin, we can define the difference this way: abstraction, asking the students -- all of them, not just one at a time -- to draw their thoughts out of the immediate context and to reflect before responding; addressivity, with teachers directing student thought for the purpose of articulation instead of communication by the questions and the various audience considerations their assignments include; awareness, asking the students to acknowledge their thought processes; and articulation, which asks students to explain the process by which they are assimilating new concepts and drawing conclusions.

Approaches to reading and writing critically will be a continual thread as we move from learning styles, to communication skills, to strengthening the traditional science classroom. Current classroom logistics in the "traditional classroom" -- one characterized by large enrollments and a lecture-style format -- would have to be revised in order to implement this change. Keep these points in mind as a subtext for the larger issue that concerns most of you: the education of a generation which will be responsible for scientific creativity and productivity in the next century.

The Advantages of Writing Over Speaking in the Science Classroom

The application of writing in the science classroom can be approached from two angles. The first illustrates why scientific concepts and writing are important factors in cognitive development, and the second asserts that, for our purposes, in classroom settings certain aspects of writing lend it to heuristic application and further extend cognitive development. The first angle is based on theory, drawing from Lev Vygotsky's Thought and Language, in which he points out the important role scientific concepts have in the mental development of children, and how writing is cognitively different from speech. The second angle also draws upon theory. M.M. Bakhtin's work on speech genres shows how teachers, creating written assignments, are able to focus the "addressivity" of student "utterances" in a way that is not possible through oral utterances. The difference between oral and written utterances, according to Bakhtin, as well as the definition of addressivity will follow our examination of Vygotsky's distinction between spontaneous and scientific concepts and their influence upon mental development.

Outside of the confines of the traditional science classroom, we can look forward to incorporating science, not as a means of instructing students on compartmentalized topics, but for the overall development of thought processes. Writing has a specialized role in this development as it requires the practice of an awareness which is not present in the context of speech. Lev Vygotsky in Thought and Language emphasizes: "as long as the curriculum supplies the necessary material, the development of scientific concepts runs ahead of the development of spontaneous concepts" (1986, p. 147). He later speculates that there are two different types of reasoning and that the development of scientific, or nonspontaneous, concepts influences the development of spontaneous concepts. In this scenario a teacher's assignments are a source of concept formation and "determine the fate" of the initial mental development of students" (Vygotsky, 1986, p. 157). As he asserts that reflective consciousness is provoked by the introduction of scientific concepts, we begin to see that scientific concepts influence not only children's systematic ordering of spontaneous concepts, but also their way of thinking to themselves, which is articulated as their inner speech (1986, 171).

This realization is followed by Vygotsky's distinction between spoken and written speech. Writing in the classroom is important for students, because it requires different mental processes than speaking does. He notes: "the development of writing does not repeat the developmental history of speaking. Written speech is a separate linguistic function, differing from oral speech in both structure and mode of functioning. Even its minimal development requires a high level of abstraction . . . [requiring] a double abstraction: abstraction from the sound of speech and abstraction from the interlocutor" (1986, p. 181). Children do not have the motivation to write that they have when speaking, which is the immediate response and, as Vygotsky explains, "In written speech, we are obliged to create the situation, to represent it to ourselves" (1986, p. 182). The assumptions which underlie spoken thought disappear in the context of written thought where we must explicate the situation and complete our thoughts, while also projecting towards an imagined audience without the benefit of immediate response. For Vygotsky writing "enhances the intellectuality of the child's actions. It brings awareness to speech"

(1986, p. 183). Though first year college students cannot be considered children, and have already assimilated a range of scientific concepts before entering post-secondary education, writing is still able to encourage their mental agility, to affect the abstraction of their thought away from the spoken, and to require reflection.

Vygotsky has asserted that scientific concepts influence and order the development of spontaneous concepts, as well as have a strong influence upon overall mental development, while writing brings an awareness to speech. This awareness is complemented by M. M. Bakhtin's "addressivity." As we are concerned with the mental development of our students, we can use scientific concepts in conjunction with heuristic writing to enhance this awareness and to highlight addressivity. Bakhtin describes speech genres (including oral and written) under which different utterances may be grouped (1986, p. 60). Echoing Vygotsky's study of inner speech, Bakhtin emphasizes that: "Language essentially needs only a speaker -- one speaker -- and an object for his speech. And if language also serves as a means of communication, this is a secondary function that has nothing to do with its essence" (1986, p. 67-68). He then stresses the utterance as a "real unit of speech communication" whose boundaries are determined by a "change of speakers," a change which is made "in order to relinquish the floor to the other or to make room for the other's active responsive understanding" (1986, p. 71).

Here a distinction can be made between an utterance and a sentence: the latter is not demarcated on either side by a change in speaking subject; it has neither direct contact with reality nor a direct relation to others' utterances; it does not have semantic fullness of value; it does not have the capacity to determine directly the responsive position of the other speaker, that is, it cannot provoke response (1986, p. 73-74). Addressivity then, according to Bakhtin, distinguishes an utterance according to its quality of being directed towards someone, a quality which is not characteristic of a sentence. "Both the composition and, particularly, the style of the utterance depend on those to whom the utterance is addressed, how the speaker (or writer) senses and imagines his addressees, and the force of their effect on the utterance" (Bakhtin,1986, p. 95). This quality complements Vygotsky's view of writing as abstraction and reflection; both men have described cognitive aspects of writing which ask writers to deliberate their intentions. From the mouths of psychologists and linguists, the potential for writing to influence the development of thought processes can be seen even more concretely in student responses to heuristic writing assignments.

The abstraction of thought by writing (calling for reflection) and its element of addressivity (away from a waiting and responsive audience), allows teachers the opportunity to direct their students towards a specified, though absent, audience (e.g., asking the student to explain a lab procedure to a younger student or to correct someone's previously held assumption as it was articulated in 1613). Through heuristic writing the teachers can also open up a dialogue within the student, asking them to focus on how they can learn best and to articulate any difficulties they may be having (e.g., asking a student if, with the correct solution, they can rework last week's problem set describing how they miscalculated, or to try and trace the development of a particular discovery as they see it after assigned readings). In both instances the teacher is requiring the students to inscribe "written utterances" on their papers, rather than to merely compose sentences.

This abstraction away from any interlocutor clears away some of the issues which may figure into a spoken response in the classroom. The bell signalling the end of class is not about to ring. The negotiable time frame of a written assignment allows students a chance to synthesize, to make connections with other topics, to draw conclusions, and for overall reflection on the question posed. They can consult sources and confirm facts, while choosing their words carefully. Their written response does not necessarily have to be broadcast before the entire class, and instead of having only one student respond to a question, each student is able to respond.

The issue of directed addressivity is especially important for students who feel uncomfortable or do not get the opportunity to speak up in class. When describing danger points for women in the sciences, Barbara Furin Sloat notes many women drop science concentrations after the first semester of undergraduate courses "which apparently serve to discourage undergraduate students at a time when they most need support" (1993, p. 199). She adds "women ask fewer questions in undergraduate courses and engage less often in debate with other students and faculty members" (Sloat, 1993, p.199). Through writing a non-threatening space is created which can foster individual learning and still challenge students to continually reevaluate their approaches to and their thoughts about science. Even in the course of a classroom lecture, writing can be used to motivate the students away from passive listening and instead ask them to take some responsibility for the classroom dynamic, when the teacher asks for in-class writings. In "Journal Writing Across the Curriculum" Toby Fulwiler notes: "In one-sided discussions, where a few students dominate and others can't participate, interrupt with a short writing task and sometimes the situation reverses itself" (Fulwiler, 1982, p. 21). In that space students can describe problems and concepts in <u>their own language</u> rather than struggle for the appropriate words in front of their professor and colleagues. Evelyn Keller in <u>Reflections on Gender and Science</u> explains that:

> The characterization of both the scientific mind and its modes of access to knowledge as masculine is indeed significant. Masculine here connotes, as it so often does, autonomy, separation, and distance. It connotes a radical rejection of any commingling of subject and object, which are, it now appears, quite consistently identified as male and female. (1985, p. 79)

Writing heuristically offers voice to students regardless of gender, learning styles, or classroom performance. It also opens a space within the sciences which is not necessarily defined by "separation, autonomy, and distance." We can speculate on the profound differences gender, race, and ethnicity have on student approaches to learning and articulation. It does not seem very compassionate to insist upon the definition of every deviation away from the scientific norm before setting out to accommodate the variation of student styles in the classroom. Writing, in this case, is a way of inviting each student into the discipline, instead of asking them to earn their right to be there by adopting another voice.

Topic Knowledge & Writing Strategy Planning Activities :

- prewriting, planning, and outlining
- information review and synthesis
- content and rhetorical analysis of
- professional and peer text models using criteria checklists, criterion-referenced and reader-based peer response guides, and self evaluation forms (355)

From: Jacoby, S., et al. "Genre Based Developmental Writing Course for Undergraduate ESL Science Majors." Academic Writing in a Second Language: Essays on Research and Pedagogy. Diane Belcher and George Braine, eds. Norwood, NJ: Ablex Pub. Corp., 1995. 353-373.

Some Perspectives on Teaching Writing in the Science Classroom

There are a wide range of methods for incorporating writing and reading skills into the science classroom, with each encouraging students to develop different skills. Incorporating writing into the classroom allows teachers to create lesson plans which include discourse analysis, position papers, and research methods, and also provide the opportunity to use writing heuristically. Heuristic writing assignments ask students to focus on their problem solving techniques and the process by which they understand and assimilate unfamiliar concepts. This type of assignment also allows them the chance to describe their thoughts and observations in their own language. This type of writing is different from writing a position paper, because instead of asking the student to synthesize and frame extrinsic information, the student is required to examine "how" they are learning, instead of only conveying "what" they have learned. This process can be as simple as having the students write their way through a lab experiment, or write an essay explaining how they would teach the chosen topic. These methods can be adapted for specific situations, depending on the needs of your students. In the classroom where students are not native speakers, the use of writing and reading offers the opportunity for students to increase their comprehension of scientific discourse and distinguish and later use the subtle English of the sciences.

While teaching English for specific purposes, Sally Jacoby, David Leech, and Christine Holton created a course design with the intent of teaching second language students the nuances of writing an experimental report: "the sophisticated combination of description and persuasion necessary in the scientific argument" in addition to vocabulary and syntactic structures (1995, p. 351). While thinking of their students' needs outside of the context of their class, they decided that the lesson plans ought to strengthen the students' overall writing abilities, as well as help them write laboratory reports proficiently. As we read about the course we can see that reading strategies influence writing strategies. The challenge for Jacoby and her colleagues was to combine topic knowledge and writing strategies (drawn from the research of Hayes and Flower on the planning phase of writing activities (1987)) which include: prewriting, planning, and outlining; information review and synthesis; and content and rhetorical analysis of professional and peer text models (using criteria checklists, criterion-referenced and reader-based peer response guides, and self-evaluation forms (1995, p. 355)); in addition to considering "how to shape information both to suit the needs of an audience and to accomplish their own rhetorical purpose" (1995, p. 355). They paraphrase Rymer, asserting: "this ability is as crucial to writing research reports as it is to other forms of academic writing because the experimental paper is a highly 'rhetorical enterprise,' serving 'both as the vehicle for giving meaning to [experimental] observations and for persuading the scientific community that those observations are truths" [sic] (1995, p. 356).

As Jacoby and her colleagues conduct their classes, they try to give students concrete examples to analyze. One sample research report given to students concludes with the statement: "These data suggest that, at least during development, the presence of estrogen receptor alone is insufficient for the induction of either vitellogenin synthesis or the receptor itself" (Reigel, et al. cited in Jacoby et al., 1995, p. 362). Jacoby and her colleagues then point out: "In this sentence, the authors/ researchers argue that 'the presence of estrogen receptor alone is insufficient . . . itself,' but they embed this conclusion in a tentative introductory clause aimed at making their claim more acceptable to their readers" (Jacoby et al.,1995, p. 362). By reading their explanation of rhetorical strategies we will have a clearer understanding of how discourse analysis works in a classroom setting. Jacoby and her colleagues are taking this excerpt as an utterance, to refer back to Bakhtin, and examining it in terms of its inherent addressivity. Upon pointing out the author's hesitantancy, they explain that it is expressed in several ways:

> First, they choose to build their sentence around the verb *suggest*. The choice of this verb sets up an epistemic frame of less than full certainty within which to understand their claim. Secondly, the writers modify their claim with the adverbial phrase *at least during development* to indicate that the claim should be viewed as valid within given parameters. However, the words *at least* in the phrase lend slightly more certainty and potentially wider applicability to their conclusion. Moreover, the subject of the introductory clause, *these data*, focuses the readers' attention on the observable data rather than on the inferential process of the researchers themselves (1995, p. 362).

Jacoby and her colleagues conclude: "It is from such lexical choices that a writer can build grammatically, logically, and discursively effective expressions of thought" (1995, p. 362).

While critical reading and writing skills should be developed in the science classroom, Jacob's discourse analysis and composition is not heuristic writing. By looking into general purpose classrooms we can discover ways of including heuristic writing, position papers, and research skills. Suggesting writing activities for the high school classroom, Glynn and Muth list: explanatory essays in which students describe a complex science concept; a field trip in which students record reactions and observations; environmental action letters; newspaper accounts (1994). They also recommend laboratory logs in which students report observations, hypotheses, methods, interpretations, findings and mistakes, or science journals in which students describe participation in activities and reflect on actions and experiences (for example during participation in a science competition) (1994, p.1066). They stress authenticity within the writing tasks, that is, "they must involve a real audience and they must inform the uninformed, persuade, or call for action (Glynn and Muth, 1994, p. 1066). While these methods were articulated for a high school setting, they can be adapted to meet a range of student needs.

Of those methods listed, journals appear to be one of the most effective ways of establishing heuristic writing within classroom practices. Fulwiler explains that teachers as well as students can benefit from the introspection of keeping a journal because each minute of writing generates new ideas (1982, p. 16). If the teacher collects the journals, he mentions that they "can be spot checked, skimmed, read thoroughly, or not read at all, depending on the teacher's interest and purpose" but the less often a student receives feedback from a teacher, the less likely a dialogue will grow between them (Fulwiler,1982, p. 16). While experimenting with rhetorical strategies, students are noting new ideas and creating a record of their intellectual growth, but their journal can also make them more conscious of the classroom dynamic by asking questions like: "'What is your part in this discussion?' or 'Try to trace how we got from molecules to psychopaths in the last fifteen minutes' or 'Why do you think Tom just said what he did?'" (Fulwiler,1982, p. 21). In addition, once you ask a question out loud, one person can respond, if you ask for a spoken response, but by using writing 45 people can respond and their answers cannot be so easily forgotten. In addition to being used in class, the journal can become part of student preparation before class, asking them to "write about each day's lecture topic prior to attending class; after class, they are asked to write a class summary or write out questions to the lecture" (Fulwiler,1982, p. 23). These are just a few of the ways journals can enhance science classrooms. As we examine two other examples of writing in the classroom, we can see that heuristic writing, through journals, would have improved both classes by asking for the students to reflect upon and respond to the aims of the teachers.

Asking students to articulate their reactions to classroom experiences in a journal is one application, but writing assignments can also require that they synthesize key concepts or that they relate materials introduced in the classroom with community-based issues. "Science and Technology," a course offered during 1992 at St. Joseph's College in Connecticut, used writing to achieve the goal of emphasizing "the student's ability to use information to shape personal positions on a few issues of particular interest" (Markham and McKone, 1993, p. 306). The assigned position papers required students to "formulate and justify their own opinions" (1993, p. 306). In this instance an informal journal can provide the space where students consistently write, generating ideas and recording thoughts. Instead of being driven by the need to articulate "an answer," the student is freed to make connections and to speculate. The journal can then become a record of the process the student went through to compose the paper, noting research difficulties or uncertainties about the assignment.

Research and organizational skills are an important part of writing term papers and these skills can also be addressed in science-based writing assignments. In 1988, at Clarkson University in NY, a biology instructor and a writing instructor began working together to teach sophomores in biology how to write a review article (Hotchkiss and Nellis, 1988, p. 45). They note: "Without specific instruction sophomores: cannot choose an appropriate topic for a paper, do not know how to use library and research facilities, do not give themselves time to research a topic and get references" (1988, p. 46). Again we can see the emphasis on "what" the students know favored over "how" they know it. With the assumption that research skills are lacking, no exception is made for the students; no questions are asked in an attempt to find out why they do not know these steps. After being given a list of topics and an overview of the library, students in Hotchkiss' cell biology course were expected to compose a bibliography of articles published within the last three years pertaining to their topic with an option to revise. Hotchkiss does not state if any goals were established besides the requirement of completing the assignment, and student reactions to this assignment are not available to see how they viewed the task. The students were then asked to begin writing their reviews, to attend workshops (including one on plagiarism and organization), and to participate in individual conferences which were scheduled prior to the due date in order to augment the writing process (1988, p. 46-47). The use of writing workshops and team teaching across the curriculum expands the biology lab into an area in which interdisciplinary skills are taught and practiced, but in this instance heuristic writing in the form of a journal or logbook would have contributed an important dimension to their project.

Writing Activities

- explanatory essays in which students describe a complex science concept
- a field trip in which students record reactions and observations
- environmental action letters
- newspaper accounts
- laboratory logs in which students report observations, hypotheses, methods, interpretations, findings and mistakes
- science journals in which students describe participation in activities and reflect on actions and experiences; for example during participation in a science competition (1066)

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These classes utilized different aspects of writing in the science classroom, but one factor against the incorporation of writing workshops, journals and other forms of writing, discourse analysis, and peer review into science classrooms is the lack of time for the students and teachers, both of whom are coping with a challenging workload. Given time constraints it is much quicker to teach the break down of an experimental report and have students hone their styles by observing how published reports are constructed (i.e., noting typical styles of attribution, the points addressed in discussion sections, etc.). But without an heuristic component, writing is limited to communication and is unable to be a place where students articulate their processes and teachers respond to them. Vivian Zamel notes: "Unfortunately, the description of discourse or interpretive community has too often been reduced to identifying the language, conventions, and generic forms that supposedly represent the various disciplines" (1993, p. 29). When a student's understanding of academic discourse is limited to simply appropriating particular structures and phrases then writing, Daniel Bartholomae notes, "can become more a matter of 'imitation or parody than a matter of invention and discovery,'" while Peter Elbow notes the possibility that it "masks a lack of genuine understanding" (Bartholomae, Elbow cited in Zamel,1993, p. 29). More than the language of science students need to understand the process of scientific reasoning, and heuristic writing provides a space for opening up a dialogue between teachers, who have the experiences, and students who are only beginning to experiment.

We can see the context for student writing is being actively shaped by these teachers. Jacoby and her colleagues set out to achieve particular goals for their students. Their goals are not part of a hidden agenda, but instead enlist the students in order to achieve them. Collaboration becomes an inherent part of their writing process. An increasing number of non-native speakers in the sciences have to learn English, or a European language, in order to communicate their research across the scientific community. These students have the added benefit of carefully parsing scientific discourse and dismantling scientific claims, in addition to focusing on style and form. Additional methods for incorporating writing into the traditional science classroom include Glynn and Muth's writing activities, which can be ways of incorporating heuristic writing, in addition to Markham's use of the position paper and Hotchkiss's emphasis on methods of research and notation. All four of these approaches to teaching writing include methods, but they reveal four instances of long-term vision in which heuristic writing can focus students, while the teachers can determine the needs of their students, ask for their responses, and shape their pedagogy accordingly.

Incorporating Communication When Recreating Classroom Configurations

While it may seem that "teaching" and "writing" in the science classroom are mutually exclusive, and that any emphasis on "teaching" has no place in a discussion about writing, this is not possible. Because if the teacher is not aware of the fact that writing can be used as a heuristic device while trying to include it into their curriculum and if the teacher is not sensitive to diverse student learning styles, then writing will become an exercise in mimicry: a repeated lesson in ways to emulate the learning style and writing conventions of the teacher. James Slevin has succinctly stated that many teachers think of student writing as distanced from their own writing and the course activities, and in this scenario:

> Student writing is perceived, simply, as a neutral means towards the expression of thought. What counts is *what* the student knows, as if *how* she knows (the way of reading that becomes the way she writes, the way of writing that so profoundly influences the way she reads and thinks, and the "responsive" situation that precedes and follows her discourse) were a problem different in kind. Such a view of discourse removes writing from the context in which it occurs. (emphasis original, 1988, p. 12)

In addition to asking the student to conform to their learning styles, and ignoring "how" students are learning, those teachers are also overlooking the potential that writing has for opening a conversation about the class and for receiving feedback from the students.

While various attempts have been made, setting down guidelines to achieve a classroom dynamic which is balanced, both in terms of gender and in race, we continue to overlook the consequences of teaching practices because of our reluctance to look into each other's classrooms and to admit that teaching is an acquired skill rather than an inborn talent.

Sheila Tobias in her study, "They're Not Dumb, They're Just Different," descibes the experiences of seven "second tier" students[1] who were placed in science college-level courses (1990). All of the subjects, except one, had not taken college-level science; they were excelling in their own post graduate fields including literature, anthropology, and philosophy. Tobias reports: "With one exception, all did very well in their courses. One subject tied for the highest grade in a (summer school) class. The others were easily among the top ten percent" (1990, p. 16). These nonscience majors identified the following factors which detracted from the science classroom environment: a lack of community in a competitive environment; being taught through a microphone; and large-sized classes. They also noted students remain passive, quietly taking notes and modelling the professor and they also reported an overwhelming number of quantitative problems which prevented students from dealing with "how" and "why" questions (1990, p. 19-27).

Many capable students still move away from the sciences towards other fields after

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[1] People who did not pursue science for a variety of reasons.

experiencing the traditional science classroom. How different are the classroom experiences of students who choose to pursue a scientific career versus those who do not? The answer to this question reveals another communicative gap, or structural problem in the sciences. In Tobias' study we can see that students with a humanities background expect individual attention, collaborative community, interaction between teachers and students within science classrooms. We cannot ask would it be wrong for a science student to expect as much from their classes, without also asking if such an expectation is feasible. We are faced again with the challenge of altering classroom logistics in order to facilitate pedagogical change. The communication skills and academic community which are developed at the undergraduate and graduate level, grow out of the importance placed upon independent research, a lack of emphasis upon teaching as a skill, and the reluctance to cross disciplinary lines to improve the overall educational structure with the quality of life of both students and teachers in mind. This is the context into which students enter college. It is also the context which will affect how they view their responsibilities within communities later on in life.

At the very least, there is a communication gap stretching between teachers and students in the context of the traditional science classroom. The teachers have experience not just with their subject but also with the communicative practices of their field. They are already part of a chosen community, though we cannot know how often they consider students to be members of their community, instead of merely confining their priorities to departmental and administrative colleagues. Trying to understand communicative practices within the sciences, students who are taught only subject materials must blindly jump the gap by mimicry and imitation. The students who do not fall from the degree track will then take their teachers' places at the podium.

We have discussed the gap between scientists and non-scientists, the gap between students whose learning styles are and those who are not compatible with the traditional science classroom paradigm, and we have mentioned the gap between science teachers and students. It is obvious that the challenge to change our classroom format by incorporating heuristic writing is also a request for the reconfiguration of classroom logistics, and an invitation to dissolve the meritocracy which privileges some and prevents access for others.

Instead of criticizing the educator who has no time to pay attention to pedagogy, we can trace the weaknesses of our system of education back to its structure. We can locate them in our student-teacher relationships, in the dynamics which are established in our classrooms between students and across disciplines. We can see that these weaknesses are extending into the foundation of our society. We can also amend them by emphasizing pedagogy and communicative practices across disciplines, as well as by revising classroom logistics which do not provide adequate models for collaborative and cooperative communities. The privilege granted to certain learning styles in the science classroom and which later excludes the non-scientist from participating and often even understanding scientific developments leads to the creation of a fragmented society. These gaps leave us precious little ground to stand on as we try to see the potential impact education will have on our society in the upcoming century. The decisions and revisions we enact now can help us build a community based on collaboration and cooperation. This structure -- stronger and built with long-term consequences in mind -- can encompass our classrooms and communities if we are willing to support it.

Addressing Racial and Gender Equity

Critiques of traditional science classrooms (organized around lecture formats with large enrollments) claim that we are failing to address the needs of our students. We continue to reinforce the traditional structure of science classrooms when we refuse to focus on the long-term effects of science pedagogy on the scientific profession, and by being reluctant to ask questions like: "What kind of structural problems exist in the science profession, and how could these problems be redressed by revising our current pedagogy?" Not only should we be asking these questions, but we should also be searching for ways to resolve them.

The use of writing in science classrooms will remedy some of the problems of the traditional science classroom. Loyalty to the ways in which we were once taught, combined with efforts to merely maintain the educational system which is already in place, has two consequences for the sciences and science teaching. Traditional science classrooms perpetuate gender and racial inequity at the post-secondary level as a result of a weeding-out process that does not readily accommodate students who do not have (or cannot conform to) the approaches to learning which are encouraged in the sciences.

A wide range of student learning styles should be integrated into the development of teaching materials and pedagogical approaches; the consequences are evident in studies by Marshall Sundberg and Michael Dini, who have shown that attempts to appeal to a variety of learning styles result in increased comprehension and, eventually, application of scientific concepts for both female and male students. Richard M. Felder, professor of chemical engineering at North Carolina State University has isolated different learning styles, noting a predilection in his students for either sensing or intuitive perception; visual or verbal input; inductive or deductive organisation; active or reflective processing; sequential or global cognition (1993, p. 287). Students with a sensing perception, more adept with visual input, and possessing the other learning preferences listed in the first half of the duality are apt, according to Felder, to succeed in science courses (1993, p. 288). Perhaps the identification of learning preferences does not predict potential success or failure in the sciences on the part of the student, as much as it is an earlier indicator of how their educational needs will be met in the traditional classroom structure. Writing opens the space for students to individually process their classroom experiences, and also gives the teacher a way to monitor reactions and adjust lesson plans accordingly. The required articulation which is built into such a lesson plan may also compensate for students who are reluctant or do not have the opportunity to speak out in class.

The inherent discrimination which favors certain learners in the traditional science classroom's "weeding-out" is part of its emphasis on professional vocation. This practice turns away capable students, while also denying many students the chance to study science unless they want a career in the sciences. In addition to perpetuating racial and gender inequity in the sciences, our adherence to the traditional classroom structure has a second consequence for our students and the sciences as a profession. The traditional structure does not always prepare students who <u>do</u> continue in the sciences for the communicative tasks required of their later roles in academic, corporate, and community settings. The lack of emphasis upon communication skills in the sciences, with the exception of Rennsalear Polytechnic, the University of Minnesota, and a few other universities, assumes first of all that scientists will complete their studies and not decide to enter the fields of journalism, policy studies, political science, etc., and secondly that a scientist will not need these skills to manage a variety of roles. Being a professional in the sciences may in fact require that they write research reports, draft grant proposals, meet with board members, or even serve as liaisons between researchers and other members of the community.

The process of "weeding-out," with little attention being paid to the communicative skills of the students who do remain in the sciences, results in a structural problem for the science profession, namely the inability to bridge communication gaps. One of these gaps separates the scientist from the non-scientist. On one side stands the scientist who is unconcerned with explaining and perhaps unable to rephrase his or her work in non-scientific terms, to people who are not scientists. The people on the other side of the gap range from congressional representatives to corporate sponsors, and from colleagues in other departments to first-year students. The consequences of this gap for scientists include funding problems; the enforcement of disciplinary pigeon holes; and a lack of appreciation for the process and products of scientific thought. One of the most detrimental consequences for non-scientists is the inability to understand and participate in scientific discussion and development.

In other words, though science is affecting our society, many people within our society are refusing to even acknowledge the impact of these changes and the process by which they occur, let alone take an active role in the process. This refusal is actually being encouraged in our classrooms, instead of being challenged. Increasingly widened by the professionalization of the sciences in our education system, this communication gap leaves a disproportionate number of women and other minorities standing opposite the scientists. After questioning racial, ethnic, and gender diversity in American classrooms Lewis J. Kleinsmith in his essay "Racial Bias in Science Education" explains that:

> science education tends to illustrate a pernicious form of institutional racism referred to as indirect institutionalized racism . . . [referring] not to conscious deliberate attempts by individuals . . . but rather to organizational practices that have a negative impact on racial minorities . . . it is not discriminatory intent, but rather discriminatory outcome, that defines this kind of institutionalized racism. (1993, p. 182)

He castigates "weeding-out" practices as the "easiest thing for faculty members to do" and then emphatically notes that "such practices are socially irresponsible in an era in which our country no longer produces enough scientists and engineers to meet its future needs" (1993, p.189). Before we consider our country's needs, we have to think about our students, female and male, across a range of races: how will they act responsibly in our community as citizens? Beyond the needs of our country's labor demographics we must recognize that national borders no longer define our sphere of social responsibility. And as teachers, who are not merely occupational trainers, we cannot just think about students in terms of their professions. We cannot be only concerned with turning them into productive workers, or think of them as products shaped by our particular institution and then placed within a fixed social slot. Students should be sent the message that learning the conventions of scientific writing is not enough, cannot be enough, if they are to understand their discipline and speak out in their communities.

While racial bias is part of the inequity within the traditional classroom, there is also a discrepancy between the number of males versus the number of females who remain in the sciences. For a compelling account of the clash between standard ways of communicating in the sciences and individual paradigms linked to gender, take Evelyn Fox Keller's comments on Barbara McClintock in Keller's Reflections on Gender in Science, or her biography of McClintock in A Feeling for the Organism. After identifying science as a project founded on traditionally masculine ways of evaluating, hierarchizing, and conquering, Mary Rosner states, "both Keller and McClintock imply that the geneticist could have been more effective if she had 'translated' her results into the language, values, and so on, of the scientific community" (1994, p. 487). This argument is relevant to our discussion of student learning styles when we seek to redress gender inequity in the sciences, while also acknowledging that the traditional classroom sets students who cannot adopt the favored paradigm for learning against those who already have it or are able to conform to it. Instead of enticing students -- female and male -- to explore the sciences, education becomes an initiation which permits entry only to select students. Writing, as we noted earlier, can provide a space which is not as socially exclusive. This space does not necessarily have to be isolated, as journal entries become the basis of discussions or are shared with other students.

Conclusions

By attempting to address different learning styles in our classroom curricula, a wider cross-section of our students will be able to participate in the sciences. While there may be several pedagogical changes we can make to expand the number of students able to participate in the sciences, the use of writing in the science curriculum is one specific change which will strengthen the traditional classroom structure by engaging students' diverse learning styles while also providing the means for bridging the communication gaps that undermine the scientific professions. The use of writing in traditional classrooms is usually limited to the transcription of results as finished products (i.e., lab reports). But writing can be a heuristic device in the classroom in addition to providing the opportunity for teachers to encourage students to develop critical thinking and writing skills.

By interrogating our ideas about how scientific writing is composed, we can then ask our students to think about the impact context has on writing and, through our assignments, encourage them to become critical readers of scientific discourse. Lawrence Prelli explains, "whether a scientist is working in the laboratory, reflecting on problems in the study, or preparing a final draft for publication, considerations of audience will permeate his or her thinking" (1989, p. 111). By acknowledging that "instrumentation, collaboration, publication, and investment" influence scientific experimentation, is not to discredit it (Knorr-Cetina, 1981, p. 58). Instead, by understanding the forces which operate in the process of scientific writing, we can identify the skills we need to teach students. We can also try to compensate for the attitudes ingrained in the rhetorical style of scientific writing, and invest more time in considering ways to enhance the learning paradigm in science classrooms.

Attitudes embodied in the conventions of scientific writing influence they way students are taught. The mark of success requires that the students identify with those attitudes; feelings about colleagues and about their own agency are interpellated within these conventions. Wilkinson reveals a few of the values ingrained in scientific rhetoric when he explains: "first person singular is often inaccurate because the agent is rarely one person, . . . peer scientists are not interested in the participants in the research, i.e., that a colleague helped design the experiment, that a technician performed most of the analyses, that an undergraduate student performed certain analyses, and so on. Readers are interested primarily in knowing exactly what the research question is. what was done, what was found, and what the findings mean" (1992, p. 322). Not only does this focus ignore part of the context of the experiment, but it also de-values the individuals working on the experiment.

Scientists' writing is not objective, because they are part of a system and their experiences and needs often define their options. Similarly we can say that students are already part of a system when they enter a classroom. S. Glynn and K. Muth have stated this succinctly: "The students' expectations, beliefs, values, sociocultural background, and existing knowledge have an influence on the processing of information. What students construct determines what they learn" (1994, p. 1059). Students, whether in high school or as graduates, do not have a complete paradigm internalized for comprehensive learning. Instead of only relaying knowledge, teachers must also be able to help the students develop skills.

Science teachers can employ heuristic writing to strengthen students' internal paradigms for comprehensive learning, but the students will be the ones to draw this paradigm out of the classroom and into their communities. This means that the teachers should not only be concerned with posing questions, but they must also be attentive to the kinds of questions they ask. Teachers can challenge their students to understand how historical change affected communication in the sciences, to become aware of the genres are available for scientific writers, and to examine the societal context within which authors were writing scientific papers and how it influenced their writing. Heuristic writing, whether it takes the form of a journal or essays, gives the teachers the means for not just posing these types of questions in class, but also allows them to evoke an individual response from each student. In addition, peer exchange, collaborative papers, and discussion groups using classroom writing as an initial point of departure, incorporate group dynamics into the traditional classroom structure . Peer exchange can range from a critique of writing style to reading and responding to the content of another student's paper. This approach is similar to journal clubs in biology as it brings students together to discuss an aspect of their subject which they choose to present, but writing assignments give teachers the opportunity to focus the class on issues which may not be included in academic journals, to require that the students articulate the process as well as the product of their research, and they also allow students the option of contributing their own speculations and experiences.

These activities create a working model for students to carry into their professional lives, and pose an alternative to current competitive practices driven by independent scholarship aimed at personal recognition. The teacher then has the option of responding privately, and of considering the students' concerns when developing or revising lesson plans. This interaction is simply not possible in the course of a classroom lecture or even in a discussion section, where not everyone has the opportunity to speak or has had the time to reflect upon the issues presented.

While the use of heuristic writing may provide a solution to the communicative gaps within the science profession; while it may provide opportunities for students with learning styles that are not addressed in the traditional science classroom[2]; while science teachers may even agree that they would like to initiate this kind of interaction with their students; any attempt to even discuss improving the quality of education in our science classrooms is a waste of time, if we agree that the only reason it cannot and will not be developed and implemented is because of classroom logistics. The overwhelming ratio of students to teachers, the responsibilities which constrain the time teachers have for students, and the pre-professional pressures which channel students into specialty fields contribute to our current classroom logistics. In this scenario courses are too concerned with covering the required material to wonder if the students are comprehending, much less communicating.

In addition to creating smaller classes, a student-focused approach would require changes in teacher training, or, in some cases, the implementation of teacher training. In order to develop communication skills in the sciences, expectations for designing curricula would also have to grow to make more allowances for concrete and abstract course goals. This would mean gradually redefining assessment in terms of short-term <u>and</u> long-term

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[2] students with a strong inclination towards intuitive perception, verbal input; deductive organisation; reflective processing; global cognition -- the other side of Felder's coin (1993, p. 287).

effects, despite the fact that in both cases the latter may be more difficult to assess through quantitative testing. These kinds of changes have been implemented before, in other disciplines. Composition classrooms, for example, have witnessed a move away from teaching writing as a product, fine tuned with proper mechanics, to a process.

Though our writing classrooms and our science classrooms are usually separated, their disciplines have had a common experience: both composition and science teachers have made the mistake of focusing on their subject material while ignoring the needs of their students in a social context beyond the classroom. This mistake, when made by writing teachers, relegated writing instruction to the composition classroom and has curtailed its potential for constructive change by limiting composition to the conventions of punctuation and grammar instead of opening it to challenge the student's ability to participate within his or her community. Writing teachers' past failure to recognize the student within the context of society, can be compared to the same neglect in the sciences which contribute to the communication gaps weakening the science profession. Now writing offers the scientists ways of addressing students' pedagogical and communicative needs. This attempt does not have to come from within one department, but can be developed across disciplines. We can ask: where are writing teachers during this conversation? In addition to structural and curricular changes, teachers need to start collaborating across disciplines on issues of pedagogy and communicative goals, if our colleges and universities intend to have a positive impact on our communities.

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ROCKEFELLER UNIVERSITY'S SCIENCE OUTREACH

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The process of scientific inquiry is the spirit of the National Science Education Standards and is embedded in all elements of science education reform. Scientists, along with Science Outreach teachers and students, who are immersed in the process of scientific inquiry can and must play an important role to encourage and nurture children who begin life with a natural curiosity about themselves and their worlds. Institutions of higher learning are needed to organize their prodigious resources and volunteer efforts within formal programs of Science Outreach. It is hoped that this report will encourage others to work toward improving science literacy for all.

Reform and Research

The National Science Education Standards advocate that children should learn the **content** of science through the **process** of scientific inquiry. Therefore, one challenge for science education reform is for students and their teachers to learn the content and process of modern scientific inquiry by engaging in research and by communicating their findings to others. Thus, precollege teachers and students need opportunities to gain mentored laboratory research experience and have access to national and international competitions such as the Westinghouse Science Talent Search and the International Science and Engineering Fair (ISEF). The Rockefeller University's Precollege Science Education Outreach Program (Science Outreach) has trained over 250 students from diverse schools and 30 teachers since its inception in summer of 1992. Researchers, working in 75 independent laboratories, provide *pro bono* mentoring in the biomedical and physical sciences while Science Outreach provides funding for a few students, for all teachers, and for teachers' action plans. Action plans, complete with budgets, describe how teachers aim to translate their research experience back into their schools for their students and colleagues. To date, 11 schools have received funding to support their teachers' action plans. The program's steering committee and staff assist in all phases, including evaluation.

In 1995, 10 (out of 300 nationwide) Science Outreach students became semifinalists in the Westinghouse Science Talent Search and two (out of 40 nationwide) proceeded to the finals where they became second- and fifth-place winners. Science Outreach students always had success in the Westinghouse, but 1995 was unprecedented. Moreover, two girls won a first- and a third-place at the regional NAACP Afro-Academic, Cultural, Technological and Scientific Olympics. Helping to foster these exemplary science competitions, the University hosted the local ISEF for the first time. ISEF is a good model for modern scientific research and fosters collaborative team projects. In addition to submitting a research paper, 70 students presented posters of their individual or team projects. Winners proceeded to the international fair in Tucson, Arizona where they won a first- and a third-place. Although these successes indicate high quality and strong commitment, it is also important for students to sustain interest in research. The behaviors of entering competitions and sustaining interest in science research may not necessarily be connected and the author is planning longitudinal studies which address this issue.

A Brief History

The Rockefeller University, founded in 1901, as The Rockefeller Institute for Medical Research was the nation's first institute dedicated to biomedical research and, in 1954, formalized its preeminence as a center for training the most talented young scientists in the world by inaugurating a graduate training program. Over the years, 19 scientists associated with the University have received the Nobel Prize, 14 have won the Albert Lasker Award, and five have been named Fellows of the John D. and Catherine T. MacArthur Foundation. Currently, 27 scientists at Rockefeller are members of the National Academy of Sciences.

The Rockefeller University has a long history of informal Science Outreach programs. Every Christmastime since 1959, leading Rockefeller scientists have presented the latest in their research to a packed audience of precollege teachers and students. This public series is named for its founder, biochemist Alfred E. Mirsky, who patterned the series on the Faraday Christmas Lectures held at the Royal Institution. Every summer during the sixties, graduate students conducted laboratory research courses for advanced high school students. By the late sixties, graduate students were involved in one-on-one mentoring experiences for students with weak science training before the program was eclipsed by tighter funding for research, among other factors.

It was not until the mid-eighties that this volunteer activity was renewed. Specialized secondary schools for science, math, and technology began offering research courses for their advanced students and contacted the University for assistance in placing their students with mentors for the purpose of gaining laboratory research experience. The University's response was very positive. Moreover, then University President and Nobel laureate, Joshua Lederberg encouraged scientists to apply supplemental federal funds toward supporting underrepresented students and teachers. The University even instituted a simple application process which formed the foundation for the Science Outreach Program. However, it was not until 1992 that a formal program was institutionalized with the appointment of the current director who has a doctorate in biochemistry, broad experience in K-16 science education, and an understanding of the culture and ethos of laboratory research in the biomedical and physical sciences.

The Science Outreach Program is Established

Even though the high school research courses developed by the specialized schools led to many students becoming Westinghouse semifinalists, finalists, and winners, the teachers felt no need to associate with University scientists who mentored their students. It wasn't until 1991 that these same teachers who had pioneered the research courses for their top students decided that they, too, needed to learn the latest in scientific research. Reading scientific articles or attending occasional lectures was not enough. These teachers felt the need to learn science as their students had, by becoming totally immersed in the content, process, culture, and ethos of modern laboratory research.

Responding to this need, the President's Office created a steering committee chaired by noted neuroscientist, Professor Bruce S. McEwen, and composed of master teachers from diverse schools and Rockefeller scientists. Spearheaded by Nobel laureate and University President, Torsten N. Wiesel, seed funding was raised from federal, private, and corporate foundations to appoint the first and current director, Dr. Bonnie Kaiser. With the help of the committee, the director selected five high school science teachers from diverse schools to gain two summers of mentored laboratory research experience and to work with the committee, their mentors, and colleagues in their schools to translate their research experience into active learning for their students and colleagues. The director also worked with teachers and community groups to recruit 10 underrepresented minority and minority students to gain mentored laboratory research experience. Two of those students became Westinghouse semifinalists even though one had no prior knowledge that the talent search existed.

The program maintains a steady-state of about six new and six returning teachers each summer. The overlap provides guidance for the new teachers and refreshes the returnees. No restrictions are placed on number of years of teaching or whether teachers come from public, private, or parochial schools. Some continue working a few hours per week during the school year and some stay for a third summer by raising their own support or by volunteering. They bring students for laboratory tours, and have their mentors assist in class especially when introducing experiments they designed as a result of their research. In addition to receiving funding for their action plans, teachers are directed to clearinghouses for usable equipment and to forums for presenting workshops to other teachers locally and across the nation.

All teachers recommend students who would gain from having a mentored laboratory research experience. This practice is largely responsible for the explosive growth in the number of Outreach students since 1992. During the first summer, there were 10. The next, 40 students with 15 supported by grants. The following summer, there were 70 students with 24 supported by grants. In the summer of 1995, there were 100 students with 36 supported by grants. Many return even as college interns and when they are sophomores or juniors, they may apply to the University's Summer Undergraduate Research Fellowship (SURF) program. With 75 independent laboratories and after only four summers, the University appears to be reaching its capacity for Science Outreach.

Moreover, the first group of Science Outreach students are now making decisions about graduate school and careers. The program has a database which can be used to track students for a longitudinal study. Such a study would be most helpful to learn how Outreach students' research experiences affect their decisions to pursue or persist in science careers, especially in the current economic climate. Increasing the number of students in the program also increased the likelihood that students and teachers would be in the same laboratories. It would be useful to explore how interactions among the students, teachers, and mentors influence students' decisions to pursue science teaching as a career. It would also be useful to explore how teachers and mentors are affected by their experience. For certain, mentors are learning pedagogical skills from teachers.

Evaluation and Evolution

The program had the foresight to involve an evaluation component from the beginning. The director and evaluators interview the teachers, students, mentors, and laboratory heads and gather additional information by formal and informal means which is used to improve the program's response to teachers' needs. Evaluation shows that teachers change from depending almost completely on lecture format to making the laboratory experience the central focus. In some cases, their schools alter schedules to allow more time for teaching laboratory science. Many teachers are pursuing higher degrees in science education while continuing to teach full time and most are conducting or planning laboratory- or technology-based workshops for their peers.

One Outreach teacher from a specialized school met regularly with all 24 of his students during the summer to review their research and progress in writing their Westinghouse papers. Partially as a result of these meetings, this teacher had seven Westinghouse semifinalists the first year and nine the next. Thus, the director instituted a requirement for all Outreach students to write research reports and meet in small groups every week during the summer. These meetings are also attended by the director, a teacher, and a scientist who facilitates student communication. Having to explain their research to their peers helps prepare students to write research reports. In combination with attending regular laboratory meetings, these activities helped students understand the science driving their experiments, and became - for teachers and students - a real benchmark in their learning science. Understanding the science discussions in their laboratory meetings became a right of passage into the culture, ethos, content and process of research. They had passed a milestone (Etzkowitz & Alonzo, 1996).

By working together in the laboratory, teachers' and students' prior notions of each other's roles become blended, and in some cases reversed. Teachers gently have to disavow students of their misperceptions and, in so doing, realize their own new role as collaborators. Laboratory heads deserve kudos for nurturing highly supportive learning environments which are conducive to students and teachers taking on new roles. Students, who had started their projects the preceding school year, often are the one's helping teachers learn how to use a sophisticated piece of equipment or perform certain techniques. On the other hand, graduate students and postdoctoral students who mentor high school students seek out teachers for their advice on how to teach the students. Teachers also can validate for the mentors that their charges are operating at a very high level, not seen in high school classrooms. Moreover, teachers learned that some of their students, who may not have been considered the top students in class, were able to perform at very sophisticated levels when placed in collaborative settings and given important research projects (Etzkowitz & Alonzo, 1996).

The mentoring, or apprenticeship, process prevalent in graduate research laboratories for training graduate students, is successful with precollege students and teachers as well. One-on-one mentoring uncovers misconceptions quickly while inclusion in designing and performing experiments, and analyzing the data collected, helps dispel incorrect notions. Students are primed to learn because they are trained on a "need-to-know" basis. Teachers are quick to incorporate this technique into their style with their own students.

Another observation concerns the conventional notion that teachers always must be "givers of knowledge." Students ask questions, teachers answer questions. Within the collaborative culture of a research laboratory, this notion is also confronted and dispelled. Experiments are done because no one knows the answers. The tenacious persistence of this perception, held by students, parents, administrators, and the teachers themselves, may have important implications for science education reform where teachers are expected to be facilitators in the process of guided inquiry. Unless teachers have enough training so that they can master the content and process of the science they are expected to teach, they may not feel comfortable in their new role. Indeed, the first thing that Outreach teachers implement in their classrooms is not the introduction of some new experiment or technology, but the **process of scientific inquiry** as they learned it in their collaborative research groups.

This year, 10 Westinghouse semifinalists and two finalists did their research projects at Rockefeller. This achievement, while unprecedented, is subordinate to fostering sustained involvement in research and nurturing student's passion for research. Some Science Outreach students, independent of whether or not they entered the Westinghouse Science Talent Search, have a broader horizon and continue working in their laboratories once their projects are "finished." Also, many researchers set a goal for high school students and teachers which is the same for all in the laboratory, and that is: the production of a publishable paper. In order to be included, one must perform above the level of technician and write a report which makes an identifiable contribution to the advancement of the field. They may then share co-authorship on papers which appear in prestigious peer-reviewed journals. This year, at least two teachers and six students became co-authors (Etzkowitz & Alonzo, 1996).

The program is evolving in other ways, too. Scientists gave seven workshops for various groups of teachers over the past two years. The program, while continuing to offer faculty-conducted workshops, is helping to establish Science Outreach teachers as presenters for their peers. Because these workshops are held in school science classrooms, they are expected to be highly successful at encouraging more teachers to implement new techniques and technology with their students. Beginning next year, all teachers' action plans will have to contain a design for a workshop in addition to classroom activities for students. In order for their schools to receive funding for their action plans, teachers present their plans and budgets to the steering committee at monthly meetings held during the school year. The discussion which ensues among master teachers, faculty, and educators results in suggestions for integrating the experiments with other sciences or in further experiments which could be explored, or easier, less-costly techniques or equipment which might be used.

Last year, the steering committee explored issues related to high school students who do laboratory research and to the roles played by their teacher and research mentors. In addition to gaining insight into the expectations and responsibilities of all involved, the committee recommended that more quality science fairs were needed in order to encourage more students to engage in inquiry and more teachers to gain experience with this lively forum for learning science content and process skills. As a result, the director met with Science Service and the University became a local sponsor for the International Science and Engineering Fair (ISEF). Seventy students presented individual or team projects covering 21 categories in the biomedical and physical sciences. The winners attended the international fair in Tucson where they won a first-place in biochemistry and a third-place in zoology.

Scientists and Science Education

Implementing the National Science Education Standards benefits from scientists, teachers, and students working in partnership to bring the spirit of inquiry into the classroom. Science Outreach can, and should, be an activity of all colleges and universities. Interest may begin by having classroom visits or laboratory tours where these could serve to build sustained partnerships, organized around exemplary curricula which already exist at the elementary level and which, to some extent, already may be present in classrooms. The strength of the Rockefeller University Science Outreach program lies in the fact that it meets a need. It is important to embrace the altruism found in scientists and to become more involved in middle and elementary school education in the future.

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Women And The Sciences At The Fieldston School: A Vertical Approach

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It has been widely observed that women, too often, veer away from science in their academic careers. "The pipeline is leaking women all the way along", *Science* magazine's 1993 report on women in science uses Sue Rosser's quote. "Unless this country does something to plug those leaks, women will continue to be denied opportunities in rewarding, high-paying careers and this country is going to be worse for it." (Alper 1993) Fieldston, part of the Ethical Culture Schools, has always been a co-educational, independent school and has had a long tradition of encouraging females to pursue courses in all sciences. Many alumnae have gone on to impressive careers in scientific fields. Nevertheless, we wanted to examine if Fieldston was losing talented women in the sciences, and were there strategies we could implement to increase our retention rate and actively support and encourage our female students. We undertook a retrospective statistical analysis of recent graduates as our data base to identify and track our scientifically-talented female students. We hoped to determine whether we lose female science students and, if we do, at what point. If we could identify causes then we could begin to take steps toward ensuring that Fieldston women maintain academic and career choices and are not limited by societal pressures. Mid-study, it became clear that a follow up survey of graduates was necessary to gain further information: college choice of studies, areas of graduate studies, reactions to secondary school experiences, and recommended improvements for our program.

We have increased our efforts to support and encourage female students at Fieldston based on what our research (as well as others') which found that the presence of other women in science is a key ingredient in women's success.

A series of Venture Grants from the Ethical Culture Fieldston Schools supported our research and indicate the schools' commitment to equal opportunity.

Methods

Phase 1

Using the records of all graduates from 1988 through 1994 (total 832; females:432; males:400) we created a data base using Fox Base® in the first phase of the study. Fieldston graduation requirements allow flexibility; they include 1 year of biological science and 1 year of physical science (earth science, chemistry or physics) in grades 9-12. Students are encouraged to take more science than is required. Graduation requirements and course offerings were constant over this period with the minor exception of some elective offerings. We entered the following for each student: class year, sex, verbal SAT score, math SAT score, science courses, math courses, advanced placement (AP) science courses, AP math courses, and other AP courses. The SATs during this period were also based on a consistent scale.

We used the data base for correlation studies of the variables within the records. We dismissed grades as a measure of ability or achievement because of their subjective nature and because of the variations in program and instructors. Instead we chose SAT's as a dependent variable because they were universally part of each student's record. Although we recognize the limitations of this instrument, for our purposes, we felt that the SAT would serve as a rough indicator of a student's ability in verbal and quantitative areas and could, thus, be used in correlation studies.

In order to maintain individual privacy and also to maintain the collective privacy of the institution, we analyzed the male and female enrollments in the science courses during this period in ratio form. These ratios were then compared to the ratios of the average SATs male to female in each course. The data base also allowed us to track enrollment trends in the physical sciences

Phase 2:

In this phase of the study, we sent 720 questionnaires to graduates from 1988 through 1993. The questionnaire captured how much science each student took in college, any graduate school experience, and the major course of study. It measured students' feelings about their high school preparation in the sciences. It was also used to track changes in major as well as the rationale for these changes. Free response questions elicited comments about their high school science experience as well as any suggestions for changes in the program that might improve females' opportunities in science. 107 questionnaires were returned after the single mailing with approximately twice as many female respondents as male. This information was added to the data base and further correlation studies were performed. Descriptive comments were read, and analyzed. We recognize that respondents are not necessarily representative of the entire population.

Results

The data are presented in table form as follows:

Table 1

Total Enrollment Figures For Fieldston 1988-1994

Class Year	Total Students	Total Males	Total Females
1988	123	54	69
1989	117	56	61
1990	110	59	51
1991	127	65	62
1992	115	59	56
1993	124	49	75
1994	116	58	58

Table 2

Enrollment in Science Courses 1988-1994

Science Course	Total	Male	Female
All Fieldston	832	400	432
Earth Science	377	176	201
Biology	398	177	221
Intensive Biology	426	219	207
Chemistry	413	182	231
Intensive Chemistry	216	121	95
Physics	237	129	108
Intensive Physics	235	138	97
AP Biology	94	47	47
AP Chemistry	22	11	11
AP Physics	38	33	5

Table 3

Ratios of Males to Females in Science Courses by Enrollment and SATs

Course	TOTAL	M/F Ratio	M/F Eng SAT	M/F Math SAT
All Fieldston	832	.928	1.001	1.063
Earth Science	377	.875	1.005	1.072
Biology	398	.801	.988	1.066
Intensive Biology	426	1.057	.993	1.041
Chemistry	413	.79	.988	1.042
Intensive Chemistry	216	1.27	.967	1.026
Physics	237	1.19	.979	1.031
Intensive Physics	235	1.42	.995	1.023
AP Biology	94	1.000	.948	1.005
AP Chemistry	22	1.000	.990	1.007
AP Physics	38	6.6	.895	1.000

Table 4

Chemistry and Intensive Chemistry Enrollment by Class Year

Class	Chemistry			Intensive Chemistry			All Chemistry		
Year	Total	Male	Female	Total	Male	Female	Total	Male	Female
1988	70	30	40	4	2	2	74	32	42
1989	57	24	33	36	19	17	93	43	50
1990	58	27	31	31	22	9	89	49	40
1991	57	28	29	43	20	23	100	48	52
1992	64	36	28	29	18	11	93	54	39
1993	54	20	34	41	19	22	95	39	56
1994	53	17	36	32	21	11	85	38	47

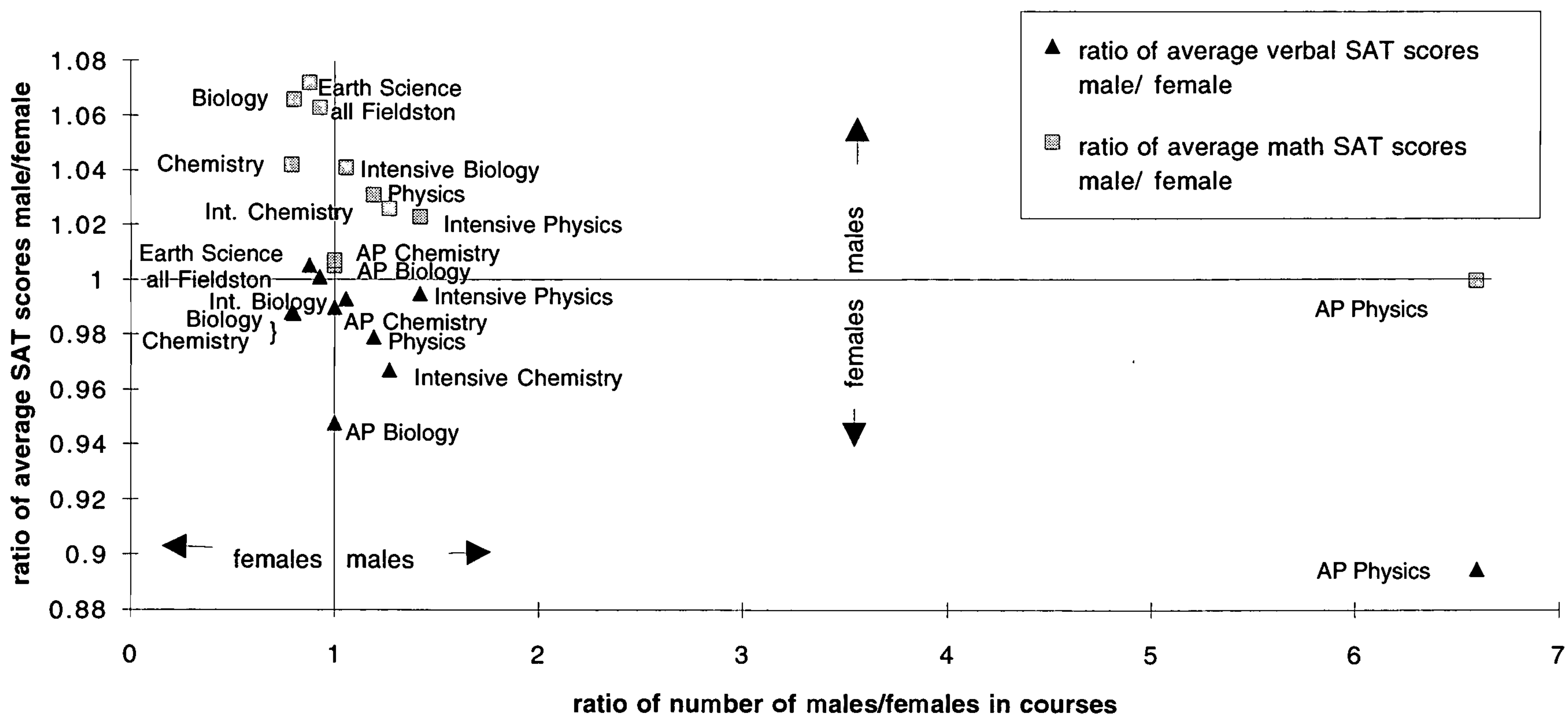
Table 5

Physics and Intensive Physics Enrollment by Year

Class	Physics			Intensive Physics			All Physics		
Year	Total	Male	Female	Total	Male	Female	Total	Male	Female
1988	14	7	7	31	16	15	45	23	22
1989	20	11	9	40	20	20	60	31	29
1990	20	11	9	36	25	11	56	36	20
1991	43	24	19	30	19	11	73	43	30
1992	43	30	13	29	20	9	72	50	22
1993	50	22	28	40	20	20	90	42	48
1994	47	24	23	29	21	8	76	45	31

The graph relates the ratios of average male to female SATs, verbal and math, to the ratios of males to females enrolled in each course.

1988-1994 Cumulative Male/Female Enrollment in Courses as Compared to Male/Female Average Verbal and Math SAT Scores



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Discussion

We are pleased to note that the analysis implies that Fieldston is serving its female population well in the sciences. However, we are aware that some females were indeed "lost" and elected not to enroll in upper level physical science courses. We expected to observe female "dumbing down", where we would find that the females in the less advanced courses would be more able than their male counterparts because of a reluctance to take the more challenging "intensive" courses. We did not find this, although we did discover a small number of students of both genders whose mathematics background would have made intensive physics the more appropriate physics course.

We also found that females are increasing the number of science courses they take. Their rate of increase is outpacing males who are also taking more science courses.

The graph visualizes our male/female ratios for both course enrollment and average SAT scores over the 1988 to 1994 period. The horizontal axis illustrates the course enrollment ratios: those courses to the left of 1 have more females while those to the right of 1 have more males. Most of our courses had nearly the same gender representation as the Fieldston population. However, in upper level physical science courses the ratios shifted. The physics, intensive physics, and intensive chemistry courses had a slightly higher ratio of males to females. Moreover, in AP Physics there is a dramatic disparity; in that course the ratio of males to females was 6.6 to 1.

The vertical axis illustrates the ratio of average SAT scores: those with a value greater than 1 indicate male strength while those with a value less than 1 indicate female strength. On the math SAT, the average ratio of male scores to female scores for Fieldston was approximately 1.06 to 1; on the verbal SAT, the average ratio was 1 to 1. The averages and ratios were determined for each course. The graph shows that the math ratio was markedly lower in these upper level courses, indicating that females who do elect the Intensive or AP level physical science courses, on average, scored similarly to the males on the math SAT. In AP Physics the ratio is exactly 1 to 1 indicating that females in this college-level course are as talented mathematically as their male classmates.

The ratio of male to female verbal SATs in all our upper level courses is less than 1, indicating that, on average, females in these courses have stronger verbal abilities. Whereas males in a given classroom may be more mathematical, the females in those same classes may have greater verbal skills. Both groups are very capable. This has a major implication for their teachers to address the students differences in learning styles and needs.

Summary and Analysis of Questionnaire

There was no significant difference in the percentages of male and female respondents who took science courses in college. Both females and males generally felt well prepared by their science experience at Fieldston. Fewer than 15 of the respondents felt unprepared (checked less than 5 on a 10-point scale) for their college courses. Of the 15 who felt unprepared, 12 were females, a disproportionate number given the ratio of the respondents. However, those females who felt less well prepared for their college courses tended to score higher on their SATs (math and verbal) than the same group of males This suggests that women may more often become victims of feelings of unpreparedness.

Almost all the respondents noted that the small class size at Fieldston was a major advantage of high school versus college. Several noted that even at Fieldston, some senior math classes were too large, supporting our hypothesis that small classes are the preferred learning environment for many students. Many also commented favorably on the hands-on learning approach at our school.

Female respondents appeared sensitive to comments made by science teachers and advisors. Many of them were distressed by comments such as "boys tend to do better in my class than girls". They asked teachers to ensure gender balance in discussions and recommend cooperative study groups for females. They stressed that advisors should be cautious when counseling advisees on course selection; modest direction, encouragement, or discouragement has a real impact on the programs actually chosen.

Both male and female students commented about computers and several wrote that computer skills are valuable in building confidence in science. Many students regretted not taking courses in computer science, physics or AP science. Many females felt that there should be more courses in engineering related sciences (e.g. computers and drafting). They also requested more three-dimensional and visual experiences.

Some females felt incompetent scientifically. They believed their environments (community or family) reinforced these feelings. Some felt unprepared mathematically, while a few said that they internalized the adage that "girls shouldn't be good in science." Many said that Fieldston allowed students to take only a minimum of science and this very freedom may have turned some away from the area. A few felt the beliefs that "men are smarter than women" or "women don't do science" were part of the general culture. Females overwhelmingly asked that science courses show more relevance to the outside world. Many asked that the sciences be integrated with other subjects.

Strategies

Based on our study, we created a peer network of females students with science interests. Two all-female study halls of ninth graders were scheduled for such students; these allowed females to work cooperatively and also to get "extra help" from female science teachers in charge. During these sessions, course selection was discussed, computers were available for game playing and analytical puzzles were provided. Quiet conversation was encouraged. Some of these female students actually refer to these study halls as their "support group." In the second and third years, tenth and eleventh graders who had "graduated" from the ninth grade study hall have visited and acted as mentors to the younger students. We envision this process will continue and will help establish a network of upper-class women with strong science interests.

We have discussed single sex education within the context of our co-educational institution, but this is a very charged subject. Occasionally, due to scheduling anomalies, we have had all-female classes. Last year there was a female physics class (with one male who elected to stay in the class) taught by a female teacher. Anecdotally, the class was more cooperative, less competitive, and more supportive than other physics classes.

We appreciatethe significance of female role models. The importance of female teachers in the sciences was clearly indicated in our questionnaire responses. Female scientists have lectured on their work to our female students with male students welcome. Our survey respondents indicated that more of this type of activity should be done, especially to illustrate career opportunities in science and engineering. We are also planning on-site visits to female scientists' laboratories. Many graduates expressed interest in our project and several alumnae have volunteered to help. We envision they could be mentors, in person or via the Internet. We also need to be more rigorous in explaining course offerings and presenting our programs to attract women.

Conclusion

In this study, we found that females at Fieldston are very well represented in our science courses with the major exception of AP Physics and to a much lesser extent in Intensive Chemistry and Intensive Physics. However, anecdotal responses indicate that female students are influenced by messages sent by their peers and teachers about their ability and prospects in science. In addition, there are many females who feel intimidated or unprepared for advanced courses. Advisors, mentors and teachers must participate in course selection to support and encourage females to take the advanced, quantitative courses.

Our new female study hall has fostered peer mentoring and collaboration accomplishing many of the suggestions made by our graduates. Suggestions that science courses, overall, be more relevant and connected to other disciplines (without sacrificing rigor) will help focus curriculum discussions.

Undertaking this study for the past 2 1/2 years has raised our awareness of our female students and their needs. As we emerged as the "women in science" teachers, females sought our advice on course selection and other issues. We also began substantive dialogue with our peers. Our efforts strongly suggest that a small amount of support can have great impact in helping females feel comfortable in their abilities and enthusiastic about scientific studies.

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The Cat in the Hat Comes Back

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There are widely circulated and accepted myths concerning science learning and teaching occurring in our professional community; they suggest that young children cannot design controlled experiments and hands-on investigations of scientific phenomena which would lead them to make their own discoveries, that they accrue scientific literacy mainly through observation and measurement activities, that they cannot sustain a long-term involvement on a specific topic, and that developmentally appropriate curricula is not academically rigorous.

To that proscribed limited and limiting view of science I say **humbug:** Young children can do and think science if we, the adults, support them in a way to look at the world.

The subject is hats - the children have been asked to bring in their **favorite hat** for sharing at circle time. Imagine a classroom where the children's attention is focused on a **"Farmer's hat"**... the kind commonly depicted in story books, TV cartoons and movies st in rural life. The children are laboriously brainstorming and generating a list of questions about this hat. A sample follows...

- What is the hat made of?
- Is the hat good for everyone...?
- Is the hat made by hand? By machine?
- Is the hat waterproof?
- Will the hat fit everyone?
- Why do people wear hats?
- Can the hat be used in another way?
- Can the hat be recycled?
- Can the hat go into the washing machine?

Always the focus is on children doing an activity or project and/or engaging in an experience or explorations. The thematic approach is designed to enable young children to use their hats as a problem solving tool. Attention will be given to relevant resource materials, the integration of all disciplines as well as strategies used to develop critical thinking and cooperative learning. Their hats provide the spark that ignites the interest of both teacher and student.

All too frequently National Reports bemoan not only the state of children's knowledge in science, but also the state of science education across the United States. All too frequently educators and teachers lament the shortage of time, meager resources, and lack of confidence as reasons for "not doing science" with young children.

Hopefully this presentation will demystify science experiences for young children by providing new curriculum approaches, by suggesting different strategies, by supporting an integrated broad-based global interactive program. It will incorporate tenets of economics, manufacturing, geographical concepts, occupational art and design, laws and patents, diversity, religious and cultural customs, past and present practices, seasonal hat gear, and health advice. This integration of subject matter will enhance, enrich and support the children's own discoveries during their hat projects. It shores up the teacher's self confidence, it permits flexibility in styles of learning and in styles of teaching.

We reach out to the children for their creative solutions and abounding energy - not only do the children find themselves empowered through their impact and involvements, but the teachers feel empowered also. Their view of the role of science in young children's lives is dramatically altered... But above all, this project is incredibly rewarding and great fun for everyone involved.

SAMPLE LESSONS

- GEOGRAPHICAL

People around the world developed different headgear to withstand the elements. For example, Eskimos used walrus fur, seal fur, reindeer skin, for all their clothing. Children select different geographical areas of the world to study and explore. After collecting data (computers, library, videos) they make a critical analysis of the hats worn by the inhabitants of each area. Were they suitable for the climate and weather conditions? Were these hats hand made or machine made? Were these hats waterproof? Were the hats all similar in design? Did the leaders of the community have different hats? Those students interested can delve into costume design and begin to research and compare clothing from different areas. Some new concepts should emerge from this study such as: most inhabitants use materials at hand to create ordinary every day head gear. For instance, farmers in Mexico either weave their own straw hats or buy them cheaply at a local market in their own town.

- MONEY MATTERS

Money is used around the world in exchange for goods and services. Countries use different units and symbols for their currencies. Children can share their foreign coin collection. We can visit a library and/or coin exchange shop to learn about the different moneys. In England the basic unit is the pound. In Japan the basic unit is the yen. In Mexico the basic unit is the peso. Children look at different samples of money from different countries and compare them to U.S. moneys.

- SHAPING UP

Let's visit a hat factory. If the children live in an area where they can actually visit a hat manufacturing shop, they should request a visit to see how hats are manufactured. The use of machinery, the use of computers, the use of patterns, molds, shapes, sizes, hand presses, materials, are all part of this scene. Students can discern the specialization of different occupations and learn about the myriad steps it takes to manufacture a hat. If there are no factories to visit I suggest that educators peruse through the attached reference sheet for appropriate material. In addition children should have the opportunity to visit hat stores.

- HISTORY: ITS ALL ON THE HEAD

Why did Indians wear feathers? Why did pirates wear the tri-cornered hat? Why did the knights wear helmets? Children do research on the head gear of specific groups. They must be able to debate and defend the appropriateness of the specific headgear to the purpose it was intended for.

- THE OCCUPATION DECIDES THE HAT

  Think of chefs, think of football players, think of firemen, think of astronauts, think of nurses, think of the bride and groom, think of the king and queen, think of the Pope and the Rabbi... why are they wearing the hats they wear?

- FAMOUS PEOPLE IN ACTION

  What did General Washington wear when he crossed the Delaware? What did President Lincoln wear when he delivered the Gettysberg Address? What did Daniel Boone wear when he went hunting? What did Pocahantes wear when she met Captain John Smith? What did Little Red Riding Hood wear when she met the wolf? What did Farmer McGregor wear when he caught Peter in his garden? What does the witch wear on Halloween? Children debate the purposes of these headgears. Again, the teacher may have to assist them in researching the history of costumes and clothing throughout the ages. It is the children's perceptions that matter; if these perceptions need clarification we assist them in moving forward.

- RELIGION DICTATES THE HEADGEAR

  There are videos on the different religions of the world. Children can view them and begin to see the commonalties of headgear and discern the foundations of why different groups may or may not wear designated head coverings.

- LESSONS ON COMMERCIAL DYEING, HAND DYEING, MAKING PATTERNS BECOME PART OF THE LEARNING EXPERIENCE

  Comparisons between artificial and natural fibers culminate in some simple experiments and explorations. Individualized activities are geared toward the developmental ages of the children.

- MATHEMATICS: PATTERNS, SYMMETRY, SHAPES, MEASUREMENT AND DESIGN ALL PLAY OUT IN THIS ACTIVITY

  The teacher plans appropriate lessons to shore up these concepts.

- ECONOMICS

  Students compare prices of different hats. Children follow the sequence of a hat from its inception to its sale to its function. They begin to understand why the price of the hat keeps changing as each individual responsible for, example; the manufacturing, the packaging, the transportation, the advertisement, the sales all change the price of the hat to the consumer. They develop and write their own sequence story book, for instance; The Hat that Jack Wore on the Way to Meet the Giant. For example, Jack's mother bought the wool from the man who had sheep. She knitted the hat herself but had to bring it to the dye maker who dyed the hat for her in big vats. So many individuals in the town loved the hat that they asked Jack's mother to knit hats for them...The children begin to envision the exchange of money and/or goods and the profit that Jack's mother needs to receive to compensate for her time and effort. She also had to pay people in order to get the raw materials.

- TECHNOLOGY

  For one day compare the hat you would wear fifty years ago, one hundred years ago, five hundred years ago--try to imagine what it would be like a hundred years into the future. Keep these questions in mind: Was your hat made by hand or machine? Was it made with the same basic materials as it was one hundred years ago? How long did your hat last? Was your 100 year old hat environmentally sound?

- SURVEY

  How many people wear hats today? Is there a difference in gender, age, occupation.

- WEATHER AND CLIMATE

  What do people wear when it snows, when it rains, when the wind blows, when the sun shines?

- EXPLORE PROVERBS AND COMMON SAYINGS INVOLVING HEADGEAR: For example, there is a B in your bonnet, there is a feather in your hat, you've capped it, hats off to you.

- BE YOUR OWN DESIGNER

  Design your own hats for people in different occupations, people who live in different climates, for your pet, for play, for sports, for theater, for babies and senior citizens, for astronauts and deep water divers. Try to use environmentally appropriate material. Children can have a hat fair and invite other classes to see them. Think of the Statue of Liberty and her headgear.

- CREATE A TIMELINE

  What hat did you wear when you were one, when you were two, when you were three? Continue until you reach the age of the child in your class.

- ORIGINAL WRITING

  Compose poems, write stories, rhymes about hats: example, Police Captain Holmes' missing hat.

- LITERATURE COMES ALIVE

  Children can read stories such as *The Cat in the Hat* by Dr. Seuss, *The Cat in the Hat Comes Back* by Dr. Seuss, *Pele's Favorite Suit,*, *The Quilt* by Ann Jonas, *The Emperor's New Clothes* by Hans Christian Anderson, *The Principal's New Clothes* by Stephanie Calmenson, *Immigrant Girl: Becky of Eldridge Street*, by Brett Harvey, *The Hundred Dresses* by Eleanor Estes, *The Lorax* by Dr. Seuss, *Crow Boy* by Taro Yashima, *The Snowy Day* by Ezra Jack Keats, *Dollars and Cents for Harriet* by Betsy Maestro, *Ashanti to Zulu: African Traditions* by Margaret Musgrove, *We are Best Friends* by Aliki, *The Three Hat Day* by Laura Geringer and *Caps for Sale* by Esphyr Slobodkina.

- ART ACTIVITIES

  Origami, fashion shows, hat sculptures, painting, clay work, etc. Dramatic play will also enhance this exploration.

- SCIENCE

  Study endangered animals. Which animals are extinct because they were hunted down for clothing? Does government make laws to protect animals? Is it moral to satisfy fashion dictates?

- ADVERTISING

  Create your own advertisement to convince the public to buy your hat, to convince the public that it is the best hat around, it is the best deal in town. Use a lot of descriptive words.

- SEE ATTACHED CLASS LESSON OF A THIRD GRADE CLASS AT HORACE MANN LOWER SCHOOL

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World View, Unit 1. A Social Studies Sound Filmstrip Program. Cassette and Teacher's Guide included.

Clearinghouse - Winter '95

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What do the third grade students in Room 210 at the Horace Mann Lower School all have in common? They are immersed in an environmental project documenting endangered and extinct bird life here in the United States in the last 25 years. They make use of all the new technology available to them. They collect and organize their data into managable reports. Utilizing the library's resources they build on their previous knowledge to confirm any changes in the data, good and bad ones.

Each student , whether working individually or collectively, pursues a project or task which will then be codified in a resource book for the whole school. The teacher goes from group to group asking questions, making comments, offering suggestions. She quietly takes notes on what she sees and hears. A student suddenly comments: "Wait till you see what I brought in from home..." The student unfolds a full page ad featured in the New York Times. The ad shows illustrations of **Feathered Fall Hats.** The student connects his studies with the advertisement.

At meeting time the student shares the ad with his peers. The stage is set. As expected the students, en mass, are enraged. The teacher, prudent and insightful, guides them into a dialogue. She is tuned into the impact of an unplanned lesson, the teachable moment. She helps the students stay on course.

- Is there a problem?
- Let's identify the problem.
- Let's collect some data.
- Verify information
- Consider possible actions.
- Consider the consequences of the action.

Some of the students' suggestions are:

- Write letters to the Department Store responsible for the ad- they state their concerns and ask for pertinent data such as origin of feathers used and type of bird feather.
- Meet the buyer of the millinary department and collect pertinent data.
- Ask for samples of feathers and have an expert identify the feathers.
- Picket the store. This led to a discusion of civil rights, permits, laws, etc.

- Send spies to the store....parents can check out the hats that are featured in the ad. A discussion about ethical behavior and use of licensed inspectors vs spies ensues.

  Gently probing their suggestions, the teacher helps the students realize that they can take positive actions. The students follow up on their own suggestions ; they refine their techniques. they firm up their strategies and move on. I will share with you the fact that the students were truly changed by this experience. They never expected to unearth the results that they did!

- Many of these feathers were ordinary turkey feathers that were dyed or hand painted for special effects.
- Some feathers came from molting birds.
- Some countries allowed individuals to pluck feathers from birds that have died. They are washed and dried on racks and then sold to hat manufacturers.
- Some individuals are bird farmers and breed certain birds for their feathers. They are licensed by the government and do not harm the birds.
- Many countries, but not all, have environmental laws controlling the pilferage and destruction of endangered wildlife.
- The department store initiated an examination of their policies on the importation of specific items for sale in their store.

  They learned a valuable lesson in stewardship and in being an advocate for the environment. Science does impact on our everyday lives! Bravo to these students and their sensitive teacher!

Resources:

Birds, Birds, Birds, National Wildlife Federation, 1412 16th St., NW, Washington, DC. 20036-2266.

Greta Nilsson, *Endangered Species Handbook,* Animal Welfare Institute, P.O. Box 2650, Washington, DC 20007. (One copy is free to educators.)

Julian May, *Giant Condor of California,* Creative Educational Society, 1972.

Dr. Seuss, *The Lorax,* Random House, 1971.

World Wildlife Fund has "Buyer Beware" brochures on illegal wildlife trade and a <u>Wildlife Trade Education Kit</u> containing background information, activities, and a slide program. For information write TRAFFIC (U.S.A.), World Wildlife Fund, 1250 24th St., NW, Washington, DC 20037.

Robert McClung, *America's Endangered Birds: Programs and People Working to Save Them,* Morrow, 1979

Endangered Species: Wild and Rare, National Wildlife Federation, 1412 16th St., NW, Washington, DC 20036-2266.

Esther S. and Bernard L. Gordon, *There Really Was a Dodo*, Walck, 1974.

Conserving America, Champion of Wildlife, is a video with accompanying activity and resource guide. Video and/or guide available from the National Wildlife Federation, 1400 16th St., NW, Washington, DC 20036-2266.

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BIOETHICS FORUM

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"Biology is dead." "All we do is read the book." "Plants and animals - I thought biology was one continuous lecture." (Daughter's comments on biology.)

"Biology - it is a social experience." "Who needs frogs; we have guys that talk." "We dissect ideas." (Different daughter - different teacher.)

Biology in the context of STS learning is not just facts. In the context of Bioethic Forums (Videodiscovery, 1995), biology becomes a social experience in which there are topics such as:

- Fetal Alcohol Syndrome: Maternal Responsibility for Health of Fetus
- DNA Database for Criminals: Associating Behavior with Genetics
- Employees' Rights vs. Public Safety: Genetic Screening
- Breast Cancer Susceptibility: Acting on Incomplete Research Data
- Human Life Span: Using Biotechnology to Alter "Normal" Traits
- Herbicide- and Pest-Resistant Plants: Releasing a Transgenic Organism into Nature
- AIDS Resistance Gene: Determining Gene Ownership
- Gender Selection: Using Genetic Information to Choose a Child
- Development vs. Biodiversity: Putting an Economic Value on the Environment
- Infant Transplants: Conceiving a Child for its Tissue
- Alzheimer's Disease: Using Animals in Research
- Euthanasia: Setting Priorities

Each Forum begins with a person presenting a bioethical dilemma in a short video clip. This person is faced with a challenging situation for which students are asked to provide counsel. For example, the Fetal Alcohol Syndrome Forum begins with a restaurant owner statement: "I tell every new employee, 'Read this sign every day before work.' The other day, my best waiter refused to serve a pregnant woman alcohol . . . says it's dangerous to the fetus. Today, the woman threatens a lawsuit unless I fire the waiter. This time I don't know who is right or whose rights I am responsible for. Customer? Employee? Fetus?"

Every student comes to any given situation with a different background of experiences. The 40 second laser disc clip may produce an hour of productive discussion.

The laser disc presents information in a stimulating format. Each Forum contains 3-4 dozen resource files that provide information which supports or otherwise relates to an ethical dilemma. The resources may be video interviews, photographs, charts, lab results, and written documents. Given the introductory statement above, wouldn't you like to hear from the waiter and the person who was refused alcohol? What is so bad about drinking when pregnant? It is all there on the laser disc.

The Forums are designed so that two different approaches can be used. A consensus format requires that the teacher or a student leader to guide the entire class throughout the process, controlling and displaying information as requested by individuals or groups. The teacher leads a discussion and evaluation of each resource using provided teaching strategies. The class identifies stakeholders, the impacts of decisions on each stakeholder, and the values held by each of the characters. This is effectively accomplished by displaying a resource for the entire class, posing stimulating questions, and then breaking into small groups for further discussion. Then the groups provide inputs toward a class consensus.

Alternatively, after viewing the opening scene, small groups or individuals may identify with a character or an interest group representing a given position. They may choose characters dramatized in the Forum or other real-life people or groups they feel should be represented. This process may require some teacher intervention to assure balanced representation and to encourage students to investigate a viewpoint they do not presently hold.

Students then explore and analyze information from the perspective of their position. A mix of the video disc player, student resource book, case sheets, and other resources suggested by students become the "textbook." Their presentations may be written, verbal, or multi-media with peel-off bar codes for presentation of laser disc information. The goal is to make an effective case for their viewpoint. One effective approach is to record presentations on videotape using live video, laser disc clips, video disc clips with "voice over," or their own graphics. When all groups have completed their work, the class convenes for a Forum.

The next step in the process involves a full discussion of the issue and the positions of the stakeholders. The goal is to try for whole-class consensus. It often requires real creativity to develop a solution that everyone can support or live with.

The final step gives each student an opportunity to express their personal response to the process and the solution. This is achieved through an essay in which individuals are asked to articulate thoughts and feelings about the bioethic issue and compare this with the decisions reached by the class. Often we must live with societal decisions with which we do not agree.

Each Forum is in itself a documentation of enhanced STS literacy. In the context of six components of STS literacy (Daugs, 1994), each Forum centers on a concept. A concept is represented by a language symbol, such as fetal alcohol syndrome. When a person first hears or sees the language symbol, the concept may have little meaning. The concept component of STS literacy is represented by a language symbol. The concept resides in the mind and is different for every person.

The comprehension component of STS literacy relates to how a person puts the concept into written or verbal form. In the case of the Bioethics Forum model, this may include a multi-media presentation. The model is rich in opportunities for verbal exchange and expression of ideas.

The application component of STS literacy is enhanced in Forums through use of higher-level thinking skills and technology process skills which are part of problem solving procedures. In many cases, the challenges presented in classroom interactions will stimulate further investigations requiring science and technology process skills.

The attitude component of STS literacy is significantly enhanced by the Forum model. Anger, joy, fun, interest, and wanting more are evidence that students buy into Bioethics Forums.

The creativity component of STS literacy is the essence of the Forums. Each situation begins with a challenge to the imagination followed by much thinking, planning, and incubation. Solutions are a creative product. The evolution of the product is both whole-class and individual. It is the creative process that has such positive impact on student attitude.

Each student comes out of a Forum with a bigger picture of the central concept. This is the integration component of STS literacy. In fact, the big picture of a concept, such as fetal alcohol syndrome, is so much bigger than the sum of the parts (concept, comprehension, attitude, application, creativity) that one might say, "Forget the frog and scalpel. Bring on the laser disc, a new problem, and some guys I can dissect." (A hypothetical student.)

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Daugs, D. R. (1994); Improving Science Teaching: STS Literacy, pp. 90-117, The Home Teacher, Inc., Logan, Utah.

SCIENCE SLEUTHS: A GROUP APPROACH TO USING MULTI-MEDIA

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There are no frogs at the lake this year. A frog fancier calls in the Science Sleuths to find out why. The stage is set for an investigation of ecological factors which might have influenced the frog population. *Science Sleuths Elementary* (1995), a laser disc curriculum, invites the learner into a technologically-enhanced problem-solving experience.

The model used in *Science Sleuths Elementary* can be applied to a variety of problem-solving situations. Though presented in a step-by-step format, students should be informed that problem-solving is not a straight path and that random sidetracks may result in innovative solutions to a problem. The problems (topics) presented in the *Science Sleuths* program have concrete solutions, but are all also open to discussion and debate.

The problem-solving approach involves five steps. These are elaborated as follows:

Step 1: Identify the Problem.

Ask: What is the problem we need to solve?

Students often need help in sorting through information and issues to identify the root of the problem. Until the basic concept is identified, students cannot make a plan to solve it. It is important to allow a variety of perspectives. What may be a problem needing a solution for one student may not be for another student.

For example, in "The Frog File Episode," students need to sort information until they identify food webs as the concept basic to solving the problem of missing frogs.

Step 2: Develop a Plan.

Ask: What do we need to know to solve the problem?

Sorting information is not a linear process. The laser disc allows random access to a variety of information. Some of it is not needed for solving the problem of missing frogs. The model effectively represents how complicated it is to solve many problems. The plan may consist of listing a main problem and its smaller parts with questions accompanying each part. Looking at one small question at a time helps organize information.

Step 3: Gather Information.

Ask: Where can we go to get information needed to solve the problem?

By seeking information needed to answer questions posed in the plan, students accumulate data. The sources available include interviews, observations, books, articles, and experiments, many of which are on the laser disc. Students need to carefully evaluate relevance of information and credibility of sources.

Step 4: Sort-Link-Solve.

Ask: How does the information fit together?

Students need to connect the pieces of useful information into patterns. Studying relationships should lead to a solution to the problem. In the case of the missing frogs, students need to understand food webs and some general principles of ecology. Facts such as "bass eat frogs" have special meaning when linked to bigger ideas of population dynamics.

Step 5: Verify the Solution.

Ask: Does the answer make sense?

Problems may have more than one solution. Each solution should be supported by facts that fit into a logical big picture.

The *Science Sleuths Elementary* model effectively develops six important components of STS literacy. These are:

- Concept Component:
  Each problem centers on a major concept. The major frog episode concept is ecosystems. If we were to make a concept web for episode relationships between concepts, the web would illustrate some very traditional science themes.
- Comprehension Component:
  The comprehension component refers to how a person puts a concept into language. The *Science Sleuths Elementary* model promotes listening, writing, and discussion. Facts become language statements needed to solve problems.
- Application Component:
  Students may use both science and technology process skills to solve the problems. Episodes are structured so that much of what has traditionally been taught as hands-on becomes minds-on in the sense that experiments and data are presented on the laser disc. Students still must organize the information. In most cases, problems presented on the laser discs could not be investigated as efficiently in an actual investigation. This program includes six investigations that can be done effectively in the classroom. Hopefully the teacher would facilitate a follow-up investigation of the students' choice in which they would apply many of the skills shared on the video discs.
- Attitude Component:
  The problems presented in *Science Sleuths Elementary* are problems the children can relate to. Most emphasize societal context. When students get into the problem-solving process, they find it fun, interesting, and personally rewarding. The group interactions promote valuing contributions of all students.
- Creativity Component:
  All episodes are structured so that creativity is enhanced. The presentations encourage challenges to the imagination. Students then incubate ideas and plan for solving problems. This non-linear process allows for a wide variety of creative approaches. Students then try out their ideas and evaluate their solutions. This can be a creative process as it generates new knowledge for the student.
- Integration Component:
  Students that participate in a problem-solving episode have a "bigger picture" of the concept then before they started. A student participating in the missing frogs episode would have a bigger picture of the concept "ecosystems" then before the investigation. Each student would have a different big picture. The pictures would include food webs, niches, algae, food chains, predators, tadpoles, and bass. Each person's level of STS literacy would have been enhanced in all six dimensions of STS literacy (Daugs, 1994).

Teachers can use two basic approaches to using the *Science Sleuths* laser discs. The mystery problem and all the clues remain the same, but the presentation method is different. The guided format provides a video presentation for each episode with automatic stops for class discussion. Student actors investigate the problem from their clubhouse. The actors model the problem-solving process, but do not solve the problem. That step is left for the students. The advantage of this approach is that it allows for a higher degree of teacher control and input. Case sheets enhance the data collection process. This format lends itself to total class instructions.

In the explore format, students view an introduction and are then free to choose from a list of possible "clues" to aid in the investigation. They are not guided by either the teacher or the student actors present in the guided format. This format lends itself to individual or small group investigation.

An effective approach to using this technology would be to use the guided format for two to three episodes, two to three episodes for small group episodes, one for individual investigation, and then have students originate their own problems and conduct their own investigations applying the skills and techniques used in the *Science Sleuths Elementary* model.

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HANDS-ON SCIENCE EDUCATION IN RURAL PENNSYLVANIA

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Science education in the United States has come under increased scrutiny over the past years, and there is a growing consensus that more can be done to improve the way in which science is taught (Jacobson, 1992). To help improve science education, many have suggested "hands on" learning in which students perform experiments to discover scientific phenomena for themselves (Flick, 1993; LeBuffe, 1994; Shymanski et al., 1983). This makes sense because science is about experimental investigation rather than the learning of a set of facts. The main obstacle that science education faces is linked to economic problems of schools districts (Hadfield and Lillibridge, 1991).

Science Education in Pennsylvania

In Pennsylvania, property taxes are the major source of school revenue, resulting in a large disparity between the wealthy and poor school districts (Richard, 1995). In 1990, per pupil spending on education ranged from $3334 to $9741. In rural areas, the lack of funding is a reason why there are few experiments performed. Many of the schools are underfunded so that over ninety percent of the school's budget goes to salaries. After taking care of repairs of infrastructure, there is virtually no money for academic equipment. In the primary grades, science class often meets only twice a week, which gives teachers a more difficult job in justifying additional funding for these classes. Without equipment such as batteries, magnets, and microscopes, experimental science becomes difficult. Often classrooms have one piece of various types of equipment to be used for demonstrations by the teacher, but very little science equipment available to the students themselves. The exception to the lack of equipment is the computer. State budget line items have included "technology" funding" where "technology" has taken on the limited meaning of "computers." This means that all of the schools have computers, although there is the lack of basic science equipment.

A related problem is classroom overcrowding. Some kindergarten classes have up to 34 students. This can make it difficult for teachers to control a class conducting experiments.

Another problem in rural Pennsylvania is the lack of any major science museum that children would be able to visit. In urban areas, there are large museums for science such as The Franklin Institute in Philadelphia and The Carnegie Science Center in Pittsburgh. Children in the urban and suburban areas can access these individually or during school field trips. In many rural areas, no such experience is available.

The Children's Museum of Bloomsburg

The Children's Museum of Bloomsburg is a non-profit traveling museum which started in 1985. The museum helps alleviate the equipment problem by bringing science kits and classroom exhibits to elementary schools. It is run entirely by volunteers and funded entirely by individual, organizational, and corporate donations Its service area includes five north central Pennsylvania counties: Columbia, Montour, Northumberland, Snyder, and Union. The service area includes 52 elementary schools and over 20,000 students in kindergarten through sixth grades.

The Children's Museum of Bloomsburg currently offers four room-sized exhibits. The exhibits are portable so they can be placed into a van for transportation from school to school. This transportation is provided by the state funded Central Susquehanna Intermediate Unit, which provides a van that is generally used for mail service between the schools. The exhibits have between ten and twenty separate stations, each of which has a hands-on activity in which children can discover a scientific principle. Each station has an instruction plaque which guides a student with suggested activities. These instructions are aimed at the upper elementary levels. Younger students are generally led through the exhibit by teachers. The exhibits strive to address the question of how the science is relevant to the students' everyday lives. At the end of each exhibit, there are questions for students to test themselves on what they learned. Each exhibit typically costs about $2500 in equipment and supplies and requires substantial amounts of volunteer time to build.

The large exhibits cover the following topics:

- **Puzzles and Illusions:** The exhibit starts with several optical illusions. Students then examine motion and animation by using a zoetrope and praxinoscope, both of which employ a series of still pictures that spin inside a wheel to give the illusion of motion. A strobe machine shows how motion can appear to be frozen. Other stations allow students to investigate what happens when they see themselves through convex or concave mirrors. Three dimensionality is investigated by using pairs of pictures that children view through glasses with different colored lenses. The students are invited to draw their own three dimensional drawing with colored markers.

- **Simple Machines:** This exhibit teaches basic concepts of force and work. Many of the hands-on stations involve lifting weights with simple machines such as pulleys, levers, and inclined planes.

- **Magnetism:** Students learn the basic principles of magnetism such as attractive and repulsive forces by investigating how magnets interact with each other in a variety of configurations. The students view magnetic fields for bar magnets, horseshoes, and rings by using iron filings encased in plastic boxes. Students also use electromagnets to investigate basic relationships between electricity and magnetism. They discover what effect increasing the amount of electric current or the number of turns in a coil has on the strength of the electromagnet. The students also investigate how a beam of electrons can be deflected by a magnet using a black and white television set.

• **Body Works:** This exhibit takes students on a tour of the human body. Students study a life-size plastic skeleton and a soft sculpture of a person with removable organs. Digestion is studied by using a pinball machine that simulates the path of food. There are displays about joints in which children see how models of joints work and then compare them to the joints in their own bodies. Students operate model lungs, a heart, and an ear.

In addition to the large exhibits, The Children's Museum of Bloomsburg has several classroom kits available. The kits come in boxes with all needed equipment, student instructions, work pages, and teacher's guides. One kit is on electricity, which is based on a prototype from the Boston Museum of Science. There are kits on sound, energy, astronomy, and meteorology, which are from the Franklin Institute. There is also a kit on Music, which was developed by the Children's Museum itself, and a kit on the American Home 100 years ago, which was produced by the Children's Museum in conjunction with the American History Museum in Hershey, PA.

The underfunding of elementary schools in rural Pennsylvania has created a vacuum in which hands-on science education can be virtually absent from the curriculum. By having room sized exhibits and classroom kits travel from school to school, even the most underfunded school has access to some of the equipment needed so that students can have some experience at hands on science education. While this should not provide an excuse for a lack of government funding for education, nor can it alleviate the problem entirely, this type of system should provide a model for many areas where the desire for hands-on science education is present, but the funding is not.

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EFFECTIVE, ENERGIZED EDUCATION -- STS AT ITS BEST

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Energy management is an ideal focus for STS education, It is interdisciplinary, deals with real-life problems, teaches and enhances important academic skills and saves real energy and real money. Best of all, it gives students a way to change the future..

Our experience in teaching energy management skills to students in grades 5 - 12 has convinced us that this is education that works. Energy management education begins with an understanding that we (the students) use energy. A list is made of how the students used energy from when they got out of bed that very morning. Their list is annotated with the source of energy to accomplish each task. The students are then guided to identify which of these energy sources are renewable and which non-renewable. Students are are challenged to estimate the percentage of U.S. energy that comes from the four non-renewable energy sources, coal, oil, natural gas and nuclear energy. (The answer is 93%.) A simulation activity in which students experience being "has nots" is very effective in reinforcing an understanding of what the limits of the non-renewable energy sources are.

The students then tour their school, looking for problems that waste energy. Such things as open windows with the heat or air conditioning running, single pane windows, exhaust fans in constant use, doors and windows that do not close properly, rooms that are too hot, dirty radiators, all are energy wasters. More elusive information is found through use of the blueprints of the school and a visit to the boiler room.

Once the energy problems have been identified, the students determine what actions can be used to correct the problems. Often the solutions are obvious, just not in place. To persuade the school administration to take action, the students need to know how much energy (and money) can be saved by correcting each individual problem. To do this, they must gather all sorts of data. This entails measuring windows to calculate areas, finding wall and roof areas, testing the furnace for efficiency, checking thermostats to see if they are accurate, finding the average temperature of the building during the heating and/or cooling season, counting light bulbs, identifying the type of bulbs in use, measuring light levels and comparing the data with industry standards, etc. Use of the data in complex formulas involves dimensional analysis and use of exponents, important academic skills.

Once the calculations are done, the students must put their information in a report that will be presented to the school board. The report lists the problems found, the recommended action, and the estimated savings in energy for each action. In order for the report to be convincing, it must be clear, neat, well-written and interesting. The students then take their information and make an oral presentation to the school board. They must be prepared to answer technical questions about the building and their recommendations.

Below is a summary of the activities to be done in an energy management program and the academic skills that integrate in the activity.

Activity	Academic skill, concept and/or discipline
• energy problems need to be identified	observation, building orientation
• building heat loss needs to be understood	heat transfer mechanisms, thermal properties of materials, blueprint reading
• data needs to be gathered	measurement, finding areas, observation, use of test equipment, industry standards
• information needs analysis and evaluation	critical thinking, graphing, statistics
• appropriate solutions need to be identified	research, economics, technology, cost-benefit analysis
• estimates of savings need to be made	exponents, dimensional analysis, critical thinking, solving word problems
• a report needs to be prepared	written expression, computer graphics, word processing
• the report needs to be presented	oral expression, graphic design. civics

We have found that doing an energy study of a school building teaches all of the academic skills listed in the table effectively. Teachers we have worked with report whole classes of 9th grade algebra students who find the word problems in their textbook "too easy," students who have been identified as ADHD who achieve success academically, previously unmotivated students who become highly motivated, and students who were afraid to speak before the class now able to speak comfortably before their school board and town councils.

In addition to the academic learning, students are addressing real problems that need to be corrected. Our experience indicates schools can save tens of thousands of dollars a year in energy costs by implementing the common-sense recommendations of their own students..

Energy management education is a win-win situation for all concerned. The students learn and enhance needed academic skills, the teachers discover new ways to teach, the school has better control over its energy consumption and the attandant costs, taxpayers save money and limited energy resources will last a bit longer. Best of all, the students learn that their academic skills can be used to change the future -- to make a difference in the world.

THE DEVELOPMENT OF STUDENTS' HOCS - THE KEY TO PROGRESS IN STES EDUCATION

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THE DEVELOPMENT OF STUDENTS HOCS - THE KEY TO PROGRESS IN STES EDUCATION

The unprecedented technological progress and economic growth within relatively small number of nations, while bringing benefits to many, have caused severe worldwide environmental consequences accompanied by far-reaching economic-socio-political changes. The major evolving problem is that contemporary and future human quantitative and qualitative expectations cannot be met in our world of conflicting interests and *finite* unevenly distributed resources. Consequently, a clear dissonance between current trends of economic/technological growth and so-called *sustainable development* has been developed into the current environmental crisis. A major relevant question of concern is: what policies have the potential of leading to changes in behavior of -- individuals, societies, industries and governments -- that will allow development and growth to take place within the constraints and limits set by ecological imperatives and environmental paradigms.

Education is a key factor in determining, affecting and/or modifying human behavior, individuals and societies alike. Yet, contemporary education has not prepared people to handle local national and global international systems of such size and complexity as emerged within our science-based and technology-driven world. In order to survive, to maintain or generate life of quality and to simultaneously cooperate and compete successfully, both culturally and economically, in the international arena, rational and intelligent decisions have to be made timely and contextually specific, to be followed by an appropriate action accordingly. This requires an education for "problem solving decision making act", in the science-technology-environment-society

(STES) context/interrelationships guided by the "sustainable development concept" and the related value system.

Although science and technology may be useful in establishing what we can do, neither of them (solely or jointly) can tell us what we *should* do. The latter requires the application of value judgement within the capacity of *evaluative thinking* by STES - educated, socially responsible, rational citizens, as an integral part of their *critical system thinking* capacity. The present "battle cry" of science and technology education is the teaching of science and technology for *social responsibility.*

Introduction: The Problem, Rational, Purposes

In view of the overly high expectations of people in a world of conflicting/competing values and *finite* unevenly distributed resources, modern life has turned into a continuous process of *problem solving* (PS) and *decision-making* (DM), or decision-selection, from either available or as yet uncreated options (Zoller, 1991). However, although science and technology may be useful in establishing what we *can* do, neither of them (solely or jointly) can tell us what we *should* do. The latter requires the application of value judgements by *socially responsible, rational citizens* as an integral part of their critical system thinking capacity. Thus, a major purpose of science, technology, environment, society (STES) education is the development of

- the students' reasoning and critical thinking ability in the context of the specific content and processes of science in general and S-T-E-S interfaces in particular, and
- their problem-solving decision-making capacity for so they can be effective

citizens (Zoller, 1990).

This is guided by the ultimate educational ideal of the *educated person:* one who has

- the ability to be engaged in higher-order skill-based forms of inquiry (i.e. PS, DM, creative thinking) required both in the study of the disciplines and in dealing with characteristically interdisciplinary everyday life situations;
- the knowledge base relevant to these situations;
- the ability to select and apply the relevant information and skills guided by reflective, responsible attitudes; and
- the motivation and self-confidence to act accordingly and to take responsibility.

In short, a person having the "PS-DM" capability (Zoller, 1990a).

Any progress towards the attainment of the above superordinate goal would require the application of new teaching methods that would mesh with these desired learning outcomes agreed upon by science/technology educators.

Two major trends are motivating current efforts toward a reform in science education. One is a belief that it is vital for all our students to develop higher-order cognitive skills (HOCS) in all academic disciplines (Raudenbush et al. 1993) as well as in the STES context (Zoller, 1990a, 1993). The second is the belief, that students should construct a deep conceptual understanding of any scientific topic studied, rather than simply learn to apply useful algorithms to problem sets (AAAS, 1989; Zoller, et al., 1995). Ideally, both of these learning objectives should be targeted by teachers and students alike – as they are partners in the common interactive teaching-learning process. Thus, an emerging consensus has been materialized as to the urgent need for educational reform in general, science education in particular (AAAS, 1994; NSTA, 1993; U.S. Department of Education, 1991; Yager, 1993) as well as on the importance of teaching for, and evaluation of HOCS (Zoller, 1993; Zoller et al., 1995). Nonetheless, the debate concerning educational policy that would ensure realization of this for *all* is far from being settled (Lynch, 1994). Moreover, it appears to be a universal phenomenon at the high school level, that a sharp contrast exists between current visions of educational excellence and currently institutionalized patterns of educational practice (Raudenbush et al., 1993). In this respect, examination/testing and student performance assessment strategies persistently remain the most regressive (e.g. Blinn, 1993) and are in *dissonance* with the current HOCS targeting.

Clearly, examinations as well as other assessment measures must be in consonance with these goals (Zoller, 1990; 1993). The crucial issue is how to translate the above into manageable and effective curricula and corresponding appropriate and reliable assessment instruments and tests. The latter are needed in order to facilitate the evaluation of students' performance in terms of HOCS and conceptual understanding; to serve as an index of the teaching goal attainment; and as a formative mean for revising teaching strategies accordingly.

Our present study has been guided by the following beliefs (a-c) and research-based findings (d-e): (a) The development and acquisition of HOCS by our students should be a prime instructional goal in science and technology teaching. (b) Examinations which drives the curriculum and constitute an integral part of the teaching-learning process, should not only be in consonance with the teaching/instructional goals, but should also, meaningfully contribute towards the attainment of these goals (Zoller, 1994). (c) Students and teachers should not only actively participate in the teaching-learning process, but should become *partners* in the process in order for the current reform in science and technology education to succeed; (d) Both college and high school students unquestionably prefer examinations which emphasize understanding and analysis rather than tests of plain knowledge and rote learning; that the use of open-book examinations be permitted; and that time duration of examinations be virtually unlimited; e.g., take home-type exams (Zoller & Ben-Chaim, 1988; Ben-Chaim & Zoller, 1995); (e) Despite awareness of students' exam-type preferences, science teachers persist in administering their own "pet-type" examinations (Zoller & Ben-Chaim, 1988; Ben-Chaim & Zoller, 1995).

Based on our belief that (1) examinations and assessment should serve as support systems for both students and teachers to achievement of the predetermined learning objectives; (2) a crucial precondition for the improvement of science and technology teaching and learning is the matching of teaching experiences to the particular needs, concerns, and *preferences* of the learners; and (3) assessment should be in the service of the current reform in order for the latter to materialize (Kulm & Malcom, 1991), the main objectives of our recent action-oriented international studies were:

1. To assess students' performance on algorithmic, lower-order cognitive skills (LOCS) and conceptual exam questions and to look for correlations (if any)

between their achievements on these categories across different populations.

2. To explore the possibility of identifying HOCS and LOCS students via "post factum" analysis of their performance on science examinations of different types and level which contain both HOCS and LOCS questions as well as their *preferences* with respect to these two types.

3. To provide supporting research-based evidence that will encourage the use of HOCS-oriented examinations by science technology and environment educators, primarily as effective learning tools (matched with the STES objective goals) rather than exclusively for grading purposes.

Only selected STES education-related results are to be reported and their implications for progress in this concern discussed within this paper.

Methodology

With respect to objective 1:

Eight examination questions were constructed and designated as algorithmic, LOCS, conceptual and HOCS (Zoller et al., 1995). These questions were placed on either the mid-term or final examinations of freshman at each of the universities, two in Israel and one in the U.S. which participated in the study: Haifa University–Oranim, a liberal arts-type; The Technion Haifa – an Engineering-type; and Purdue University – a comprehensive science/engineering-type (N=66, 48, and 576 respectively).

The courses in which these questions were used ranged from chemistry courses for science, engineering, and nonscience majors as well as pre- and in-service teachers.

The corresponding student responses were categorized and scored as correct

(1) or incorrect (0). Statistical analyses included (1) a chi-square test of the differences in the performance means (0-1) within and across the universities on the respective questions; and (2) non-parametric chi-square correlations tests between the performances on each pair of questions (i.e. Q1/Q3, Q2/Q3 and Q1/Q2). In this paper we report the results related to the first three questions only: 1-algorithmic; 2-conceptual; 3-LOCS. Complementary results with respect to algorithmic and LOCS vs. HOCS questions will be reported elsewhere (Zoller *et al.*, 1996).

With respect to objective 2:

The first case study analyzed was that of the General Examination (GE) and the Panhellenic Chemistry Competition (PCC) held in Greece in 1991 for high school graduates (N=1352). The second case study was the "take-home/make your choice" mid (first) term exam in a general chemistry course administered to a class of freshman biology majors (N = 22) in an Israeli University in 1993 (Zoller & Tsaparlis, 1995).

A considerable number of items in the PCC are of a different nature than those of the standard GE items in that they require the application of known theory to novel situations (fluidity) together with higher cognitive skills, such as analysis and synthesis (according to the Bloom taxonomy); these items, then, require HOCS. Not even a single item of the PCC requires simple recall of knowledge as do half of the GE items. Operationally, however, we considered those items which were similar to the "problems" of the GE or those which required just simple application of known theory or facts (in the Bloom sense) too familiar to the student situations, as "LOCS questions". On the other hand, "original" problems (i.e. not encountered previously by the students in this format) or the application of known theory to unfamiliar situations were considered to be HOCS questions.

The Israeli case study involved a mid-term take-home examination, within a general chemistry course for freshman biology majors (prospective science teachers), consisted of a set of ten questions categorized as algorithmic (A), LOCS (L), HOCS (H), or mixed (A/L, A/H, L/A, A/L/H, etc.). The students were asked to choose just *two* questions (out of the ten) as they wish, to work them out at home while taking their time and using any material they may need, and to submit their "final product" – as a substitute for an ordinary mid-term examination – for grading.

Results and Discussion

Table 1 reveals differences between the means of students' achievements on the three categories (algorithmic, LOCS, conceptual) in each of the universities studied.

Table 1. Means of Students' Performance on Exam Questions 1-3

		Mean Scores		
University	N	Ques. 1 Algorithmic	Ques. 3 LOCS	Ques. 2 Conceptual
Haifa	66	0.88	0.77	0.74
Technion	48	0.98	0.77	0.71
Purdue	576	0.71[a]	0.46[a]	0.30[a]
Weighted Mean		0.75	0.51	0.37

[a]Significant at $p<0.01$ based on chi-square test.

The highest scores were for the algorithmic questions, suggesting the proficiency of students in both countries in using algorithms to solve exercises. The lowest scores were for the conceptual questions, while values for the LOCS questions fell between the two extremes. In all cases, the mean scores of the LOCS questions were closer to the algorithmic ones. This consistent pattern of performance at the three universities suggests the following generalizable conclusions: (a) Success on algorithmic questions in exams does not imply success on conceptual or HOCS questions; and (b) success on algorithmic questions does not imply success even on LOCS questions. Indeed, these conclusions are supported by the results of the correlation tests: neither of the questions pairs (i.e. Q1/Q2, Q2/Q3 and Q1/Q2) were found to correlate significantly ($p>0.05$). In other words: success on any question type is *not* a predictor of success on any other question type. Moreover, comparing students' scores on both the algorithmic and LOCS questions (Question 1 and 3) with their scores on the conceptual question (Question 2) suggests a further conclusion, that students can solve algorithmic problems without employing even LOCS-level reasoning. The long-range consequences are clearly an issue of major concern, given that most traditional examinations in science and technology courses are of the algorithmic-LOCS type and that students' performance is assessed and graded accordingly. Furthermore, the algorithmic – LOCS performance gap is distinctively in favor of the former, which requires for success mainly memorization and "technical" skills (...and, relatively, little understanding), but clearly not HOCS on the part of the students. The implications concerning the needed application of HOCS and critical thinking in the STES context of our demanding technology-driven society are apparent.

Of the 1352 students who took part in the 1991 PCC, only 379 achieved a score equal or higher than 35%; for these $\bar{x} = 49.0$ and $\hat{\sigma} = 12.0$. In the GE, these 379 students achieved: $\bar{x} = 87.6$, $\hat{\sigma} = 10.7$. The Spearman correlation coefficient ρ (between the performances in the PCC and GE) for these 379 students was found to be 0.42, which is statistically significant ($p<0.0001$). On the other hand, in the PCC, only 146 students achieved a mark equal or higher than 50%; for these, $\bar{x} = 61.8$ and $\hat{\sigma} = 8.8$; their performance in the GE was $\bar{x} = 92.5$ and $\hat{\sigma} = 6.9$. The Spearman ρ for these 146 students was calculated to be 0.40, which is also statistically significant ($p<0.0001$). In view of the fact that the PPC and the GE are on the HOCS and LOCS levels respectively, the considerable higher students' performance on the latter could be expected, particularly in considering the crucial role of the GE concerning the students future and their preparations towards it accordingly.

The performance data of 146 students, who achieved at least the 50% mark in the PPC, on the LOCS and HOCS questions of this exam, was as follows (Zoller & Tsaparlis, 1995):

PCC_{LOCS} $\bar{x} = 72.2$, $\hat{\sigma} = 13.4$ ρ (with GE) = 0.32

PCC_{HOCS}: $\bar{x} = 54.3$, $\hat{\sigma} = 12.1$ ρ (with GE) = 0.25

As expected, the performance on the PCC_{LOCS} items was much higher than that on the PCC_{HOCS} items. The Spearman's ρs have had low values, but were statistically significant ($p<0.01$). Significantly, there is no correlation ($\rho = 0.0$) between the score on the PCC_{LOCS} and that on the PCC_{HOCS}. This result is in accord with ours and others' previous findings, that success on LOCS-type questions does not necessarily secure success on conceptual or HOCS-type questions (Nakhleh, 1993, Zoller et al., 1995; 1996). Furthermore, student scores on HOCS and LOCS questions may be used for identifying "HOCS"- and "LOCS-students".

Let us deal now with a major issue of concern of this work: Can traditional science exams, such as the GE, be used to distinguish between "HOCS-" and "LOCS-students"? Table 2 includes all the required data (Zoller & Tsaparlis, 1995).

TABLE 2
Average marks (%) of various subgroups of students in the General Examination (GE), in the Panhellenic Chemistry Competition (PCC) and on two components (PCC_{LOCS} and PCC_{HOCS}) of PCC (the corresponding standard deviations are given in parenthesis).

	N	PCC	PCC_{LOCS}	PCC_{HOCS}	GE
1. Students with marks≥ 50 in PCC	146	61.8 (8.8)	72.2 (13.4)	54.3 (12.1)	92.5 (6.9)
2. Students in PCC with 68 ≤ mark ≤ 100	42	73.3 (4.4)	82.2 (9.8)	66.8 (6.6)	95.4 (5.9)
3. One-half of students* with marks 35, 36 or 37% in PCC	21	35.8 (0.4)	**	**	93.5 (3.1)
4. Students with marks ≥ 35% in PCC and marks 98.8-100% in GE	40	62.9 (13.2)	**	**	99.3 (0.5)
5. Students with marks ≥ 50% in PCC and marks 97.5-100% in GE	43	67.2 (8.4)	78.2 (11.2)	59.2 (11.6)	98.9 (0.87)
6. Students with marks ≥ 35% in PCC and marks ≤ 75% in GE	39	40.5 (4.6)	**	**	63.6 (7.7)
7. Students with marks ≥ 73.3 in PCC_{HOCS}	10	74.8 (7.5)	73.5 (17.1)	75.6 (3.1)	93.8 (6.2)
8. Students with marks ≥ 70% in PCC_{HOCS}	16	74.6 (6.4)	75.3 (14.6)	74.1 (3.1)	94.4 (6.0)
9. Students with marks ≥ 90% in PCC_{LOCS}	16	73.9 (7.1)	93.4 (2.3)	59.8 (11.5)	94.7 (4.7)

* See text

** Data not available because marks for the PCC_{LOCS} and PCC_{HOCS} were traced only for the PCC examinations with marks > 50.

Entries Nos. 7 and 8 show that students who have done very well on PCC_{HOCS} have not done better on PCC_{LOCS}. This may be attributed to the fact that these "HOCS-students" were not well prepared for the PCC. On the other hand, these same students have not performed on the GE better than "LOCS-students" who did not prepare for the PCC either (entry 3). This is a strong indication of the incapability of LOCS-type examinations like the GE *per se* to distinguish between "HOCS-" and "LOCS-students". In other words, only appropriately designed *examinations* which include both LOCS and HOCS items can be used for either distinguishing between "LOCS" and "HOCS-students" or, more important, for providing educators with solid feedback on students' progress in HOCS.

The students who had the best performance in the GE (entries 4 and 5), have outperformed, in the GE, the "HOCS students" of entries 7 and 8 (t-values vary from 4.69 to 5.43, which are significant at the 1% confidence level). Furthermore, these same students (as is evident from entry 5) performed much lower on PCC_{HOCS} and slightly better on PCC_{LOCS} than the students of entries 7 and 8. The students of entries 7 and 8 have not performed, either on PCC_{LOCS} or in the GE, better than the 146 students of entry 1. All these findings constitute further evidence that the GE and, apparently, similar-type traditional science exams are incapable of distinguishing "HOCS" from "LOCS-students". They corroborate our assertion for the need of combined HOCS and LOCS-type examinations not only for the identification of "HOCS students" and distinguishing between "HOCS- and "LOCS-students" but also for the promotion development of students' HOCS capacity. The latter point is convincingly demonstrated in entry 9: students with excellent performance on the PCC_{LOCS} have not demonstrated high performance on the PCC_{HOCS}. Obviously, these students must have been "LOCS-students" which require a specially tailored HOCS promotion teaching strategies. Indeed, a comparison of their performance in the LOCS-oriented GE with that of the "HOCS-students" of entries 7 and 8, reveals that they have LOCS performed equally well.

Finally, the study of freshman science students' performance – LOCS/HOCS preference relationships within a HOCS-oriented general chemistry course revealed, that the top performing students, six out of 22 (27%) preferred (given the free choice) to select and respond to *LOCS* questions from available pool of LOCS and HOCS items (Zoller & Tsaparlis, 1995). This clear-cut selection of LOCS questions only by these students, can be easily rationalized by the "student-proof" approach to grading in examination situations: i.e., the preference of what is perceived by the student to be the *easiest* possible way to get a high grade without taking any risk, regardless of conceptual understanding and/or whether or not a much more *challenging* (and meaningful) alternative is available. The pattern change in the "profile" of the questions selected by these freshman students from the top (the highest achievers) to the bottom (the lowest achievers) (i.e. LOCS → LOCS & MOCS (Mixed-Order Cognitive Skills) → .... → MOCS & HOCS), together with the overall results of the Greek case study suggests, that the HOCS-oriented instruction during the two months period preceding the exam was not sufficient for changing students' "exam-attitudes/behavior" as far as the shift from LOCS to HOCS learning is concerned. Be this as it may, this particular take-home exam as well as similar (containing HOCS and LOCS questions) examinations can be used for assessing the progress of students on HOCS pointing on the effectiveness of the HOCS-oriented teaching strategies in HOCS-oriented science courses, and monitoring the students' progress on HOCS learning.

Conclusions and Implication for Future STES Education

Our study strongly suggests that traditional methods and instructional strategies of teaching science and technology are not compatible with attaining HOCS learning. Neither are current means of assessment (i.e., algorithmic/LOCS-oriented examinations) consonant with the goal of acquisition of HOCS by our students.

The following were our main findings (1) Students in the countries studied performed consistently on each of the categories in order of algorithmic > LOCS > conceptual > HOCS questions; (2) success on algorithmic does not imply success on HOCS or even on LOCS questions, that is: there is no correlation between students "HOCS- and LOCS performance"; (3) examinations, particularly those containing both HOCS and LOCS questions, can be effectively used to identify "HOCS" – and "LOCS-students"; (4) given a free choice, LOCS questions are preferred on HOCS questions by students, apparently due to their governing "student-proof" attitude towards examinations; and (5) students taught in interactive classes by HOCS-oriented teachers, outperformed by far in all categories those taught, by the traditional way, in large lecture sessions.

In view of the above we would argue that the implied paradigm shift from an algorithmic/LOCS to a conceptual/HOCS orientation, should be moved from a research-based theoretical domain to actual implementation of either appropriate remedial or alternative HOCS-oriented teaching strategies, in order for a meaningful improvement of science and technology teaching and learning to occur. Based on the above and previous related studies, the fostering of HOCS and conceptual learning are advocated. It *can* and *should* be done and this is in essence the task ahead for, and the key to progress in STES education in our very demanding science and technology-based society.

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THE LEARNING CYCLE: A VEHICLE FOR CHANGE

IN TEACHER EDUCATION

BY

DR. JANE A. BERNDT

PRESENTED AT

THE NATIONAL ASSOCIATION FOR SCIENCE
AND TECHNOLOGY CONFERENCE

JANUARY 22, 1994

Introduction

This paper presents the findings of a six-month study which investigated the effects of the Learning Cycle in teaching natural resource sciences in the elementary school classroom. The study incorporated variables concerned with student science content achievement, student science process skills, relationship between student content achievement and teacher attitude, relationship between student process acquisition and teacher attitude, relationship between content achievement and student science attitude, relationship between process achievement and student science attitude, relationship between student process acquisition and teacher creativity, relationship between student content achievement and degree of teacher training, relationship between student process acquisition and degree of teacher training, relationship between student content achievement and quality of instruction, relationship between student process acquisition and quality of instruction, differences among student content achievement regarding student learning style, and differences among student process acquisition regarding student learning style.

The researcher investigated the effects of six predeveloped Natural Resource Science curriculum modules with the Learning Cycle strategies on student achievement at the elementary school level in Randolph County, West Virginia. The effects of the Learning Cycle strategy were tested through analyses of student process and content achievement based on the Natural Resource Science Content and Process tests. Results of content and process tests were evaluated for 154 elementary science students involved with the West Virginia study. The researcher continued examination over a six-week period. Through West Virginia Curriculum Air, Land and Water, implementation workshop participants and respective students were instructed in the three-phase Learning Cycle framework.

The Learning Cycle

In 1961, a report from three NSF-sponsored regional conferences of scientists, psychologists, teachers, and school administrators was compiled through the American Association for the Advancement of Science (AAAS) (Karplus and Thier, 1969). The AAAS report maintained that :

> Science teachers should stress the spirit of discovery characteristics of science. New instructional materials must be prepared. Preparation of instructional material will require the combined efforts of scientists, classroom teachers and specialists in learning and teacher preparations (Karplus and Thier, 1969, pp 2-3).

This report incited the funding of several elementary programs. The basis for these projects focused on children's active involvement, observations and conclusion making.

One of these select AAAS programs, The Science Curriculum Improvement Project (SCIS), based its curriculum design strategy on the Learning Cycle. Robert Karplus was an original developer. He observed during involvement with the 1959-1960 studies with teachers and children that questions about teaching arose. The questions, along with continued interaction with teachers and students, served as a strategy basis for the developers of the SCIS Project to develop a three-step approach to teaching science. The three phases based on Karplus' research and Piagetian logic, were:

preliminary exploration, invention, and discovery (Karplus and Thier, 1969). The initial phase, exploration, involves students with materials they can actually touch, see, hear, smell and/or taste. The second phase is the invention. This phase is teacher centered. Students and the teacher discuss data, ask questions, and invent an explanation for the concept they are investigating. Following an exploration the teacher introduces the language of science and names the property, concept, or processes. Discovery is the third phase of this process. During this process, students are encouraged to integrate their new ideas with existing ideas concerning the science concept. The new science ideas are expanded by the students and additional ways to further expand or test new ideas are suggested. During discovery, the teacher encourages students to organize concepts in ways developed during the invention phase.

Throughout the development of SCIS, SCIS II, and SCIS III, the Learning Cycle strategies were used to organize units as well as to develop related lessons. In the original version of SCIS an exploration, invention, and discovery module comprised each chapter.

The Natural Resource Education Series Based on the Learning Cycle

In this study rather than use SCIS material, the researcher decided to use the Natural Resource Education Series devised at West Virginia University. The Natural Resource Education Series, Forest, Land and Water: Understanding Our Natural Resources (see figure 1), includes 12 modules which focus on land and water resources, their relationships and their importance to human survival and fulfillment.

The development of this series was a joint project between West Virginia University and the United States Forest Service. Graduate students wrote and revised the original modules. The development and revision took place during 1987-1992. The modules were tested in classrooms and evaluated by science and education experts. Teacher inservice activities started, thus creating a network of users of the modules. A teacher guide, Land and Water: Understanding Our Natural Resources, was initiated.

FIGURE 1

Natural Resource Science Curriculum Module Format

Title
Background Information for Teachers
Objectives

EXPLORATION PHASE
To the Teacher
Early Childhood Activities
- Materials
- **Involve the Students in the Following Activities**
- **Possible Optional Activities**

Middle Childhood Activities
- Materials
- **Involve the Students in the Following Activities**
- **Possible Optional Activities**

INVENTING THE IDEA PHASE
To the Teacher
Early Childhood Activities
- Materials
- **Involve the Students in the Following Activities**
- **Possible Optional Activities**

Middle Childhood Activities
Materials
Involve the Students in the Following Activities
Possible Optional Activities

EXPANDING THE IDEA PHASE
To the Teacher
Early Childhood Activities
Materials
Involve the Students in the Following Activities
Possible Optional Activities
Middle Childhood Activities
Materials
Involve the Students in the Following Activities
Possible Optional Activities

Final Evaluation
Glossary and/or Concept Map
Figures (for making class transparencies)
Student Handouts (for reproduction)

The Study

The original study had three purposes, to determine the effects of implementing a Natural Resource Science Module through use of the Learning Cycle strategies in elementary grades, examine the effects of certain teacher characteristics (science attitude, creativity, degree of training, and quality of instruction) on student content achievement and the use of process skills, and determine the effects of student science attitude and learning styles (hemisphericity) on content achievement and process skills in the Natural Resource Modules and in the Learning Cycle environment. This paper will focus on the effect of the Learning Cycle and student content/process achievement and student science attitude and learning styles on content/process achievement skills.

The researcher collected and analyzed the data to determine the effects of implementing the Learning Cycle: (a) student achievement measured by the Content

Acquisition Achievement Test (McGinnis, 1989), (b) student development of process skills measured by the Process Skills Test (McGinnis, 1989), (c) student and teacher science attitudes measured by the Science Attitude Questionnaire (McGinnis, 1989), (d) teacher creativity measured by the Guilford Creative Product Generation of "Making Something Out of It" (Guilford, 1967; and Meeker, 1989), (e) degree of teacher training as reported by the Teacher Background Information Questionnaire, (f) quality of teacher instruction as measured by the Microteaching Skills in Science (Sunal, 1981), and (g) student learning style measured by the Styles of Learning and Thinking (SOLAT) instrument (Torrance, 1988). Research hypotheses were formulated and tested through the use of appropriate statistical procedures. The two primary hypotheses used in this paper were tested by use of t-test for dependent means. The remaining hypotheses were tested using the Pearson Correlation Technique.

Research Hypothesis One states: "Implementation of the Natural Resource Science Unit through the Learning Cycle at the elementary grade levels has a significant effect on students' content achievement as measured by the Content Acquisition Test." The second hypothesis states: "Implementation of the Natural Resource Science Unit through the Learning Cycle at the elementary grade levels has a significant effect on students' process skills development as measured by the Process Acquisition Test." The additional hypotheses being addressed in this paper state: "Student attitudes toward science prior to implementing the Natural Resource Science Unit through the Learning Cycle at the elementary grade levels have a significant relationship with student content achievement as measured by the Content Acquisition Test." The second relevant hypothesis states: "Student attitudes toward science prior to implementing the Natural Resource Science Unit through the Learning Cycle at the elementary grade levels have a significant relationship with students' process skills development as measured by the Process Acquisition Test.

Rationale for the Learning Cycle

Since inquiry requires a hands-on approach, Lombard, Konicek and Schultz (1985) stated that exploration and development of explanations are processes of science. While testing hypotheses and exploring, students begin to develop explanations. Similarly, Tobin (1986) emphasized Bloom's (1984) concern with students' overt engagement in classroom activities. Bloom (1984) described overt engagement as functioning or in some way responding in a relevant manner to instruction and instructional material. As an example, overt engagement can include discussion, manipulation of materials, creating models, measuring, using numbers, writing, drawing, and graphing. Students can use process skills overtly to formulate responses to questions, infer, interpret data, justify points of view, explain events or procedures, or interpret or describe results. Conversely, covert engagement incorporates thinking in relevant ways about what is going on in the classroom (Bloom, 1984). Process skills can also be used covertly when students attend to the teacher during instruction, contemplate the plan for an investigation, or consider how a graph is to be interpreted. The Learning Cycle strategy addresses this.

Statistics from implementation of SCIIS in the Richardson Independent School System (Kyle, et al., 1985) indicate SCIIS (Learning Cycle Process) students more frequently chose science as their favorite subject. Over 75 percent of these SCIIS students found that science is fun, exciting, and interesting. Conversely, over 50 percent of non-SCIIS students found science boring (Kyle et al., 1985).

Researchers state the process approach is preferred by students over the traditional text-oriented science. Students involved with such process approaches according to other research studies performed more positively with tests of general achievement, process skills and math (Shymansky, et al., 1982).

A completed SCIS study (Linn and Thier, 1975) indicated that better logical thinking was exhibited by those fifth graders who worked through the SCIS energy sources unit. This particular SCIS study focused on rural and suburban settings.

Such Learning Cycle programs enhance logical thinking with essential process skills such as observing, classifying, measuring, describing, inferring, questioning, interpreting, experimenting, formulating problems, constructing principles and predicting (Carin and Sund, 1989). Students who worked with SCIS for five years performed at a higher level in process observing, classifying, measuring, experimenting, interpreting, and predicting, than students in the text-oriented classes (Weber and Renner, 1972)..

Student attitudes change as they become more comfortable with what they are doing. Brown (1973) found that students developed improved attitudes when working with SCIIS as compared to non-SCIIS students. These SCIIS students' science attitudes tended to improve their figural creativity (Brown, 1973).

Because learning style, according to Dunn (1990) is a biological as well as developmental characteristic, individual differences exist. Due to these personal differences in individuals, a teaching method may be effective for some and ineffective for others.

The right half of the brain processes information holistically. Thus, the Learning Cycle approach does fit this style. It frequently facilitates visual thinking (Vannatta, 1979). Students utilizing this portion of the brain will tend to think in images. According to Vannatta (1979) and McCarthy (1980), this visual thinking process is basic to solving many types of problems. Vannatta (1979) cited experiences such as Alexander Fleming indicating that visual and creative thinking (right side of the brain) are instrumental in problem solving.

The Sample

The teacher sample of this study comprised fourteen teachers from seven different elementary schools. Teachers were selected by administrators of the Randolph County Schools and project directors of West Virginia University from a population of approximately 120 teachers in the Randolph County School System in Elkins, West Virginia.

In this study, over a six-week time span teachers were given a questionnaire and testing packet for Natural Resource Science Modules and the original Natural Resource Science Modules (Sunal, et al., 1991). The teachers were instructed to study, research, and implement their modules in the science classroom. Based on ideas and activities from the Natural Resource Science Workshop, teachers selected, planned and implemented these modules. Students were given pre and post tests on achievement and process skills tests.

Statistical Treatment

The pretest-posttest design was used to determine the effectiveness of the Learning Cycle strategy in teaching natural resource sciences in seven elementary schools. This design consists of the following phases: (a) administration of a pretest to measure students' process and content skills as dependent variables, (b) application of experimental treatment to subjects as an independent variable, (c) administration of posttest to remeasure students' content and process skills as dependent variables, and (d) examination of the gain scores for appropriate interpretation.

The data collected for the study were coded numerically and compiled for computer analysis and subsequent tabulation. The dependent and independent variables were involved in this study. For the purposes of this paper the dependent variables included: (a) student content achievement as measured by the Content Acquisition Test (McGinnis, 1989), and (b) student process skills acquisition as measured by the Process Acquisition Test (McGinnis, 1989). The independent variables were: (a) implementation of the Learning Cycle strategy, (b) student science attitudes, and (c) student learning style.

The t-test for means was used to analyze the first two hypotheses. The student science attitudes utilized the Pearson Product-Moment Correlation Coefficient analysis. The learning styles were tested through the use of the one-way analysis of variance.

A step-wise regression analysis model was used to estimate the amount of variation in student content and process achievement accounted for by student science attitude. A multiregression analysis model was utilized to estimate the amount of variation in student content and process achievement attributed to student learning styles.

With regard to the nature of this study and in accordance with the studies concerning human behavior, the 0.05 level of significance was adopted to test all null hypotheses.

Analysis

The Learning Cycle strategies had a significant effect on student progress in content achievement. The posttest mean = 54.9 > pre-test mean = 49.2, t = +32.17, df = 153, and $p < 0.001$.

Effect of Implementing the Natural Resource Science Module Through
The Learning Strategies on Students' Content Achievement

Achievement	MEAN	S.D.	t-value	P-value
Post-test Scores	54.9	0.0	+32.17	< 0.001
Pre-test Scores	49.2	9.7		

Degrees of Freedom = 153
Number of Observations = 154
Note: Asterisk denotes a statistically significant difference at the selected level.

There is a significant effect in implementation of the Natural Resource module through the Learning Cycle strategies at the elementary grade levels on students' process skills. Statistical results indicate post-test mean = 51.6 > pre-test mean = 46.9, t = +21.24, df = 153, and $p < 0.001$.

Effect of Implementing the Natural Resources Science

Module Through the Learning Cycle Strategies on Students'

Process Skills

Process Skills	MEAN	S.D.	t-value	P-value
Post-test Scores	51.6	8.9	+21.24	* <0.001
Pre-test Scores	46.9	9.3		

Degree of Freedom = 153
Number of Observations = 154
Note: Asterisk denotes a statistically significant difference at the selected level.

A positive statistically significant relationship exists between the two variables after the experiment. The results show content process mean = 5.71, S.D. = 2.20, student attitude mean = 3.06, S.D. = 0.45, df = 152, $r = +0.237$ and $P = 0.002 < 0.05$. According to these results the more favorable the students' attitudes toward science, the greater their progress in content achievement.

Relationship Between Student Attitude Toward Science and

Content Acquisition Achievement of Science Students Using the

Learning Cycle Approach

Variable	MEAN	S.D.	CORRELATION	SIGNIFICANCE
Content Gain	5.71	2.20	$r = +0.237$	* $P < 0.002$
Student Attitudes	3.06	0.45		

Degree of Freedom = 152
Number of Observations = 154
Note: Asterisk denotes a statistically significant relationship at the selected level.

There is no positive statistically significant relationship between variables on student attitude toward science prior to implementing the Natural Resource Science Module through the Learning Cycle strategies with students' process skills development. Results indicate a process progress mean = 4.69, S.D. = 2.74, student attitude mean = 3.06, S.D. = 0.45, df = 152, r = +0.07, P = 0.187 > 0.05. This could mean that a high rating on the student science attitude test does not necessarily have a relationship with the student process skills development at the elementary grade levels when implementing the Natural Science Module through the Learning Cycle strategies.

Relationship Between Student Attitude Toward Science and

Process Skills Acquisition Achievement of Science Students

Using the Learning Cycle Strategies

VARIABLE	MEAN	S.D.	CORRELATION	SIGNIFICANCE
Process Gain	4.69	2.74	r = +0.072	P > 0.187
Student Attitude	3.06	0.45		

Degree of Freedom = 152
Number of Observations = 154

The hemispheric preference of students was not a contributing factor in the students' content acquisition. The results show a left hemispheric content mean = 5.16, S.D. = 1.56, right hemispheric content mean = 6.02, S.D. = 2.55, whole hemispheric content mean = 5.60, S. D. = 1.24, df = 2/151, F-value = 2.481 and P = 0.087 > 0.05.

Effect of Student Learning Style (Hemisphericity on Student Content

Achievement Measured by the Content Acquisition Achievement Test

LEARNING STYLE	MEAN	S.D.	D.F.	F-value	P-value
Left Hemisphere	5.16	1.56	48		
Right Hemisphere	6.02	2.55	89	2.481	0.087
Whole Hemisphere	5.60	1.24	14		

Degrees of Freedom = 2/151
Number of Observations = 154

The hemispheric preference of students was not a contributing factor in the students' process skill acquisition. The results show left hemisphere process mean = 4.61, S.D. = 2.52, right hemisphere process mean = 4.89, S.D. = 2.98, whole hemisphere process mean = 3.80, S.D. = 1.70, df = 2/151, F-value = 1.047, P = 0.354 > 0.05. There was no significant difference between the students' progress in science process skills with regard to their learning styles.

Effect of Student Learning Style (Hemisphericity) on Student Process

Skills Measured by the Process Skills Acquisition Test

LEARNING STYLE	MEAN	S.D.	D.F.	F-value	P-value
Left Hemisphere	4.61	2.52	48		
Right Hemisphere	4.89	2.98	89	1.047	> 0.354
Whole Hemisphere	3.80	1.70	14		

Degree of Freedom = 2/151
Number of Observations = 154

Summary

Overall, the findings of this study indicate that the implementation of the Natural Resource Science Curriculum through the Learning Cycle strategies has positive and significant effects in science content and process skills achievement of elementary school students. The findings also indicate that the factor which most influences students' science content achievement is their attitudes toward science. A process approach such as the Learning Cycle strategies that develops overt engagement in classroom activities (Bloom, 1984; Linn and Thier, 1975; Piaget, 1964; Butts, 1984) effects positive change on the content achievement of students.

Student attitude has a positive relationship with student content achievement and has no significant relationship with student process skills development. A process approach such as Learning Cycle strategies which develops overt engagement in classroom activities (Bloom, 1984; Meiring, 1980; Good, 1971; Bratt, 1977 and 1973) does facilitate attitude change in conjunction with student content achievement. Holistic science inquiry strategies such as the Learning Cycle do facilitate student science attitude change in the elementary school.

The student learning style does not significantly affect the content and process skill acquisition achievement of science students in elementary grade classrooms implementing Natural Resource Science Module through the Learning Cycle strategy. The test results indicated no significant differences in gain in content and process skills acquisition across three modalities of learning tests. In other studies, most significant findings were indicated with right and whole brain modalities. Based on the findings of Frank (1984) and Dunn, Beaudry, and Klavas (1989), right hemisphere and whole brained processing should be facilitated by activities which involve visuo-spatial and tactuo-spatial approaches. Results of this study did not support this even though the Learning Cycle does utilize such approaches. According to a study by Dunn, Beaudry and Klavas (1989), however, a multi-sensory approach such as the Learning Cycle facilitates right tendency of dislike for structure. This study does not indicate the importance of learning styles. Consideration for learning styles should be given when implementing Learning Cycle designed for teaching science modules.

Conclusions

Clearly, the process approach to science teaching does have an effect on outcomes in achievement both content and process. The attitudes toward science change as students engage in hands-on activities. According to Kyle et al., (1985) students involved in process programs (a) wish for more science time, (b) realize that science teachers value questions and prefer questioning, (c) realize science is useful in daily living and will be useful in the future--acknowledging that curiosity is an integral part of science, and (d) manifest more positive views of science and scientists then non-process students.

Students seem to improve with the hands-on process approach. This process approach offers more than a different strategy for teaching elementary science. Researchers state that the process approach is preferred by students over the traditional test-oriented science. Overall in other research studies, students involved with process approaches perform more positively with tests of general achievement, process skills and math (Shymansky et al., 1982).

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THE ROBERT RODALE LECTURE

• Christine Von Weizsacker, Leading European Spokesperson on Biotechnology & Genetic Engineering
Saturday, February 10, 9:00 AM
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CONFERENCE EVE PLENARY:

"Technology, Corporations and Jobs in the Global Political Economy"
• Ward Morehouse, John Cavanagh and Rustum Roy
Thursday, February 8, 7:30 PM
Support by MASCO Charitable Trust

THE MATERIALS RECYCLING SUMMIT

• Dennis Weaver, Founder, Institute of Ecolonomics,
Leading Advocate of New Environmental Technologies
"'Ecolonomics —A Cause Worth Fighting For"
Saturday, February 10, 4:00 PM

SECOND JACQUES ELLUL SYMPOSIUM

• Jerry Mander, Public Media Center, Giving Keynote Address:
"Television and the Global Homogenization of Consciousness: Cultural, Political & Social Consequences"
• Panelists: Dick Stivers, Namir Khan, Bill Vanderburg; moderator Rustum Roy
Saturday, February 10, 10:10 AM - 3:50 PM

THE BARBOUR LECTURE

"The Life and Work of Ian Barbour, Theologian and Philosopher"
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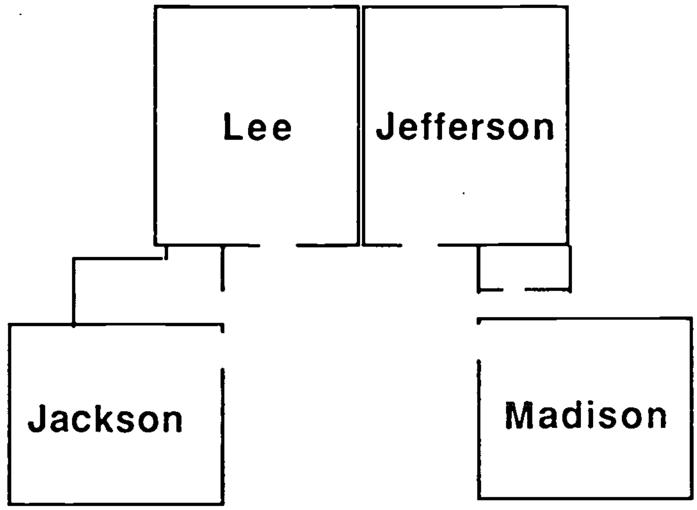
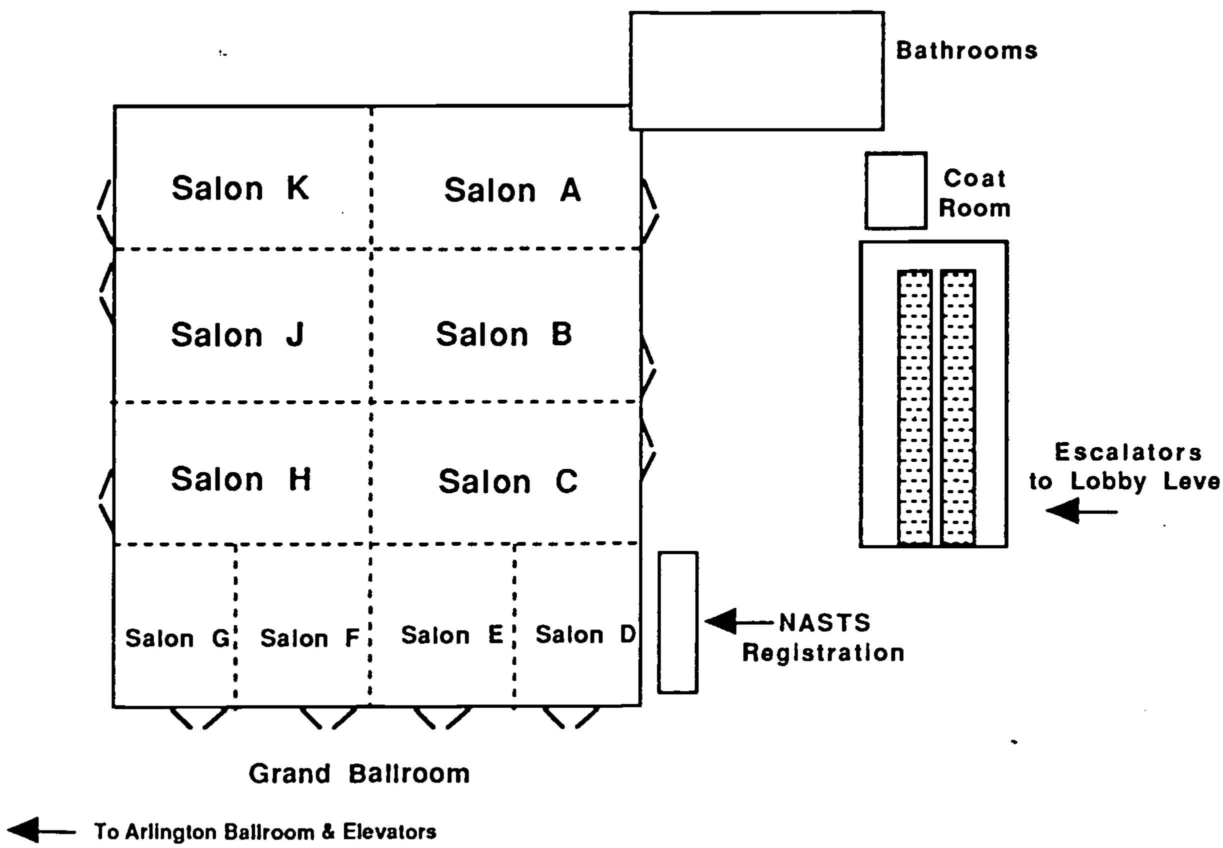
HOTEL MAP



Lobby Level



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Beverly Nelson, Science, Technology and Chemistry Teacher, Hackensack High School, NJ
Diane Robinson, Interdisciplinary Science Center, Hampton University
Virginia Wilson, North Carolina School of Science and Mathematics
Karen Zuga, Department of Educational Studies, Ohio State University

VALUES AND RELIGION ASSEMBLY
Co-Chairs: **Deva Beck**, The Wellness Foundation, Washington, DC; **Richard Dietrich**, STS Program, The Pennsylvania State University

APPLIED SCIENCE, TECHNOLOGY AND ENGINEERING ASSEMBLY
Co-Chairs: **Taft Broome**, Howard University; **Tom Liao**, Chair, Department Technology & Society, SUNY Stony Brook

HISTORY, PHILOSOPHY AND SOCIOLOGY OF SCIENCE AND TECHNOLOGY ASSEMBLY
Co-Chairs: **Paul Durbin**, Philosophy Dept, University of Delaware; **John Wilkes**, Social Science & Policy Studies, Worcester Polytechnic Institute
Robert McGinn, Assoc. Chair STS Program, Stanford University

ORGANIZATION

The National Association for Science, Technology and Society (NASTS) was formed in 1988 to bring together the increasing number of persons and groups actively concerned with STS. In some ways, NASTS is a federation of already existing sectors of interest: K-12 educators; post-secondary educators; policy makers; scientists and engineers; public interest activists; museum and science center staff; religion professionals; members of the print and broadcast media; and participants from the international community. NASTS goal is to provide a forum where members of these sectors can gather and take the pro-active stance to guide science and technology as reflections of our underlying values. NASTS seeks to provide the venue for all its members to meet as equals to discuss, debate, and share concerns for society's handling of science and technology. NASTS is organized as a 501(c)3 non-profit educational corporation. Its president and board of directors, guides the Association. Its address is 133 Willard Building, University Park, PA 16802, Phone 814/865-3044, FAX 814/865-3047, E-Mail ejb2@psu.edu.

STS-10 REGISTRATION AND INFORMATION

Conference Registration Desk, Arlington Foyer, First Floor

Thursday, February 8	6:00 PM - 8:00 PM
Friday, February 9	8:00 AM - 5:00 PM
Saturday, February 10	8:00 AM - 12:00 PM

BREAKFAST, LUNCH & DINNER SUGGESTIONS

In the hotel, the **Terrace Restaurant** (level 1) serves breakfast, lunch and dinner. The **Atrium** (foyer level) also serves food and drink.

There is an underground mall at the hotel, "The Crystal City Underground," where you will find several fast food lunch and early supper places at the Food Court. Ethnic restaurants can be found 3 blocks south on S. Eads on 23rd St. (left out hotel, right on 23rd)

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HOTEL SERVICES:

Shuttle Service: Complimentary van service is available every 15 minutes to and from National Airport, starting at 6:00 AM and running until 11:00 PM. The metro stop is located less than five minutes from the hotel via an underground walkway.
Indoor pool: Located on the lobby level of the hotel; open from 6:30 AM-9:30 PM daily.

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SUBMISSION OF PAPERS

All presenters at STS-11 are invited to submit papers for possible inclusion in both the Proceedings of the Conference which are published in the ERIC database and the *Bulletin of Science, Technology and Society*. If the latter, please indicate whether you want the paper considered in the academic refereed section. Please send two copies of double-spaced manuscript to Dr. Dennis Cheek, RI Department of Education, 22 Hayes Street, B-4, Providence, RI 02908. APA format is preferred and will be required for final versions of the ERIC proceedings volume. One copy of your paper will be sent to the Managing Editor of the Bulletin of STS, the other copy will be edited by Dennis and Kim Cheek and returned to you with instructions for preparation of camera-ready copy. Prior proceedings volumes are available within the ERIC system under the search name of Dennis Cheek.

CONFERENCE EVE PLENARY:

Thursday February 8, 7:30-9:30 PM

Location: Salon C

Part 1: 7:30

Presentation of Honorary Membership : **Congressman George Brown**, D(CA), Ranking Member, House Committee on Science, long-time supporter of STS at the highest levels.

Part 2: 8:00

Chair: **Ward Morehouse**, President, Council on International and Public Affairs, NY

Participants: **John Cavanagh**, The Institute for Policy Studies, Washington, D.C.

Responder: **Rustum Roy**, NASTS Corporation Chair

Technology, Corporations and Jobs in the Global Politcial Economy

PLENARY 1:

Friday February 9
8:30-9:50 AM
Location: Salon C

Welcome: Jane Konrad, NASTS President and Conference Chair (8:30 AM)

Introduction: Taft Broome, NASTS Vice President and Conference Chair (8:40 AM)

Speaker: Henry Petroski, Chair, Civil & Environmental Engineering, Duke University

To Engineer is Human!

Session 1: Friday, February 9, 10:00 - 11:00 AM

1.1 Panel — Education — Lee

Deconstructing the Technical-Cultural Dichotomy in Educational Practice

A multiracial group of graduate students and faculty grounded in several disciplines, began a "reading group" in 1992. The purpose of the group was to examine, the ways in which science, technology, and educational theories, together with various disciplines from the arts and humanities, interact to construct and reproduce gender, race, and class. We examined critically ways in which we can bring this knowledge to bear on our day-to-day activities as teachers, researchers, and instructional technologists. In May 1994 we combined individual reflections on *The Racial Economy of Science* in a scripted dialogue.

This session will present an edited 10-15 minute video excerpted from a group reading of the 1994 dialogue, to be followed by a new scripted interactive dialogue which will reflect on how subsequent readings, activities, and ideas have grown since then. Audience members will be invited to join in a continuation of the discussion. Handouts, including a complete list of our readings to date, will be available.

Suzanne K. Damarin (presider), Ohio State University, Columbus, OH.

1.2 Paper — Education — Jackson

Presider:

10:00 - 10:20 — Irma Jarcho, The Day School, New York, NY. *Ethical Decisions in Science, Technology, and Medicine for the High School Classroom.*

10:20 - 10:40 — John L. Roeder, The Calhoun School, New York, NY. *Bringing STS to Both Science and History Courses.*

10:40 - 11:00 — Noel Hammatt, Louisiana State University, Baton Rouge, LA. *Social Studies Through Time, Touch, and Technology.*

1.3 Workshop — Education — Madison

General Science Courses as a Vehicle for Teaching STS to Everyone

Because all high school and college students take at least a few science courses, it is feasible to teach STS topics to everyone by including these topics within our general science courses. This is especially easy and exciting to do in science courses for nonscientist, because these courses are flexible, conceptual, and taught to students whose interests span a broad range.

This workshop will teach teachers how to teach specific STS-type topics — such as ozone depletion, global warming, SETI, and pseudoscience (e.g., creationism, UROs) — to their students in general science courses. Transparency masters and information sheets containing references and other teacher background material will be distributed. Discussion will include the relationship of specific STS topics to various sciences and controversial points which must be dealt with sensitively in a diverse class (e.g., religious feelings in the coverage of creation). Participants will also be asked to brainstorm a list of significant global/national issues and determine their connection to science.

Art Hobson, University of Arkansas, Fayetteville, AR.

1.4 Workshop General Salon D

How to Give an Abysmal Conference Presentation

How many times have you been to conference sessions where presenters convey interesting information abysmally? No doubt, you thought to yourself, "I wish that I had that skill." Now is your chance to learn how to turn a topic dear to your heart into a sure cure for insomnia.

The experiential *style* of the proposed workshop and its *content* draw on my years of research into communication between technical and nontechnical people, between the person who knows — the "expert" — and the one who needs to know — the "non-expert." Based on this research, related educational research, and years of experience experimenting in the classroom, I have designed and presented numerous workshops on "reinventing teaching" for university educators and corporate trainers in the U.S. and Australia.

Participants will relate good and bad experiences, brainstorm and work in small groups to develop approaches for their own presentations and workshops.

William D. Rifkin, Ph.D., Wellengong, NSW.

1.5 Paper Technology Salon E

Presider:

10:00 - 10:20 — Ismail Ipek, University of Pittsburgh. *New Technologies and Intelligent Computer Assisted Instruction (ICAI) in Relation to Instructional Design Systems for Education.*

10:20 - 10:40 — Gladius Lewis, University of Memphis. *Issues in the Use of Acrylic Bone Cement I Arthroplasties.*

10:40 - 11:00 — M. David Burghardt, Hofstra's Center for Technology Education, *Engineering Involvement in K-12 Education.*

1.6 Workshop Education Salon F

Course Design and Implementation Using Artificial Intelligence Software

Instruction can easily and effectively be planned on the computer with three interrelated and interdependent application software packages that form an integrated system based on artificial intelligence. The software includes the essentials of planning an entire course that is focused on student outcomes: enables to plan a unit of work that is consistent with the goals and objectives outlined in the syllabus and assessment tools that insure that evaluation is consistent with the preceding instructional elements.

Projected computer images will engage participants in the key decisions in constructing the elements of a syllabus, guide and monitor them in planning while key decisions are aggregated. Content goals will enable the writing of performance objectives which specify content, detail quantity/quality/efficiency /durability standards, and the conditions under which evaluation will take place.

Jerry Streichler, Bowling Green State University, OH.

1.7 Workshop Values & Religion Salon G

Sustaining Health: Individual and Community Wellness For the 21st Century

Two-hour workshop

A wholistic understanding of health and human wellness acknowledges the interplay of mind, emotions and body operating on both bio-chemical and bio-electrical levels of energy, as well as mental and spiritual levels. This understanding calls for a holistic approach.

With the resurgence of interest in self-help, there is also development of alternative medical science and the relationship of psychological and spiritual breakthroughs for medicine. This growing body of knowledge leads us to harness these energies and technologies to bring about sustained individual, community, and global wellness for ourselves, the environment, and future generations.

Deva Beck and Jeremy Wright, The Wellness Foundation, Washington, DC, and Toronto.

Session 2: Friday, February 9, 11:10 AM - 12:10 PM

2.1 Workshop | **Education** | **Lee**

Bioethics Forums

Bioethics Forums is a high school videodisc curriculum designed to immerse students in ethical dilemmas. The topic shared in this presentation is fetal alcohol syndrome. The presentation will provide a model for dealing with ethical issues in the context of problem identification, accessing information, identifying stakeholders, identifying values involved, examining options, and considering processes. The approach emphasizes group interactions and multimedia presentations.

Donald R. Daugs, Utah State University, Logan UT.

2.2 Panel | **Education** | **Jefferson**

Engineering Literacy

Special panel and discussion with Plenary Speaker and others on "Engineering Literacy."

Henry Petroski, Chair, Civil Engineeing, Duke University; **Taft Broome**, Civil Engineering Howard University, Washington, DC; **Paul Durbin**, respondent, University of Delaware.

2.3 Paper | **Education** | **Jackson**

11:10 - 11:30 — **Christopher Schultz**, University of New Mexico, Albuquerque, NM, *Community and Tradition, Technology and Learning: Apprenticeship Training in Germany and Bridging the Preservation vs Progress Divide.*

11:30 - 11:50 — **Wieslaw Grebski**, The Pennsylvania State University, Hazelton, PA, *Technology Education Through a Co-op with Industry.*

11:50 - 12:10 — **Art Rosser** and **Jerry Richter**, Central Missouri State University, Warrensburg, MO, *Technology and Change - 2000.*

2.4 Workshop | **Education** | **Madison**

Multimedia Using the Digital Chisel

Teachers and students can produce interactive portfolios, lessons, storybooks, reports, presentations, or tests — the possibilities are endless. Colorful graphics, movies, sound, text, and animation help you create your own multimedia projects. You don't need to be a programmer to use this program. It's easy enough for young students to use yet powerful enough to take you as far as you can imagine.

The audience will learn how to integrate multimedia authoring into their curriculum using their own materials. They will see examples of projects and be able to participate in creating a multimedia project in the session.

Staci Reed, Pierian Spring Software, Portland, OR.

2.5 Paper | **Sociology of S & T** | **Salon D**

11:10 - 11:40 — **Susan Hagedorn**, Virginia Tech, Blacksburg, VA, *Scientist Answers to Public Concerns on Biotechnology: Rhetorical or Conceptual Mismatches?*

2.6 Workshop | **Education** | **Salon F**

The Development of Students' Higher-Order Cognitive Skills - the Key to Progress in Science-Technology-Environment-Society Education

In view of the overly high expectations of people in a world of conflicting and competing values and finite, unevenly distributed resources, modern life has turned into a continuous process of problem solving and decision making or decision selection from either available or as yet uncreated options. Thus, a major purpose of science-technology-environment-society (STES) education is the development of the students' high-order cognitive skills (HOCS) Our multidimensional, research-based systemic approach to STES curricula and to the teaching, learning, evaluation, and self-evaluation of HOCS will be described.

Uri Zoller, Haifa University, Oranim, ISRAEL.

Session 2: Friday, February 9, 11:10 AM - 12:10 PM

2.7 Workshop **Values & Religion** **Salon G**

Sustaining Health: Individual and Community Wellness For the 21st Century
Two-hour workshop (continuation)

For full description, see Session 1.7.

Deva Beck and **Jeremy Wright**, The Wellness Foundation, Washington, DC, and Toronto.

Breakfast, Lunch & Dinner Suggestions

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2.8 Workshop **Education** **Salon E**

Technology at the Core of the College Curriculum

As students go forward to business and industry, it is critical that they develop a sense of responsibility in applying technology for the improvement of society. The interdisciplinary nature of technology provides a relevant subject to incorporate into the university curriculum. The elective course, "Technology and Society," is now being reviewed for inclusion in the general education requirements.

In this workshop, the presenters discuss various aspects of the course: content, multimedia delivery, instructional materials, and the development of interactive student groups.

Charles Patrick and Ahmad Zargari, Morehead State University, Morehead, KY.

Session 3: Friday, February 9, 1:30 - 2:30 PM

3.1 Special Lecture **Values & Religion** **Jefferson**

The Life and Work of Ian Barbour

Noted theologian and philosopher Ian Barbour, author of *Religion in an Age of Science* and *Ethics in an Age of Technology* speaks.

Responders: **James Nash**, Wesley Seminary, Washington, DC and **Leonard Waks**, Temple University, Philadelphia, PA.

3.2 Roundtable **Any Topics** **Salon C**

Some of you may not have been able to submit your proposal for a panel, workshop, or paper in time. Others of you may want to share with others a hot idea that just occurred to you. The "Open Roundtable" is for you—the brilliant as well as the chronologically challenged. Simply snag a table in Salon C, set up a sign on the Table indicating your topic, and talk to whomever shows up. When done, vacate the table for someone else. For attendees, here is a chance to speak informally with colleagues who are working on a new idea in its preliminary stages, or on a very informal basis. There is no AV nor moderators.

Session 3: Friday, February 9, 1:30 - 2:30 PM

3.3 Roundtable — Philosophy of S & T — Jackson

An Interdisciplinary Examination of the Connections Between S & T, Language Idioms, and Evolving Human Conceptions

Advances in S & T impact social institutions and culture —from architecture, music, art and literature, to the more elusive use of idioms in language. Here, I focus on evolving language idioms and explore their implications for psychology, social psychology and cognitive development.

The presentation will include numerous visual and audio examples—word "morphing," computer-generated images of transmutation. Questions will be posed for groups to consider.

Brian Garvey, Monmouth University, New Jersey.

3.4 Workshop — Education — Madison

***Active Physics:* An STS Approach for Students Who Wouldn't Otherwise Study Physics**

Active Physics is an activity-based, Thematically-oriented approach to the study of physics for high school students who would otherwise not study physics. Developed by the American Association of Physics Teachers (AAPT) and the American Institute of Physics (AIP) with assistance from the American Physical of Society (APS), this course is currently being field-tested in fifty schools throughout the U.S. and will soon be ready for wider dissemination. The themes of Transportation, the Home, Sports, Health and Medicine, Communications, and Predicting the Future were chosen for their relevance to high school students' lives and thus bring an STS approach to the study of physics. This course is based on alternative assessment, which is the focus of course activities. Prefacing course activities with a "What do You Think?" question gives them a constructivist approach.

Come to this workshop to experience an alternative assessment and an activity-based lesson leading up to it.

John L. Roeder, The Calhoun School, New York, NY and **Arthur Eisenkraft**, *Active Physics*, Ossining, NY.

3.5 Paper — History — Salon D

The Role of History in Developing Technological Literacy

2:40-3:00 — Patricia C. Click, Division of Technology, Culture and Communication, School of Engineering and Applied Science, University of Virginia, *Cultural Context, Engineering, and Aesthetic Choices: Historical Analysis and Technological Literacy.*
3:00-3:20 — Kathryn A. Neeley, Division of Technology, Culture and Communication, School of Engineering and Applied Science, University of Virginia, *Reframing Technical Artifacts.*
3:20-3:40 — Melvin Cherno, Division of Technology, Culture and Communication, School of Engineering and Applied Science, University of Virginia, *Using 19th-Century Newspapers to Put Technology in Perspective.*

3.6 Workshop — Education — Lee

"Principles of Engineering" in New York State

This combination of lecture, demonstration, and hands-on activities will present a description of the "Principles of Engineering" program developed for New York State secondary schools. Attendees will participate in one of the student activities which are part of the program's case studies.

E. Joe Piel and Tom Liao, SUNY-Stony Brook, NY.

Session 4: Friday, February 9, 2:40 - 3:40 PM

4.1 Panel — Education — Lee

The Dangers of Scientific Literacy

It is important to discuss the potential dangers involved in any attempt to make a "quick fix" of the public's failing score on tests purported to measure scientific literacy. As vital as science and technology are to the life of every citizen, many current tests and surveys have been characterized as a search for questions for a new Trivial Pursuit! Sophisticated students know that high scores come to those who give the *expected* answers, be it right, wrong, or somewhere in between." Yet if our goal is a citizenship knowledgeable about science, how can dangers be avoided? What is it that we should be trying to teach our students? How should "progress" in this effort be measured?

Each panel member will give brief presentations of their view of the dangers, present answers to the above questions, and the discussion will be opened to the audience.

Susan A. Hagedorn, Virginia Technical Institute, Blacksburg, VA.

4.2 Panel — Applied S, T & E — Jefferson

Preventive Engineering = Engineering + STS

Two neighboring engineering faculties have turned to STS to educate engineers to help advance the technological frontier in a way that is sensitive to social and environmental issues. Preventive engineering approaches are based on three concepts: ecology of technology; information; and values as "set-points." The principles and methods, the curricula of several courses, and a unique approach to self-directed learning will be presented to the audience by three teacher practitioners. A discussion will follow the three individual presentations.

Willem H. Vanderburg, University of Toronto; **Namir Khan**, University of Toronto; **Robert Hudspith**, McMaster University, Hamilton, Ontario.

4.3 Paper — Education — Jackson

2:40-3:00 — Paul Jablon, Brooklyn College, Brooklyn, NY, *Some Dilemmas of the Constructivist Approach to Science: When the Cultures of the Learner and of the School Intersect.*

3:00-3:20 — Pei-Jen Chen and Huoy-Jia Tzeng, NTTC, Taipei, Taiwan, *Beyond Education Reform: Beyond Science Reform.*

3:20-3:40 — Chen Hsia Wang, National Taiwan Normal University, Taipei, Taiwan, *Mapping as a Thinking Tool.*

4.4 Workshop — Technology Education — Salon D

The Role of History in Developing Technological Literacy

In order to grasp the role of technology education in education, particularly higher education, a close look at its historical perspective and its emergence as a field seems inevitable. This presentation focuses on the following topics:

1. Role of technology in providing appropriate tolls, techniques and systems to meet human survival needs;

2. Evolution of technologies;

3. Transition of manual to industrial arts, and then to technology education; and

4. Current purposes for technology education.

Ahmad Zargari, Charles Coddington, and Charles Patrick, all of Morehead State University, Morehead, KY.

Session 4: Friday, February 9, 2:40 - 3:40 PM

4.5 Roundtable **Education** **Salon F**

Integrating Science, Technology and the Environment: Life Cycle Analysis and Green Design

Green design - or, Design for Environment (DFE) - has been gaining status as a research paradigm in engineering education to make considerations of environment inherent in the teaching and practice of engineering. This talk will discuss some of our attempts to make this approach a tool in general courses at pre-college (elementary and secondary) and college level. Part of the talk will be the presentation by students in a general environmental studies course at Carnegie Mellon of their comparative life cycle analysis. This will demonstrate the successful use of the paradigm.

Jane Konrad, Indira Nair, Terry Lumish, Joan Chen and **Anuj Gupta**, Pittsburgh Regional Center for Science Teachers and Carnegie Mellon University.

4.6 Workshop **Applied S, T & E** **Salon G**

Inventor's Toolkit

This hands-on workshop will introduce the Inventor's Toolkit, an interactive system that leads an inventor through a network of questions in order to create an expanded disclosure document designed not only to protect the initial ideas but also to complete the development of an invention and present it to patent attorneys, Patent Office Examiners, licensing agents, design engineers, manufacturers, and others.

The workshop will consist of timed segments in which the participants make their own lists in response to the prompting lists that are part of the system. These prompting lists grew out of the author's own experience as an inventor, writer, teacher, and student of creativity, as well as the strategies of experts such as A.L. Osborn, Edward de Bono, Gorden Glegg, C. Jones, and others.

Otis Douglas, Longwood College, Farmville, VA.

4.7 Paper/Roundtable **Education** **Madison**

2:40-3:00 — Donald Daugs, Utah State University, Logan, UT, *Sustainable Science Education.*

The context of this presentation is the Tofflers' *The Third Wave*. Criteria are presented to identify curriculum as promoting yesterday's industrial society or tomorrow's information age. Feedback will be solicited for setting criteria for a sustainable STS curriculum in the context of meeting the needs of *A New Civilization*.

3:00-3:40 — Lori Moran, Iona College and **Nicolyn Ausiello**, Iona Preparatory High School, New Rochelle, NY, *Cowabunga! An Introduction to the Internet*.

If your school has internet access, but you've never "surfed the 'net'", it's time to get your feet wet! This presentation will cover the basics: how the internet got started, what it can and can't do, and how to search for information. We'll also show you what to watch out for (there are some "sharks" in the water!). Conference attendees can also "NET-work" and share favorite addresses.

4.8 Workshop **Values & Religion** **Salon E**

Renewing Society & Emerging Educational Models: Recyclables, Renewables & Regenerators

Drawing from the emerging models of sustainable earth communities based on values of planetary stewardship and life-cycle learning, this workshop will present newly validated approaches to education and social transformation.

Dr. Conroy will outline models of learning and communication showing the implications of several technologies of recycling and regeneration now available to teachers, preachers and social empowerment leaders. This workshop will connect local community change in schools, congregations, and businesses to the global paradism shifts of the late 1990s.

Don Conroy, Director, The North American Coalition on Religion and Ecology (NACRE), Washington, DC.

PLENARY 2:

Friday February 9
3:50-4:50 AM
Location: Salon C

Introduction:	Jane Konrad, NASTS President
Speaker:	Colonel Richard M. Satava, MD in the U.S. Army Medical Corps; Program Manager, Advanced Biomedical Technologies Program at the Advanced Research Projects Agency
Topic:	"Surgery in the Twenty-First Century"

Session 5: Friday, February 9, 5:00 -6:00 PM

5.1 Workshop — Education — Lee

Science Sleuths: A Group Approach to Enhancing Multimedia

Science Sleuths is a laser disc-based elementary science curriculum produced by Video Discovery. The approach emphasizes problem solving in a variety of STS contexts. Basic steps in the learning process include identifying the problem, developing a plan, gathering and sorting information, and obtaining and verifying the solution. A real strength of the approach is the suggested strategies for student groupings which include student moderators of small groups, moderated teams, and cooperative teams.

This workshop will demonstrate the technology and model the methodologies possible with the program. Resources include interviews, videos, photos, real life episodes, data bases, and teaching strategies.

Donald R. Daugs, Utah State University, Logan, UT.

5.2 Paper — Education — Jackson

5:00-5:20 — **Janice Koch**, Hofstra University, Hemptstead, NY, *STS Education: Leveling the Playing Field for Women and Minorities.*

5:20-5:40 — **Cheryl Ney** and **Karla Davis**, Capital University, Columbus, OH, *Getting Safe: Transforming the Culture of Chemical Hygiene.*

5:40-6:00 — **Michael A. Hayden**, Mississippi State University, Mississippi State, MS, *Age, Gender, and Multicultural Factors Related to Technological Literacy.*

Session 5: Friday, February 9, 5:00 -6:00 PM

5.3 Workshop | **Education** | **Madison**

An Integrated Science Program for Secondary Schools

This presentation describes a three-year science program for secondary schools which contains and extends the content and concepts of traditional course in physics, chemistry, biology and earth and space sciences. The Integrated Science curriculum is modular so that it can be woven together from "problem platforms." These are large problems which can be chosen to address the learner's characteristics, potential for engagement, and resources of a particular setting. A successful platform leads to the students' identification of essential questions from which the content emerges. Participants will be asked to demonstrate the validity of the preceding statement and to construct the elements of a tightly-integrated curriculum based on one of two problem platforms. The alignment of the resulting content sequences with AAAS and NRC guidelines will be examined.

John Eggebrecht, Sue Styer, Ray Dagenais, Don Dosch, Norm Merczak, Margaret Park and David Workman, Illinois Math and Science Academy, Aurora, IL.

5.4 Panel | **Technology Citizenship** | **Salon D**

Ethical and Political Dimensions of Technological Citizenship

This panel explores the meaning of, and opportunities for, citizenship within the context of large-scale technological systems. Two conceptions are presented: (1) how various technologies enhance or diminish opportunities for practicing citizenship (e.g., video and cyberdemocracy); and (2) the rights and opportunities for shaping the very ways these technologies govern us.

Andrew D. Zimmerman (moderator), Delaware Technical & Community College; **Terrell W. Bynam,** Southern Connecticut State University, **Tara McPherson,** University of Southern California; **Michael R. Ogden,** University of Hawaii; and **Jesse S. Tatum,** RPI.

5.5 Panel | **Salon E**

Wilkes Panel

Presentations by students of John Wilkes, Worcester Polytechnic Institute.

5.6 Workshop | **Education** | **Salon F**

At the Crosswalk: A Student Problem, A Teacher Initiative

The NSF-funded Urban Math, Science, Technology Leadership Project has been working with secondary school teachers for the past two years. On the basis of a pre-engineering class model at Brooklyn Technical High School, the Project is working to assist math, science, and technology teachers in developing a design approach to instruction and learning. This workshop will engage participants in a science design activity developed in a Project participant's classroom. This will be followed by a discussion of the approach to create a student-centered learning environment.

Ed Goldman and Murray Shabat, Brooklyn Technical HS, Brooklyn, NY; **Dorothy Bennett,** Center for Children and Technology, NY.

Board of Directors Meeting

Friday February 9

8:00-10:00 PM

Location: Jackson Room

INSTITUTIONAL MEMBERS
ADVISORY COUNCIL BREAKFAST MEETING
Saturday, February 10
7:30-8:50 AM
Location: Madison Room

Chair: Stephen H. Cutcliffe

- **Carnegie Mellon University:** Indira Nair
- **Central Missouri State University:** Arthur J. Rosser
- **Colby College:** James Fleming
- **Gloucester County College:** George A. Randall
- **Iona College:** Victor Stanionis

- **Lehigh University:** Stephen H. Cutcliffe
- **Michigan Technological University:** Terry S. Reynolds, Chair
- **National Taiwan Normal University:** Cheng-Hsia Wang
- **Pennsylvania State University:** Carl Mitcham
- **Perdue University:** Leon E. Trachtman

- **Raritan Valley Community College:** Jere Jones
- **Rensselaer Polytechnic Institute:** Deborah Johnson
- **Southern College of Technology:** Edward A. Vizzini
- **Stanford University:** Robert E. McGinn

- **University of California, Davis:** Howard G. Schultz
- **University of Pittsburgh, Johnstown:** James Hales
- **Utah State University:** Donald Fiesinger
- **Wooster Polytechnic Institute:** Douglas W. Woods

PLENARY 3:
Robert Rodale Lecturer for 1996
Saturday February 10
9:00-10:00 AM
Location: Salon C

Introduction: Rustum Roy, NASTS Corporation Chair

Award Presentation: John Guffey, Exec. Vice President, Calvert Social Investment Fund, Vice Chairman, Calvert Group Funds

Speaker: Christine Von Weizsacker, Leading European Spokesperson on Biotechnology & Genetic Engineering

Session 6: Saturday, February 10, 10:10 - 11:10 AM

6.1 Second Jacques Ellul Symposium Salon C

Television is undoubtedly one of the most influential technologies in a modern society. Without it, our individual and collective social, economic, political and moral lives would be very different. Traditional societies looked to the past, their tradition, customs, values and morality to guide the present. With the weakening of traditional values and morality, modern societies have created alternatives. This Second Jacques Ellul Symposium will examine how television helps to provide this guidance for life in a modern society by mediating many relations between individuals, groups and institutions. Television is an important factor in deciding the fundamental question of technological autonomy: Is the influence of society on technology more decisive than the influence of technology on society?

Part 1: The Role of Television in Contemporary Civilization (2 hours: 10:10-12:20 PM)

Keynote Address: **Jerry Mander**, Public Media Center, San Francisco, author of *Seven Arguments for the Elimination of Television* and *In the Absence of the Sacred: The Failure of Technology and the Survival of the Indian Nations*

Keynote Title: "Television and the Global Homogenization of Consciousness: Cultural, Political & Social Consequences"

Part 2: Television as a Response to the Needs and Problems of a Modern Society (2 hours: 1:40-3:50 PM)

Panel Discussion: **Dick Stivers**, "Visual Morality and Tradition — Society's New Clothes?" **Namir Khan**, "Television and Political Democracy;" **Bill Vanderburg**, "Will Television Change Society or Society Change Television?" Moderator: **Rustum Roy**.

6.2 Paper Education Jackson

10:10-10:30 — David Burghardt, Hofstra University, Hempstead, NY, *NYSTEN - A Technology Education Teacher Training Network with a MST Focus.*

10:30-10:50 — Sulaiman Ngah Razali, University of Malaya, 59100 Kuala Lumpur, Malaysia, *The Contribution of Malaysian Vocational Education Towards the Development of a Skilled Work Force.*

10:50-11:10 — Patrick N. Foster, University of Missouri, Columbia, MO, *Polarity in Historical Ideologies of Technology Education.*

6.3 Paper Education Madison

10:10-10:30 — R. Eugene Mellican, University of Massachusetts, Lowell, MA, *Scientific Literacy: What Does it Mean and Can it be Taught?*

10:30-10:50 — Doris Z. Fleischer, New Jersey Institue of Technology, Newark, NJ, *Preparing Disabled Students for Careers in a Technological Society.*

10:50-11:10 — Barbara Silber and Tama Seife, Fieldston School, Bronx, NY, *Women and Science at Fieldston School.*

6.4 Tutorial Education Salon E

How Various Teacher Education Audiences Construct Their Understanding of STS

This presentation will share findings of a series of qualitative studies of how various teacher education audiences construct their understanding of STS. These audiences include preservice science teachers, preservice elementary teachers, inservice science teachers, and inservice social studies teachers. These findings identify relevant factors that influence how various audiences developed their understanding of STS in various innovative courses at the University of South Florida. The findings have been used to develop a template for STS courses for various teacher audiences. Participants in this presentation are encouraged to share their insights or relevant research regarding how teachers understand STS.

Thomas LaPorta and **Barbara S. Spector**, University of South Florida, Tampa, FL.

Session 7: Saturday, February 10, 11:20 - 12:20 PM

7.1	Second Jacques Ellul Symposium	Salon C
	Part 1 (continued): The Role of Television in Contemporary Civilization. See 6.1 for full description.	

7.2 Panel Education Lee

STS at Schools of the NCSSSMST

A panel of teachers from two member schools of the National Consortium of Specialized Secondary Schools for Mathematics, Science, and Technology (NCSSSMST) will report on efforts to include STS issues in the curricula. The importance of these specialty schools for the expansion of scientific and technolgical studies at the secondary level will be addressed. The presenters will discuss STS curriculum ideas for science, mathematics, and the humanities.

Virginia S. Wilson and James A. Little, North Carolina School of Science and Mathematics, Durham, NC, and Sally Bellacqua, Thomas Jefferson High School, Fairfax, VA.

7.3 Paper Education Jackson

11:20-11:40 — Bonnie Kaiser, Rockefeller University, New York, NY, *Rockefeller University's Science Outreach.*

11:40-12:00 — Howard G. Schutz and Susan B. Kaiser, University of California-Davis, Davis, CA, *An Educational Odyssey: Science and Society at UC Davis.*

12:00-12:20 — Rosalina Streichler, University of California-San Diego, CA, *Using Cognitive Learning Strategies as Training Tools for Science, Technology, and Social Science Education.*

7.4 Panel Technology/Environment Salon D

Developing Country Perspectives on Technology/Environment Conflicts

Three graduate students, each representing a different country, will report on the technology/environment conflicts in their respective countries. Common patterns will be highlighted. There will be time for discussion at the end.

7.4 Panel (cont.)

Chair: John Byrne, University of Delaware. *Participants:* Jessie Manuta (Philippines), Tze Luen Lin (Taiwan), and Subodh Wagle (India), all graduate students, Center for Energy and Environmental Policy, University of Delaware.

7.5 Workshop Education Salon E

The Digital Campus

The Digital Campus is a new development from the publishers of the Digital Chisel. The Digital Campus contains content covering many academic areas. By traveling through the buildings and rooms of this campus, you can access and learn the course material.

The audience will learn about new multimedia technology and how to integrate software into their curriculum. Audience will have the opportunity to talk about trends in educational software and have their questions answered by a software developer in the field.

Staci Reed, Pierian Spring Software, Portland, OR.

7.6 Tutorial Education Salon F

Writing in the Science Curriculum

Traditional science classrooms perpetuate gender and racial inequity at the postsecondary level as a result of a weeding out process that cannot accommodate a variety of learning styles. This "weeding out" is part of the traditional classroom's emphasis on professional vocation, but in addition to turning away capable students it also denies many students the chance to study science without necessarily wanting to become scientists. The traditional structure also does not always prepare students who do continue in the sciences for the communicative tasks required of their later roles in academic, corporate, and community settings.

This presentation will look at a few critiques of traditional science classooms and ask "How can writing be used heuristically?" in order to help strengthen the structure already in place for teaching science.

Laura Blasi, Georgetown University, Washington, DC.

Brown Bag Lunch for Education Assembly

Grab a quick lunch in the Crystal City Underground and meet back in Salon G for an informal meeting of the Education Assembly of NASTS

Co-Chairs: Janice Koch and John Roeder
Location: Salon G *Time: 12:45-1:30 PM*

Breakfast, Lunch & Dinner Suggestions

In the hotel, the Terrace Restaurant (level 1) serves breakfast, lunch and dinner. The Atrium (foyer level) serves some food and drinks.

There is an underground mall at the hotel, "The Crystal City Underground," where you will find several fast food lunch and early supper places at the Food Court. Ethnic restaurants can be found 3 blocks south on S. Eads on 23rd St. (left out hotel, right on 23rd)

Session 8: Saturday, February 10, 1:40 - 2:40 PM

8.1 Part 2 Second Jacques Ellul Symposium Jefferson

Television is undoubtedly one of the most influential technologies in a modern society. Without it, our individual and collective social, economic, political and moral lives would be very different. Traditional societies looked to the past, their tradition, customs, values and societies have created alternatives. This Second Jacques Ellul Symposium will examine how television helps to provide this guidance for life in a modern society by mediating many relations between individuals, groups and institutions. Television is an important factor in deciding the fundamental question of technological autonomy: Is the influence of society on technologys more decisive than the influence of technology on society?

Part 2: Television as a Response to the Needs and Problems of a Modern Society (2 hours: 1:40-3:50 PM)

Panel Discussion: Dick Stivers, "Visual Morality and Tradition — Society's New Clothes?" Namir Khan, "Television and Political Democracy," Bill Vanderburg, "Will Television Change Society or Society Change Television?" Moderator: Rustum Roy.

8.2 Roundtable Any Topics Salon C

Some of you may not have been able to submit your proposal for a panel, workshop, or paper in time. Others of you may want to share with others a hot idea that just occurred to you. The "Open Roundtable" is for you — the brilliant as well as the chronologically challenged. Simply snag a table in Salon C, set up a sign on the Table indicating your topic, and talk to whomever shows up. When done, vacate the table for someone else. for attendees, here is a chance to speak informally with coleagues who are working on a new idea in its preliminary stages, or on a very informal basis. There is no AV nor moderators.

8.3 Paper Education Jackson

1:40-2:00 — Bernice Hauser, Horace Mann School, Riverdale, NY, *The Cat in the Hat Comes Back!*

2:00-2:20 — Peter Stine, Bloomsburg University, PA, *A Traveling Museum for Elementary Science Education.*

2:20-2:40 — James Heinegg, Caldwell Public Schools, West Caldwell, NJ, *Engaging Children in Inquiry About Technological Values.*

Session 8: Saturday, February 10, 1:40 - 2:40 PM

8.4 Paper | **Education** | **Madison**

1:40-2:00 — Mario Junco and Constantine Hadjilambrinos, Florida International University, Miami, Fl, *Environmental Topics in Dade County's Public School Science Curricula.*

2:00-2:20 — Louis Campisi, Iona College, New Rochelle, NY, *Science and Technology Literacy: The Carbon Cycle — a Multimedia Presentation.*

2:20-2:40 — John Kwasnoski, Western New England College, Springfield, MA, *Physics of Automobile Crashes.*

8.5 Panel | **Research** | **Salon D**

STS Research at Virginia Tech
Part 1

A two-hour symposium in which four Ph.D. students from the Graduate Program in STS at Virginia Tech will present papers based on the research they are doing for their doctoral dissertations. This work exemplifies both the styles and scope of research found in our program.

Joseph C. Pitt (moderator), Virginia Tech, Blacksburg, VA; **Michael Seltzer**, *Scientific Experimentation and Its Technological Infrastructure: Radiation Genetics 1943-1963;* **Matthew Rea**, *Science, Public Policy, and Values: The Northern Rocky Mountain Wolf Recovery Program;* **James Collier**, *Mapping the Epistemological Territory of Science and Technology Studies;* and **Heather Harris**, *A 'Cage of Ovulating Females': Clinical Trials of Enovid at the Frontier Nursing Service.*

8.6 Tutorial | **Education** | **Salon F**

Using Multimedia to Bring Reality to the World Model

Nineteen ninety-six marks the 25th anniversary of The Club of Rome's study, *The Limits to Growth*. At that time the authors concluded that if the present trends of growth continued unchanged, the limits to physical growth would be reached in the next 100 years. The most recent update shows that the world has already exceeded some of its limits and that if present trends remain unchanged, global economic collapse seems a virtually certain prospect.

8.6 Tutorial (continued)

Using the power of multimedia, the presenters will try to illustrate graphically the key conclusions in *Beyond the Limits to Growth* in confronting global collapse and envisioning a sustainable future. Part II of the presentation will be a tutorial on how the presenters created the multimedia presentation.

Victor A. Stanionis and Pierre Swartvagher, Iona College, New Rochelle, NY.

8.7 Paper/Roundtable | **Environment & Policy** | **Salon E**

1:40-2:10 — Rafael Balderrama, Center for the Study of Science in Society, Virginia Tech, Blacksburg, VA, *Setting Technical Industry-wide Standards: Some Public Policy Dilemmas.*

The world of nongovernmental industry-wide standards is largely an uncharted territory. Engineers on leave from their companies devote nearly 10% of their time acting as part-time volunteers in hundreds of private standards-writing organizations in the U.S. This process, though slow, is of tremendous importance to society. The question is: "Can it be assumed that engineers working in these capacities also act in the public interest?"

2:10-2:40 — Alex Gurfinkel, InnovaTech Associates, Boston; **Anne Montague**, M & S Associates, Beverly, MA, *The Potential Impact of an International Technology on Developed and Developing Nations.*

Conventional environmental cleanup of contaminated soil, sediment, and industrial waste requires assessing, choosing, managing, and using many kinds of processes. Procedures are long and costly, with costs for cleanup in the U.S. alone estimated at $100B. A new technology which far exceeds EPA standards is expected to have a significant impact on cleanup procedures. It:

- cleans soils, sediments, industrial and mining wastes, recycling them to safe construction materials;
- yields safe end-products suitable for road construction, land extension, artificial soils and marine construction; and
- improves vitrification of low-level nuclear wastes and deactivation of munitions wastes.

Session 9: Saturday, February 10, 2:50 - 3:50 PM

9.1	Second Jacques Ellul Symposium	Jefferson

Part 2 (continued): Television as a Response to the Needs and Problems of a Modern Society.
See 8.2 for full description.

9.2 Workshops **Education** **Madison**

Why Do We Have to Learn This (Science) Stuff?

Students often fail to learn science skills and concepts because they see no use for them other than to get to the next level of study. An STS approach that uses real problems as the focus of interdisciplinary education is highly effective in motivating students to learn academic skills. This workshop will describe how two programs, *STEM* and *Watt Watcher*, use school energy problems to accomplish this. Workshop attendees will have opportunities to try activities from both programs and receive handouts for use in their won classrooms.

Carol A. Wilson, Wilson Educational Services, Inc., Wallingford, CT.

9.3 Panel **Research** **Salon D**

STS Research at Virginia Tech
Part 2

A two-hour symposium in which four Ph.D. students from the Graduate Program in STS at Virginia Tech will present papers based on the research they are doing for their doctoral dissertations. This work exemplifies both the styles and scope of research found in our program. *See Session 8.5 for description.*

9.4 Roundtable **Applied S, T & E** **Salon F**

Sharing Research Results, Ideas and Issues Through Publication in the Journal of Technology Studies

Participants will be informed about The Journal of Technology Studies, including description of its purpose and rationale, history of its development, role it has played in service to the professions in technology, and the ways and means that professionals devoted to STS may prepare and submit papers and manuscripts for review and publication.

The Journal of Technology Studies is a refereed publication of Epsilon Pi Tau, the International Honorary for Professions in Technology. The audience will be encouraged to review samples of recent journal issues and the journal's authors' guidelines. There will be time for questions, comments and suggestions.

Jerry Streichler, Epsilon Pi Tau, La Jolla, CA.

9.5 Paper **Values & Religion** **Salon E**

2:50-3:20 — Lloyd Dell, The Pennsylvania State University, University Park, *Christian Values for Environmental Education.*

3:20-3:50 — Richard Dietrich, The Pennsylvania State University, University Park, *Motivating Students Through STS Pedagogy.*

9.6 Paper **Philosophy** **Salon G**

2:50-3:20 — David Levinger, STS, Rensselaer Polytechic Institue, Troy, NY *STS Ideas in Engineering Education.*

3:20-3:50 — Wenda Baüchspies, STS, Rensselaer Polytechnic Institute, Troy, NY, *What Can the Classroom Teacher Learn from Michel Foucault?*

PLENARY 4:
Saturday February 10
4:00-5:00 PM
Location: Salon C

Introduction: Don Conroy, President, The North American Coalition on Religion and Ecology (NACRE)

Speaker: Dennis Weaver, Founder, Institute of Ecolonomics, Leading Advocate of New Environmental Technologies, Actor (Gunsmoke, McCloud)

"Ecolonomics"—A Cause Worth Fighting For

Session 10: Saturday, February 10, 5:10 - 6:10 PM

10.1 Panel Applied S, T & E Jefferson

Technology and the African-American Experience

Taft Broome (moderator), Civil Engineering, Howard University, Washington, DC; **Susan Cozzens**, RPI (on leave at NSF); **Paul Shuldiner**, University of Massachusetts, Amherst; **Willie Pearson**, Wake Forest University, location.

10.2 Workshop Education Jackson

The Nevada Science Project

STS issues are recognized in the effort to make science teaching relevant to all science students. In the State of Nevada, a unique organization of science teachers known as The Nevada Science Project (NSP) spends each summer studying issues which are STS in nature and then endeavors to develop novel curricula which demonstrate and encourage discussion of such issues. This past summer the southern Nevada Science Project completed a three-year critical study of the Colorado River system and the concept of sustainability. The northern Nevada Science Project completed a study entitled "Nevada Deserts and Biodiversity."

10.2 Workshop (continued)

This presentation will share the work developed by the Nevada Science Project teachers during their summer institutes and discuss the philosophy of the project. The audience will be asked to participate in one or two activities developed by the NSP teachers.

Ellen Ebert, Green Valley High School, Henderson, NV; **Mike Robinson**, University of Nevada, Reno.

10.3 Workshop Education Madison

Technology for All Americans Project

The Technology for All Americans Project is funded to the International Technology Education Association by the National Science Foundation and the National Aeronautics and Space Administration to create standards for technology education This presentation will focus on the process of developing a Rationale and Structure for Technology Education which will be developed before the standards are produced.

Richard Satchwell, Technology for All Americans, Blacksburg, VA.

Session 10: Saturday, February 10, 5:10 - 6:10 PM

10.4 Panel — **Education** — **Salon D**

Wilkes Panel

Presentations by students of John Wilkes, Worcester Polytechnic Institute.

10.5 Paper — **Sociology of S & T** — **Salon E**

5:10-5:40 — Robert McGinn, Stanford University, *Ethics and the Engineering Consultant: The Case of the Composite-Material Bicycle.*

5:40-6:10 — Constantine Hadjilambrinos, Florida International University, *Technological Choice and Community Development.*

10.6 Workshop — **Education** — **Salon F**

Sizing Up the Shoe: Highly Localized Interdisciplinary Explorations

Using the shoe as an example, this presentation develops the notion that observation of what is commonplace in our surroundings can lead to instructive multidisciplinary and interdisciplinary explorations. The shoe is an extraordinarily ordinary object, but when questioned, it becomes extraordinarily complex.

10.6 Workshop (continued)

Participants will go through the steps of the exploration process with something nearby, to see what is really before them, to be observant and curious about what is there, to devise plans for finding answers to those questions and, in the process, discover a need for the skills and knowledge the various disciplines can offer.

Stephen Lafer, University of Nevada, Reno, NV.

10.7 Roundtable — **Education** — **Salon G**

What Are the First Principles for Teaching and Advising Students in S &T? An Exploration.

The issues about teaching and mentoring all students to develop understanding, confidence and ethics in doing or using science and technology have been discussed nationwide for over a decade. Many practical schemes have been discussed. This session will begin with a definition of the first principles — self-respect, integrity and authenticity in the learning and doing of science and technology as the central tenet to guide teachers and mentors in grades K-12, and the university.

Indira Nair, Carnegie Mellon University, Pittsburgh, PA.

NASTS Board Dessert Reception

for Nasts Members and Conference Attendees

Saturday, February 10, 8:30-9:15 PM

Followed by a brief NASTS Members Meeting

9:15-10:15 PM

Location Both Events: Salon C

Session 11: Sunday, February 11, 8:40 - 9:40 AM

11.1 Paper **Public Policy** **Madison**

The technological advances are currently seen as threatening for society. Americans are worrying because in the near future there will not be enough jobs for qualified people. Technology would take care of the work, and the owner's of business would make more money while hundreds or even thousands of people would remain unemployed. This is a worrying situation, but it is not new for 250 billion people living in what some call the "Third Word." It is an interesting issue that depending on where are values are, we see ourselves. Where is the Third World? Why do we need to think of those who live under conditions fo poverty, meaning that they can not afford to have education, an appropriate nutrition, health care and housing, as living in a different world? Of course their lives are very different, but we all live in the same planet.

The value system implied in the chain of thoughts that lead to this "third class" connotation behind the concept of poverty would be analyzed, as well as the role of technology in the concept of Development.

Adriana Jaramillo, Pennsylvania State University, PA.

11.2 Panel **Education** **Salon D**

Wilkes Panel

Presentations by students of John Wilkes, Worcester Polytechnic Institute.

11.3 Tutorial **Education** **Salon E**

How is STS Implemented in K-12 Schools?

A study revealing different ways STS is currently being implemented in K-12 schooling across the US will be presented. Snapshots of varied interpretations of STS in elementary and secondary schools will be described. These include but are not limited to STS as (1) topics taught in science classes, (2) an instructional approach, (3) a curriculum organizer.

Barbara S. Spector and Thomas La Porta, University of South Florida, Tampa, FL.

11.4 Workshop **Education** **Salon F**

Plastics: An STS Curriculum for Upper Elementary Grades

This workshop will present a variety of activities from "A Young Scientist's Guide to Plastics." This program has over 100 pages of STS-based activities for the upper elementary grades on the topic of plastics. Activities are written in learning style format and range from investigating the chemical and physical properties of plastics to recycling to just plain fun. Participants will receive sample lessons and will participate in three hands-on activities.

Donald R. Daugs, Utah State University, Logan,UT.

Session 12: Sunday, February 11, 9:50 - 10:50 AM

12.1 Workshop | Public Policy | Madison

Road Building: The Epitome and Carrier of Technological Destruction and Population Growth

Roads enabled the spread of civilization, its advantageous aspects, its negative impacts, and its destruction. A growing segment of environmental thinkers on technology and society has rebelled against "progress" as a function of clearing land "going to waste" and "developing" land for narrow pursuits.

The road-fighting movement dates to the 1960s. Until the creation of the Alliance for a Paving Moratorium (APM) in 1990 there was no coordinated, strategic effort to link people and issues. It became clear that in addition to stopping freeways — and suggesting alternatives such as trains — on the grounds of preventing pollution, saving lives in accidents, and lessening dependence on foreign oil, *auto-free* living was just as essential in order to bring about a sustainable society. It has become clear in the burgeoning car-free and road-fighting movement, that roads and parking lots are also the means of (1) maximizing multinational corporate control of goods, jobs and the landscape, and (2) spreading human population and allowing population growth.

Jan Lundberg, Fossil Fuels Policy Action, Arcata, CA.

12.2 Panel | Education | Salon D

Wilkes Panel

Presentations by students of John Wilkes, Worcester Polytechnic Institute.

12.3 Workshop | Education | Salon E

Oil Spills in the Middle School Classroom

Participants in this hands-on workshop will actually create oil spills and investigate their effects on such materials as wood, rocks, and feathers. Some of the currently used methods of cleanup will then be used to examine their effectiveness. Ways to make cross-curricular connections with the oil spill theme will be presented. Handouts for educators will be provided.

Catherine Stephenson, Westmont Hilltop School District, Johnstown, PA.

12.4 Workshop | Education | Salon F

Teaching Science to All Students

"What I've Learned and What Works" while teaching physics, chemistry, and science and technology to general level high school students (many of whom are mainstreamed or classified as ESL) will be shared. The ways of teaching science to the top 15% do not work for the bottom 50%. As a result of work on alternative ways to teach and assess science for the general level student (especially the low-motivated and underserved), sample lessons, methods of instruction and alternative methods of assessing chemistry, physics, and STS — and tips on how to help these students succeed in science and enjoy it at the same time — will be shared.

Beverly Nelson, Hackensack High School, Hackensack, NJ.

PLENARY 5:

Sunday February 11
11:00 AM-12:00 PM
Location: Salon C

Introduction: Janice Koch, NASTS Board Member, Co-Chair Education Assembly

Speaker: Robert Yager, New NASTS President, Leading STS Educator, Science Education Center, University of Iowa

"STS: Where We Are, and Where We Are Going"

STS-12 PLANNING MEETING

(Will meet after lunch)

Sunday February 11

12:45-2:45 PM

Location: Madison

Open to interested NASTS Members

STS 11 - CONFERENCE PLANNER

Special Notes		What, Who & Where
	FRIDAY: February 9, 1996	
	7:15 - 8:20 AM	Breakfast Meetings
	8:30 - 8:45 AM	Welcome
	8:45 - 9:50 AM	PLENARY 1 (Henry Petroski) George Brown
	10:00 - 11:00 AM	Session 1
	11:10 AM - 12:10 PM	Session 2
	12:20 - 1:20 PM	Lunch (Meetings)
	1:30 - 2:30 PM	Session 3
	2:40 - 3:40 PM	Session 4
	3:50 - 4:50 PM	PLENARY 2 (Richard Satava - tentative)
	5:00 - 6:00 PM	Session 5
	8:00 - 10:00	Board Meeting
	SATURDAY: February 10, 1996	
	7:30 - 8:50 AM	Breakfast Meetings
	9:00 - 10:00 AM	PLENARY 3 (Christine Von Weizsacker)
	10:10 - 11:10 AM	Session 6
	11:20 - 12:20 PM	Session 7
	12:30 - 1:30 PM	Lunch (Meetings)
	1:40 - 2:40 PM	Session 8
	2:50 - 3:50 PM	Session 9
	4:00 - 5:00 PM	PLENARY 4 (Dennis Weaver)
	5:10 - 6:10 PM	Session 10
	8:30 - 10:30 PM	NASTS Members Business Meeting
	SUNDAY: February 10, 1996	
	8:40 - 9:40 AM	Session 11
	9:50 - 10:50 AM	Session 12
	11:00 AM - 12:00 PM	PLENARY 5 (Bob Yager)
	12:00 - 12:20 PM	Change of Guard and Conference Close
	12:30 - 3:30 PM	STS-11 Planning Meeting

STS-11 CONFERENCE EVALUATION FORM

Please complete and mail before March 1, 1996 to NASTS, 133 Willard Bldg., University Park, PA, 16802.

1. With which one assembly or grouping do you most closely affiliate?

    ____ Education (Cutting Across K-12, College, University, and Informal Education)
    ____ History, Philosophy and Sociology, and Science and Technology
    ____ Applied Science, Technology and Engineering
    ____ Public Policy
    ____ Values & Religion
    ____ International STS
    ____ Other ______________________

2. How did you hear about the conference?

3. Why did you come?

4. What did you like best about the conference?

5. What one aspect would you most like to see improved next year?

6. What topics would you most like to have covered next year?

7. Who would you like to hear address the conference next year?

8. Is there some way you would like to participate next year? (Include your name & phone number, or contact us.)

9. What additional comments or suggestions do you have?

REVISED FORM 10/91

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