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ABSTRACT

Twenty-six papers illustrate the wide reach of Science, Technology, and Society (STS) studies and education. A sampling of the first section on general STS studies includes: (1) "Technology, You, and the Law" (Kenneth S. Volk); (2) "The People From 'Away': Ending Racial and Economic Exploitation in the Siting of Toxic Wastes" (Glen J. Ernst); (3) "Constructing Space: The Shaping and Uses of the NASA-CIRSSE Two-arm Robotic Tested" (Jeffrey L. Newcomer); (4) "Irradiation of Food" (Martin L. Sage); (5) "Biotech or Biowreck? The Implications of 'Jurassic Park' and Genetic Engineering" (Sharon L. Chapin; Leslie D. Chapin); and (6) "Overcoming Computer Anxiety in Adult Learners" (Mick Lantis; Marilyn Sulewski). A sampling of the second section on energy themes includes: "Incorporating Environmental Externalities into Electricity Markets" (Steven E. Letendre); and "Equity Concerns in U.S. Nuclear Energy Politics" (In-Whan Jung; Young-Doo Wang). A sampling of the third and fourth sections that present articles on STS Collegiate Programs and STS in K-12 education include: (1) "Design Methodology in STS Programs" (Marc J. deVries); (2) "Science, Diversity, and Community: Revitalizing Introductory Science Curricula: An Overview" (Jacqueline Ross); (3) "Trends and Dilemmas in Science, Technology and Society Education within K-12 Schools in the United States" (Dennis W. Cheek); and (4) "Minds 2000+, Internet and Global Change" (James L. Barnes). (DK)

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Foreword

Twenty-six papers by a total of forty-six authors illustrate the wide reach of STS studies and STS education which attendees of the annual National Technological Literacy Conference have come to expect. All levels of the educational systems of many nations from preschool through graduate schools have been impacted by this international movement. The National Association for Science, Technology and Society (NASTS) and its active membership have been key players in calling attention to the importance of this movement and its message. As NASTS convenes its tenth anniversary conference in 1995, it is clear that STS education has found a permanent home on the international educational landscape.

This past year witnessed the loss of a key advocate for STS education as NASTS President, Alice Moses, left this world for the rewards of the next. All the membership of NASTS will miss Alice's practical and informed perspective on STS education, especially as it related to elementary school education. It is fitting both that several papers address her favorite arena of education within this proceedings volume and that this product be placed with the ERIC system in her memory.

-- The Editors

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General STS Studies

TECHNOLOGY, YOU AND THE LAW

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The United States legal system plays an important historical and contemporary role interpreting the extent of influence between technology and the Constitution. For this reason, Science/Technology/Society curriculum should include activities designed to have students understand this interpretive role. These activities not only serve to broaden students' knowledge and appreciation of associated technological and constitutional issues effecting their lives; but hopefully, a new skill to critically examine and discern the future impacts of technology and the law will be gained. One specific STS activity designed to foster these skills uses actual court cases and a panel of student "judges." Through cases involving constitutional guarantees of free press, right to assemble, and protection from unreasonable searches, students can participate through role playing in the legal decision-making process.

This discussion will elaborate on the above instructional strategy. Due to the importance of technology and the interpretation of our laws which effect each individual's rights, a closer examination of Constitutional issues in STS programs will be presented. This discussion and outlined activity may serve as a catalyst for examining the legal implications of technology in STS courses.

The Early Influence of Technology on the Constitution

Technology has influenced the Constitution in many ways over the years. This influence can even be seen during the conception and drafting of the Constitution. Two examples can be given: the regulation of commerce between states, and the protection of free speech and press.

During the colonial period, a division of skills and outputs took place. The northern states were the center of industry and manufacturing, while the southern states were agriculturally based. Duties and tariffs were a major concern. Such acts would have restricted the flow of technology between the various states i.e., Stamp Act, 1764; Townshend Act, 1767. As noted by Cullop (1984) the regulation of commerce was one of the major compromises to be settled in writing the Constitution. Because of the differences in technological applications and the potential of duties being imposed, Congress was given the power to control commerce.

Statutes were often passed by colonial assemblies which regulated speech and press. Licensing of printers was one such means of regulation. Although neither royal governors nor local courts seemed to enforce the laws with any degree of regularity or stringency (Leder, 1968), it is possible the Framers of the Constitution wanted to make sure that press licensing would not be a part of law (Urofesky, 1991). Another important influence of technology on the Constitution was the case of John Peter Zenger. At issue was the power of the press (applying the available technology) and the freedom to print material that was considered by some to be seditious. In 1735, Zenger was charged with libeling the British Governor through the publication of an article in the Weekly Journal, of which he was the editor. Zenger was found not guilty. The case was considered landmark since it established truth as a defense for sedition, and it would be up to a jury and the courts to decide the truth.

Thus, according to Chafee (1969: 21), the Framers of the Constitution wanted to "wipe out the common law of sedition and make criticism of the government, without any incitement to lawbreaking, forever impossible." The First Amendment directly addressed the issue of speech and press regulation; and being the first amendment, it occupies a preferred position in the hierarchy of protected rights. The first ten amendments to the Constitution can be considered an integral part of the Constitution since several States refused to ratify the Constitution without a promise of a Bill of Rights (Wilson, 1987).

The Early Influence of the Constitution on Technology

The Constitution has also exerted influence on technology. Again, this influence can be seen in the framing of the Constitution. In Article 1, Section 8 of the Constitution, it states: Congress shall have the power "to promote the progress of science and the useful arts by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries." This led to the creation of the United States Patent Office and the licensing of technological innovation.

The first regulatory action by the U.S. Congress was in 1852 (Burke, 1979). That year, Congress passed a law setting standards for the design and safety of steamship boilers. In essence, technology was being regulated by Congress. Today, Congress continues to influence technology and other issues. Of the nearly 7,000 bills introduced in each congressional session, many deal with technology in a variety of areas such as medicine, computers, and telecommunications. Although approximately three percent of the bills introduced are eventually passed into law, Congressional influence on technology can be considered significant.

The Interpretation of Law

In accordance with provisions set up in the Constitution, there are three branches of government. In very general terms, the Legislative Branch makes the laws, the Executive branch enforces the laws, and the Judicial Branch interprets the laws. Although each branch plays a significant role, it is the Judicial branch which ultimately must define the meaning and scope of the Constitution. It was the case of *Marbury v. Madison* (1Cr. 137. 206, 1803) which set the legal precedent for the latter's role and responsibility as being the final interpreter of the Constitution (Harrell and Anderson, 1988).

Considering the delineated role Congress has in making laws, the responsibility of the Judicial branch in interpreting laws, and the impacts and legality of recent technology, an STS activity can be designed to have these technological issues examined by a court of student "judges."

"You" Be the Judge

An STS activity designed for students to actively discuss legal issues involves the use of student "judges." With selected court cases that deal with the use or application of technology, the judges can then decide the outcome of the case. After the background facts are presented and the student judges make their decision, the actual court outcome is announced. This outcome is then used to clarify the constitutional implications and guarantees derived from the decision. Structured as a one-period lesson, or as a five-minute "quickie" using one select court case at the end of a period, this activity can provide entertaining and thought-provoking discussions on constitutional issues.

To begin this activity, court cases must be collected through various sources. These cases, involving the use of technology might deal with guarantees of free press, the right to assemble, and/or the protection from unreasonable searches. Two excellent sources to collect sample cases are The Wall Street Journal and the Rutgers Computer and Technology Law Journal.

In the former source, the Law Section often provides very current examples of the application of law and technology. Once a bank of cases have been collected, with summative background information, the "court" can be called into session.

For optimum student involvement, three "judges" are selected from the class. These judges proceed to the front of the class, but before they take their seats, they are asked to put on robes signifying their judicial authority. Graduation robes make very adequate judicial garb to enhance the role playing. Also, before the cases are presented, the opening prologue which starts each session of the Supreme Court is said to those in attendance.

> Oyez, oyez, oyez, all persons having business before the honorable, the Supreme Court of the United States, are admonished to draw near and give their attention, for the Court is now sitting. God save the United States and this honorable court.

A visual display of the court cases plays an important part in having the students understand the technological relevance. Two ways this can be accomplished: with overhead transparencies or computer presentation software.

Through the use of traditional overhead transparencies, a photograph or cartoon can be used to illustrate the case. The legal question is then presented below. At the bottom of the transparency is the answer, as cited in the actual court case. This lower portion remains covered until the judges make their decision. Figure 1 shows an example of this method.

Figure 1

Can a state place a disposal fee on out-of-state hazardous waste, but not waste generated in the state?

NO. Chemical Waste Management v. Hunt

504 US, 119 L Ed 2nd 121, 112 S CT No. 91-471.

The court found that no state (Alabama) can isolate itself from a problem common to several states by raising barriers to free trade. Violates the Constitution's commerce clause.

The use of computer presentation software offers the advantage of introducing sound and video clips, as well as interactiveness into the discussion. Software packages such as Compel work well in this situation. By placing a scanned photograph or cartoon into the presentation slide, YES and NO buttons can be inserted. When the decision is made by the judges, the corresponding button is then selected. The response linked to each button would show the actual court outcome and an amusing sound effect to indicate correct or wrong decisions.

Recent Technological / Constitutional Issues

Over the years, technology has had an impact on our guaranteed rights. Although many of these issues have been "settled" through legislative or judicial actions, the pace of new technological development has created the possibility of new laws and interpretations which were impossible to conceive of only yesterday. These impacts influence our ability to approve, use, accept or reject technology in ways which may restrict, expand, intrude or alter our lives in countless ways. The following examples dealing with the right to privacy, freedom of speech, and right to free assembly will illustrate how recent technology has had an impact on the Constitution. These cases can be used as examples for the courtroom simulation.

Technology often impacts our right to privacy. Although not specifically stated in the Constitution, the right to privacy has been interpreted and implied from the Fourth Amendment which guarantees the right to be secure from unreasonable searches. Since the first case that a court accepted the idea of a "right to privacy", *Pavesich v. New England Life Insurance Company* (122 Ga,190, 50 S.E.68, 1905), judicial acceptance of the interpretation has become more commonplace (Goode, 1983).

Telecommunications is one new area of technology which has raised issues about our right to privacy. With wiretaps being conducted as early as the 1880s by police conducting investigations and stockbrokers trying to obtain secret information (Goode, 1983), our right to privacy in communications has been a source of concern. Over the years courts have issued decisions on the legality of wiretaps. In 1928, the Supreme Court ruled wiretapping was not an unauthorized search (*Olmstead v. United States,* 277 U.S. 438), but later the Court overruled *Olmstead* in *Silverman v. United States,* (365, U.S. 505, 1961). *Silverman* dealt with the use of bugging devices in a place which the Court determined to be a constitutionally protected area. Legislation also has dealt with issues of wiretaps, with Section 605 of the Federal Communications Act of 1934, and the Omnibus Crime and Safe Streets Act of 1968, as examples.

The recent development of sophisticated communication devices has led to a myriad of new impacts on our right to privacy. For instance, when a person's cordless telephone conversation is listened in on by a neighbor, does this violate their right to privacy? This issue was recently decided in *Tyler v. Berodt,* (877 F.2d 705, 8th Cir., 1989) held before the 8th Circuit Court. This case involved the Berodts who used their own cordless phone to monitor and record the phone conversations of their neighbor. The Court held that the cordless phones were not "wire communications" protected by the Wiretap Act. The Court further found that the speakers had no justifiable expectation of privacy since they were aware their conversation was transmitted by a cordless telephone.

Privacy in the workplace is another issue being challenged by recent developments. There are many types of techniques that are available to employers to monitor and control the workplace. This intrusion into our privacy has been termed by some to be the start of the "electronic sweatshop age" (Rothfeder, Galen, and Driscoll, 1990). Fish-eye cameras watch for employee theft, computers track their performance and time-on-task, and drug testing checks their physical state. These and other technologies have given employers powerful tools to invade the privacy of their employees, often without their suspecting it. Litigation in this area is also just beginning. For instance, in *Bright v. Northwest Medical Center* (U.S. App., New Orleans, 1991), the employee was found not able to claim overtime pay for being monitored with a beeper and having to remain sober for possible call-in as a condition for his employment. The judge found there was no overtime pay for putting up with oppressive working conditions (Moskowitz, 1991). Therefore, the nine-to-five workday is quickly becoming a twenty-four hour responsibility, accountability, and indebtedness to one's employer.

Our right to free speech as guaranteed through the First Amendment has also been impacted by recent technology. One example is the introduction of Caller Identification (ID) services by various telephone companies. This service, now feasible through the use of sophisticated computer software, allows the receiver of telephone calls to identify the caller by a device which displays the caller's telephone number.

Caller ID service is currently available in selected areas, yet their impact is being felt. According to Sinclair, (1991), around three percent of the customers in the Washington D.C. area now have this service; with the majority of users being businesses and government agencies. The use of Caller ID has been credited with a decline in reported obscene phone calls and a more efficient delivery of pizzas.

Two issues of privacy can be raised: (a) does a person have a right to know who is calling them; and (b) does a person have a right to freely call another individual, business or government agency without fear of having their number registered and recorded? Both positions are being championed by various groups.

Again, the implementation of this technology has already spawned legislative and judicial action: California *Statute c. 483, 1989* requires callers be notified of the possibility of display and that they be able to withhold such display on a case-by-case basis without charge. Pennsylvania's Supreme Court recently held that Caller ID services violated state and federal constitutional privacy protections (*Barasch v. Pennsylvania Utility Commission,* Pa. 576 A 2nd 79. 1990). Given the discrepancy which exists between states' laws, and the desire by telephone companies to expand this particular service, this issue will surely continue to spark debate and must ultimately be decided in higher courts.

The First Amendment to the Constitution also protects the right of people to peacefully assemble. The Fourth Amendment prohibits unreasonable searches and seizures. Through the capability and expansion of surveillance technology by segments of our society, the confidence of going about one's own business without the fear of being watched has changed. Sloan (1991) discussed this growth of technology when he stated: "states will have the capabilities to strengthen their coercive capabilities, and instruments of control over their citizens". He continued to caution, "on the other hand, the very same technology may help lessen the importance of the state as the preeminent political actor and enable new non-state actors to challenge the coercive power"(Sloan, 1991: 9). Galliti (1983) substantiated Sloan's contention by reporting there are more private security employees than there are combined federal, state and local law enforcement personnel. This has created a situation in which surveillance by security cameras in stores, parking lots, theaters and other public places has affected our right to assemble, in subtle, yet threatening ways. This power of technology has created the need to carefully balance the public's right to peacefully assemble and the public's right to safety.

One court case related to the use of indiscriminate surveillance that stands out is *Katz v. United States*, (389 U.S. 347, 1967). In this case, the Court found that "the Fourth Amendment protects people and not simply areas," and therefore, where a person "justifiably relies" on privacy, it is an unreasonable search for the government to intrude either physically or in any other manner without a warrant. Since that time, the explosion of surveillance techniques has produced different opinions from the courts. In *People v. Henderson,* (220 Cal App.3d 1632, 270, 1990) the California Court of Appeals ruled that the Fourth Amendment bars evidence gathered in warrantless videotaping. In a somewhat conflicting decision, the New York Court of Appeals found in 1990 that random videotaping of pedestrians for later identification by an attack victim was admissible evidence. Thus, it seems the legality of surveillance directed specifically at an individual differs from the broader use of surveillance on groups. Again, these issues will probably continue to be debated in the courts.

Besides these examples of technology and the law, others are noted. Again, it is cautioned that when using cases for the earlier-discussed student activity, sufficient background information be obtained. This information is critical for setting the stage for student debate. The following cases further illustrate recent technological advances and capabilities are being subjected to judicial decisions.

- Can a computer operator claim damages from a public employer for not providing a safe place to work? (carpal tunnel syndrome)

  NO, Haririnia v. Amtrack 89-1431 DC. (1990). The court determined it was accepted working conditions at the time.

- Can weather modification be done even though it may harm private property?

  YES, Slutsky v City of New York 197 Misc. 730, 97 NYS 2nd 238 (1950). The public need was found to be more important than private interests.

- Do you have property rights to your body parts, should they be removed during an operation?

  NO, Moore v The Regents of the University of California 51 Cal. 3rd (1990). The court determined unless you are informed earlier, body parts may be used for medical research without approval.

- Can DNA tests be admissible as evidence?

  YES, State v Ford, 392 SE 2d 781 (1990). Although polygraph tests are not, it was determined DNA testing is statistically reliable.

- Is aerial photography or observation an invasion of privacy?

  NO, California v Ciraolo, 476 U.S. 207 (1986). The open sky is not considered private property.

Additional Applications

Although actual court cases have been used in this exercise, it is envisioned new cases, not yet determined by the courts, can be designed for students to answer. For instance:

- What are the legal ramifications of the Genome Project to genetically "map" individuals?
- What limits of free speech exist with automatic telephone dialing machines?
- How long should medical technology keep people alive?

Hypothetical situations which may be more relevant to students' daily lives may include:

- Should a student's record located on computer files be available to employers? Specifically, what information should be made available and for how long?
- If a blood test was developed to check for alcohol, even one month after consumption, should schools conduct random tests on students, as a requirement for graduation?
- Should students wear ID bracelets in order to be electronically located and monitored in school?

These technologies can be analyzed and debated as to their impacts on the rights of privacy and speech, protections from being a witness against oneself, or protections against cruel and unusual punishments.

Conclusion

This paper presented examples of how the Constitution is continually being interpretated due to new technological developments. These interpretations are made by the judicial system which dete ,ines our rights to privacy, speech and assembly. Through the use of a simulated court with "judges", students can actively participate in making decisions about our technological society.

In order for students to understand the personal costs and benefits of technology, educators involved in STS are advised to encourage activities and discussions of a Constitutional nature. With such activities included in STS courses, students will gain a better appreciation of their responsibility to ask questions, critique the issues, and participate in our democratic process.

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TECHNOLOGICAL CITIZENSHIP AND FUTURE GENERATIONS: THE SIMPLE GIFTS ETHIC

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This paper have two purposes.

First, to present the name and idea of *Technological Citizenship (TC)* as a systematic, participatory framework for STS and for work in scientific literacy. I will urge NASTS members to adopt this name and its related terminology in their work on STS and scientific literacy. I invite you to do so even if your specific views of meaningful citizenship within technological societies differ from mine.

Second, I will present the *transgenerational* leg of the citizenship frame. This is called the Simple Gifts ethic. This addresses the potential problem that present generations will impose a world onto future laypeople and even experts which is so complex and rapidly changing that the costs in time and effort of "keeping up" with it—of maintaining scientific literacy about it—would be unduly burdensome.

I. Technological Citizenship

Quite frankly, the meaning of the term "Technological Citizenship" ought to be self-evident. If not, I have failed in my mission to provide a singular, streamlined name for a participatory framework for STS.

A. General Citizenship

As the name suggests, TC implies a *citizenship.* A citizenship is a form of membership, status, standing or stature of equality of some sort of persons within a bounded realm. This status is woven of rights and responsibilities. It is woven of a civic ethos. A civic ethos is an *understanding* of the realm's boundaries, workings, limitations, interdependencies and of its tradeoffs; and of the limits on rights which they imply. Usually this citizenship status affirms some overarching purpose or goal. In general, citizenship probably achieves the goal of *reconciling.* It reconciles autonomy of the individual with the reality of interdependence which collective life imposes. It *ennobles* the individual. It does so by contextualizing, "cocooning" or "nesting" the individual within a greater whole. This greater whole in turn guarantees the individual *dignity* and *certainty.* Frankly, not all theories of citizenship profess that citizenship status holds any overarching value that is greater than the sum of the parts. But in my deconstructive quest to "distill" everything, and to streamline and simplify it, I seek such single purposes [Barbalet 1988; Bookchin 1987; Janowitz 1980; Banfield 1992; Turner 1986].

B. Technological Citizenship

What, then, is *Technological* Citizenship? *TC* is membership, status, standing or stature within a bounded realm. The bounded realm in question is the one created by subjectivity to the impacts of technologies; or to "technology" in the abstract. This status is characterized by *equality* between experts and laypeople in the ability to comprehend the impacts of the technologies around them. In the most ideal versions, TC also seeks equality between laypeople and experts in the ability to control technology's impacts; and to verify their safety from impacts at any time [Frankenfeld 1992].

I. A. 1. Rights of TC

This TC status is woven of rights and duties. Rights of TC include:

* the rights to *knowledge* about the existence of impacts of technologies surrounding one--particularly *hazardous* impacts.

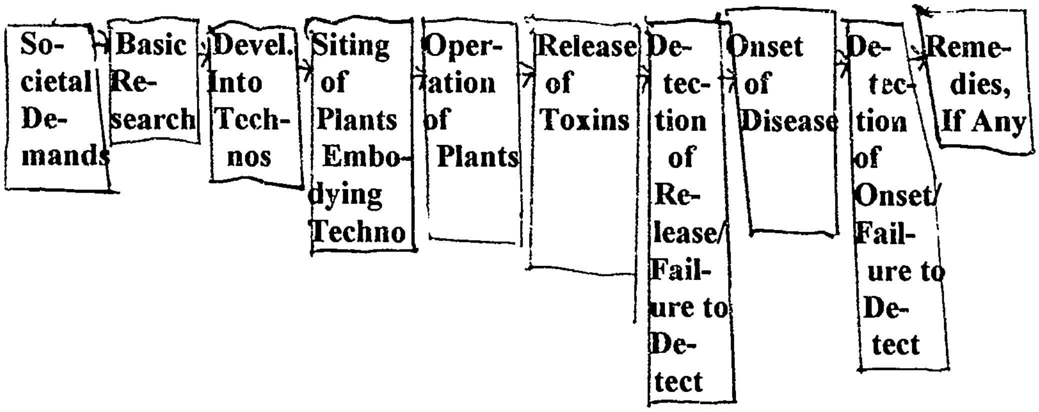
* the rights to ongoing knowledge about specific releases of hazards at all times.

* the rights to *participate* in the siting of technologies, in Technology Assessment (TA) studies through which technologies are initially approved for use.

* the rights to participate in the detection of releases of harms. This may include subsidies to groups or individuals for detection equipment and for epidemiological studies. In my version, rights of TC might even include

* the rights to participate in setting broad societal research priorities. Thus, the advent of any new, world-changing technology and its impacts can at least be claimed to be subject to *more* "consent" than at present; and thus can be claimed to be more legitimate.

The decision nodes controlling technologies which technological citizens have the right to participate in are shown in Figure I.:



The trick is to make participation in these decision nodes *informed* and meaningful. Education programs of scientific literacy are probably a prerequisite. In my founding paper on TC, I discuss other measures such as science courts and "Ulyssean procedural safeguards" for ensuring that consent will be informed and "meaningful" [Frankenfeld 1992].

I. A. 2. Duties of Technological Citizenship

Duties of citizenship within complex societies include:

* the duty to *assimilate* and *use* the knowledge about how technologies work and how science proceeds which one has a right to be provided through programs of scientific literacy.
* the duty to actually *use* channels of participation which are provided.

* the duty to develop a *civic ethos* about the boundaries and limits of complex society, of its interdependencies, its *unity* of benefits and costs and the tradeoffs between costs and benefits which *integrate* the individual into the collectivity.

* the duty to exercise *judgment* when participating in decisions controlling technological impacts. Judgment in this case involves paying attention to the fact that technologies convey benefits *as well as* costs, duties *as well as* rights, onuses with bonuses.

Bluntly, the single duty of being a citizen within technological society is to *acknowledge interdependence* in all of its rich senses. It is to acknowledge interdependence among humans, specifically between lays and experts. It is to acknowledge interdependence between the society and technology itself. It is to acknowledge the fact that technology amplifies the impacts of human acts; and that this increases human interdependence.

I. A. 3. Overarching Goals of TC

Hence, if there is any overarching goal of TC, it is also a goal of *reconciling*. In the founding articles on the model, I hold that the overarching goal of TC--as both an ideal and descriptive/analytical frame--is to *reconcile* on the one hand, the goals of continued technological dynamism--which is the value-neutral term for "progress" or "advancement", terms which I avoid--and, on the other hand, individual autonomy, dignity, and assimilation with other people and surroundings, as opposed to estrangement and alienation from them. Stated differently, in the most abstract, anthropological terms, the overarching goal of citizenship within technological society is to come to terms with an increasingly distanciated *societal division of labor*. It is to come to terms with the abstract concept of *division of labor* in general. Actually, TC's main goal is to get us to stop using the word, "distanciated".

I. B. Examples

Citizenship within technological societies takes place within the sphere or bounded realm of putative *technological polities*. Technological polities are constructs defined as "spheres of subjectivity to the impacts of technolo*gies*--usually hazardous impacts--or of technolog*y* in general". The techno-polity's "state", which enforces these rights and responsibilities, varies in accordance with the scope of impact of the given technologies.

For meaningful citizenship within spheres of subjectivity to exist, there should exist regulatory institutions which regulate the impacts of the given technology. The jurisdictions of these institutions should be coterminous with the level of impact of given technologies. These institutions must then enforce rights and duties. They must give *meaning* to the status of citizenship within the "technological polity". In advanced versions of the model, these institutions should permit meaningful public participation in the siting and detection of the technology at hand. In the *most* advanced forms of TC, they should allow public participation in the very *advent* of technologies by scientists.

I. B. 1. Toxic Chemicals

Take for example the case of toxic chemicals. The unit of production and of emissions of effluents is the chemical refining plant. The impacts of the pollution and benefits of a chemical refining plant may transcend cities and counties. The institution charged with the creation of scientific literacy on the plant's benefits or hazards might be, say, a state or national EPA. Or it might be something at an unusual level of organization which is almost exactly spatially coterminous with the emissions of the refining plant. An example might be an Air Quality Management District [AQMD] or, say, a River Basin Authority. If deep, thick, rich Technological Citizenship exists, subjects would actually have participation in the *siting* of such plants through this authority. They might receive their scientific literacy training about the plant's and technology's workings, hazards, and benefits from this authority. They might have some form of accountability over detection of the plant's hazards and account over evacuation plans and other remedies through this agency; or via public interest citizens groups organized *appositionally* to this statist agency.

I. B. 2. Nuclear Weapons

A second example is nuclear weapons. The sphere of subjectivity to the technology of nuclear weapons is global in scope. The statist agency charged with information about effects and paths of subjectivity and charged with preventing renegade developments of weapons should also be global. An example of a global-level regulatory agency which enforces citizen "rights" and "creates" or "interpellates" citizens within this technology's sphere is the IAEA [International Atomic Energy Agency]. The IAEA in fact detects and prevents the further development of nuclear technologies by nations which currently lack them. While it does not protect individuals per se against imperilment, it does address a technological problem at the decision node of conversion of scientific know-how into usable technology. In that sense, it is paradigmatic of a statist institution of technological citizenship as defined.

While these statist institutions governing spheres of subjectivity to technological impacts do not presently provide for participation by affected subjects in the control, detection, remedy, siting and advent of the given technology, they potentially *could* in the future as citizenship within these technospheres deepens, thickens, broadens and becomes richer.

II. The Simple Gifts Ethic

Across generations, people who *will* live in the future ought to be able to participate in the control, detection and remedy of technologies we impose upon them in the present. They ought to benefit from permanent education institutions and trust funds to maintain their scientific literacy about the technological hazards and benefits we impose upon them.

But descendants cannot also participate in the *siting* nor *advent* of technological hazards which impact them which forebears impose upon them. Many of these are developed and sited in the present. They carry long life spans. Witness toxic chemical wastes generated now which will still be potent centuries hence. Witness radioactive wastes which are generated now and will be potent for *tens* of thousands of years. Technological *know-how* such as how to create biological weapons which is devised by forebears is almost *completely* irreversible. It is difficult to put such technological "genies" back into bottles once they are released. Know-how cannot be collectively "forgotten".

TC holds out the hope that returning technological genies of perilous instruments to their bottles is not completely impossible. It seeks to define criteria for how the seemingly irreversible *nuclear age* would be "ended". There have been proposals for this suggested in the *Bulletin of the Atomic Scientists* for decades. Given the near total irreversiblity of perilous know-how, the nuclear age would likely only end when we found a conclusive cure for physics. The *Bulletin* has also entertained schemes for identifying and preventing the release of all future world-imperilling scientific and technological genies of the magnitude of nuclear weaponry as early as possible in the continuum of development. These schemes are similar to my Simple Gifts ethic.

Those technologies and know-how and their impacts which we devise and impose today cannot be directly consented to by those who will live in the future; except perhaps by proxy approvers called *"ad litem"* representatives. At the very best, such long-lived impacts can only be "legitimated" through appeals to the social contract--the looser, hypothetical covenant among members within a civilization in all generations which governs and prescribes how each should be treated by the other in order for the societal arrangement to be considered just or good. For example, long-term, even irreversible technological impacts which forebears impose upon descendants may be considered "legitimate" even though descendants do not directly consent to them *if* the *procedures* under which they were *imposed* or *devised* are fundamentally legitimate.

Legitimacy might be based upon the fact that the innovation and siting procedures *consider* future people's interests from their perspective through some sort of Rawlsian scheme. A Rawlsian scheme [Rawls 1971], as revised by Brian Barry [Barry 1989], involves an equitable process for making decisions wherein participants would know all impacts of such decisions on poor and rich, gifted and not, present or future generation, but would *not* know in which class or generation they would be. Fearing the worst, they would choose those decisions which hurt the most vulnerable least, and whose costs and benefits are most equitably distributed. *"All the world's a stage, and all its players merely seeking Equity minimum!"* Or legitimacy might be *claimed* to exist because "legitimate" procedures of scientific inquiry were used, a hollow consolation.

Different theorists hold different criteria for intergenerational legitimacy. What is crucial is that we all use the *language* of the social contract, of *contractarian* legitimacy. This usually involves concepts of "indirect consent", "hypothetical consent", "proxy consent" or whatever. We should not use the language of citizenship or democracy which implies legitimacy through actual, direct, explicit consent [MacLean 1986].

My Simple Gifts ethic [Frankenfeld 1993] delineates such a set of criteria for making legitimate impositions of impacts of technologies *across* generations. Bluntly, these criteria are quite stringent.

The ethic is concerned with avoiding the imposition of an *aggregate constellation* of hazards which is so great that future generations of experts and laypeople cannot comprehend, govern it, detect it, cope with it or cope with the pace of change, and/or financially afford the world we leave them. The ethic seeks to avoid imposing upon future generations of laypeople and experts a relatively irreversible infrastructure for scientific innovation which places them on a fast and accelerating *treadmill* of change with which they cannot keep up.

Bluntly, through this Simple Gifts ethic, I do not seek to bequest future generations the "gift" of a world which is as "simple" as ours; only one whose complexity and pace of change is not *absolutely* overwhelming. I seek to create a social contract which permits us to continue our most stringent ideals of scientific literacy for future generations without overwhelming them, despite inevitably increasing complexification of the world around them. Again, I seek to avoid the advent of world-imperilling scientific and technological "genies". At the very least, I seek to develop a generic "geniology" for identifying which lines of basic science are most likely to be most potent. I seek a homeostasis of assimilation of people with their built world; or at least a homeostasis of the *opportunity* for laypeople and experts to assimilate.

II. A. Specific Provisions of the Simple Gifts Ethic

I will present the provisions of the Simple Gifts (SG) ethic in a form that is well, *simple.*

My formal journal article on the ethic, by contrast, couches the ethic in impenetrable neo-Lockean terms of "equal options" of free time. This involves leaving time for descendants free from learning and participating in controlling that is "as much", "as good" and "as accessible" as ours. If you crave the formal version of the ethic, I invite you to read the original published paper and the book on transgenerational equity of *material* resources by Edith Brown Weiss [Frankenfeld 1993; Weiss 1989].

There are essentially three major types of measures for creating the intergenerational covenant of simple gifts:

(1) **Substantive measures** (gifts of substantive constellations of technologies which are simple)
(2) **Compensatory measures** (swaps)
(3) **Participative-Legitimative measures** (reins)

Reins can be supplemented by two other types of measures: (4) Outright Caps upon certain types of technologies and (5) Procedural Safeguards of informed consent. These are for those deontologically-inclined risk ethicists who prefer Maginots to marginals and the political thicket to the [Stephen] Breyer patch.

Gifts

Through gifts, we would bequeath to future generations the substantive gifts of trust funds and other resources to guarantee continued programs of scientific literacy. Through this, they would continue to meaningfully know about the technological hazards and other impacts we leave. We would leave them trust funds to pay for the equipment for monitoring and remedying the hazards and other impacts we leave them. This is similar to actual, existing laws within CERCLA, the Comprehensive Environmental Resources Conservation and Land-Use Act and the Superfund Act. The Superfund part of the Act comes closest to internalizing the "costs of complexity" of technological hazards. It does so by placing the often complex and prohibitively costly burden of discovery--and often *uncertainly* costly and *open-endedly* costly burden of discovery--on the potential offender. The SG ethic is similar, but more comprehensive.

Swaps

Compensatory measures would entail:

(a) The withdrawal of equivalent installations and entire technologies from use—although never know-how, as it can never be withdrawn or forgotten—in order to offset advents of new perils;

(b) The devotion of some percentage of R&D (Research and Development) funds for new, potentially hazardous technologies to studying the effects of existing and potential environmental hazards. This is sometimes called balancing innovation with *assimilation;* or balancing innovative research with diagnostic research.

(c) A possible one-time halt of *all* R&D until we "catch up" with our assimilation of the entire extant stock of hazards to a level deemed sufficient. With an emphasis on *possible.* This is quite controversial.

Through these "swaps", society will keep a rough homeostasis of layperson or expert controllability vs. vulnerability despite a changing mix of technologies.

Reins

Proceduralistic, participative-legitimative measures would include:

(a) Bruce Tonn's realistic/minimalist Court of Generations to permit suits by *ad litem* representatives of future generations. This court would enjoin impositions of disutilities upon future generations or sue for compensation (Tonn 1992). This would include the yoking of future generations with greater perils and greater regulatory burdens than ours.

(b) Channels of participation in:
—The ongoing monitoring of hazards we impose
—The siting of hazardous technologies we develop
—The approval of research by the relatively permanent R&D infrastructure we impose;
—The relative *size* of the R&D *infrastructure* within the technological society so that the R&D infrastructure we impose upon descendants does not remain, insulate itself and metastasize through bureaucratic inertia creating an accelerating treadmill of change. Reversibility through accountability is a hallmark of democracy theory [Laslett and Fishkin 1992].

Controls would entail representatives *ad litem* of the interests of future generations in present decisions on technology. Through these participative-legitimated procedures, future perils and new worlds or technological "ages" such as the nuclear world or genetic engineering age, would be more validly approved than they are now. They would be more legitimate than they are now. Such proxies might be expected to advocate the fourth type of measure:

(4) Outright Caps, or the *a priori* avoidance of *all* technologies with specific characteristics. These might include:

–Long-term and irreversible hazards such as chemical and radioactive wastes;

—The large-scale use of any unfamiliar technology, however seemingly benign

–Technologies whose workings and detection of harms are only comprehensible to experts. This will avoid imposing more and wider situations of subordination of laypeople to experts and growing inequality between them and vulnerability by laypeople to experts than now exist. It will avoid the greater subordination of *experts* to society's stock of complex potential hazards than now exist. It pursues the goal of collective informed consent.

Other characteristics of novel technologies and installations which *ad litem* representatives would avoid imposing or would impose only subsequent to showing R&D and conducting rigorous prospective Technology Assessment to foresee consequences of each critical step–i.e., other criteria for caps–would include:

* Inherent harmfulness of a technology, defined by the number of people who can be killed or afflicted in a single strike;
* Inherent potency, even if harmfulness is unknown . This is sought given that technologies are so often double-edged swords;
* Inherent leverage of the knowledge potentially disclosed by any R&D project even when the harmfulness of any technology it may produce is unknown. Leverage is the level of fundamentalness with which any knowledge probes life or matter and allows manipulation of them.
* Inherent structural complexity of the mechanism of operation or media or ecosystem through which harm is inflicted. Structural complexity is defined in terms of the number of differentiated parts, times the variety of parts, times the tightness of coupling. This seeks to avoid the creation of and penetration of more world-imperilling genies equivalent to the nuclear genie. It seeks to induce a generic "geniology" or study of which characteristics of technologies or research are inherently perilous.

Some might wish to make these characteristic *binding* by imposing (5) Procedural Safeguards to prohibit the very *consideration* of technologies with perilous characteristics. They might wish to have procedural safeguards to guarantee collective informed consent by laypeople and even experts, similar to informed consent procedures for individual patients for treatments by physicians. The hypothetical scheme for implementing this is quite peculiar [Frankenfeld 1992].

III. Your Role

Before we worry about imposing a world onto *future* generations that is not too complex, our first concern is to attempt to approximate citizenship *within* generations. The enterprise of STS and of scientific literacy within it which informs NASTS should be concerned with informing *existing* laypeople of the complex technologies and science that surrounds them. It should be concerned with pursuing the ideal of meaningful citizenship within technological societies.

It is arguable that we will never attain the stringent, highly participatory ideal for technological citizenship I have outlined. We may never even achieve the looser social contract for complex societies I have discussed. Perhaps the best we can do is to improve programs of scientific literacy.

Still, I would argue that programs of scientific literacy *themselves* would be improved if they were *nested* into the larger ideal of citizenship. That way, the state would have a clear, unambiguous, binding *responsibility* to provide information and to provide it in a timely, comprehensible manner. Laypeople would have a binding *right* to this. They would have a clear *duty* to learn what is presented to them and to use it in their active participation. They would hold a clear duty to utilize information with *judgment*, neither opposing every new installation which affects them in the NIMBY tradition nor accepting each new one. Under my scheme for TC, there would be *limits* to how much laypeople would be *required* to learn in order to be considered "meaningful" citizens within technological societies. Also, "NIMBY" [*unconditionally* Not In My Backyard] would be replaced by the more conditional "NUCLEUS" [*possibly, but* Not Unless Consent has been Legitimately Expressed, Upstream/Understandingly by Stakeholders].

In short, TC would provide the deeper *"why"* for scientific literacy which it now lacks. It would provide a single, clear name for the vague movements toward greater democracy and public participation which some STS scholars and practitioners seek. This would invest deeper and richer meaning to scientific literacy and STS. It might open research, debate and practice on entirely different methods for reckoning with the current distanciated division of labor within technological society such as improving and tightening trust and trustworthiness and its related orientations of confidence and reliability.

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THE PEOPLE FROM 'AWAY': ENDING RACIAL AND ECONOMIC EXPLOITATION IN THE SITING OF TOXIC WASTES

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We can here, I think, invoke a simple rule: that those who command space can always control the politics of place even though, and this is a vital corollary, it takes control of some place to command space in the first instance.

David Harvey, **The Condition of Postmodernity**

The toxic remainders of contemporary extraction, production, transportation, and waste treatment processes wind up somewhere. That 'somewhere' is increasingly near the poor and people of color, throughout the world and in the United States. Though environmental action has been associated with, and its goals and tactics restricted by, white middle class constituencies, there have been in the last decade increased and often spontaneous community organizing efforts in poor and minority U.S. neighborhoods. These have focused on actual and potential waste storage sites and processing facilities (incinerators, sludge conversion plants, etc.) in those communities.

We will broadly examine some of the factors contributing to this emergence, particularly by using geographic and power considerations regarding space and place. We will also consider the tactics which such groups employ, and something of how their members come to take part in struggles for environmental justice

THE PRODUCTION AND PROFIT OF TOXICS

While it is a commonplace of progressive economics to explore the ways in which capitalists extract profit (surplus value) from the efforts of workers, it is ecologically more sound to recognize the series of 'extractions' that are used to produ e profit. There is first the extraction of resources from the mineral and biomass systems of the earth. (Only recently have preliminary ways of 'paying the earth' for its largesse -- site reclamation at mines, reforestation, use of renewable energy sources -- been consciously returned to something of the priority they had among certain Paleolithic peoples.) The second extraction is from the workers, that amount beyond what labor is paid and what the productive processes cost, which owners accumulate for further investment, as Marx argued.

The third and fourth extractions concern the residues of production, that non-biodegradable 'stuff' that must be put somewhere. The third extraction of surplus value is from those persons and communities near or under or upon whom the residues are placed. What is 'extracted' is their health, or the viability of their community, in unstated and non-negotiated exchange for reduced post-production costs. The fourth extraction is from 'the long-term future', those cultures, persons, animals, and plants often unborn who will yet have to cope with this same 'stuff' decades, centuries, and millennia from now, or who will never be born because their ancestors were rendered inviable. These third and fourth extractions are often classed as 'externalities'; but it is precisely their profit-making potential, their surplus value in other words, that makes them so desirable in the eyes of some. Toxics, in other words, are a positive part of the profit equation of their producers. This paper explores what happens when 'people of the third extraction', the people from 'away', demand their due, and seek to 'raise the price' of externalizing toxics.

We need to consider one other factor regarding the actual production of toxins. The overall levels of pollution, and the amount of toxic wastes, have increased dramatically in the years following World War II. As has been known for several decades, these increases far exceed the combined growth in the population and in the econometrically-measured standard of living. What accounts for the remaining pollution increases? A series of cascading changes in agricultural methods, production technologies, and new products that increasingly depart from historical, 'natural' or labor-intensive methods by increasing energy inputs, creating new chemicals and substances, and then emitting or transporting these 'somewhere' (see Commoner, 1971:142-147). The continued holding down of energy costs has allowed capitalist producers and state-command economies alike, after recognizing the toxicity of these outputs, to more easily move them 'away'. The question is: which 'away'?

THE GEOGRAPHY OF TOXICS

The Geography of Toxics World-wide

The wider pattern of industrialized nations using Third World countries as convenient and compliant dumping grounds for industrial toxins and even some radioactive wastes is now a well-documented commonplace (Anderson, 1988). Appropriate for its racial implications in the U.S. is the fact that Africa has been especially exploited in this regard (Schisse, 1988; World Press Review, 1988).

One effort to alter the pattern of exploitation is the Basel Convention, which was drawn up to preclude the Third World from becoming the OECD's toxic dump of choice.

In a sadly predictable development, the Convention has become instead the legitimation of many facets of just that practice. Few of the original signatories have ratified the agreement, with delays from the U.S., Canada, and all the European Community except France. Further, OECD environmental ministers have sought to develop a 'green list' of acceptable-to-transport toxins (lead and cadmium, because they're recyclable; dioxin-generating plastics, as they're not burned until arriving at the dump site, if then) meant to circumvent the spirit of the convention (Webb, 1992).

Most revelatory of all was the recently leaked memo from the chief economist of the World Bank, Lawrence Summers, in which he injudiciously defended the wisdom of shipping toxics to low wage countries; affirmed them getting high pollution industries because they are "vastly *under*polluted"; and argued that, since they have a higher mortality rate anyway, cancer-causing toxins will have "very little direct health impact...I think the economic logic behind dumping a load of toxic waste in the lowest-wage country is impeccable and we should face up to that" (Foster, 1993:10-11). Given the sizable policy-setting impact which the World Bank and the IMF have on so many Third World nations and their poorer citizens, such an approach portends no likely change in who will receive increasing amounts of toxins.

The Geography of Toxics in the United States

The details in the United States are consistent with world-wide patterns: 80% of hazardous waste sites and pollution emitting facilities are in or near communities of color. Fully 65% of Americans of color live in polluted communities (Fischer, 1993). "Mean household income and the mean value of owner-occupied homes were not as significant as the mean minority percentage of the population" in differentiating ZIP code areas with greater or lesser numbers of hazardous waste facilities and large landfills (United Church of Christ Commission for Racial Justice, 1987: 13). The racial impacts of toxic waste are rather evenly distributed amongst Black, Hispanics, Native Americans, and Asian/Pacific Islanders (Bullard et al., 1990: 9). America, one might say, does provide equal opportunity for toxic exposure to all its minority citizens.

An interesting confirmation of the connection of race and the location of hazardous waste dumps has occurred in a working class suburb of New York. The town of Haverstraw, having been built over mines from an earlier brick-making era, found that its subsidence problems were remediable by land-filling with discarded wallboard. But decomposing Sheetrock emits hydrogen sulfide fumes, which can prove fatal at high dosage. A string of questionable business deals and irregular environmental permits led to the construction of 18 homes, which were offered (without forewarning of the risks) to Black and Hispanic families assumed to be "happy just to own a home". The now-organized residents, having failed to gain redress from various governmental units, feel "robbed, robbed of everything we have...They used a piece of paper, a piece of legal paper"(Gruson, 1993).

Toxic exposure is not confined to specific waste dumps or processing facilities. Sometimes, serious toxic residues are literally at home, lead paint being a prime example.

Because the problem is so widespread, especially in older homes and apartments, and particularly in poor and minority neighborhoods, the number of children with some degree of lead poisoning is high and rising. With clean-up estimates using professional crews sometimes ranging up to $145,000 for a home, and $20,000 per apartment, and with entrepreneurs multiplying as the total U.S. clean-up is projected to cost $600 billion if professionally done, the possibility is high that many will get very rich and the poor will get lead. Depending on how EPA and state regulations are written, concerned parents who are handy with home repair might be able to do this themselves, though how much this will be promoted and explained is uncertain. What is surer is that a great deal of lead and lead poisoning will further blight the lives of poor and minority children (Martin, 1993).

Another form of dumping plagues U.S. cities. Though not toxic until ignited, the approximately 200 million tires that are scrapped every year in the U.S. are, because landfills are reluctant to accept them, increasingly winding up in huge mounds in poor urban neighborhoods. While many repair shops and tire dealers properly dispose of the carcasses (which are hauled to shredders for about $1 each), entrepreneurs from underground economies sidestep state and federal regulations by hauling them away for half that and then dumping them by the truckloads in the Bronx and similar low-income areas (Marriot, 1993).

It is understandable, given these multiple forms of toxic assault which minority and poor communities are subject to in the U.S., that persons might expect the federal agency responsible for protective efforts to be an advocate for environmental justice. Yet a recent study published in the National Law Journal contends that the U.S. Environmental Protection Agency employs differential enforcement and legal methods depending on the racial composition of the community in which the offending corporation or SuperFund site is located. Among its findings:

✓ Penalties for hazardous waste violations averaged six times higher if the site was located in a white community;
✓ SuperFund sites in minority areas took longer to get on the list, and the start of remedial action took longer;
✓ EPA-selected methods tended toward containment of hazardous wastes in minority neighborhoods, but toward treatment in white communities (Associated Press, 1992).

As on the planet, so in the nation: the 'Third World' is wherever toxins and toxin generators create it.

REFLECTIONS ON SPACE AND PLACE

The geography of toxics, and of grassroots resistance to them, deserves further attention. For the complex dynamics of place and space bear heavily on which pollutants in which places can be confronted, and in what ways.[1]

The tangible by-products of former and current production processes, especially toxic ones, are often substances that occupy an identifiable place. While they can be dispersed into fluid systems -- rivers, oceans, sewers, the atmosphere -- they can also be spatially contained in waste dumps or in storage containers or, as with some tragicomic episodes regarding toxic ash, on barges roaming the high seas in search of a 'home'. It is precisely spatial containment (or at least the toxins being in some identifiable zone) that allows *community* organizing rather than *issue-based* organizing to take place. For the sake of this discussion, let us call the spatial zone somehow within range of a particular toxin (or toxin agglomeration, as is true for most dumps) the 'toxin-affected community'.

Places, communities conscious of themselves *as* communities, are constituted by a combination of historical, racial and ethnic, economic, bureaucratic, and environmental or bioregional factors. Community organizing and mobilization efforts depend, in part, on the prior existence, at some level of awareness among the affected residents, that they and certain other persons in fact do constitute a 'human community'.

There is really a third set of actors on this geographic stage, namely, the bioregion and its micro-environments. This is the 'biological' or 'ecological' community, whose diversity and complexity are precisely its strength. Much industrial and human activity of the last several centuries (especially since disconnecting from water, wind, and animals as power sources) has been conducted oblivious to the 'place' which ecosystems form, and has proceeded as if they were just a simple 'space' in which economic activity could profitably be conducted.

How the 'toxin-affected community' intersects with 'human communities', with the 'ecological community', and with 'industrial or commercial space' depends, in part, on the nature of the toxin. Some, like lead paint and radon, are usually so ubiquitous and local (house or dwelling related), and so overlain with the specific history of a building's maintenance, as to make identification of a 'toxin-affected community' a difficult step. Others, such as tire-dumping and spontaneous junkyards, are mobile in siting, episodic in occurrence, and contributed to from so many disposal streams as to make it highly difficult to connect the site with any specific set of perpetrators.

Likewise, widespread airborne toxins, such as acid rain or the Chernobyl radiation cloud, form 'toxin-affected communities' so vast as to render community organizing efforts and resistance if not impossible, at least administratively quite complex. Acid rain and Chernobyl differ critically, however, as regards the location and number of inputs. The Chernobyl inputs came from a single source, several hundred feet in diameter (albeit one that was typical of a specific type of Soviet nuclear reactor and a whole history of national policies). Acid rain, however, has multiple inputs, with multiple and distinct structures of accountability, spread out over hundreds or thousands of square miles.

Toxic waste storage or processing facilities create a more definable 'toxin-affected community', one which, critically depending on the flows in the ecologic place, may be roughly coterminous with one or more human communities. Such a confluence of spatial communities renders neighborhood-based resistance more effective, and more likely than in other configurations of 'toxin-affected communities'. It is arguably just this vulnerability that prompted capitalists and state socialists alike to site toxic waste 'storage' in more vulnerable communities.

If we might risk a generalization worth further research, it seems that the larger the number of toxic inputs, the wider the region generating inputs, and the larger the 'toxin-affected community', the more difficult the task, for bureaucrat or activist, of successfully altering the problem. Whereas the fewer the number of inputs, or their being bounded by a succinct perimeter, and the more previously self-identified as 'community' are the persons in the now 'toxin-affected area', the easier the task of resistance. Depending on the fabric of laws, there might be a lower bound here as well, below which the opportunity costs of resistance climb: namely, in 'toxin-affected communities' so small, or so fractured into previously self-identified communities, that the necessary coalitions would be too fragile or improbable as to make resistance likely.

As the opening aphorism from David Harvey suggests, power is critically connected to the control both of space and of places. This is especially so given the history of property rights in the U.S. For human communities to gain control of their place, to see it as a place and not merely a space or sphere for economic activity, and to see themselves as legitimate residents and citizens of that place, is for them to exercise real and ecologically-apt power.

Though his arguments concern the ways in which space is modified and controlled by ever more globally-mobile capital, it is helpful to quote Harvey's (1990: 232-234) logic, from which the above discussion in part derives:

> Superior command over space has always been a vital aspect of class (and intra-class) struggle...[T]he ability to influence the production of space is an important means to augment social power. In material terms this means that those who can affect the spatial distribution of investments ... in physical and social infrastructures ... can often reap material rewards. ... Influence over the ways of representing spaces, as well as the spaces of representation, can also be important. If workers can be persuaded, for example, that space is an open field of play for capital but a closed terrain for themselves, then a crucial advantage accrues to the capitalists.

An illustration of the structuring of space via toxic storage occurs in the South Side Chicago community of Altgeld Gardens. The neighborhood of 10,000 predominately African-American citizens is constructed atop the landfill of human and industrial wastes left from half a century of the Pullman railroad coach company. This location has since 'attracted' at its periphery dozens of other landfills, so that it has "the greatest concentration of hazardous waste sites in the nation." Neighborhood activists have dubbed this a 'toxic doughnut', with their homes 'in the hole' (Ervin 1992:15; United Church of Christ Commission for Racial Justice, 1987: xiv,39). Given the foregoing discussion, and the spatial configuration of toxicity, it is not surprising that Altgeld Gardens is the site of organized resistance.

ENVIRONMENTAL JUSTICE: THE 'Others' SPEAK FOR THEMSELVES

The first African-American protest of hazardous waste siting took place in Warren County, North Carolina in 1982, when a site there was selected to store 32,000 cubic yards of PCB-contaminated soil. Though the demonstrations, supported by the United Church of Christ's Commission for Racial Justice, did not halt the site, they did:

(1) prompt an early GAO study on major toxic sites in the South;
(2) hasten the NAACP's 1983 adoption of its first-ever resolution on hazardous wastes; and
(3) lead as well to the United Church of Christ's 1987 Toxic Wastes and Race in the United States study (Bullard, 1990b:103, 105; Commission for Racial Justice, 1987: xi).

Since then, an ongoing wave of environmentally focused justice actions and demonstrations have taken place in minority communities, particularly in the South. These have included Houston's middle class Northwood Manor neighborhood opposing the siting of a toxic dump within 1,400 feet of the high school; Alsen, Louisiana's suit against a toxic waste incinerator in the 'chemical corridor' along the Mississippi River; and the more recent Gulf Coast Tenants' Organization's "Second Great March Against Poison" focused on the same chemical confluence on the Mississippi (Bullard, 1990a: 50-54,65-69,76).

While the environmental movement that emerged in the U.S. in the 1960's was viewed with considerable suspicion in minority communities "as a smoke screen to divert attention and resources away from the important issue of the day -- white racism", and such concerns as "wildlife and wilderness preservation, energy and resource conservation...were not high priority items on the civil rights agenda", the influx of new and often highly polluting industries and toxics facilities prompted some major changes in emphasis (Bullard, 1990a: 31f). While the pattern of industrial siting was initially welcomed in poor, Black, Southern communities, with local toxic burdens being seen as the trade-off for jobs and economic growth, the promised jobs often didn't appear, and environmental quality sagged further. Increasingly the issue is now recast in terms of why the costs are localized while the benefits are dispersed elsewhere. Bullard suggests that the following questions have come to the fore: "Are the costs borne by the Black community imposed on them to spare the larger community? Can environmental inequities (resulting from industrial siting decisions) be compensated? What are 'acceptable' risks?" (Bullard, 1990b: 109).

As suggested earlier, the patterns of siting of toxic wastes world-wide tend to run overtly on cost minimization principles. Yet it is perhaps more accurate to see this as decided by conflict minimization principles, i.e., whoever lacks the operational citizenship strength to resist the generators of toxins is most likely to get them. Thus 'Third World' locations, explicitly *in*cluding poor and urban and so-called 'minority' communities in the U.S., have chosen to raise the conflict quotient to fend off toxic dumps.

The Benefits and Tactics of Resistance

Organizing around toxics in minority communities has come to display a number of advantages beyond the usual benefits of community organizing:

- It taps the natural NIMBY mindset. Although the 'NIMBY' resistance within middle-class white communities has often been converted to the 'PIBBY' principle, 'Put In Blacks' BackYard', this maneuver, initially tolerated by African-Americans, is increasingly resisted.[2] Some have suggested that a better slogan is "Not In Anyone's Backyard!"

- It involves a phenomenon sufficiently widespread to allow for linkages across the US. Due to the racial pattern of siting of toxic waste, there is obvious potential for trans-cultural cooperation, particularly amongst African-American, Latino, and Native American populations.

  Rev. Benjamin Chavis' recent appointment as executive director of the NAACP means that a long-term civil rights' activist with a solid grounding in the racial and class-based structure of environmental toxins and abuse now heads the largest civil rights organization in the U.S. It is likely that an ongoing racial and environmental justice emphasis will be nurtured and developed, enlightened by Chavis' own involvement in toxic justice reports and actions. But one leader does not resolve a long-standing breach in justice activism. As Michael Fischer has pointed out, a number of recent major environmental conferences (in San Jose, CA; Washington, D.C.; and New Orleans, LA) each had 60-80% minority involvement, with those percentages representing not a handful but many hundreds of persons (Fischer, 1993; Schneider, 1993).

- It has a secondary support structure, especially in the technical expertise of the traditional environmental movements. Those groups, precisely because they have been distinctly white and middle-class, are becoming more sensitive to expanding their constituencies and working with minority communities.[3]

- There is a growing body of supportive law and precedent, not least the national toxic waste laws and SuperFund cleanup, that allows communities to pursue legal remedies with some hope of redress.

  While, as mentioned above, the support of the EPA has recently been questioned on grounds of racial equity, there is some success with the filing of lawsuits, particularly at the state and local levels (Tsao-Naikang, 1992). Different legal remedies exist that minority communities may pursue to preclude the development of new toxic waste sites in their area **if** they already have too many sites for racial equity. Such siting constitutes racial discrimination analogous to any municipal service, and remedies exist in common, state, and constitutional law.

- The 'conceptual landscape' of the problem, in which large corporations and municipalities attempt to inflict the 'down-side reality' of technology upon poor communities world-wide and upon the earth and its ecosystems, provides inherently rich opportunities for self-education and consciousness raising of a systemic, economic, political, and ecologic sort within those poor communities. It has, in other words, creative counter-systemic potential as well as the more constrained anti-systemic posture. It also can teach middle-class allies about the class structure of their society.

- The development of local citizens' technical knowledge; the demystification of corporation scientists' allegedly 'value-free' "technical decision[s] based on cost evaluation, risk assessments and engineering/scientific calculations, not on 'emotional' or 'political' decisions"; the formation of networks of 'citizen experts' to sustain local grass-roots efforts with carefully researched analyses of the environmental and health risks, and the economic consequences, that recur in one locality after another (Blumberg & Gottlieb, 1990).

It would be naive in the extreme to think that, for example, the waste-incinerator industry has remained silent in the face of growing challenges from communities surrounding potential, profitable sites. They have come to employ a range of tactics such as using complex information, to be interpreted only by 'technical experts', many of whom are employed by the waste disposal industry, to evaluate risk factors by methods often guaranteed to provide answers consistent with their employers or colleagues viewpoints. Some in the industry are also filing lawsuits "against community activists, adding an additional layer of expertise-related intimidation"(Blumberg & Gottlieb, 1990, 742f). While most would hesitate to call this reaction a benefit to community groups, it does further reveal corporate wiles and the need for open public information and debate on questions often well concealed.

Yet one response by urban minority communities to the waste incinerator industry provides a highly provocative example of what a 'neighborhood alliance' can do. It starts in Brooklyn, at the site of the proposed Williamsburg-Greenpoint incinerator (Johnson, 1993). The 'toxin-affected community', typical of urban spaces, is an all-too-frequently conflicted mix of African-American, Puerto Rican, Italian, and Jewish neighborhoods. Yet the local Community Alliance for the Environment (CAFE) has brought together, for the first time, this racially and ethnically diverse set of communities to fight the siting. Further, because the incinerator construction and administration is to be done by Wheelabrator (whose parent, Waste Management, Inc.[WMI], is one of the largest incinerator operators in the U.S.), CAFE has begun to develop a dispersed-sites' coalition with other communities in the U.S. that either have or are threatened with a WMI waste-disposal incinerator. The organizing frame, in other words, is all the neighborhoods, wherever they're located, affected by a WMI facility, a coalition with a potential membership in the millions of people.

This expanded cognitive frame is astute as to the role of capital in the creation of this 'wider neighborhood'. Rather than form an alliance with 'all toxin-affected communities in New York State' (which would have certain benefits in state court litigation) or even 'all incinerator sites in minority communities', CAFE has defined the 'enemy' as a particular corporation and its operational practices wherever they are sited. As the globalization of capital proceeds, CAFE's expanded frame for collective action creates a highly appropriate if logistically complex redefinition of 'place', of 'neighborhood' and of 'ally': Everyone who lives near, downwind, or downstream of a WMI incinerator lives in 'our place'. They are **our** neighbors.

CONCLUSION AND PROSPECT

In assessing newly emerging community-based environmental activism within minority constituencies in the United States, we have seen that careful attention to the economic and spatial motives behind corporate efforts to site toxic waste dumps in minority neighborhoods helps to explain some of the dynamics of such confrontations. If we add this to the history of civil rights/environmental relations, it is not surprising that minority involvement in other 'environmental movement' issues has shown little ripple effect growth. That is not to say that minority persons are unconcerned with such things as resource conservation and wildlife; in many years of working in minority urban communities, the author has not found that to be so. It is to say that, for many, the tasks of living and surviving in a racist and classist society take much of their available strength. Protest actions need to be 'closer to home', to the place known as 'community', to engage sustained involvement (although the CAFE example suggests an effective means of extending 'local' to a powerfully wide stage).

What is developing may become a people of color alternative environmentalism, which brings ecological issues, particularly toxics, into a larger, more holistic, mix of social justice concerns. What is emerging are networks of minority activists mindful of but somewhat functioning outside the hegemony of white environmentalism. While I have seen only scant evidence of direct cooperative linkages to Third World struggles, the consciousness is certainly there. Yet the commonality of North America as place, as a system of bioregions, as well as the shared language and interwoven history, even the convoluted effects of media, may lead African-American, Latino and Native American environmental justice advocates to rely more on one another than on 'official Third World' allies. Whether Euro-American environmentalism will respond constructively to the emergence of such a powerful and critical ally, with a larger justice agenda, is unclear.

NOTES

1. One critical factor regularly ignored in community organizing literature (though often tacitly confronted by organizers) is what geographers call the spatial form of a problem. Having consulted a number of community organizing texts, both scholarly and practical, I have been unable to find any

clear exposition and few references to the fundamental role that spatial forms and humanly perceived places play in the construction of specific community problems, in the types of resistance which certain spatial forms require or preclude, and in the spatial configurations and consequences of possible or desirable outcomes. This discussion is, therefore, exploratory and theoretic within the domain of community organizing and toxics.

2. Bullard,1990a: 5. Particularly in the U.S. South during the 1970's, when strong efforts were being made to increase the industrial base and lure various corporations to relocate in the region, "many civil rights advocates, business leaders and political officials...relaxed enforcement of pollution standards and environmental regulations, and often looked the other way when violations were discovered." All but one of the states that "led the nation in attracting polluting industries (e.g. paper, chemical, and waste disposal) in the 1970s were ... Texas, South Carolina, North Carolina, and Florida. (Bullard, 1990b: 102.)

3. This 'advantage' is more in process of emerging than a given reality. In the introduction to Bullard et al. (1990:3) the Panos Institute's Dana A. Alston points out that the more holistic approach of minority environmental groups that integrates environmental concerns into "a broader agenda [of] social, racial, and economic justice" has occasioned "conflict with the mainstream environmental movement, which people of color perceived to be mostly White, middle and upper class, and insensitive to the needs and agendas of minorities" and remiss in hiring people of color onto their own staffs. The tension is similar to that which progressive activists have long had with mainstream environmentalists: "During its formative stages, [environmentalism] was viewed as an establishment-sponsored effort to divert attention from more fundamental (and potentially Leftist) issues such as civil rights and military involvement ... This negative appraisal ... was reinforced by Leftists' concerns with environmentalists' class position, political ideology, ... and dependence on strategies that appeared to be minimally disruptive." (Gale, 1983: 179).

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CONSTRUCTING SPACE: THE SHAPING AND USES OF THE NASA-CIRSSE TWO-ARM ROBOTIC TESTBED

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I have examined one group of engineers in an academic research center and their attempt to develop a large robotic demonstration platform over the course of several years. The engineers were members of the NASA-sponsored Center for Intelligent Robotic Systems for Space Exploration (CIRSSE) at Rensselaer Polytechnic Institute (RPI), and they attempted to develop an autonomous, two-arm robotic testbed to simulate space-based construction using theories of intelligent control.

I begin by explaining how the negotiations of CIRSSE researchers amongst themselves and with their NASA sponsors helped to shape the form and function of the robotic testbed during its development, but were not the only factors involved. Then, I examine how researchers used the robotic testbed to legitimate their research to their NASA sponsors and attract new resources, and how they organized their developmental efforts to allow students to graduate and researchers to produce publications. By using the robotic testbed for so many diverse missions, CIRSSE researchers were able to temporarily create a space in which they could operate with a great amount of autonomy. However, as researchers developed the robotic testbed more, it became less flexible, and eventually it became a hindrance to CIRSSE researchers as they tried to negotiate with NASA personnel and adapt the relationship to changing conditions. Finally, I will briefly explore some of the implications of this form of specific-application-oriented funding for academic researchers.

CIRSSE was formed as part of the NASA University Space Engineering Research Center (USERC) program in July 1988, and it remained a NASA-USERC until October 31, 1992, at which time the original grant expired. During the 52 months that CIRSSE researchers were part of the USERC program, they began to develop a two-arm robotic testbed for the purpose of demonstrating intelligently controlled autonomous construction in space. Over the course of its development, the robotic testbed became central to almost all activities at CIRSSE and represented the link between CIRSSE and NASA, despite the fact that researchers had not developed it to the point that it could be used to demonstrate intelligently controlled autonomous construction, even by the end of the NASA-USERC grant.

Initial Plans

The form and capabilities (or planned capabilities) of the CIRSSE robotic testbed were the results of many factors. The most significant of those many factors were the agendas of the two main organizations involved -- CIRSSE researchers and NASA personnel -- negotiations that took place among the two groups and between them, the shared thought style (Fleck 1981) of CIRSSE researchers, and contingent constraints that arose during development.

The USERC program was established during NASA's reorganization following the *Challenger* explosion. NASA provided seed money to establish the centers, which were expected to produce space-oriented researchers and technologies, and eventually become self-sustaining by creating ties with industry. The RPI faculty who drafted the proposal to form CIRSSE were members (and so most of their students were as well) of a Robotics and Automation Laboratory (RAL). The RAL was a loosely connected organization that served as a thought collective for its members. They shared common research interests (intelligent machines for robotics and automation) and common perceptions of where their research could be applied (industrial manufacturing settings). The USERC program offered CIRSSE researchers a chance to support a wide variety of research projects and the integration of them on a scale that small grant support could not. The researchers' strategy was to create a demonstration that was both an integration of much of their on-going work and of interest to NASA. CIRSSE researchers presented the robotic testbed to NASA as a method of demonstrating assembly, disassembly, and repair in space. However, the shared thought style of the RAL researchers led them to approach the problem of proposing a robotics task to NASA as they would propose an industrial manufacturing task.

Researchers' initial conception of the robotic testbed (Figure 1) was of two standard six-link manufacturing robot arms placed on a single platform, which would have the ability to move with six degrees-of-freedom, and controlled using the theories of intelligent control that they had developed. The planned robotic testbed would have allowed CIRSSE researchers to demonstrate intelligent control, and also require them to apply many other research projects, such as planning for assembly tasks and dual arm control, as well. (Having the two robot arms on a single, movable platform would allow CIRSSE researchers to design their controllers for the system as if it were floating in space.) Meanwhile, intelligent controllers and planning

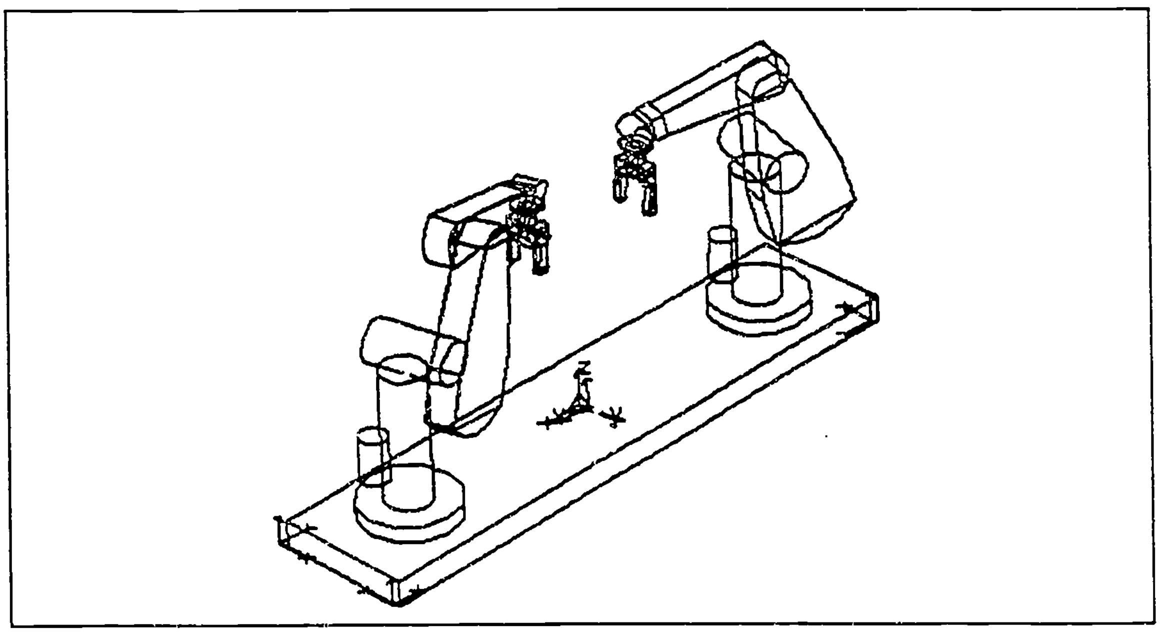

Figure 1: CIRSSE robotic testbed as initially conceived by researchers

algorithms for autonomous construction were of interest to NASA personnel since the robotic testbed was similar to the Flight Telerobotic Servicer (FTS) that NASA had proposed to construct the planned space station.

CIRSSE researchers had negotiated among themselves to determine the plans for the robotic testbed, but their plans were influenced very strongly by their perception of the type of technologies NASA personnel were interested in, as well as their desire to continue on-going research projects, and their shared thought style. NASA personnel also negotiated internally, and eventually selected nine of the 115 proposals that were submitted in response to the USERC program notice, one of which was for CIRSSE. NASA's acceptance of the CIRSSE proposal was an implicit statement that NASA personnel had agreed that CIRSSE researchers were likely to produce something that was of interest to NASA. However, later events implied that the two groups did not share a common conception of what the robotic testbed would eventually be capable of demonstrating and the value of that demonstration.

The Changing Path of Development

The initial proposal set a development path for CIRSSE researchers and their robotic testbed, but the plan as it existed on paper and in their minds did not hold up to the contingencies of the laboratory. Significant problems arose when researchers attempted to purchase a platform for the robotic testbed. The performance specifications they had agreed upon required a platform that had six degree-of-freedom controlled motion capabilities, with a movement response rate at least equal to the end effectors of the robot arms, fit inside an available laboratory, and cost no more than $70,000. The platform that researchers required did not exist (except in their minds). All commercially available platforms failed on at least one, and usually more of the aforementioned requirements.

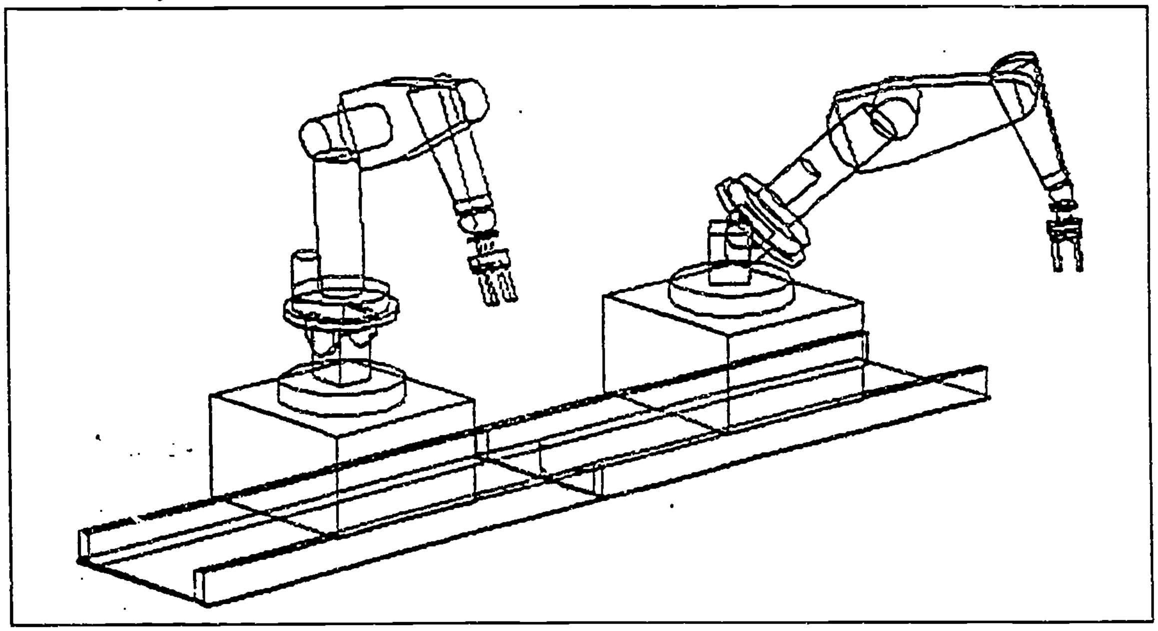

Figure 2: CIRSSE robotic testbed as constructed

The dilemma was apparent to researchers within six months of the beginning of the grant, and different potential solutions were mentioned to NASA in a status report (although input from NASA was not solicited). CIRSSE researchers settled upon a compromise and selected a demonstration project. The combination of the two is important. Researchers chose to purchase a system with two separate platforms on a common rail (Figure 2). Each of the separate platforms had only three degrees-of-freedom (including the rail), but met the other requirements of reaction speed, size, and cost. Equally important, the platform allowed CIRSSE researchers to continue with most of their plans. They were still able to integrate, and hence support the smaller projects that had made up much of the work in the RAL prior to the NASA grant. As a result, they did not have to significantly alter their approach to the problem, and they would still have had a complex system under intelligent control if they had been successful. What they sacrificed was the ability to simulate construction in space by an unfettered two-arm robotic platform. This left the link between the robotic testbed and space missions (and hence NASA) much less readily apparent.

CIRSSE researchers solved this problem by selecting a demonstration project for the robotic testbed. What they elected to do was have the robotic testbed autonomously construct a tetrahedron out of struts and nodes. This mimicked (on a much smaller scale) what NASA was proposing to have the FTS do during the construction of the proposed space station. In some ways this linked the robotic testbed (and hence CIRSSE) more closely to NASA than the original plan did, but it did so by attaching the work at CIRSSE to a specific mission, rather than to a generic capability that might be applied to several missions. The platform was not delivered to CIRSSE until April 1990, 21 months after the beginning of the grant, but by selecting and ordering it, CIRSSE researchers started down a path that would prove difficult to diverge from at a later date.

Using the Robotic Testbed

Once they acquired a platform for the robotic testbed, CIRSSE researchers made extensive use of the robotic testbed in almost all laboratory activities. Before the platform was delivered, CIRSSE researchers were able to operate with very little input from NASA, but were unable to carry out many of their own plans due to the lack of proper equipment. After the platform was delivered, CIRSSE researchers continued to enjoy research autonomy, and they were able to begin to integrate their many independent projects into a single large demonstration. Meanwhile, CIRSSE researchers began to make more use of the robotic testbed in other facets of laboratory activity. More and more, they used it to legitimate smaller projects to NASA personnel, to attract new resources, and to augment their publication rate and allow students to graduate in reasonable periods of time.

Legitimating Research

CIRSSE researchers used the robotic testbed to legitimate much of their research to NASA personnel. The developmental plan CIRSSE researchers adopted for the robotic testbed reflected a compromise between their varied goals and their organizational and institutional commitments. As part of this compromise, researchers used the robotic testbed's development as a means to allow them to continue funding research projects that were already underway when the CIRSSE grant began. Three research projects that served as good examples were adaptive control, petri nets representations of assembly tasks, and assembly planning. All three were research topics being studied in the RAL that researchers adapted to the CIRSSE mission and continued.

Linking research programs that were already underway to the robotic testbed development allowed researchers to continue work on them; the robotic testbed project provided funding and a convenient case study to examine. Various research projects from the RAL were adapted to fit into the robotic testbed development project. They were not, however, the only available means to accomplish the tasks at hand. Even within the constraints of the CIRSSE intelligent control structure (itself an on-going research topic) and the desired form and capabilities of the robotic testbed, there were multiple choices available for the form and function of various subsystems that were to make up the intelligently controlled robotic testbed. Many of the subsystem forms were, it seems, chosen because they were familiar and grounded in on-going research, not because they were thought best for accomplishing the project in the most efficient or space-like manner.

Obtaining Resources

CIRSSE researchers used the robotic testbed to legitimate smaller project research from the initial proposal until the end of the NASA grant. The delivery of the platform for the robotic testbed effected their ability to legitimate other projects, but not as much as it effected their ability to use the robotic testbed to attract new resources. Once CIRSSE researchers had obtained all of the major hardware portions of the robotic testbed it became much easier to advertise, even if it did not work as they eventually expected it would, and so they used it to represent research at the Center.

The most striking way to ascertain how CIRSSE researchers used the robotic testbed to represent the Center is to examine how they used it in public relations materials. Such descriptive brochures contained only the most superficial descriptions of the research that took place at CIRSSE. This created an idealized image of the laboratory that left the actual status of research projects unclear. Yet such descriptions were the Center's face shown to the outside world, and served to attract resources such as new members and new sponsors. For example, one brochure was sent to prospective graduate students to attract them to the Center by introducing them to the rudiments of the laboratory and its research (it could also be shown to potential sponsors). What made these brochures effective for CIRSSE researchers was the use of specific pictures combined with generic descriptions of the laboratory that were related to, but did not explicitly explain the pictures.

There were two descriptive brochures featuring CIRSSE, both produced during 1991, after all of the major equipment portions of the robotic testbed were in place. One was a brochure produced by NASA to explain the USERC program, which included a single page (two-sided) pullout on each Center in the program. The other, produced by CIRSSE, was a twelve page (plus cover) pamphlet specifically about CIRSSE. What was immediately notable about both was the prominence of pictures of the robotic testbed and the space-truss assembly demonstration, either the actual entity, in whole or in part, or computer images of the idealized version that was described in the original proposal.

There were two pictures in the CIRSSE portion of the USERC brochure, and both included versions of the robotic testbed. One was a computer model of an ideal version of the robotic testbed (i.e., the one originally proposed) attaching two struts together. The other showed a portion of each of the robot arms, including the grippers, on one side of the picture, and two researchers on the other. In addition, there was a computer in the background with an image of a two-arm platform on the screen. Actually, the researchers were on the platform in a place they normally would not be (at least when the robotic testbed was operating), and the computer terminal had been turned around from its normal operating position for the picture. Moreover, there was no direct relation between the image that was on the computer screen and the actual robotic testbed. Inferences drawn from the picture could lead to very inaccurate conclusions as to how researchers interacted with the robotic testbed, both directly and via computer interfaces. The images associated the work at CIRSSE with the robotic testbed and the assembly of space-truss structures, without giving any feel for or description of what the robotic testbed was actually capable of at the time.

The brochure that described only CIRSSE used images of the robotic testbed in a similar manner. Six of the twelve photographs in the brochure included some portion or image of the robotic testbed (another was a computer image of a truss assembly sequence). The most striking picture showed one arm attaching the final strut into a tetrahedron that the other arm was holding onto. This picture was included with a description of the robotic testbed. This picture was remarkable in that the robotic testbed had not been developed enough so that it could construct a tetrahedron out of struts and nodes without being remotely operated by a human. However, since both new members (mostly in the form of graduate students) and a continued influx of funding from sponsors new and old were essential for the Center's survival, from the point of view of representing and selling CIRSSE, advertising based on where the Center was trying to go made perfect sense. Using pictures of the robotic testbed gave readers concrete impressions to go with the descriptions of the research at CIRSSE, without fully explaining anything.

Producing Research Output

CIRSSE researchers required legitimacy and resources to continue with their work, and they used the robotic testbed to secure both of them. In addition, CIRSSE researchers used their developmental efforts on the robotic testbed to enhance their publication rate and to allow students to graduate efficiently. Publications and trained researchers were two types of output that CIRSSE was expected to produce as an academic research center. Such research centers are also frequently expected to produce techniques and technologies as well. In the case of CIRSSE, researchers were expected to develop the robotic testbed into a useful simulation platform. These three types of research production are obviously interdependent upon one another, yet they remain distinct -- researchers could pursue one at the expense of the others. Whether any one form of research output is more important to a researcher or organization than the others is a function of the standpoint of the researcher or organization. For their part, publications from USERCs were less valuable to NASA engineers and administrators than other forms of research output from the various centers. Technologies, techniques, and researchers were more tangible, and therefore immediately useful. For researchers at CIRSSE, all forms of research output were important to the point that they could not afford to have the extended development of the robotic testbed halt other forms of research output.

What CIRSSE researchers did was use their developmental efforts on the robotic testbed to produce publications and help students complete their graduate work. To further elaborate on the production of research output at CIRSSE, I have examined the work on the development of grippers for the robotic testbed more closely. Three students, two graduate and one undergraduate, were directly involved in the CIRSSE gripper project, along with two faculty members, between the summers of 1989 and 1991. One student was given the task of the mechanical redesign of the grippers (which were made shorter, lighter, and designed specifically to pick up struts). Once the mechanical design had been completed, and the grippers constructed, one graduate student and one undergraduate student, were respectively given the tasks of writing the gripper controller software and choosing and building the electronics. Along with completing the work assigned, the latter two students used their results as a thesis and a senior project. In addition, the work of all three students was used to write a paper on the grippers, which was presented at a conference. Furthermore, the thesis, the senior project, and the conference paper were also published as CIRSSE reports. Thus, in the course of getting grippers for the robotic testbed designed, operating, and integrated into the robotic testbed, two students fulfilled requirements for graduation, and one conference paper and three reports were produced.

A New Round of Negotiations

CIRSSE researchers were able to use the robotic testbed to legitimate their work, to attract new resources, and to enhance their research production, mostly because they were able to operate with a high degree of autonomy in their relationship with NASA. CIRSSE researchers obtained their autonomy from NASA through the agreement that members of the two organizations had reached regarding the future usefulness of the robotic testbed. The agreement had allowed CIRSSE researchers to develop the robotic testbed as they saw fit, and even to alter the design when their original one proved to be unworkable. However, members of the two organizations did not share the same conception of how the robotic testbed linked CIRSSE to NASA. For CIRSSE members, the testbed itself was the link, but for NASA personnel it was the demonstration project -- the autonomous construction of a space-station-like truss -- that linked the two organizations together.

The agreement began to crumble on April 16, 1991, when NASA administrators announced a change in the space station construction plans (US Congress 1991: 22). The station was now to be constructed on the ground and taken into orbit in sections, which were to be attached to each other in space. The mission that strongly linked the robotic testbed, and with it CIRSSE, to NASA no longer existed. This event was coupled with a general reduction in NASA budgets, which put more pressure on NASA personnel to demonstrate that resources were being used wisely.

What followed the change in the space station plans was an aborted negotiation between NASA and CIRSSE personnel as to how the robotic testbed (and CIRSSE) would fit into NASA plans. The main incidents in the negotiation were: a status report by CIRSSE members, a site visit to CIRSSE by a NASA review team and a report based upon the visit, an official reply to the review report and a proposal to cover the next five years of research at CIRSSE (the original grant was due to expire October 31, 1992), and a NASA peer review team evaluation of the CIRSSE proposal. I refer to the negotiation as aborted, because NASA personnel decided not to renew the CIRSSE grant before members of the two organizations had reached an agreement on what the future of the robotic testbed was to be.

People in both organizations attempted to influence those in the other in order to define the organizational relationship to fit their own needs. For CIRSSE researchers the robotic testbed was the link to NASA. It was also the focal point of almost all of the projects underway in the Center. Most of the theoretical projects had their applications oriented towards it, and many other projects were directly related to its development. This meant that significant changes to the robotic testbed had the potential to effect almost all research underway at CIRSSE, and in many cases significant changes to the testbed would have led to researchers' abandonment of other projects. The task for CIRSSE researchers became convincing NASA personnel that the robotic testbed was indeed useful for space robotics research, specifically research that was relevant to upcoming NASA missions. The difficulty for CIRSSE researchers was that the robotic testbed's form was concretely established and difficult to alter, and most of the work at the Center was intertwined with it. CIRSSE researchers were willing to make changes to the robotic testbed, but only superficial changes that would not require significant alterations to the myriad of projects that were underway and attached to it.

CIRSSE researchers initially attempted to legitimate the robotic platform as it was, but that plan met with criticism from NASA personnel that CIRSSE researchers lacked a firm plan and leadership. In response, CIRSSE researchers subtly redefined the robotic testbed as a planetary construction simulation platform, without changing it, and announced plans to make the laboratory which housed the robotic testbed more "planet-like" by cluttering the work surface and varying the lighting conditions. The only significant change that CIRSSE researchers proposed in the short-term was to change the upper levels of the intelligent control hierarchy so that the robotic testbed could be telesupervised as well as operate autonomously. This served two direct purposes. First, it was a simpler task for CIRSSE researchers to accomplish. Second, NASA was more prone to using systems with human involvement than fully autonomous systems for the types of missions CIRSSE researchers were trying to simulate.

NASA personnel did not accept CIRSSE researchers' redefinition of the purpose of the robotic testbed, but recall that they had not viewed it in the same manner to begin with. Whereas CIRSSE researchers considered the testbed itself to be the link to NASA, NASA personnel had considered the truss construction demonstration project to be the tangible product from the Center. Thus, when the space station construction plans were altered, NASA personnel expected CIRSSE researchers to come up with a demonstration that was directly applicable to NASA, or even better, a mission usable technology. However, the demonstration project had effectively become part of the robotic testbed, portions of the testbed had been designed and built specifically to accomplish that task. Therefore, to CIRSSE researchers, abandoning the truss assembly demonstration was equivalent to fundamentally altering the robotic testbed.

Negotiations regarding the future of the robotic testbed ended abruptly when the USERC program director, faced with the choice of cutting funding to all centers or defunding one completely and leaving the rest alone due to a shrinking budget, decided that the CIRSSE grant would not be renewed upon its expiration. This decision left CIRSSE researchers with a large, partially completed robotic simulation platform that was structurally linked to space research, and no external interest in supporting its completion.

Conclusions

The robotic testbed was both a product of and a major part of CIRSSE. CIRSSE researchers used it in multiple ways, and most of the research at CIRSSE was related to it in some manner. Furthermore, the robotic testbed owed much of its form to the results of negotiations between CIRSSE and NASA personnel, CIRSSE researchers' assessments of NASA needs, their research agenda, and their shared thought style. Yet social negotiation was not the only factor that affected the form and function of the robotic testbed. Initially, changes resulted from researchers' reactions to contingent constraints that they had to account for. The constraints were not static, but researchers were also not able to deal with them in the manner that they dealt with external actors. These constraints did not act on the robotic testbed as much as they caused a reaction on the part of CIRSSE researchers. Moreover, as the robotic testbed's form became more concrete, the project became difficult to alter. In this respect the robotic testbed project had the kind of "momentum" that Thomas Hughes (1989) has discussed, and in the end CIRSSE researchers entered into a pattern of "reverse adaptation" as described by Langdon Winner (1977). A significant difference was that the robotic testbed was not the type of large technical system that Hughes and Winner have discussed, but a relatively insignificant robotic simulation platform. In effect, the "momentum" the robotic testbed acquired after CIRSSE researchers initial conception of it served to frustrate their later negotiations with NASA personnel.

The inability of CIRSSE researchers to secure sufficient support to complete the basic development of the robotic testbed raises concerns about the ability of researchers to conduct basic technological research. The experiences of CIRSSE researchers was an example of how sponsors can attempt to influence academic research through specific-application-oriented funding. Moreover, even though NASA personnel did not make explicit requests regarding the form and function of the robotic testbed until after the Spring of 1991, CIRSSE researchers still managed to develop the testbed so that its links to space were explicit enough that they were not able to interest industrial sponsors in it. While the CIRSSE case represents only one example, the implications of it are that researchers must choose between short-term applied projects with some resource security, or risk the failure of their projects due to financial reasons if they wish to undertake longer-term, larger, or less applied research.

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Irradiation of food: boon or bane?

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Treatment of food with ionizing radiation is a technology that arouses vigorous support and heated opposition. Proponents state this technology can make our food supply more wholesome by destroying pathogens, extend shelf life by reducing or eliminating microorganisms that cause spoilage, control insect infestations of fruits, grains, and spices, retard sprouting, and delay ripening of fruit. Opponents maintain it is liable to poison us with unknown carcinogens produced by the radiation processing and allow the relaxation of good hygienic practices in food processing. In this paper we will present a brief history of food irradiation and then discuss the current status of this technology in the United States and elsewhere. Next we will offer several possible explanations for the passionate reactions this technology arouses. Finally we shall discuss the probable future of irradiation of food. The book Safety of Irradiated Foods (Diehl, 1991) is an excellent account of all aspects of food irradiation.

At the present time there are two major types of irradiators in use: electron accelerators and gamma-irradiators. Electrons emerging from an accelerator do not readily penetrate and are therefore not directly useable for processing of bulk materials. Accordingly these electrons are generally used to produce X-rays which are then used for processing materials. Cobalt-60, a man-made radioactive isotope, is the most common source of gamma-rays for processing. Since most of the controversy concerning food irradiation involves the use of gammas, only this type of facility will be discussed.

A typical cobalt-60 (Co-60) irradiator consists of a source, a storage pool, a conveyer system, a shielded radiation chamber, and a control panel. Since Co-60 emits potentially lethal gamma-rays the irradiation of products must be controlled remotely from outside a shield that prevents the escape of radiation. In addition there must be a way to shield the cobalt when workers have to enter the radiation chamber. Typically the radioactive material is mounted on a movable rack which can be lowered into a water-filled pool. The pool is deep enough so that no gammas can escape when the source is submerged. The conveyer system allows the operation of the facility with the continuous movement of containers past the source while allowing finished product to emerge from the chamber and unirradiated product to enter. Batch processing with a less complicated input system is an alternative. The entrance and exit must be designed so that no radiation escapes from the chamber and so that no one can enter while the source is exposed. The irradiator is basically a simple device. Food or other materials to be treated pass by the radioactive source and are exposed to gamma radiation. The dose of radiation depends on the amount of Co-60 in the source, on geometry, and on the length of exposure. The facility may have the ability to control temperature and the atmosphere of the irradiation chamber.

While there has been a spirited controversy about treatment of comestibles with ionizing irradiation during the last decade, this type of processing has been proposed and tested since early in this century. In 1905 a British patent was issued for the treatment of cereals and grains with radiation from radium or other radioactive elements for the purpose of improving their quality and prolonging their storage life (Diehl, 1991). The patented process could not be successfully commercialized at the time since there was no adequate supply of radioactive material for providing the radiation. Similarly the commercial implementation of trichina inactivation in pork using X-rays proposed by a scientist at the United States Department of Agriculture (USDA) in 1921 was not possible since X-ray machines with sufficient power were not available at the time (Diehl, 1991).

The development of electron accelerators and the increased availability of radioactive nuclei following the growth of the nuclear industry during the 40's and 50's changed the picture. Now sufficiently intense sources of ionizing radiation were available to allow processing of food and other materials on a commercial scale. Government laboratories in the United States, Canada, and a number of European countries began studying food irradiation. Much of the work in the United States was carried out at the Army Research Laboratory at Natick, Massachusetts where a food irradiation facility was built in the early 60's. This laboratory produced and tested irradiated food for use by the military since palatable food that could be stored for long periods under ambient conditions would be of obvious benefit. NASA astronauts have used products developed at Natick (Josephson, 1983). Many foodstuffs have been treated with radiation. Table 1 summarizes the use of irradiation for treating edible substances.

Table 1 Uses of food irradiation

PRODUCT	PURPOSE	DOSE
potatoes, onion, garlic, ginger	inhibition of sprouting	low
cereals, fruit, dried fish and meat, fresh pork, sushi	insect and parasite disinfestation	low
fresh produce	delay in ripening	low
fresh fish, strawberries	shelf life extension	moderate
fresh and frozen meat, fish, and poultry	elimination of spoilage and pathogenic organisms	moderate
meat, poultry, seafood, prepared foods, special sterile hospital diets	industrial sterilization	high
spices, enzyme preparations, natural gums	decontamination	high

The first commercial use of food irradiation was for the disinfestation of spices using an electron accelerator in Germany in 1957 (Diehl, 1991). Processing with ionizing beams of electrons was replaced by chemical fumigation in 1959 when a law was passed which banned food processing with electrons, gamma rays, or X-rays. The first commercial use in

North America took place in Quebec in 1960 where potatoes were treated with gamma rays to inhibit sprouting. The plant was not profitable and closed after one year.

Food irradiation in the United States is under the jurisdiction of the Food and Drug Administration (FDA). By law, irradiation is regulated as a *food additive*. In the last few years a number of products have been approved for radiation treatment. At present less than ten per cent of the spice used in the United States is irradiated for decontamination. Some fruit is also irradiated to control ripening. Chicken and pork may be treated with moderate doses of radiation but no commercial scale processing is taking place. The FDA requires that all irradiated foods bear a government approved logo and a statement that it had been treated with radiation, while products containing irradiated items like spices do not require such information on their labels. The first commercial radiation facility designed specifically to treat foods started processing in 1992 in Florida. Table 2 lists items that have U.S. approval with the year of approval by the FDA. Poultry required an additional approval by the Department of Agriculture which was granted in 1992.

Table 2. U.S. approved uses of food irradiation (GAO, 1990)

PRODUCT	PURPOSE	DOSE	YEAR
fresh foods	inhibition of growth and maturation	low	1986
any food	insect disinfestation	low	1986
dry enzyme preparations	microbial disinfestation	moderate	1985
dried herbs, spices, tea	microbial disinfestation	high	1983
fresh pork	trichina elimination	low	1985
fresh and frozen poultry	salmonella and other bacteria	low	1990

Other items are currently under study. There is strong interest in treating red meat, especially since there have been several deaths in recent years due to the consumption of hamburgers that were contaminated with a virulent strain of E. coli, a commonly occurring bacterium.

Three states, New Jersey, Maine, and New York, have blocked the sale of irradiated foods. The ban in New Jersey has expired. The moratorium in New York State presents an interesting picture of the politics of food irradiation. It was first enacted in 1991 for a two year period and then renewed in 1993 for an additional two years. The original bill was introduced with little public notice and with vigorous support by the New York Public Interest Research Group (NYPIRG). The alleged purpose of the original measure was to allow New York State an opportunity to study the safety of food irradiation. Yet in the next two years no official contact was made with the FDA, the Army Natick Laboratory, or various international agencies that had studied the process. In fact a request for information from the pertinent legislative committees showed that New York legislators were not presented new information about the efficacy or safety of food irradiation when a vote for extension of the ban took place in spring 1993. Only after the extension was approved for a second two year period did the legislature call hearings. These hearings presented arguments both pro and con concerning the sale of irradiated foods.

Food irradiation has been strongly supported by a number of international organizations associated with the United Nations including the World Health Organization (WHO), the International Atomic Energy Agency (IAEA), and the Food and Agriculture Organization (FAO). A book published by the World Health Organization provides information for the general public and policy makers on how food irradiation might help "in controlling two of the most serious problems connected with food supplies: the huge avoidable losses of food through deterioration and the illness and death that result from the use of contaminated food."(WHO, 1988: 5) This book points out the advantages of irradiation for reducing food-borne diseases and extending storage life of food in tropical countries. However it shows there are many economic problems that must be dealt with before radiation processing can help contribute to making a developing country self-sufficient in food.

Many countries other than the United States have approved the use of food irradiation. The use for disinfestation of spices is widespread, as are uses to control sprouting and ripening. Decontamination and shelf life extension of chicken is allowed in a number of countries including Bangladesh, Brazil, Chile, Israel, the Netherlands, and South Africa. These six countries allow the most products to be irradiated, but even they restrict what can be treated. As is the case in the United States, the use of food irradiation is growing and many countries are allowing new items to be processed.

There are numerous other industrial uses of radiation processing including sterilization of medical supplies, pharmaceuticals, and cosmetics using gamma irradiation. The use of penetrating radiation to kill microorganisms offers many advantages to conventional heat treatment or chemical fumigation. Products can be sterilized while in closed shipping containers so there is no need to handle the material until it is used. In addition the problems associated with toxic residues from chemical fumigants is avoided. In 1985 over 30% of the disposable medical devices produced in the United States were sterilized this way (Diehl, 1991). Treatment of non-comestibles has not led to wide-spread protests and has been proven to be cost-effective.

The controversy surrounding food irradiation is similar to many debates about technology. While there are disputes between experts over facts, often the most vigorous disagreements are really partisan arguments rooted in values (Mazur, 1981). What are some of the issues that have been raised in the debate over food irradiation?

- *Irradiation may make the food radioactive.* The sources that have been approved, gamma-rays from Co-60 and cesium-137, X-rays with energy less than 5 million electron volts (Mev), and electron accelerators operating at energy less than 10 Mev, cannot induce radioactivity.

- *Irradiation causes chemical changes in the food and may produce toxic substances.* All food processing as well as storage leads to chemical changes. There is not conclusive evidence of the formation of measurable amounts of unique radiolytic products (URP) (Pauli and Takeguchi, 1986).

- *Radiation may kill microorganisms that cause spoilage while not destroying more resistant pathogenic organisms like Clostridium botulinum that causes botulism. The food may be dangerous and not appear spoiled.* Other forms of food preservation can lead to the same problem. Control and monitoring of irradiation processing is needed to assure food is subject to the proper amount of radiation.

- *Radiation-processed food may cause long-term health effects.* There is no definitive evidence to support this claim. A few studies have been interpreted as showing that the processing leads to unsafe food but these studies have been dismissed by *experts* as flawed and inconclusive (WHO, 1988). This is one of the issues on which opponents and proponents most vigorously disagree.

- *Radiation treatment destroys vitamins and other nutrients.* The same is true of storage and many forms of food processing. If necessary, radiation processed foods could be enriched as is done with flour.

- *Food that has been irradiated has an off taste.* If people do not like the taste of a product they do not have to use it. The same statements can be made about many canned goods. Consumers decide for themselves as long as the product is wholesome.

Supporters and opponents of food irradiation both argue that the technology will affect the quality and safety of the food supply. Any belief that the food supply is in danger will strongly influence the public. Supporters of irradiation, including international organizations like WHO and FAO, say the benefits outweigh the small possibility of risk for approved irradiation procedures. Opponents look at the same studies and question the safety of irradiated foods. As with any dispute involving safety, absolute proof is impossible (Mazur, 1981) so we are left arguing how much evidence is enough. Many of the groups actively opposing the technology have names associated with purity of food and water such as the New York Coalition for Alternatives to Pesticides (NYCAP) and Food & Water, Inc. Food and Water, Inc. has run a number of advertisements about food irradiation trying to convince the public of the dangers posed by the process. The following statement was broadcast many times on 57 Florida radio stations during the summer of 1991 (Katzenstein, 1992: 60):

> What if you found out that those fresh fruits and vegetables everyone keeps telling you to eat more of might kill you? No joke... Supermarkets have started selling radiation-exposed foods: spices, processed foods, and soon, meats and fruits and vegetables.... Many scientists are saying irradiation makes foods unsafe, changes the molecular structure of food, destroys nutrients. And new studies show how ingesting radiation-exposed foods causes genetic damage, which can lead to cancer and birth defects...

Their campaign continues. In an attempt to counter the arguments that might lead to a USDA test of irradiation of hamburger to control bacterial contamination, Food & Water, Inc. ran informational advertisements in a number of newspapers during March 1994. One quarter-page spot on the op-ed page of the New York Times on March 16, 1994 read "The government's next radiation experiment?" and showed a child eating a sandwich. "Radiation-exposed meat: We're all the guinea pigs."

NYCAP also argues that consumers want tasty, fresh, nutritious, wholesome food, not food with a longer shelf-life. They attribute the desire for longer shelf-life to a highly centralized food industry (NYCAP, 1993a). Most consumers determine freshness by appearance, taste, and smell. For example, if radiation processing allowed strawberries to appear and taste like freshly picked berries for several weeks (WHO, 1988), many people would call them fresh and be willing to use them. Consumer reactions to test marketing of irradiated papayas in California and irradiated mangoes in Florida has been generally positive (Diehl, 1991). Perhaps NYCAP is objecting to the national and international enterprises that grow and market produce.

However, much of the opposition to radiation processing may be based on anti-nuclear feelings. For example, in Germany the term *radioaktive Behstrahlung* or *radioactive irradiation* has been used to label the process (Diehl, 1991). The opponents of the technology have been so successful with this label that the media has generally adopted the expression, and Germany is one of the countries in Europe with the greatest restriction on radiation processing. In the United States there is wide-spread opposition to nuclear power and related industries which may contribute to fear of radiation and radioactivity. Opposition to the use of cesium-137 centered on the fact that it was a waste product from nuclear fission. On the other hand Co-60 is produced for the specific purpose of irradiation, and is made like many isotopes used for medical purposes. NYCAP mentions only one proponent, Nordion, involved in lobbying against the extension of the New York moratorium on sale and distribution of irradiated food (NYCAP, 1993b). Nordion is a supplier of Co-60.

One big change may occur in the technology for food irradiation that could greatly change the debate. Highly efficient and cost-effective generators of penetrating radiation using electron accelerators are under development (Welt & Welt, 1993). If these irradiators largely eliminate the need for Co-60 then one of the main causes of public concern will be removed. The technology will no longer be directly connected with the nuclear industry which is certainly one of the major reasons for public distrust.

The use of irradiation to treat food will continue to grow. The more people are given a chance to become familiar with irradiated foods, the more they will find the technology a welcome addition to the food processing industry. Just as heat pasteurization of milk to reduce the spread of certain diseases has become the norm so radiation pasteurization or radurization of poultry, meat, and fish may gain wide-spread use if salmonella and other disease-causing organisms cannot be controlled in other ways. Extension of shelf life of fresh fruit and vegetables with radiation may prove attractive to many consumers as will the elimination of the need for chemical fumigation of some foods. Room-temperature stable foods produced with irradiation may be a common convenience within a decade. Once the public accepts some irradiated foods then others will be tried. If these products are considered more desirable for whatever reason they will be purchased. Continuing the present labelling law in the United States will allow individuals to decide on using or avoiding this technology.

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Inarticulate Science? Representing and Understanding Science for Public Use

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In this paper, I shall draw upon a study of some aspects of the public understanding of science, undertaken jointly with colleagues at the University of Leeds. Following a few preliminary remarks about the public understanding of science, I shall report briefly upon our research and our findings, and then conclude with some of the implications of this work, as I see them, for science education.

The public understanding of science

The need for a greater 'public understanding of science' has been urged from a number of standpoints. As an example, the interactions of science and technology with society have generated a reaction against the exclusiveness of scientific and technological activity which has not only prompted demands from different groups for participation in the control and direction of that activity (Nelkin 1978, 1982) but also provided the rationale for the emergence of STS as a field of research and curriculum development. From a different standpoint, illustrated by a report from the Royal Society of London on *The Public Understanding of Science*, an understanding of science is often presented as important for economic well-being and competitiveness, for effective participation by citizens in a democratic society, for employment in an increasingly technological working environment, and for personal satisfaction and well-being (Royal Society 1985).

This advocacy of greater public understanding of science sustains a corresponding academic interest, not least in attempts to measure it, which has been rather slower to develop in the United Kingdom than in the United States. A review of this literature allows me to make the following comments. First, the term 'public understanding of science' is often used as though it were interchangeable with another slogan of our times, scientific literacy. Second, the public understanding of science is commonly seen as multi-dimensional, incorporating, as a minimum, an understanding of scientific concepts and of scientific methodology, allied to the display of scientific attitudes. Third, attempts to quantify the public understanding of science have universally produced results that those who do the measuring, along with many others, have judged to be very disappointing (e.g., Miller 1986). Fourth, these attempts at measurement reveal a number of severe methodological problems, one of which is of particular importance in the context of this paper. I refer to the fact that many estimations of the public understanding of science have been characterised by a serious mismatch between those whom John Ziman (1984) has categorised as 'insiders' and 'outsiders' with respect to science. The insiders' view is concerned with abstracted and decontextualised scientific knowledge and with the possibilities of discovery and validation. In contrast, the outsider or lay perspective is much more instrumental and concerned with knowledge in the context of use. In addition, many studies have failed to recognise the heterogeneity of the public whose scientific understanding is being probed, thereby overlooking, for example, that social and economic circumstances influence the priorities which individuals assign to specific problems having a scientific dimension and that what is one person's 'acceptable risk' is another's 'vexatious nuisance' or 'intolerable hazard' (Douglas and Wildavsky 1982; Wynne 1984).

It is notions such as heterogeneity and instrumentalism, captured in the term science for specific social purposes, (Layton, Davey and Jenkins 1986) which underpinned the Leeds study to which I would now like to turn.

The Leeds Case Studies

A basic assumption of our investigation into adults' needs for, and use of scientific knowledge was that exploration to the depth we wished to go could usefully be undertaken only if the adults with whom we were working shared a common concern or problem. We also took the view that there was no good reason why most members of the general public should quest after knowledge such as the thermodynamics of non-equilibrium systems, the origin of cosmic radiation, the distribution of air bubbles in polar ice or the electron spin resonance of free radicals, however important these may be to the work of professional scientists. It was necessary for us, therefore, to choose particular contexts for our study of people's understanding of science. For two of our studies, we eventually settled on disability and disadvantage, and worked, respectively, with the parents of children having Down's Syndrome and elderly people, living in straightened financial circumstances, seeking to manage a domestic energy budget designed to keep themselves warm, well-fed and healthy. Our third context for study was one in which science-related issues were being addressed in the public domain and we worked with elected local councillors and their professional officers faced with a set of problems arising from the disposal of toxic waste and the seepage of methane from a landfill site into domestic dwellings. Our fourth group of adults had a direct interest, for example as employees, pregnant women or neighbours, in a controversy over the leak of radiation from the Sellafield nuclear complex in Cumbria in the north west of England. To a greater degree than the other three, this last study opened up issues to do with the political economy of science, i.e., the ways in which different groups managed the scientific information to which they had access and its interface with their extra-scientific interests and positions.

The bulk of our data was acquired by interviews, loosely structured, not significantly limited by time and, where appropriate, conducted and recorded in people's own homes. For each of the first three case studies, we had a prepared schedule of questions and topics on which we wished to elicit comment but this was not a prime determinant of the shape and structure of the conversation. In the event, there were few instances where, at the end of the day, items on the schedule had not been addressed, often cyclically and in increasing depth. Where appropriate, our interview data was augmented by other relevant material such as Committee Minutes and reports for the toxic waste study, newspaper reports for the Sellafield investigation, and, in the case of the energy study, published advice from government and non-government sources about how to keep warm. Our sample size varied. For example, we interviewed thirty two families having a Down's Syndrome child and four hundred and fifty people living in the towns and villages of West Cumbria in which the Sellafield nuclear facility is located.

Time does not permit me to summarise each of the case studies. I shall, therefore, offer a glimpse of the findings of the energy case study involving elderly people, before drawing upon this and, as appropriate, the other case studies in my concluding section. A full acount of the case studies is available in Layton, Jenkins, Macgill and Davey (1993).

A scientific approach to domestic energy management by the elderly, living alone, is likely to involve a number of elements. These include:

(i) consideration of the possibility of exchanging a larger dwelling for accommodation which is smaller and makes fewer energy demands

(ii) choosing a cost effective method of providing heat for warmth and cooking, e.g., the use of a cheaper fuel, off-peak electricity supplies, using one-cup kettles

(iii) making optimum use of available energy devices, including switching off unnecessary lights, controlling temperatures with thermostats, having a shower instead of a bath, employing strategies for preparing meals which minimise energy demands

(iv) reducing heat loss by insulation and double glazing

(v) monitoring energy consumption both *in toto* and in respect of individual appliances and, where appropriate and possible, taking corrective action

(vi) using data, e.g., weather forecasts, to anticipate sharply increased or diminished energy demands and to respond as required, e.g., by adjusting the amount of clothing worn. Within a fixed income, severe weather might suggests warming part rather than all of a domestic dwelling.

Elements of this kind, underpinned by scientific data, formed the advice, given freely to elderly people by government and charities concerned with their welfare on a scale that amounted to a national campaign.

For the elderly people we studied, moving house was not a realistic possibility. Indeed, they had moved to the house, precisely because they had relatives nearby who could help to look after them in times of difficulty. A few were attached to the house because they had always lived there and had many friends in the district. Likewise, relative energy costs were not necessarily the determinant of choice between gas and electricity for cooking and heating. For one elderly lady who had once owned a gas cooker, electricity was 'cleaner', mainly, although illogically, because the gas central heating at her grandchildren's house led to the walls at the back of the radiator becoming dirty! Safety considerations were also important, one lady preferring electricity to gas because she had a poor sense of smell.

All of the elderly people we talked with had considered the use which they made of the energy devices to which they had access. Some turned their heating down, or off, when they went out. One put the heater on in her bathroom about an hour before she was going to use it. Doors were often kept open, or closed, to facilitate, or restrict, the movement of heat between rooms. A similar concern for economy was evident in the variety of cooking arrangements which the elderly people deployed. A casserole, too substantial for a single meal, was cooked as a whole and then divided into portions for storage in the freezer. Dishes, like stews, which could be re-heated had an obvious attraction. A hot oven was used to cook more than one dish. One lady even put a small container of water over the pilot light on her gas cooker and left it overnight so that, in her words, 'In the morning, it wouldn't need as much energy to bring the water to the boil'.

However, this apparently 'efficient' use of energy appliances was frequently over-ridden by other concerns. One elderly lady provided additional heating in the room she did not normally use because this was her 'best' room and, therefore, the one in which she chose to be interviewed in for the study. Another switched on her electric fire because the interviewer was coming and she liked the simulated coal fire effect which the fire provided. One interviewee had abandoned the use of an electrically heated towel rail because she saw it as posing a safety risk to her small grandchildren. Another left her heating on because of concern for the well-being of her aged cat.

As for insulation, everyone in the study knew that grants were available to pay, in part of whole, for loft insulation. Those who had installed such insulation, however, were not able to detect any significant changes, either in their fuel bills or in their sense of warmth. Given the ages of the people in the study, it is not surprising that relatively expensive forms of insulation relating to cavity walls or double glazing, seemed to be of less immediate interest than more personal and localised methods of minimising heat loss, such as a 'sausage' to prevent underdoor draughts or the hanging of heavy or thermal curtains.

However, as with other aspects of domestic energy management, there were differences between daily practice and the dictates of a rational energy policy. While the insulating role of curtains was readily acknowledged, any suggestion that the curtains in a bedroom might be kept closed during the day was strongly resisted. There was concern that neighbours would draw an unfavourable impression or even conclude that something was seriously wrong with the householder. Some of the elderly people believed strongly in opening some or even all doors and windows for a short period each day to bring in fresh air, judged necessary for good health.

There was evidence in our study of a sense of the quantitative in the management of domestic energy. Some checked their meter reading every day and one gave herself a daily allowance of units, adding that she didn't understand therms but was well able to do the necessary algorithmic operation to relate consumption to likely cost. That heating generally cost more than lighting was well understood but as long as overall energy consumption did not lead to an excess of expenditure over income, a variety of energy practices could be sustained despite the fact that many of these practices conflicted with a efficient energy management. Unsurprisingly, this financial criterion was a fundamental importance to our sample of elderly people and it allowed them to override, often quite consciously, advice available to them. For example, the charity *Age Concern* supplied thermometers designed to indicate when a room temperature falls to a point at which an elderly person might be at risk from hypothermia. Common responses were ' I never look at it', 'I know what it will be before I look at it' and if it's just about in the blue and I feel OK, I don't bother'.

It would be a mistake to describe the behaviour which I have just described as 'unscientific'. To do so would be to assume that a scientific approach is both appropriate to, and adequate for, an understanding and evaluation of the management of domestic energy by the elderly. Such an assumption is invalid because it fails to acknowledge the complexity of human behaviour and, more particularly, to accommodate the notion that elderly people may understand the management of domestic energy in terms that are significantly different from, but not necessarily less valid than, those of the scientist or heating engineer. What we see, to borrow Stern and Aronson's terminology, is elderly people acting as consumers, investors, members of a social group, expressers of personal values and problem avoiders (Stern and Aronson 1984). An elderly person can be regarded as fulfilling, simultaneously or at different times, a number of different roles and, as a result, making judgements about energy practice on grounds which are appropriate to each role. Heating, lighting and fuel, like curtains, may be chosen, or rejected, on aesthetic grounds. Expensive insulation is rejected because, as a capital investment, it is unlikely to generate sufficient return. Keeping out of debt is a strongly held personal commitment, along with being near one's younger relatives.

The evidence of the case study, therefore, is that elderly people manage their domestic energy in ways that are much more subtle and complex than might be understood - or even dictated by - a consideration of the nature of energy itself. Individual and social preferences act as powerful influences upon the ways in which fundamental scientific ideas relating to energy and its conservation are integrated into the everyday practice of the elderly. In other words, in addition to the obvious economic dimension, there is both a psychology and a sociology of domestic energy usage. More generally, from the four case studies, scientific knowledge and values do not readily transfer from one social context to another, and there are significant problems of accommodation when scientific knowledge generated in one context, that of understanding, is translated to another context, that of use.

Representing and Understanding science for public use

The first point to make is that our case studies, like a number of others, lend very little support to science as a coherent, objective and unproblematic entity, characterised by certainty and direct applicability to everyday life. In the case of the elderly people, where the science was relatively unproblematic and capable of some direct application, scientific knowledge was integrated with, or often overridden by, other considerations to which they gave greater importance in their scheme of things. The Down's parents rejected much of the science they were offered by the medical profession as inappropriate, untimely and irrelevant to their immediate concerns. The councillors dealing with the waste disposal issue neither possessed nor sought actively detailed knowledge of the relevant science, taking note of it only after mediation by their technical officers, a kind of surrogate science selected to articulate with the councillors' particular concerns. Both the Down's parents and the Sellafield studies illustrated the fragility of much of the available science and its inability to provide unambiguous answers to the questions being asked. Ziman has summed up this general point particularly well. Reviewing a series of ten U.K.projects concerned with the public understanding of science, he concluded that the most important finding of the research program was that science is not' a well-bounded coherent thing, capable of being more or less "understood".... (It) is not a sharply-defined and special type of knowledge which only starts to be misrepresented and misunderstood outside well-defined boundaries by people who simply do not know any better....In this programme of research, we have seen many everyday questions that cannot be addressed properly, let alone answered, simply in terms of a shortfall in potential understanding' (Ziman 1991, 100-101).

Many examples can, of course, be offered to illustrate this point but I find Ravetz's insight particularly helpful. He has described us as having moved from a situation in which 'hard' scientific facts were seen in opposition to 'soft' values to one in which, inescapably, 'hard' decisions (i.e., difficult and definitive ones) have to be made on the basis of a scientific input which is irremediably 'soft' (Ravetz 1990). The attendant educational concern is that many science teachers, and other promoters of science, may still be premising their work on a belief about the objectivity and certainty of science which has become obsolete or, at best, valid only in certain special cases.

This understanding of science in the real world and its entailed notion of a plurality of sciences is, of course, not new. We can, for example distinguish *strategic science*, directed towards supporting or enabling technological innovation, and *mandated science*, concerned with science in the context of recommendations or decisions of a policy or legal nature. These are somewhat different from the notion of a fundamental science, driven by curiosity without thought of possible utility or application, with which school science in the United Kingdom remains principally concerned.

I do not need to elaborate for an STS audience the problematic nature of science, particularly when it comes to using it for social purposes. We should note, however, that this perspective has important implications for what it means to 'understand science' as a lay member of the public. It is not simply that science takes on a much less solid and reliable appearance than that portrayed in many formal educational settings. For example, in the Sellafield study, a radio-biological estimate of the number of cases of leukaemia which it was calculated could have been caused by accidental and other leakages from Sellafield over a twenty year period depended upon a series of assumptions, almost all of which were challengable. We need to re-think the notion of the lay adult as a passive consumer or recipient of expert knowledge. The domestic energy practices of the elderly were guided not only by understanding the physics of heat conservation but also by aesthetic, personal convenience, self-concept, financial and other considerations. Brian Wynne gives the example of sheep farmers who, after Chernobyl, were advised by agricultural scientists that radiocaesium in their stocks would be flushed out more quickly if sheep were grazed on the lusher pastures of the valley floor than on the grasses of the high fells. Both the practicality and credibility of this advice was questioned because the farmer's local knowledge had shown that intensive grazing on valley grass could damage a fragile resource of critical importance for future breeding cycles of their sheep (Wynne 1991). In reality, people do not encounter scientific knowledge as free-floating and unencumbered by social and institutional connections. The questions ' From whom? 'and ' From where?' and 'From what institutional source?' are central to judgements about the trustworthiness and reliability of the knowledge on offer. A corollary is that the public uptake (or not) of science is not based so much 'on *intellectual capability* as much as socio-institutional factors having to do with social access, trust and negotiation as opposed to imposed authority' (Wynne 1991, 116). A consequence is that scientific knowledge does not commonly occupy a central place in everyday life practices. Rather the process of integrating it with other knowledges, such as personal judgements and situation specific knowledge, frequently relocates science to the periphery if it does not remove it from the scene altogether.

The perception of scientific knowledge held by the adults we studied was much less as a cathedral of understanding of the natural world than as a quarry or company store to be raided for particular purposes. Sometimes, the store didn't stock what was needed. Occasionally, the store wasn't regarded as trustworthy and another store was considered. Sometimes, what was on offer had to be altered. Always, what was available had to be accommodated with other knowledges in a specific context. In other words, the relationship of the lay adults to scientific knowledge was interactive, critical and purposive. It was about creating new knowledge or, where possible, restructuring, reworking and transforming existing scientific knowledge into forms that served the purpose in hand. Whatever that purpose (political social, personal, etc.), it was essentially concerned with action or capability, rather than the acquisition of knowledge for its own sake (Jenkins 1992).

The case studies have an obvious resonance with work that has been done in the field of situated cognition (e.g., Rogoff and Lave 1984; Lave 1988) and with studies into the nature of technological, or more generally, of knowledge in action (Durbin 1989). The resonance lies in the importance of context in knowledge generation and use, and in the transformation, re-working and re-contextualising that must usually take place if knowledge generated in one context is to deployed successfully in another. In my judgement, there is an urgent need to know much more about these processes of transformation and re-working if scientific knowledge is to articulate with practical action. Not everyone would agree, of course, that science education should be about articulating scientific knowledge with practical action, despite the emergence of STS programmes, the frequent commitment to science education for citizenship or the emergence of technology as a distinct curriculum component. What is often missing in developments of this kind is curriculum attention to those social, institutional and economic dimensions of the scientific enterprise which, in Wynne's view, may be more important in influencing the public uptake of science than the more commonly emphasised scientific concepts and methodology (Wynne 1991).

Finally, the case studies suggest strongly two other important messages for the pubic understanding of science. These are the need for flexibility of access by adults to science and for opportunities for interaction between the producers and users of science. Questions arise, therefore, about the kinds of institutional provision which would allow this flexibility and promote the necessary dialogue. Some answers, 'science shops', for example, have yet to prove themselves over time. Other initiatives, such as the French Boutiques de Science, have come and gone. The most fundamental question, of course, is whether an interrogative science education, which at some points is likely to challenge the existing political economy of science, can ever command the necessary support from the scientific community itself.

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SCIENTIFIC LITERACY, NBIAP, AND PUBLIC PERCEPTION OF BIOTECHNOLOGY

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> There are two truths in this world: one of the laboratory, and the other of the media. What people perceive as the truth is truer in a democracy than some grubby little experiment in a laboratory notebook (Koshland, 1990: 1381).

The record-setting release of the movie Jurassic Park last year has raised a minor storm of controversy over the importance of images presented in popular media upon the future conduct of science. Articles and editorials in news magazines and major newspapers decried (or relished, depending upon the viewpoint) the fall of the reputation of scientists. But even prior to the release of the movie, the major newsletter of the biotechnology industry, Genetic Engineering News, raised a banner of alarm over the book and its vitriolic introduction to biotechnology:

> Who would take such a story [Jurassic Park] seriously? How about the group of community activists that successfully halted the field tests of frost-resistant crops in California? Or another group that successfully thwarted the construction of a biotechnology facility in Massachusetts?
>
> No, I don't think we can be complacent.... The country is vast, and there are millions of people who have no idea about biotechnology: what it can do, and what it cannot do. This book, and certainly the movie, may be their introduction to the field (Liebert, 1991: 4).

Since many voting non-scientists in the general public receive a great deal of their knowledge of how science and scientists work from popular media (Hagedorn, 1993: 10):

> In the minds of many students who reject science, the white, male, frizzy-haired, white-coated stereotypes--with certain facts but uncertain morality--that appear in movies such as Back to the Future and Frankenstein are the real thing. The scientists of movies and television make lasting impressions on science-wary children (The Science Teacher, 1988: 8),

a negative perception of science can indeed have a potential impact on how science is conducted--and funded--in the near future:

> Effective responses to issues of energy, food, environment, AIDS, health care, crime, and many other problems facing society require a sound foundation in science. Public policy based on ignorance or misapprehension of scientific knowledge can have very serious consequences, not just for human well-beings but for life itself. Society expects and needs both expertise and literacy in science if it is to deal successfully with many of the most pressing problems of our age (Steen, 1991: 17).

Negative images of science and technology, and biotechnology in particular, are strong and clear, but what importance do they have? Are they merely phenomena of an entertainment industry, or do they hold deeper implications on public perceptions of "real" science and the funding and conduct of such "real" science in the near future? In 1990, Science magazine, in an opening editorial, presented a mock interview between the reporter and "Dr. Noitall," an eminent NON-scientist:

> Science: We have come to ask you why scientists seem to have such a poor image.
>
> Dr. Noitall: How can you possibly ask such a simple-minded question? You are the people who have brought us nuclear war, global warming, and acid rain. You enjoy dissecting frogs, and you keep mice and rats in little cages (Koshland, *et seq.*: 1381).

In a survey conducted by Genetic Engineering News, a woman reported that:

> genetic engineering and biotechnology conjure up the specter of Nazi Germany and the quest for the super race (Potera, 1992: 23).

There is a problem with the understanding of biotechnology in a nation where, in a poll, DNA was defined as:

- a sickness,
- the smallest known molecule,
- a food additive, and
- an airport (Stone, 1989: 104).

The public in the United States has been faced with cartoons showing biotechnology as causing the end of a national symbol of childhood (Bugs Bunny crushed by a huge genetically-engineered carrot, Roanoke Times, 1992: A21) and the disappearance of a president (George Bush destroyed by a supermarket display of engineered broccoli, Roanoke Times, 1992: A13). The Washington Post presented readers with a menu of genetically-engineered foods, some of which included human gene products (1992: B1), food another publication called "Frankenfood" (Sagan, 1992: 151). In November 1993, the announcement that human cells had been cloned brought forth a spate of controversial publicity to biotechnology. Practices of investigating flora and fauna of third-world countries for new pharmaceuticals and for species collections have brought accusations of "genetic imperialism" against the United States. Media reactions to recent approval of BSt for dairy cattle by the Food and Drug Administration brought levels of public trust in government agencies to protect public interests concerning biotechnology to a new low. There are many calls for action, and the primary call is for an increase of scientific knowledge on the part of the non-scientific public: the reasoning is that if the public was scientifically literate, it could make more rational judgments on public policy based on science and not on images from popular media.

Scientific Literacy

There are many varied definitions of scientific literacy: it has been called "a concept in search of a definition" (Helgeson, 1991: 71). But most attempts at definition take in three particular elements:

- The scientifically literate person knows something about science content. They know something about major concepts in natural and physical sciences.
- But more than just memorizing facts, they realize that science is a process. They understand the role of scientific method(s) in exploring the natural world.
- Scientifically literate people recognize science's impact on society. They hold a concept of the relationship between science and everyday life and have gained skills to deal with science-related issues they encounter at home and at work.

Scientific literacy is more than facts, it is:

> applied curiosity in matters scientific. We recognize scientifically literate people not by what they know but by their capacity and willingness to learn the science they need to know it (Tobias, 1990: 62).

How well is the United States doing in scientific literacy? The present state of the profession has been described as:

> a kind of feudal aristocracy ... where a privileged few hold court, while the toiling masses huddle in darkness (Goodstein, 1993).

Briefly, what are the consequences of scientific *il*literacy for these "toiling masses"? Science is important. It has been called "the most important force for change in modern society" (Steen, *et seq.*: 12). And:

> we live in a world pervaded by science and technology; people cannot participate meaningfully in such a world unless they have

> a basic understanding of science and the scientific enterprise, and can think quantitatively (Schmidt, 1990: 61).

But when asked "what does it mean to study something scientifically," only one person in ten has any meaningful reply. How can we prevent beliefs in personally-motivated false claims? In pseudoscience? In a national poll, 2 in 5 people believed

- that rocket launchings have affected the weather,
- that space vehicles from other civilizations have visited the earth,
- and/or that luck numbers exist (Peterson, 1986: 600).

In this light, consider that when only 5 to 17 percent of the population is considered scientifically literate (Miller, 1992: 13-4), there are potentially serious consequences, not just for human well-being but for life itself, when a scientifically-*il*literate electorate votes on significant issues of energy, environment, food, crime, and health. To make matters worse, we now live in a service-oriented economy, heavily dependent on electronic information--how is the scientifically *il*literate citizen to evaluate the exponentially exploding masses of information that bombard us daily?

It has been said that "attainment of scientific literacy will likely require science to reverse its negative public image" (Miller, 1991: 197). But this negative image is constantly reinforced by the images of science and scientists projected in popular media. Frequently scientific principles are ignored in the name of "entertainment," and entertainment is considered too frivolous to contradict. So many mistakes, deliberate errors, and actual hidden agendas often go unchallenged. In an interview in Genetic Engineering News, author Michael Crichton (Jurassic Park) warned the world about the potential dangers of biotechnology:

> I wanted to sound a cautionary note. Science is wonderful, but it also has its hazards. If the book makes some people uneasy, maybe it should....[People] are uninformed and gullible....I am not through with biotechnology (Potera, *et seq.*: 23).

His book has been reviewed as "not ... good science, but ... good fiction" and "a bit of science mix[ed] with a great deal of imagination (Potera, *et seq.*: 23). But when Crichton, who holds an M.D. degree but who has never practiced medicine, claims that he is objectively and fairly presenting the "dark side" of scientific research, he is believed:

> I read Jurassic Park, and the science seemed possible....I'm not worried, but I am concerned....I've read about cows that have been genetically engineered, and I am concerned that after animals, human beings may be next....I found the science portions of the book extremely plausible (Potera, *et seq.*: 24).

He is presenting biotechnology on a level that is understandable. He is uncovering human foibles, revealing the noble scientist with feet of clay. The scientists he presents are for the most part warped by greed for wealth, fame, power, It is not an admirable picture that he paints:

> Biotechnology promises the greatest revolution in human history. It is broad based. Much of the research is thoughtless or frivolous. The work is uncontrolled. No one supervises it. No federal laws regulate it. There are very few molecular biologists and very few research institutions without commercial affiliations. The old days [of *pure* science?] are gone. Genetic research continues, at a more furious pace than ever. But it is done in secret, and in haste, and for profit (Crichton, 1990: ix-x).

Unfortunately, many people get their ideas about science from popular media. This negative image backs up the results of many public opinion polls where industrial scientists and government agents are seen as untrustworthy and with suspicious motives:

> We have seen over the years that the public is often suspicious of science and technology advances. Physics made possible the Atom Bomb, chemistry resulted in Love Canal, and Jurassic Park's genetically engineered dinosaurs may indeed alarm and stir up an uneducated public (Liebert, *et seq.*: 4).

This negative image makes it hard for the non-scientifically trained public to appreciate that even though

> science is not everything[, it] should not blind us to the fact that it is the very best of what we do have. Just as those who benefit from individual therapy can take pride from the persistent acts of will they exerted along the way, so humankind can take collective pride from the persistent determination to submit to reality therapy that has produced not only the science we now know but also an understanding of how to go about learning more (Bauer, 1992:150-1).

Vestiges of past faith in the power and structure and SAFETY of science have disappeared. Fears of biotechnology on the part of the non-scientifically educated public will be very difficult to eradicate.

The National Biological Impact Assessment Program (NBIAP)

One group working to assess public perception of biotechnology to counteract baseless fears and to research relevant issues is The National Biological Impact Assessment Program (NBIAP). Formed in 1986 within the US Department of Agriculture, the program has two goals--to help the research community comply with federal regulations and guidelines, and to share biosafety information throughout public and private scientific communities. Its mission is stated as "to facilitate and assess the safe application of new techniques for the genetic modification of plants, animals, and microorganisms to benefit agriculture and the environment." Its major focus is information exchange through advanced communication technology. Its Information Systems for Biotechnology, funded through a grant to Virginia Polytechnic Institute and State University, furnishes an electronic bulletin board, open to the public as well as the scientific community.

Public perception of biotechnology will have a great impact on funding of research and on the conduct of the science in the near future. Many (if not most) decisions about biotechnology will be made by non-scientists whose opinions may well reflect the distrust shown by the public. In the fall of 1993 NBIAP sponsored:

1. an in-depth literature review of surveys of public perception of biotechnology, and
2. research into the reflection of the science in popular and professional press.

Concerns raised by the public about biotechnology were then collated and grouped according to topic.

Public Perception of Biotechnology Issues:

Economic/Political:

- The cost of technological change might not be fairly distributed through an industry.
- Increased agricultural production and better medicine could destroy small farms unable to pay royalties.
- Animal patenting could result in greater growth by those who produce breeding stock as it has created in the seed industry in recent years.
- Imposition of technologies could give unfair advantages or powers over those who do not control them.
- The impact biotechnology will have upon animal welfare practices and policies is unknown.
- Rural communities could be negatively affected by the use of biotechnology products.
- Decisions could be based on social and economic implications rather than by health, safety, or effectiveness issues.
- Public perceptions are not always based on irrational, subjective, and ignorant fears as opposed to rational, objective, and informed planning.
- Biotechnology companies might profit by building on a base of publicly funded research, and the legal problems involved need to be explored.

Moral/Ethical:

- Transgenic animals could be vulnerable to physiological or psychological dysfunctions that are qualitatively different from pathologies associated with conventional animal breeding.
- Patenting life in any substantial way could redirect the way society uses or relates to animals--or other humans.
- Procedures for disposal of test animals/products need to be determined.
- Study needs to be made of the "genetic imperialism" of the practice of free collection of genetic material from both wild and cultivated plants in third world countries where products are then sold back to the countries where they were originally obtained.

Research/Academics:

- Patenting of organisms from university research could have a drastic impact on university research structures.
- Recognizing property claims could have a negative consequence on the exchange of information among scientists or upon graduate education.
- Private funding for public researchers could sever the contact between research and the public interest.

Ecology:

- Wide-spread patenting could imply drastic changes in the integrity of species and a moral obligation to preserve nature.
- Study needs to be made on exactly what constitutes a "natural" environment for domestic species.
- Both sort- and long-term environmental impacts, with the advent of biotechnology, need further research.

Risk Assessment:

- We must decide how to evaluate consequences that might occur some time in the distant future.
- We need to identify logical issues of safety and quality of food production.
- The differences between perceived and actual or potential risks need to be established.
- The chances of "escape" of pesticide resistance into weeds with even small scale testing of current pesticide-resistant crops need to be determined.

Conclusions

Obviously, acceptance of biotechnology, its processes and products, is not a dead issue. The concerns listed above barely scratch the surface of the topic. The public needs to accept responsibility for ultimate decisions concerning biotechnology, and this includes a need for a broad-based science literacy. Biotechnologists need to appreciate the importance and validity of non-scientific concerns and need to acquire ability in the use (not abuse) of public relations and communication skills. Agricultural and environmental biotechnology can present the population of the United States, as well as the word, with vast improvements in food production and environmental quality--or biotechnology can be constrained and its potential benefits never fully realized:

> Future directions for biotechnology cannot continue to be decided based only upon the science: ethical and moral questions will have to be debated for each new application of the technology. Public perception, as an indicator of opinions of the voting public, must continue to be an integral part of future decisions about the science (Hagedorn, 1994: 8-9).

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BIOTECH OR BIOWRECK? THE IMPLICATIONS OF *JURASSIC PARK* AND GENETIC ENGINEERING

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From the 1950's through the 1980's we saw mutant genes affect humans in *The Invisible Man*, *The Attack of the 50-Foot Woman*, and in other outlandish Hollywood ways. Now that we've advanced into the 1990's we can go to the movies and see how genetic engineering has brought back the dinosaurs in *Jurassic Park*. Are these just movies about mad scientists? Or are these movies frightening to the general public and affecting their perceptions of risk in science and technology, specifically biotechnology? How does society perceive these risks? Are the risks involved in creating new (or old) forms of life worth the results? This paper addresses these issues and compares society's perceptions and expectations with the realities of science. We will begin to answer some of these questions with a brief review of the background and current status of biotechnology. With this understanding as a base, we will delve into the various surveys that deal with risk perceptions (including one we conducted in November of 1993), analyze their statistics, and make some conclusions based on those statistics.

BACKGROUND

There is little doubt that the increased use of technological advances in everyday life has had a variety of impacts on individuals in society. These impacts range from the computer making obsolete some of the jobs people currently hold, or have held, through the promises of ultra miniaturization *via* nanotechnologies, to fears of nuclear energy and nuclear war compounded by incidents such as Three-Mile Island and Chernobyl (Winner, 1986; Perrow, 1984). Other risks include toxic waste that results from high-level industrial technology such as computer chip production, to a sense that society is losing control of its technology, and technology is instead running society (Giddens, 1990).

Genetic engineering is one such technological advance that has received recent exposure due to media coverage (i.e., the movie *Jurassic Park*, and the PBS television series, *The Secret of Life*), and due to arguments from consumer advocacy groups that highlight risk issues in the popular press (Rifkin, 1984; 1991; 1992). Still other investigations have focused on the risk perceptions of technologies (Kling, 1991; Hinman, Rosa, and Kleinhesselink, 1990) such as the computer, household appliances, X-rays, and AIDS research.

Fear of technology and the discussion of its consequences are not new. Technology met with increased resistance during the industrial age when Thomas Carlyle, the famous English "litterateur" during the early 1800s (Marcus and Segal, 1989: 84), became concerned that men would not only be replaced by and dependent upon machines, but that the skills and tasks of the workers would themselves become mechanized. This view was contrary to that of Timothy Walker, a young Cincinnati attorney, who, in 1831, claimed that increased technology equaled increased leisure, which in turn equaled intellectual growth and human development (Marcus and Segal, 1989).

Thomas Hughes (1989) also has spent considerable time exploring the process of increasing technology and how it builds itself into the social fabric. The project herein assumes that we are at that point *now* — where biotechnology and its social impacts are beginning to be incorporated into the fabric of daily life. This is exhibited by biotechnological references and their increased presence in the popular media. In the United States and throughout many Western countries, we eat transgenic fruit and vegetables such as tomatoes, potatoes, and oranges. Other agricultural developments in biotechnology include improvements in the natural pest resistance of plants, improved photosynthesis, and crops that can thrive where the soil is saline (Albrecht, 1992). In Scotland, Pharmaceutical Proteins Limited, in partnership with Genentech, have created sheep that have human DNA; expected to help in the cure of some forms of emphysema, the protein alpha-1-antirypsin is produced in the bioreactor's, that is the sheep's, mammary glands and harvested through milk production (Levine and Suzuki, 1993).

RELEVANCE OF THE RESEARCH

It has been asked: what is the relevance of researching risk perceptions and public attitudes towards science and technology? Peter Sandman (1987) has said that "the public tends to dichotomize risk. Either the risk is very frightening, in which case the response is some mix of fear, anger, panic, and paralysis; or the risk is dismissed as trivial, in which case the response is apathy" (219). By defining the risks and studying public perceptions of risks, we can, with greater accuracy, educate the public to those risks. Risk perceptions shed light on levels of scientific literacy in general (Chapin, 1993).

We have found four other points of relevance. They are:

- •The development of technology and what applications are successfully introduced to the public and applied commercially, funded, or legislated depends on attitudes and perceptions of risk.
- •Educators' perceptions are often passed on to students.
- •Technology transfer — companies will invest in what they think the public will accept, which in turn affects profit potential. That is, the utility of a particular biotechnical application is not enough; it needs to have people's acceptance for it to come into daily use.
- •Many funders have little or no scientific background; they are deciding what gets funded and rely on the media for information (peer reviewers may help somewhat, but explanations of reviewers may fall on deaf ears). Fear of funding applies to fear of not funding, such as with AIDS.

In a workshop on public perceptions of risk in biotechnology, it was stated that "leaders in biotechnology research and industry must learn to communicate effectively with the public," and that "there is a strong need to fund research...in the area of biosafety assessment for genetic engineering," (MacKenzie and Berrier, 1987:171). Without research into public perceptions of risk, leaders of biotechnology cannot learn to communicate the actual risks to those who will most benefit. We must communicate science to the public to enhance scientific literacy, stimulate involvement, and sell scientific products.

THE SURVEYS

Numerous surveys have been conducted to ascertain the public's perceptions of risk in regards to science and technology. During the 1950s, the National Opinion Research Center reported that more than 90% of the public in the United States believed that the benefits of science had generally outweighed any negative aspects related to technological advances. Even more interesting was the statistic that nearly 100% of the public at that time agreed that science would provide for a higher quality of life (Berrier, 1987). By the time of the 1979 survey of public understanding of science and technology, sponsored by the Science and Engineering Indicators Program, only 78% believed, on balance, that the benefits of scientific research outweighed the harmful results; less than 87% agreed that science would provide for a higher quality of life (Berrier, 1987; Miller, 1992).

Recently, perceptions of the general public have changed considerably and scientists have been exposed to increasing scrutiny related to scientific innovation. It seems that as science grows and the number of advances increases, there is a greater opportunity for innovations to present problems in execution along with ethical and moral issues (Albrecht, 1992). By 1986, confidence in American science had diminished even further; a study conducted by Louis Harris and Associates between October 30 and November 17 of 1986 concluded that 71% of respondents believed that science's accomplishments would indeed pose some risk to them and their families. The study also concluded that respondents no longer believed that benefits would outweigh the risks to the extent that they had believed in the 1950s. Only 62% of respondents felt that the benefits justify the risks. Even now public confidence and self-efficacy in respects to technology are eroding daily; it is our belief, yet to be borne out by statistical research, that such public scandals as the human radiation experiments conducted in the 1950's and '60's and only now coming to light *increase* perceptions of risk.

In November of 1993 we conducted a convenience survey on and around the campus of Washington State University. (It should be noted that this was a limited survey conducted in an area with high levels of education; in Pullman over 85% of those 25 years old or older have four or more years of high school, and more than 88% of 18-24-year-olds are enrolled in college (Thomas, 1990).) Although 75% of respondents still believe that science developments will benefit them and their families, less than 42% believe the benefits outweigh the risks (Chapin, 1993).† The data from this survey supports the downward trend seen in earlier surveys.

Half or more than half of the respondents consistently believe that it is not necessary to constrain scientific research to avoid risks, and that some risks have been exaggerated (i.e., nearly 60% disagree that science should be constrained; 67% see risks as exaggerated) (see figure 1). One-hundred percent of the respondents have heard about a variety of risks including radioactive discharge, acid rain, the greenhouse effect, and antibiotic resistant bacteria. All respondents were familiar with genetic engineering and only 25% indicated that they worried about it.

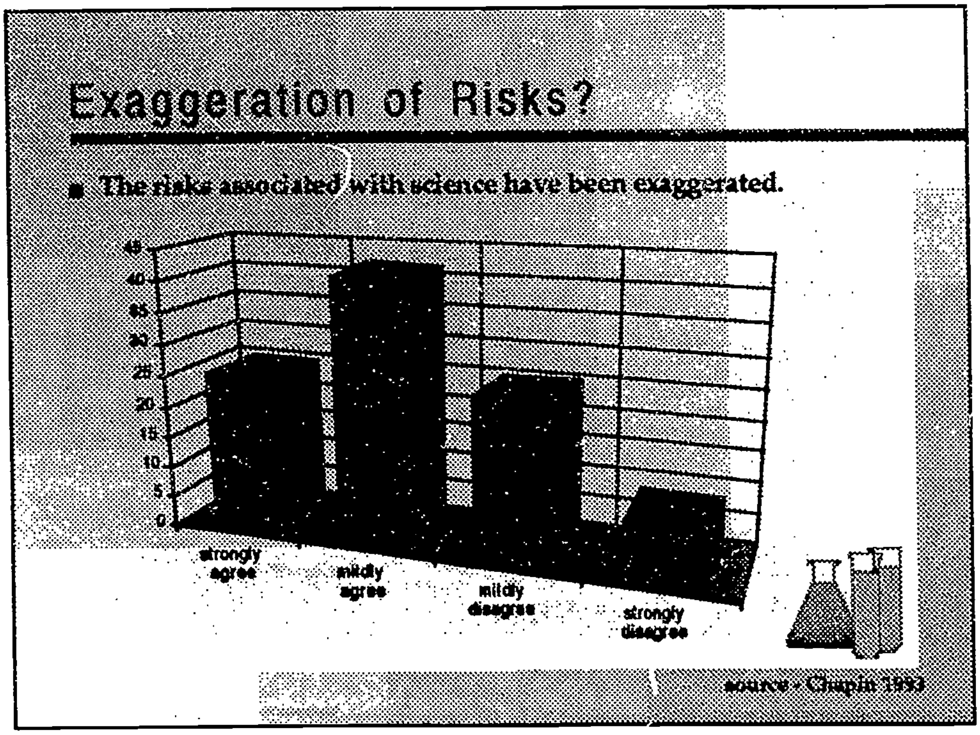


Figure 1

More specific to biotechnology, respondents in almost all cases knew what a gene is (91.67%), a chromosome is (83.3%), DNA is (91.67%), and genetic cloning is (91,67%) (see figure 2). Yet the scales were balanced as to attitudes toward genetic engineering and its role in improving quality of life; 50% mildly disagreed that genetic engineering could improve our quality of life, while only 41.67% agreed that it would. Only 16% of respondents indicated that genetic engineering was *rarely* acceptable, although percentages were even lower for plants, bacteria, and animals. Respondents were more likely to find genetic engineering unacceptable (up to 83% in some circumstances) when performed on human beings (see figure 3). Interestingly, 75% disagreed that genetic engineering was a danger to society, and 83% did not see it as a danger to them personally.

Understanding of Biogenetic Terms and Concepts - Chapin

■ **Based on what you have heard or read, do you know what...**

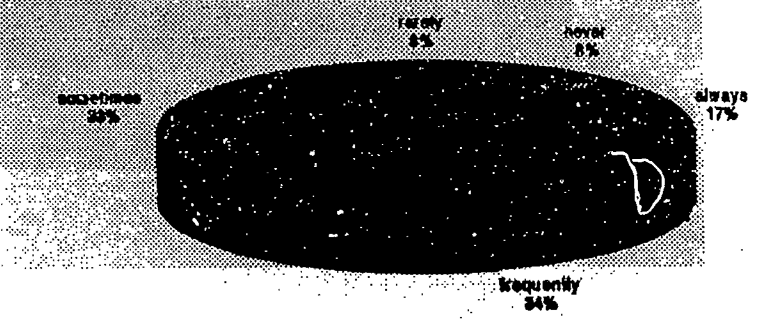
➤ a gene is?	91.7%	answer yes
➤ a chromosome is?	83.3%	answer yes
➤ genetic engineering means?	100%	answer yes
➤ genetic cloning is?	91.7%	answer yes
➤ DNA is?	91.7%	answer yes
➤ *in vitro* fertilization is?	91.7%	answer yes
➤ human gene therapy is?	58.3%	answer yes
➤ monoclonal antibodies are?	16.7%	answer yes

source - Chapin 1993

Figure 2

Gene Manipulation in Humans

■ **Is genetic engineering of *human* cells acceptable to you?**



source - Chapin 1993

Figure 3

Most respondents believe that exercising caution (67%) and avoidance procedures (58%) allows people in society to avoid risk. Nearly 92% believe they can take action to control risk in daily life, despite the fact that 75% see the world as riskier to live in than it was 20 years ago.

It is interesting to note that two-thirds of the respondents are part of a household in which someone holds a science-related job. Although only 25% were members of science organizations, 50% belonged to environmental groups. Sixty-seven percent of the respondents read or saw *Jurassic Park*; this may provide for an interesting in-depth follow-up study related to media influences of risk perceptions in biotechnology. However, of that 67%, only one respondent said that it was the first exposure to genetic cloning information. Overall, nearly 60% had been exposed to this information before.

CONCLUSIONS

Despite the fact that scientists insist that, at this point, cloning entire organisms such as dinosaurs is "...firmly in the realm of fiction" (Dugan, 1993), the layperson watching *Jurassic Park* may only have that movie source as a reference point for information. Although our study concluded that there is no relationship between watching or reading *Jurassic Park* and risk perceptions (most likely due to the high levels of education), without more accurate scientific information to explain the limitations of cloning and other aspects of biotechnology, individuals in society may shape their ideals and perceptions according to popularized versions of technological manifestations. Despite these presentations in the media, however, an individual's sense of self-efficacy will play a key role in defining the level of risk that person will experience as he or she becomes aware of genetic engineering advances (Chapin, 1993).

Clearly, the importance of understanding risks and risk perceptions is growing. Science is becoming less remote from the non-scientist citizen because of media exposure, focused efforts to improve science education and science literacy (which, in general, have the additional effect of lessening perceptions of risk), and the transfer of science-related information from the esoteric, highly technical realm, to that of everyday occurrences in newspapers and newsmagazines, novels, on-line computer forums, educational television shows, and even science fiction movies like *Jurassic Park*. Unless scientists attempt to possess a clearer understanding of factors shaping public perceptions of risk, as suggested by MacKenzie and Berrier (1987), and unless they address and correct these perceptions (or misperceptions), the general public will continue to draw erroneous conclusions from information contained in the media.

In summary, initial results indicate that there is a relationship between biotechnology/genetic engineering and risk perceptions through the intervening variables of self-efficacy and scientific literacy. Future research is needed, however, to better determine the study's reliability.

† All further references in "The Surveys" section of this paper are ascribed to Chapin, 1993.

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OVERCOMING COMPUTER ANXIETY IN ADULT LEARNERS

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Of all the technological innovations in the twentieth century, none has had more of an impact upon our society than the personal computer. From its origins in the 1970's when it was little more than a glorified calculator, it has evolved into an "information engine" which has radically altered the way we conduct our lives. Its increasing performance coupled with its decreasing cost has made it so ubiquitous and so indispensable that it is difficult to imagine an occupation that isn't affected by its capabilities.

The personal computer is an agent of change, and when it comes into the workplace it changes nearly every activity. But while this massive infusion of technology brings with it great potential to increase our productivity as a society, it also carries some intrinsic problems that must be dealt with. One of these problems is the difficulty of training workers in the existing work force so that they can operate and benefit from the increased technology. Many of these workers entered the labor market at a time when not only were computer skills unnecessary, but simple technological devices such as typewriters and facsimile machines were only used by a few individuals in the office. These older adults have turned to institutions of higher education in massive numbers in order to upgrade or acquire for the first time the computer skills necessary to operate the personal computer.

To accommodate this demand for basic computer skills, most colleges and universities have developed courses in "Computer Literacy". These courses are a vast change from the programming courses of the pre-personal computer days. Back then if an individual wanted to operate a computer, they were trained as a computer professional. Today's computer literacy courses make use of the user-friendly nature of modern hardware and software, and teach students how to effectively use the personal computer as a tool in whatever occupation they pursue. From the basics of a keyboard layout, to the more etherial ideas involved with electronic data storage. these students are introduced to technology that is exciting--and sometimes intimidating.

This attempt to "teach old dogs new tricks" is not without its difficulties. Adult learners many times have a instinctive fear of technology which leads to a considerable amount of computer anxiety. This anxiety varies from a minor amount of stress in some individuals, to full blown cyberphobia (fear of computers) in others. This anxiety is a barrier to learning, and must be dealt with by both the student and the instructor if effective education is to take place. There are a number of causes for computer anxiety, and most of these causes stem from some of the unique characteristics of adult learners. So before the computer anxiety issue can be resolved, the traits of adult learners must be examined.

One characteristic of adult learners that sets them apart from the traditional student is that a long period of time may have elapsed since they were last in an educational environment. It is not at all unusual to find situations where ten or twenty years have elapsed since the learner was last in school. These learners sometimes have trouble with study skills and must be reminded of the basic methods of learning and retaining classroom information. Many times student will try so hard to gain every detail from the text or lectures that they become overwhelmed by trivial points at the expense of the main points.

Adult learners usually carry the extra-curricular baggage of social and family responsibilities with which traditional students generally are not yet encumbered. Careers, child care, marriage, housing, and care for aging parents are just a few of the responsibilities that adult learners must coordinate with there studies. These place an additional burden upon the learning process, and tend to enhance the anxiety that a student brings into the computer classroom.

Many adult learners who are being introduced to computers for the first time have deep-seated misconceptions of what computers can and cannot do. Some have the "magic machine" misconception, where they suppose that if you learn a few magical commands a computer can do just about anything. These students have special difficulty learning operating system command syntax, since they try to memorize the individual keystrokes of a command instead of comprehending reasons for the syntax. Still other students have the "doomsday machine" misconception (derived from science fiction movies), where they are afraid they will push the wrong key and destroy the computer, computer lab, and their grade in the class ! These students require constant encouragement and reassurance that virtually any error they make with the computer can be corrected.

There are a number of techniques that can be used to help overcome computer anxiety in adult learners. They involve altering the course curricula, modifying the learning environment, or implementing new teaching techniques to better accommodate the adult learners. These techniques are not expensive or difficult to implement, but they require the instructor to be aware of the adult learner and their special needs that have already been mentioned.

Concerning the course curricula, basic is better. While many of the adult learners taking a beginning computer literacy course have had some exposure to the personal computer, many of them have never touched a computer before in their life. They are not familiar with the names of the hardware elements, they don't understand the fundamental operations of the PC, and the buzzwords and jargon that are used in describing the technology are foreign to them.

The first several classes should teach them what the various hardware elements are called, and describe their basic operation. Things as simple as where the power switch is located and the sequence of whether to power up the system unit or the display screen first may seem trivial to those who have used a personal computer a time or two, but this is important information to the first time user with a case of computer anxiety. Terms like

"RAM", or "debug", or even "PC" should be described, since they will undoubtedly be used in depicting even the most basic of computer operations. No assumption of prior knowledge should be made at all when introducing the students to the PC for the first time.

In the classroom, the use of a portable computer coupled with a data projection device is invaluable. This equipment allows the output to be projected on a screen that the entire class can see. With this teaching aid students are able to see what the results of different commands and scenarios look like before that personally sit down in front of the PC. This makes them more comfortable since they now know what to expect when confronted with a similar situation.

The computer lab should present a comfortable and non-threatening environment. Labs should be "open" in format--i.e. teaching should be done in the classroom, with the lab used for the students to work at their own speed on the various assignments that they are to master. The "command-response" method of having the instructor give computer commands and requiring the entire class to respond with the PC is particularly ineffective with adult learners. Instead of comprehending <u>why</u> they are issuing a command, they simple perform it in order to keep up with the rest of the class. This method also requires the entire class to proceed at the same pace. If an adult learner begins to fall behind, they will feel frustrated at trying to keep up with the younger students.

This open lab approach also provides another significant benefit--one-on-one time between the instructor and the students. Many beginning computer literacy students not only suffer from computer anxiety, but also have the need of constant encouragement from their instructor. Instructor feedback and support if vital if these students are to gain the confidence they need to venture past the basics of computer operation and begin to actually use the PC as a tool to improve their productivity.

An important aspect in overcoming computer anxiety in adult learners involves the selection of the software to be used in the course. At the beginning of the personal computer revolution (circa 1980) many computer literacy courses taught students how to write BASIC programs. While this approach may have been out of necessity due to the lack of user-friendly personal productivity software, it nonetheless turned off a large number of people because they couldn't see any practical benefit to coding in a sorting algorithm. Today's instructor has the benefit of being able to chose from a plethora of software packages that are relatively inexpensive, user-friendly, and powerful. Integrated packages such as Microsoft Works have the advantage that they are several programs in one, and allow the student to learn spreadsheets and databases by building upon the set commands they have learned while doing word processing.

These are just a few techniques that can be used to help overcome computer anxiety in adult learners. As computer technology becomes more pervasive, and as older learners return to school to acquire the skills to utilize this technology, these and other methods will become even more critical. The mixing of older adult learners and newer computer technology is a difficult mix, but it is a union that must be made if we are to continue to actively progress as a technological society.

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THE TECHNOLOGY OF FILMMAKING AND ITS IMPACT ON SOCIETY

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Beginning with the wheel, man has invented machines which in turn have affected man. He has a need to invent these machines, if not for physical comfort, then for entertainment in the form of increased stimulation, and this need keeps his brain ticking along scientific lines of discovery.

In the late 1800's man desired a technology to record life for history or posterity. He wished to intimately study other men, himself, the earth and then to save these studies, in essence to stop time, by freezing these images first in drawings and then in photographs. While perfecting this recording process, he discovered a positive emotional response to slight alterations, at first accidental, to the depicted reality, which made him appear more clever, wealthier, or funnier than he truly was. As public support for this fictionalized representation grew at an astounding rate, the psychological aspects became full blown: the innermost secrets, desires, and fears of man emerged from a half-conscious dream state deep in his mind, to a frightfully real physical representation --which he could experience without physical harm.

There are those who wish to face their fears, or to always be in a sunny place with kind people, or to reside on bizarre planets which require intricate mental dexterity for daily survival. The presentation of these ideas on a large screen, with an image and sound almost indistinguishable from reality, shown in a dark room to shut out the reminder that anything exists outside of the wall of moving images -- these factors of technology coupled with the desire to lose one's identity, lead a more exciting life, always with an insatiable curiosity about oneself and others -- have created for man the blur between an objective reality and the subjective world of the screen.

Technologically speaking, man began this psychological journey into himself on the day an astute observer noticed that an imprint was left on a wall, where an object had been placed in front of it in a shaft of direct sunlight. Though it had taken years for the imprint to form, the idea was born that a more light-sensitive material could quickly and accurately capture an image. It was found that copper plates coated with silver worked very well. Placing the light-sensitive plate IN FRONT OF the object and bouncing a very bright light off of the object produced variations of the features due to differing amounts of light reflected at different angles, and thus creating on the plate an image which greatly resembled the object before it. Due to the light-sensitive nature of the silvered plate, it was housed in a black box until exposure was intentionally tripped by the opening of a tiny hole -- and the camera was born.

From here it was natural that those interested in optical illusions, those who had been playing with flip pads of still photos or drawings, would find a way to bring these individual shots into a sequence which, when run at the appropriate speed, would create apparent motion -- to the immense excitement of the viewer. The sewing machine had been invented by this time, so the concept of intermittent movement was in the minds of these first inventors. If the rotary motion of an etched cylinder could move cloth along as a needle pierced the material, creating a stitch, then this same rotary motion could move light-sensitive, by now celluloid, film along at a prescribed speed with intermittent exposure to light, much like the piercing of the needle. The inventors surmised that replaying this "exposed" film at the same speed, would playback that which had been recorded, as if it were still happening before the camera. A jolly chuckle could be had by viewing such an artificial spectacle -- which looked astoundingly real to the turn-of-the-century patron.

These mechanical devices produced this magical effect due to the eye's unique property known as "persistence of vision." The eye carries a visual ghost of an image for a prescribed duration (like the dark spot you see for a period of time after looking at the sun). Early films actually have a strobe effect because you can see the space between the frames due to the slower speed. It was discovered that at a rate of 24 frames per second, there was not enough space between pictures for the eye to lose its ghost image. At this rate, the frames SEEMED to blend into one another, creating a frighteningly realistic moving image for the spectator. So if today we are viewing 31.5 minutes of black for every hour of a movie (Mast, 1986: 10), the question starkly and clearly emerges: how much of this experience is due to what we physically, or even perhaps emotionally, bring to it? Is it the viewer or the technology?

Technology changes as we are numbed to current stimuli, for only when children are tired of playing with one toy do they look around for another. When the first audience viewed a film of a train speeding toward the camera, the spectators jumped out of the way. Most likely it was not even in a totally darkened room on a very large screen. It certainly was not in color and had no sound to add what to us are necessary dimensions of reality. But the effects of this new technology did not last very long. Audiences began to tire of this trick, much like their progressive numbing to violence on the screen today. This was true in respect to technological inventiveness as well as subjects chosen for films and the treatment of these subjects, such as Hitchcock's style of conservative visual violence vs. today's graphic cinematic bloodbaths. But back to our turn-of the century inventors. They were fueled to create more and more realistic illusions: the people hungered for a more complete artificial experience, the technology answered, and for a brief moment all were ecstatic. At each blooming phase of advancement, a distinct and unpredicted psychological phenomenon was taking place: for a sustained period of time, the spectator became a part of the world on the screen. A form of involvement was discovered beyond the intentional effect of delight at increasingly realistic imitations of life. But once again, how much of this is the medium and how much is the desire of the spectator? As the intensity of the experience is lessened due to repetition, the cry is heard today as always: "shock us more" or "take us farther from ourselves", and technology spins its next miracle. Now the race to feed the hungry public imagination has led us not only to additions of sound and color, but 3-D, motion simulators, and interactive video have been born to answer the cries for "MORE REAL! MORE REAL!"

Evaluation of Audience Response

The following experiential exercises were used at the 1994 NASTS conference to evaluate audience response to specific film clips:

Now let us see how we are physically affected by an experience we know is not real. I'd like a volunteer to hook up to the biofeedback monitor. It will measure galvanic skin response which is akin to measuring temperature changes and perspiration. In other words, a tone goes higher when the person gets excited.

1. A volunteer is hooked up to the biofeedback monitor.
2. The background of the scene they are about to see is explained. (John Candy has rented this car with Steve Martin's credit card, unbeknownst to Steve.)
3. Then the freeway scene from *Trains, Planes, and Automobiles* (1987) is shown.

The galvanic skin response, which to a large extent reflects heart rate, would suggest that this person has been through a frustrating or even frightening physical experience. Even if he has seen the film many times, he would still show a physiological response. A part of him argues that if it can be replayed at will, it most certainly could not be real and happening at this moment. This machine has the power to create an illusion which can so "trick" the mind as to convince a person, at least for the moment, that what he is seeing is not only real, but that somehow he is in the picture and will be profoundly affected by its outcome.

How can this happen? What is in charge here, the eyes or the mind? Essentially, either it is the eyes and ears that are screaming "this is real --it looks real, it sounds real -- it has the magic of motion" (Andrew, 1976), and the mind fights a losing battle saying "but I know it is coming out of an electronic box" -- OR the senses say, "The sounds are not as clear as if they were in this room, the cutting from image to image is not quite the way my eye would perceive." But the desire of the mind to forgive all discrepancy for the sake of a thrill or an escape, overpowers these shortcomings to convince the body, at least for a moment, that it is real. Greek philosophers as early as 500 BC discussed these exact opposing theories: whether it was the eye or the mind that play into optical illusions. Here are the two theories taken from the Stanley Coren and Joan Girgus' book The Psychology of Visual Illusion (Coren & Girgus, 1978: 3):

\# 1. Parmenides stated, in 500 BC "The eye and ears are bad witnesses when they are at the service of minds that do not understand their language," the one point being sensory inputs are variable and inaccurate, and one of the major functions of the mind is to correct these inaccuracies to provide an accurate representation of the external environment.

\#2: The senses are inherently accurate and thus responsible for our truthful picture of the environment, and it is the mind or judgmental capacities that are limited.

Now for another test. We have observed the physical effects of the film experience. Now let us focus on the emotional effects. Study your reaction to this carefully because it is a subtle but important effect. This is a milder clip than the last one -- and I warn you because you will miss the effect unless you sensitize yourself. I'm going to read some lines to to you from the film *The Shop Around the Corner* (1940). You know I am real, but the people in the film are actors doing what they are told. Note which seems to have the greater effect on you, my reading or that in the film.

1. The speech is read from *The Shop Around the Corner* (1940):
   "My heart was trembling as I walked into the Post Office...and there you were lying in box 237. I took you out of your envelope and read you. Read you right there... Oh my dear friend."
2. Then the scene from the movie is played.
3. The audience is asked to compare the two experiences.

Seeing Jimmy Stewart do these lines, you have actually gone to a more unreal delivery than my reading. But it seems to be the stronger experience because you love Jimmy Stewart, and want fiction in a sense more than reality, or at least this reality. Though music wasn't added, soft lighting on Jimmy's close up was. This brings up technical aspects of filmmaking which are beyond the invention of the camera, and lie in the manipulative techniques used by the director and editor. Filmmakers today have full knowledge of the potential of humans to enter, or desire to enter, a subjective experience. They carefully design all production elements to assist this natural phenomenon. The number one technical goal is to never introduce incongruous information or images which will take the viewer out of the imaginary world by causing him to stop and think. Hence lighting must match shot after shot. An actor must not do anything strangely out of character unless this trait is a trademark of the filmic personality. Shots must be edited in a fluid, logical manner to carry the audience effortlessly from one image to another. Music must be unobtrusive unless the director desires that attention be shifted away from the image. These are all purely technical considerations in the filmic process which allow great manipulation of an audience's psyche.

We must not overlook the star appeal of Jimmy Stewart. Your sighs and soft feelings when he came on the screen represent an important psychological aspect of human nature which the filmmaker uses to further induce psychological immersion. Part of this reaction is not only due to his particular personality and physical traits, and your desire to know or be such a personable type, but also the fact that you have met him through a larger-than-life projection in a more-interesting-than-life setting and story. He is literally blown up in your mind, and since he is a nice guy, your affections are aroused. These same technical considerations create for you monsters and enemies which can likewise elicit from you a very real hate.

Now considering star power, let's go back farther in time to the world of Charlie Chaplin. When Chaplin first came to this country from the music halls of London, his work was pretty bawdy to the aristocracy of turn-of-the-century America. Chaplin was under great pressure from his earliest films to depict a more dignified and kinder persona (Maland, 1989). The gentility of the day, testifying to their belief in the power of film, launched a massive campaign to silence him. Thus, the educated public suspected (though did not yet fully understand) the power of the medium of film, even though the camera had only been in use for about 15 years. Scenes such as the following met with great criticism from the social elite. The first was made in 1919, the second in 1927.

The Conferees are shown two scenes. The first is of a woman being used as a gang plank and then Chaplin's attempt to fish her out of the water with a gaf hook -- all very comically handled. This scene is from *A Day's Pleasure*, 1919. The second scene is of Chaplin eating a hot dog from a baby's hands in a scene from *The Circus*, 1927.

You will note that Chaplin toned down his physical style quite a bit between 1919 and 1927. His art was profoundly effected by the society of his day in many ways. Historically, this was the beginning of the clear-cut argument between film themes and headlines: Are films created to reflect the thinking of the public, or is this medium really powerful enough to influence the public to follow its example? Interestingly enough, Chaplin insisted that film at all times should reside on the loftier plain of art, never seeking to imitate reality. This was precisely his argument when he refused to introduce sound into his films. But much of his filmgoing public began to pass him by, preferring realism, by then necessary to allow even the most casual movie goer's submersion into the artificial cinematic world, an experience to which he had become increasingly addicted.

So just as the first train film lost its power to jolt the audience out of its seat, so the antics of Charlie could not compete with the compelling new technology of sound. Economic considerations finally curbed the artistic expression of Chaplin, and he reluctantly entered the world of the "talkie". Once his voice found play through the technology of film sound, he began a constant stream of symbolic attacks which would not be quieted until social and political pressures forced him into self-imposed exile. Yes, Chaplin's art was profoundly affected by the society in which he found himself -- this in response to a battle waged by those who felt his art could have significant and lasting effect on its viewership. In any case, both preceded and also followed the other, the old chicken and the egg scenario.

Now let us consider the psychology of the person who would get so very swept away in the film world that his behavior would be affected when he left the theater. In 1951, the writer Eric Hoffer published a study of the personality types of people who join mass movements. It is my contingent that this is the same type of person, a "follower", who would be inordinately affected by the large screen image and take up the battle for a fictional character or world. In Hoffer's book *The True Believer*, he dissects what causes a person to become a "Follower." He notes:

> All ... movements, however different in doctrine and aspiration, appeal to the same types of mind....Starting out from the fact that the 'frustrated' predominate among the early adherents of all mass movements and that they usually join of their own accord, it is assumed that frustration of itself, without any proselytizing prompting from the outside, can generate most of the peculiar characteristics of the true believer. (Hoffer, 1951: ii.)

He goes on to state that among these attributes are: a desire for change, for substitutes, for relief from boredom, and a self-loathing which finds expression in hating another cause or person.

Boredom was a large factor in the lives of the people who were trying to control Chaplin. Perhaps they so feared their own potential to be led, that the power of the new technology promised to send them into tailspins from which they had to protect themselves. Hoffe. mentions how Hitler made full use of 'the society ladies thirsting for adventure, sick of their empty lives, no longer getting a kick out of love affairs' (Rauschning, 1940:268). He was financed by the wives of the great industrialists long before their husbands had heard of him (Hoffer, 1951).

The movement against Chaplin's work smacked of other traits from the Hoffer list as well, , most notably the hatred factor:

> [Violence] can rise and spread without belief in a God, but never without belief in a devil... One of Chiang Kai-shek's most serious shortcomings was his failure to find an appropriate new devil ...at the end of the war. The ambitious General was perhaps too conceited to realize that it was not he but the Japanese devil who generated the enthusiasm, the unity and the readiness for self-sacrifice of the Chinese masses. (Hoffer, 1951: 90)

It appears painfully true that those who oppose freedom of expression of the artist are those very persons who risk being most swept away by art's influence. Yes, the psychological profile for these two groups are identical.

Here I would like to add that children are naturally followers until they have lived through enough experiences to begin to make up their own minds. Their subjective and objective worlds are naturally blended, thus, the imaginary world is quite easily confused with the real one. For this reason, I take special care with any film work I know will be viewed by young audiences. The weight of the responsibility is quite clear -- and other filmmakers who understand the potential power of what they are creating, likewise choose their subject matters and treatment of those subjects carefully. But in most cases, as even in Chaplin's case, economics proves the greater factor. As long as the public financially supports screen violence, it will be with us.

At this point, I have reached a conclusion not entirely to my liking. I would so love to espouse the technology of film as the single most powerful influence on human behavior since the dawn of civilization (as most of you as technical thinkers would likely enjoy hearing), and it is this exact notion that prompted me some years ago to pursue a career in film production. But it is becoming more and more apparent that the elements that would push a person over the edge into the imaginary world come from within him, rather than without. We may only be a link which some other mediocre influence may have served just as well. You be the judge.

It is a well-documented fact that Canada has for many years received the same television programs and movies that we have in the U.S. Yet the crime rates are astoundingly different. Last year there were 68 deaths by hand guns in all of Canada. Obviously there are other factors more prominent than the hypnotic effect of screen dramatics.

I was recently working on a documentary about criminal teenagers. When questioned about his motives for repeated car thefts, burglaries, and assaults, one 16 year old told me that when he got bored, it was so bad he couldn't stop himself, and he would go get his buddies and they would go beat up somebody or steal something. This seemed a much more dominant motivation for this young man's violence than any outside influence.

In summary, the technology or filmmaking has achieved such a high degree of realism, improving itself with each psychological discovery and each new desire of an ever-more sophisticated audience, that we are now on the threshold of an interactive experience which will allow reality to enter the fiction to such an extent that these lines may be blurred forever, even for the most sophisticated observer. It is well to consider the power of technology at such times as these.

Perhaps it is not that the technology is so incredible, but that life itself is so incredible that we are transfixed at such a graphic opportunity to view it, for your heart rate will also change when you are shown a disturbing photograph. Likewise prehistoric etchings on a cave wall, totally removed from any technology or mechanical assistance, if depicting the scenes of a violent battle, can be eerily disturbing, the crudeness of the medium actually contributing to the sense of imminent reality. Similarly viewing a 1940 Jimmy Stewart scene in black and white pulls you into the '40's, rather than distancing you because the technology seems to be less real than what you are used to today. This is because you desire to enter that world. Instead of insisting that it come to you, you not only forgive all crudeness, but take it as a sign that you are in fact entering another time and place.

In closing I would like to show one last Chaplin clip. Chaplin was the greatest master of this technology during his time or perhaps any time -- being the composer, writer, director and performer -- and yet he understood that ultimately the power of sway resided in the people. This clip is Chaplin's comment on the fleeting nature of stardom, a wink to his fickle public concerning the precarious state of a filmic persona.

The closing scene from *The Circus* (1927) is shown. It portrays the tramp crumbling a paper star, bouncing it off of his foot, and walking off alone across the abandoned circus yard.

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Studies on Energy Themes

INCORPORATING ENVIRONMENTAL EXTERNALITIES INTO ELECTRICITY MARKETS: METHODS AND POLICIES

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The utility industry in the United States is a major contributor to environmental damage, as a result of the combustion of fossil fuels in the production of electricity. Two-thirds of national sulfur dioxide (SO_2) emissions and one-third of national nitrogen oxide (NO_x) emissions, which react to cause acid precipitation, are generated by the utility industry. Generating electricity in the United States causes 11% of global carbon dioxide (CO_2) emissions, the principal greenhouse gas, and one-third of the national CO_2 emissions (Pace University Center For Environmental Legal Studies, et al., 1990). Electricity markets largely ignore the environmental and social costs resulting from pollutants that are emitted during the production of electricity. Many states, however, are attempting to reverse this trend.

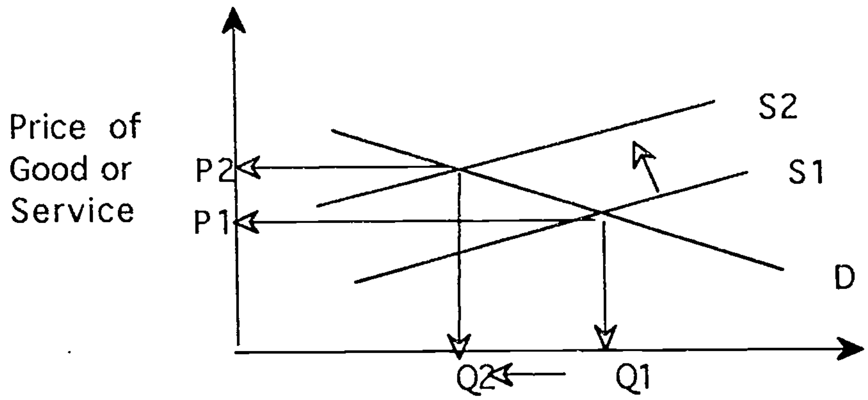
Several state public utility commissions have developed monetary environmental externality values for each pollutant released when fossil fuels are burned to produce electricity. These states vary in the extent to which they require the utilities operating in their state to consider these values during their resource selection process.

This paper discusses the two widely used methods for valuing environmental externalities: control costs and damage costs. In addition, the activities of two states are explored in detail, identifying both the methods used to estimate environmental externality values and the policies that require utilities to incorporate these values into their planning process. Several conclusions are drawn and suggestions for future policy directions are offered.

I. BACKGROUND

Externalities include those costs imposed on society that are not included in the cost of production. Economists argue that sub-optimal economic outcomes occur when external costs are not factored into the price of a good or service. If the price does not reflect all costs, both internal and external, society will tend to consume "too much" of the good. Figure 1 illustrates this situation graphically.

Figure 1
Incorporating Externalities



A producer's supply curve equals the upward sloping portion of their marginal cost curve. Including external costs would move the marginal cost curve up represented by a shift in the supply curve from S_1 to S_2. Prices will rise and consumers' demand will shift from Q_1 to Q_2. Therefore, consumption declines when external costs are factored into the price, thus, securing a socially optimal allocation.

II. ENVIRONMENTAL EXTERNALITIES FROM GENERATING ELECTRICITY

Environmental degradation, resulting from the combustion of fossil fuels, began with the transition from a wood-based economy to one dependent on fossil fuels. This process was accelerated in the nineteenth century and early twentieth century as a result of the industrial revolution (Melosi, 1992). Steam engines, operated by the combustion of coal or oil, were used to power trains, industrial processes, and a variety of other applications. Over the years, the commercial and industrial sectors turned to electricity to meet their energy needs. For example, the steam engine was replaced by the electric motor in stationary applications, taking over the position as "workhorse of American industry." In addition, entrepreneurs such as Samuel Insull were aggressively pursuing rural electrification and market consolidation. These entrepreneurs were establishing large electricity markets to capture the economies of scale resulting from expanding electricity production (Kahn, 1988).

These changes gave rise to an enormous centralized electricity industry, which burns fossil fuels as the primary means for producing electricity. Initially, the negative environmental impacts from the acquisition and combustion of fossil fuels were regional, such as air pollution and oil spills (Melosi, 1992). Today, we continue to face regional environmental damage from burning fossil fuels to produce electricity. However, we also face the potential for negative environmental impacts on a global scale. The following section discusses three specific environmental impacts resulting from the production of electricity through the combustion of fossil fuels.

Acid Rain

The combustion of fossil fuels in the production of electricity releases sulfur dioxide (SO_2) and nitrogen oxide (NOx), which combine with water in the atmosphere to form acid precipitation. In the early 1980s, a variety of studies claimed that highly acidic precipitation, caused by utility and heavy industries, was destroying the nation's lakes, forests, other natural resources, and even man-made buildings .

When it rains or snows, acid is deposited over huge stretches of land, causing disruption to both ecological systems and man-made structures. Acid-deposition results in leaching of essential nutrients from plant foliage and forest soils damaging vast stretches of forested land (MacKenzie, 1992). Acidification of lakes and streams can harm much of the plant and aquatic life, resulting in "dead" lakes and streams. In addition, acid precipitation causes degradation to the exterior surfaces of buildings and other man-made structures, like automobiles.

Air Pollution

Air pollution is another problem directly associated with the combustion of fossil fuels in the production of electricity. There are two major components of air pollution that result from generating electricity: ground-level ozone and suspended particulates. Sunlight, acting on NO_x, carbon monoxide (CO), and certain organic compounds, results in ground-level ozone (Fulkerson et al., 1990). Suspended particulates are unburned fuel particles that escape through smoke stacks and contribute to air pollution.

Not only is air pollution aesthetically unpleasant, but it can have significant negative health impacts. Breathing contaminated air can result in a variety of respiratory problems. In addition, ozone is known to cause eye irritation and is believed to weaken the human immune system (MacKenzie, 1992). The costs associated with the adverse health problems caused by air pollution are not currently factored into the price of electricity.

Global Climate Change

The production of electricity through the combustion of fossil fuels releases carbon dioxide (CO_2), a major contributor to global warming. One third of CO_2 emissions in the United States is a result of burning coal for generating electricity and industrial purposes (MacKenzie, 1992). Many scientists claim that a general warming of the earth's surface is occurring due to a build-up of greenhouse gases in the atmosphere, like CO_2. This trend is expected to continue if efforts to reduce these gases are not undertaken in an aggressive manner.

The exact environmental impacts of global warming are unknown and at this time are an area of continuing debate. In general, changing weather patterns are expected to disrupt agricultural production and lead to the loss of plant and animal life. In addition, scientists claim that the sea level will rise due to global warming. This could displace millions, perhaps billions, of people world-wide.

The potential problems of global warming remain largely a concern of scientists and environmentalists, while governments are hesitant to act in light of great uncertainties about the greenhouse problem. The unknown effects and their potential for enormous impacts have yet to be determined, let alone incorporated into the expected future costs of electricity.

III. METHODS FOR ESTIMATING ENVIRONMENTAL EXTERNALITIES

Policies for incorporating environmental concerns into energy markets can be placed into one of two general categories: pollution standards and market mechanisms. Pollution standards involve those policies that set specific limits on the amount of a certain pollutant that can be released into the atmosphere. A company that exceeds these limits is forced to take actions which would bring their emissions level into compliance with the standards. An example of this type of policy is the National Ambient Air Quality Standards (NAAQS). The Environmental Protection Agency (EPA) set specific air quality standards for different regions of the country, requiring each state to submit a comprehensive plan for meeting these air quality standards.

Although pollution standards have been widely used to date, market mechanisms for incorporating environmental concerns into energy markets are gaining acceptance in policy circles. Market mechanisms involve policies that influence the supply and demand for a good or service in order to achieve environmental objectives. Financial incentives, such as pollution fees or taxes, are put in place to motivate companies to reduce their emissions of a certain pollutant. An example of this type of policy would be a tax on SO_2 emissions.

Recently, various market mechanisms have been applied in electricity markets in an effort to internalize the external costs imposed upon society from generating power. The economic concept of an externality discussed above is crucial to the understanding of these types of policies. In particular, the economic theory of externalities suggests that the external costs be estimated and then incorporated into the price of the good or service. The policy dilemma involves determining the magnitude of the external costs from the production of electricity. This is one of the challenges facing state Public Utility Commissions (PUCs).

Quantifying and Valuing Environmental Externalities

The exclusive reliance on the internal costs of generating electricity for setting prices is becoming increasingly questionable (Hohmeyer, 1992). However, the appropriate method for quantifying and valuing environmental externalities associated with generating electricity is currently a subject of considerable debate. This debate results from both the complexity and subjectivity involved in estimating environmental externalities. Much uncertainty exists in both determining the associated damages from various pollutants and assigning a dollar value to these damages. The regulatory challenge involves balancing the social benefits with the social costs of generating electricity to arrive at an optimal level of emissions reduction. Two methods are currently being used to estimate environmental externalities, or social costs associated with electricity production.

Control Costs Approach

The control cost method uses estimates of the costs to control, reduce, or prevent the release of a particular pollutant into the air to determine the externality value for a particular pollutant. For example, the cost of a flue gas scrubbing systems, a device placed on the end of a smoke stack to reduce SO_2 emissions, equals the externality value for the emissions that are avoided as a result of implementing the technology. This method implies that the cost of the technology is equal to the damage that would result if the avoided emissions were released into the air. There is no empirical evidence to support this notion. As a result, use of the control cost method for establishing externality values has been justified on other grounds.

The justification for using control costs as opposed to damage costs, aside from the difficulties in calculation, is that they represent a proxy for what society, as a whole, is willing to pay to avoid damages from the pollutant (D.P.U. 91-131, 1992: 34). Furthermore, control cost estimates are justified based on the implicit assumption that regulators accurately incorporate the voting publics' willingness to pay for environmental control programs, through the political process.

This justification for the use of control costs is based on the notion of regulators' "revealed preference," where all existing and proposed environmental regulations are analyzed to determine the value that society implicitly places on specific environmental damages. Bernow and Marron (1990) provide a further description of the rationale for using this approach.

> In analyzing the regulations, we can identify the highest (or marginal) cost reduction strategy required by regulation. This can then be taken as an estimate of the value that regulators (society) have placed on air emissions. At the very least, it can be argued that this value represents the "revealed preferences" of regulators, and that to be consistent, it ought to be applied when decisions affecting environmental impacts are made (pp. 4-5).

Thus, the highest marginal control cost is assumed, under this method, to implicitly represent the externality value of the emission under consideration.

The simplicity of using the control cost method to value externalities is alluring; however, this method has fundamental theoretical flaws that bring its validity into question. There is no empirical evidence to suggest that a simple relationship exists between control costs and the environmental damage costs that would occur if a certain level of emissions reduction were not achieved. For example, a particular pollutant may have extremely harmful and costly effects on the environment, yet cost very little to mitigate. Thus, the use of control costs as a proxy for the potential damage caused by a pollutant has no theoretical foundation.

In addition, it is assumed that the political process determines the optimal level of pollution. Regulators will choose an optimal emissions level reduction by equating marginal costs to marginal benefits. Implicit in this assumption is that regulators have some knowledge about what the marginal benefits and costs of pollution abatement are while setting regulations. It is unlikely that the costs of controlling a certain pollutant or the marginal benefits are known during legislative debates. Thus, regulators will be unable to set socially optimal emissions reduction levels.

The control cost approach has been widely criticized for these and other reasons, including the difficulties in determining the control costs associated with CO_2 emissions. The cost of control method is appealing due to the ease in implementation, yet it lacks a sound theoretical basis. Although cost of control estimates have survived regulatory review, the majority of policy makers and prominent researchers have rejected this method in favor of the damage cost approach.

Damage Cost Approach

The damage cost approach has been embraced as the most theoretically attractive method for estimating externalities; however, there are numerous methodological hurdles which impede its implementation. This approach involves a two step process. First, the physical damage to both humans and the environment, resulting from various pollutants released during the production of electricity, are estimated. Second, a value representing societies' willingness to pay to avoid these damages is estimated. Both steps involve substantial methodological challenges and subjectivity. The general appeal of the damage cost method for valuing environmental externalities is its foundation in economic theory.

When implementing a damage function approach, the entire fuel cycle must be taken into account. Based on this approach, all emissions associated with extraction, production, transportation, distribution, and those associated with the production of electricity must be estimated. The human health impacts and all environmental damage associated with the aggregate fuel cycle emissions need to be estimated. This poses an immense analytical challenge involving extensive data collection, modeling, and calculations. There is much scientific uncertainty regarding the exposure-response relationship between pollutants and the environment. For example, it is difficult to accurately establish the number of respiratory cases resulting from ground-level ozone. This uncertainty is magnified when the discussion turns to CO_2 and global warming -- no one knows with certainty the environmental impacts which will result from global warming.

However, if we can establish some reasonable damage functions resulting from electricity generation, we then have to place an economic value on these damages. Ultimately, values must be placed on health and mortality risks in order for analysts to determine the dollar value society places on avoiding the risk of sickness or death. In addition, economic values need to be established for various aspects of the environment. For example, the value society places on avoiding the destruction of forests and lakes from acid rain needs to be estimated.

The risk of sickness or death and the environment are considered non-market goods, meaning they are not traded on the private market and therefore do not have an explicit economic value. Two main methods are used to estimate economic values for non-market goods: revealed preference methods and contingent valuation methods. Both methods have their strengths and weaknesses and both pose substantial analytical challenges. Despite these challenges, several states have taken steps toward incorporating externalities into electricity markets through the resource selection process.

IV. STATE ACTIVITY IN DEVELOPING AND USING ENVIRONMENTAL EXTERNALITIES

The issue of developing environmental externality costs and incorporating them into electricity markets has not been fully addressed at the federal level. However, many state public utility commissions (PUC) throughout the United States have been actively pursuing this issue. PUCs face two interrelated policy decisions that must be addressed when considering environmental externalities in utility planning. First, they have to approve a method for quantifying and valuing environmental externalities associated with the production of electricity. The main methods used to perform this task were discussed in the previous section. Next, state PUCs need to determine how these externality values should be used to influence electricity markets.

State requirements for the consideration of environmental externalities by utility companies vary considerably in their scope and complexity. Most states have investigated the use of environmental externalities in utility planning. States can either require qualitative or quantitative consideration of environmental externalities. Of the thirteen states that require quantitative consideration, only five have endorsed specified monetary values for external environmental costs: California, Massachusetts, Nevada, New York, and Wisconsin (ADSMP, 1993). In the following section I discuss in detail how both New York and Massachusetts developed externality values and incorporated them into their utility planning process. The discussion will be limited to the externality values for CO_2, SO_2, and NO_x emissions. (See Table 1).

Table 1
Environmental Externality Values
New York / Massachusetts

	New York	Massachusetts
SO2	$ 1,271 / ton	$ 1,500 / ton
NOx	$ 6,081 / ton	$ 6,000 / ton
CO2	$ 107 / ton	$ 24 / ton

New York

New York was the first state to mandate that utilities explicitly consider environmental externality values in the resource selection process. In 1989, average control cost calculations were first applied on a mixture of an advanced control technology (ACT) and low-cost control technology (LCT) at an existing coal-fired generating facility (Fenichel, 1993). In 1991, New York changed their valuation methods. SO_2 externality values were developed using the damage costs method; whereas, CO_2 and NO_x externality values were developed using the regulators' "revealed preference" method, based on the highest marginal control cost for these pollutants. Their change in methodologies paralleled the research communities rejection of the average control cost valuation method.

The ECO Northwest study estimated that 95% of the reported SO_2 related damages were human deaths. Therefore, New York decided to use only the risk of mortality to develop externality values for SO_2 using the damage cost approach (New York Energy Office, 1991). They estimated that 12.44 deaths per year would occur from the SO_2 emissions cap set by the National Ambient Air Quality Standards (NAAQS). Related studies were analyzed to determine what value humans place on a 0.001 percent (1/1,000) risk of death. These studies suggested that humans place a value ranging from \$20.00 to \$60.00 on the 0.001 percent risk of death. This translates into a \$2 million to \$6 million value of a human life (New York State Energy Office, 1991). Using the mid-point of \$4 million, New York's SO_2 tonnage cap translates into \$50 million of damage costs. Therefore, the environmental externality value per ton of SO_2 is \$1,271.

Damage cost estimates for CO_2 and NO_x were not available for New York State. Thus, the regulators' "revealed preference" method was used, based on the highest marginal control cost. Existing and pending legislation was analyzed to determine the highest marginal cost to comply with these regulations. The Clean Air Amendment Act (CAAA) of 1990 set limits on NO_x emissions; thus, the highest marginal control cost of meeting CAAA standards was used to infer a marginal damage cost point. Since CO_2 is not a regulated pollutant the highest marginal control cost was based upon achieving a 10% reduction in CO_2 emissions from 1988 levels. These methods resulted in a \$6,081 per ton externality value for NO_x and a \$107 per ton value for CO_2.

New York's PUC used these values to establish environmental adders and mandated their use in the resource selection process. Specifically, New York State uses environmental adders for incorporating environmental externalities into the utility bid evaluation process for all new supply-side and demand-side projects. The environmental adder is considered with all other project costs when the utility is selecting resources to meet future demand. This method makes environmentally dirty projects more expensive relative to other less polluting projects. This method represents a partial mechanism for internalizing the external environmental damage costs into electricity markets.

The state PUC established a maximum 1.4¢ per kWh environmental adder based on the most environmentally damaging resources (Fenichel, 1993). This value was developed based on a combination of the externality estimates for each emission discussed above. Energy conservation projects are assumed to have no environmental impact, thus, receiving the full 1.4¢ per kWh credit. A project is accepted only at the bid price, not including the environmental adder. Environmental externalities are internalized only to the extent that a project is selected over less expensive projects. In addition, this method only impacts future resources, ignoring the environmental externality costs associated with current electricity generation facilities.

New York's treatment of environmental externalities is not consistent with the underlying economic theory. While their extensive analysis to generate SO_2 externality values using the damage cost method is based on sound economic principles, the method used to calculate CO_2 and NO_x externality values is based on the regulators' "revealed preference" method. This method rests on the often faulty assumptions that regulators act rationally and attempt to choose environmental regulations based on some knowledge of the marginal damage cost.

Moreover, these externality values, once determined, are not fully internalized into New York's energy markets. Internalizing externality costs allows consumers to receive proper price signals. However, New York's treatment of externality values does not allow consumers to receive correct price signals. Thus, consumers will continue to consume electricity at socially sub-optimal levels.

Massachusetts

Massachusetts first began to investigate the use of environmental externalities in utility integrated resource planning (IRP) in 1988. By August, 1990, the Massachusetts Department of Public Utilities (DPU) ordered utilities to use monetized environmental externality values for all filings involving resource cost-effectiveness tests (Fenichel, 1993). The Massachusetts DPU relied on externality values for certain pollutants based on a study conducted by the Tellus

Institute. The Tellus Institute developed externality values based on control costs or regulators' "revealed preference" method. They analyzed existing and proposed legislation regulating each pollutant to arrive at the highest marginal control cost reduction strategy to comply with these regulations.

Both SO_2 and NO_x are federally regulated with state emission levels set by the NAAQS. The NO_x externality value of $6,500 per ton was based on the cost of installing selective catalytic reduction on a 10 MW natural gas turbine. This technology has been deemed the best available control technology (BACT); thus, representing the highest marginal control cost to comply with NAAQS.

The externality value of $1,500 per ton of SO_2 was based on the cost of installing flue gas scrubbing systems on utility generators. Again, the cost associated with this technology is considered the highest marginal control cost, which is then assumed as the amount society is willing to pay to avoid the damage associated with one ton of SO_2 emissions.

Since CO_2 is an unregulated pollutant it is impossible to directly apply the regulators' "revealed preference" method. The Tellus Institute used the costs associated with planting trees to develop a carbon sink as the highest marginal control cost value. Massachusetts DPU feels that global warming is a real and substantial threat, thus, adopting a $24 per ton externality value generated from the Tellus Institute's analysis.

Massachusetts approach to internalizing external costs of generating electricity is similar to New York. In general, Massachusetts environmental externality policy is intended to influence Massachusetts utilities to acquire resources that are least-costly to society (D.P.U. 91-131: 92). Utility companies are required to take into account externalities that would be caused by the resources under consideration. Environmental externality values have been applied to utility resource planning and demand side management (DSM) cost-effectiveness tests. Coal-fired generation facilities cannot compete with gas-fired generation facilities when including environmental externality values into the cost of the facility. In addition, DSM activity has increased by approximately 3% due to the inclusion of externality values (Freyer, 1993). Again, Massachusetts' treatment of externality values represents a partial mechanism for incorporating these values into electricity markets. Since external costs are not fully internalized into the price of electricity. As a result, society will continue to consume "too much" electricity.

V. CONCLUSIONS

Current state requirements for including environmental concerns into energy markets do not fully internalize all external costs from producing electricity into the price. Consumers continue to receive incorrect price signals, leading to socially sub-optimal levels of consumption. A pollution tax could be used as a means for internalizing externality costs associated with generating electricity. This method is considered the most equitable and efficient way to internalize environmental externalities (Pace University Center For Environmental Legal Studies, et al., 1990).

The revenues generated from a pollution tax would be used to establish an environmental fund to repair the damages that have already occurred. In addition, this fund could be used to finance research and development in the areas of energy efficiency and renewable energy sources. Society needs to explicitly recognize the environmental damage caused by our daily use of electricity. A pollution tax on electricity would be a step towards explicitly acknowledging the relationship between energy consumption and the quality of the environment.

As discussed in this paper, the current methods used to estimate environmental externalities presents theoretical and practical challenges. The control cost approach lacks a sufficient theoretical basis and represents an attempt to merely adjust current generation technologies with pollution control devices. On the other hand, damage cost estimates will never capture all the damages which result from the production of electricity. Large sums of research dollars are being spent to determine the damage to humans and the environment from the production of electricity. These efforts are counterproductive. Resources would be better spent on increasing the adoption of energy efficient technologies and renewable energy sources.

Incorporating environmental externalities represents an adaptation to current generation technologies; whereas, a change in our current energy systems is required for long-run sustainability. Policies should be more aggressive in the arena of promoting energy efficiency and renewable energy sources. Increased efficiency lowers energy consumption which reduces the potential environmental and social costs associated with the production of electricity. Renewable energy sources do not cause substantial environmental externalities, thus, should be the basis for future energy systems.

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TWENTY YEARS AFTER THE ENERGY CRISIS

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It was December 1973. Becausc the U.S. had supported Israel in response to an October attack by Egypt and Syria, Arab nations had embargoed oil sales to the U.S., and gasoline was in short supply. My local gas station had no gas at all to sell for weeks at a time, and I had to drive farther to get what I could buy. The day after Christmas we went to Kentucky to move our things to New Jersey. Our trip back in a U-HAUL truck began on a Saturday afternoon, and I can still remember entering the Pennsylvania Turnpike shortly before midnight, not knowing whether I would be able to find enough gasoline to make it all the way through. (Due to the gasoline shortage, President Nixon had asked gas stations to close on Sundays, and the Pennsylvania Turnpike had complied.)

In the wee hours of Sunday morning I found the gas stations of Breezewood, PA, lit up like Las Vegas. But the refueling possibilities were narrowed to an emergency ration delivered by a Turnpike vehicle as dawn crept over Norristown. It was the first time I paid more than a dollar for a gallon of gasoline.

A few years later we again endured the shortages of gasoline -- at least on the East Coast, where the days cars could receive gasoline were restricted by whether the license plate number and day of the month were both odd or even. This time it was the summer of 1979, and the cause was once again rooted in the Middle East: because of its kindness to the deposed Shah of Iran, the United States was no longer being sold Iranian oil by the Ayatollah Khomeini.

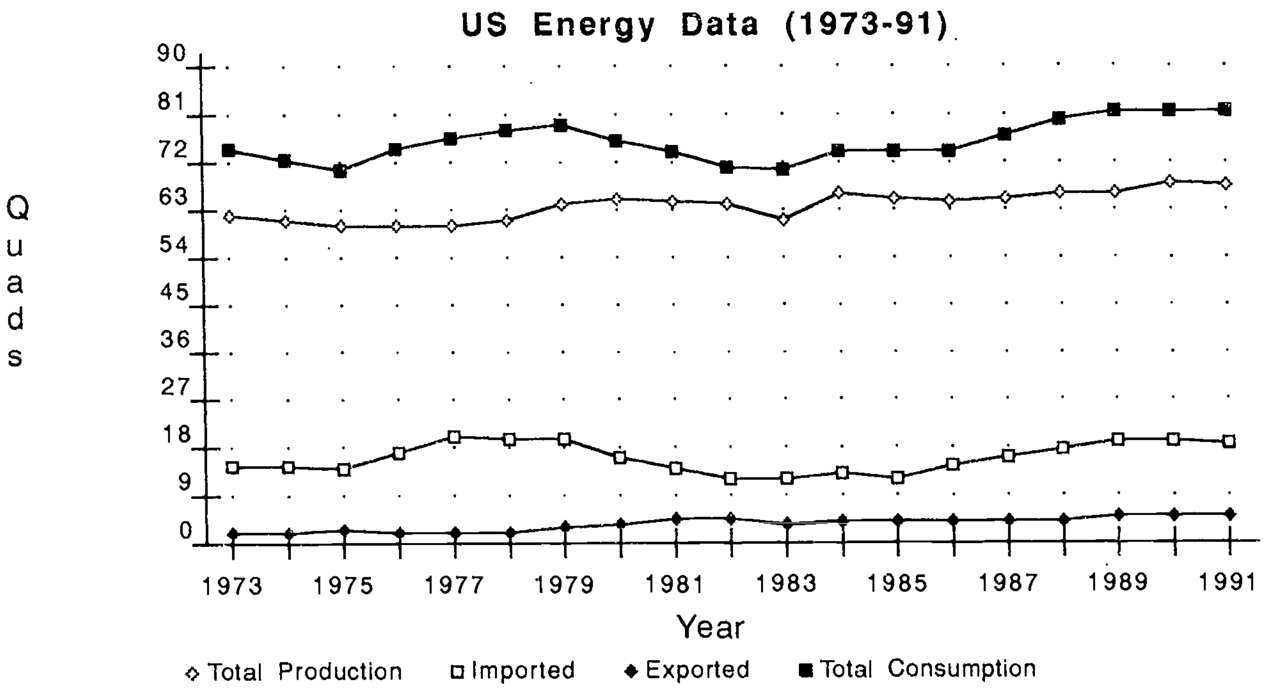
A number of studies of past U.S. energy use and predictions of its future emerged during the years between the two energy crises faced by the United States in the 1970s. Two were sponsored by the Ford Foundation -- *A Time to Choose* (1974) and *Energy: The Next Twenty Years* (1979). Also published in 1979 was the Final Report of the Committee on Nuclear and Alternative Energy Systems (CONAES) of the National Research Council, *Energy in Transition: 1985-2010*, and the first report of the Energy Project at the Harvard Business School, *Energy Future*, by Stobaugh and Yergin. Those years marked the evolution of ERDA (Energy Research and Development Agency) into DOE (Department of Energy), with a subsequent series of National Energy Plans.

It is now twenty years after that first energy crisis spawned by the Arab oil embargo. How have America's "production" (more correctly, conversion of energy *to* a convenient form) and "consumption" (conversion of energy *from* a convenient form) matched the predictions of these earlier studies? How well have we done in using energy more efficiently? To what extent have we been able to develop alternatives to our traditional fossil fuel energy sources? Have we learned from the two gasoline shortages of the 1970s to be prepared if another should occur tomorrow?

The accompanying table shows the energy produced, imported, exported, and used (in quads, or quadrillion Btu) by the United States, 1973-1991, obtained from the Energy Information Administration of DOE. The following graphs are based on these data.

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Coal Production	14	14.1	15	15.7	15.8	14.9	17.5	18.6	18.4	18.6	17.3	19.7	19.3	19.5	20.1	20.7	21.3	22.5	21.6
Nat. Gas Production	22.2	21.2	19.6	19.5	19.6	19.5	20.1	19.9	19.7	18.3	16.5	17.9	17	16.5	17.1	17.6	17.8	18.4	18.4
Oil Production	19.5	18.6	17.7	17.3	17.5	18.4	18.1	18.2	18.1	18.3	18.4	18.8	19	18.4	17.7	17.3	16.1	15.6	15.6
NGPL Production	2.6	2.5	2.4	2.3	2.3	2.2	2.3	2.3	2.3	2.2	2.2	2.3	2.2	2.2	2.2	2.3	2.2	2.2	2.3
Hydro Production	2.9	3.2	3.2	3	2.3	2.9	2.9	2.9	2.8	3.3	3.5	3.4	2.9	3	2.6	2.3	2.8	2.9	2.9
Nuclear Production	0.9	1.3	1.9	2.1	2.7	3	2.8	2.7	3	3.1	3.2	3.5	4.2	4.5	4.9	5.7	5.7	6.2	6.5
Other Production	0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Total Production	62.1	60.8	59.9	59.9	60.2	61.1	63.8	64.8	64.4	63.9	61.2	65.9	64.8	64.3	64.9	66.1	66.1	67.8	67.5
Imported	14.7	14.4	14.1	16.8	20.1	19.3	19.6	16	14	12.1	12	12.8	12.1	14.4	15.8	17.6	19	19	18.4
Exported	2.1	2.2	2.4	2.2	2.1	1.9	2.9	3.7	4.3	4.6	3.7	3.8	4.2	4	3.8	4.1	4.8	4.9	5.2
Total Consumption	74.3	72.5	70.6	74.4	76.3	78.1	78.9	76	74	70.8	70.5	74.1	74	74.2	76.8	80.2	81.4	81.3	81.5
Residential/Comm.	24.1	23.7	23.9	25	25.4	26.1	25.8	25.7	25.2	25.6	25.6	26.4	26.7	26.8	27.6	28.9	29.4	28.9	29.6
Industry	31.5	30.7	28.4	30.2	31.1	31.4	32.6	30.6	29.3	26.1	25.7	27.8	27.2	26.6	27.8	29	29.4	29.9	29.7
Transportation	18.6	18.1	18.2	19.1	19.8	20.6	20.5	19.7	19.5	19.1	19.1	19.9	20.1	20.8	21.4	22.3	22.6	22.5	22.3
Electricity	19.9	20	20.3	21.6	22.7	23.7	24.1	24.5	24.8	24.3	24.9	26	26.5	26.6	27.6	28.6	29.3	29.6	29.9

U. S. Energy, 1973-1991, in quadrillion Btu (quads)



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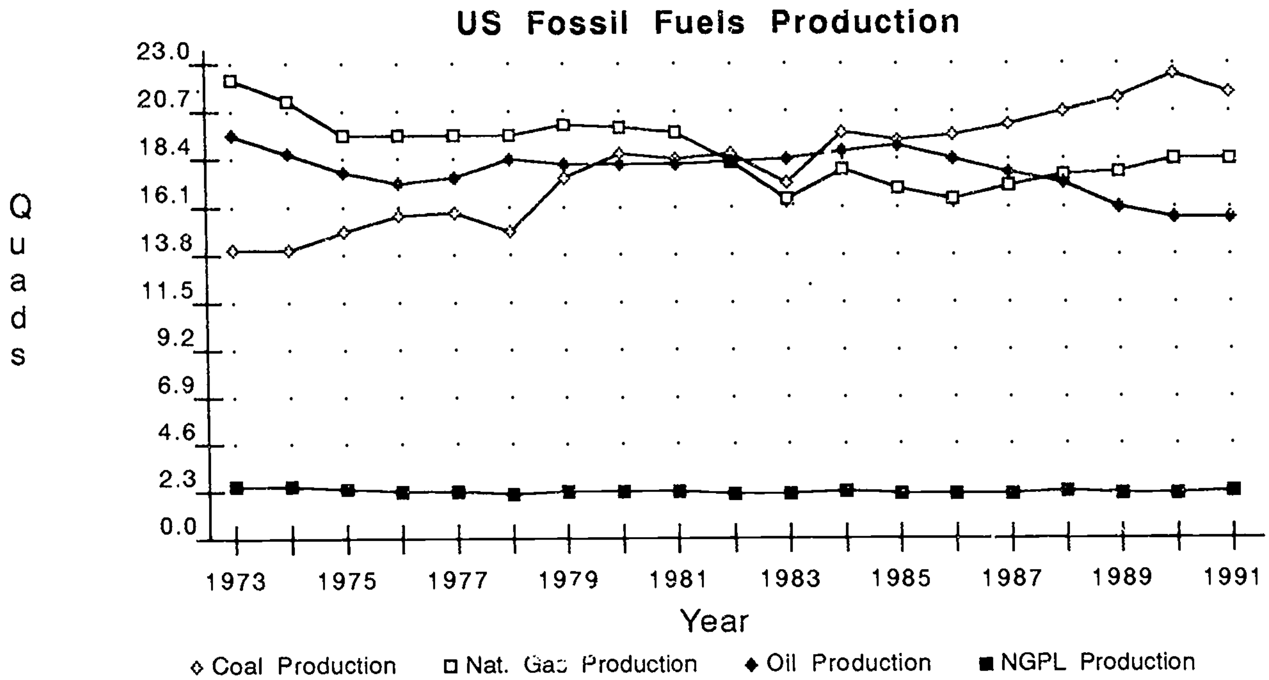
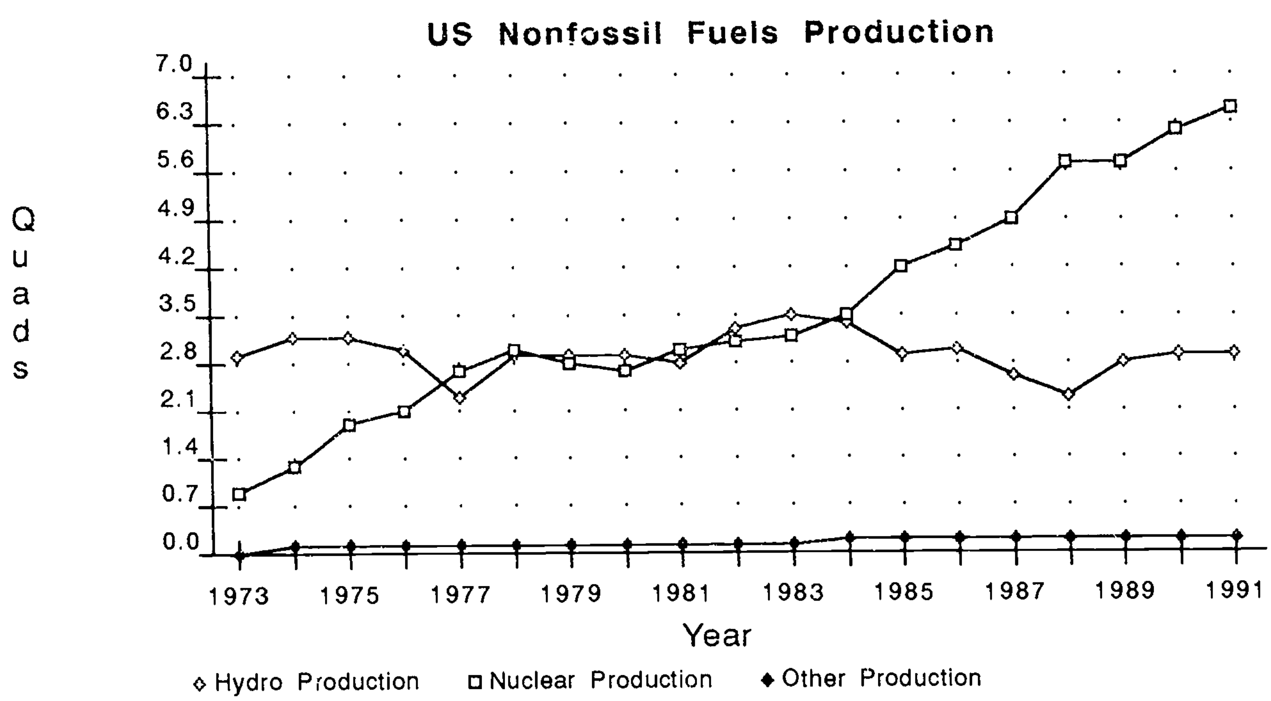
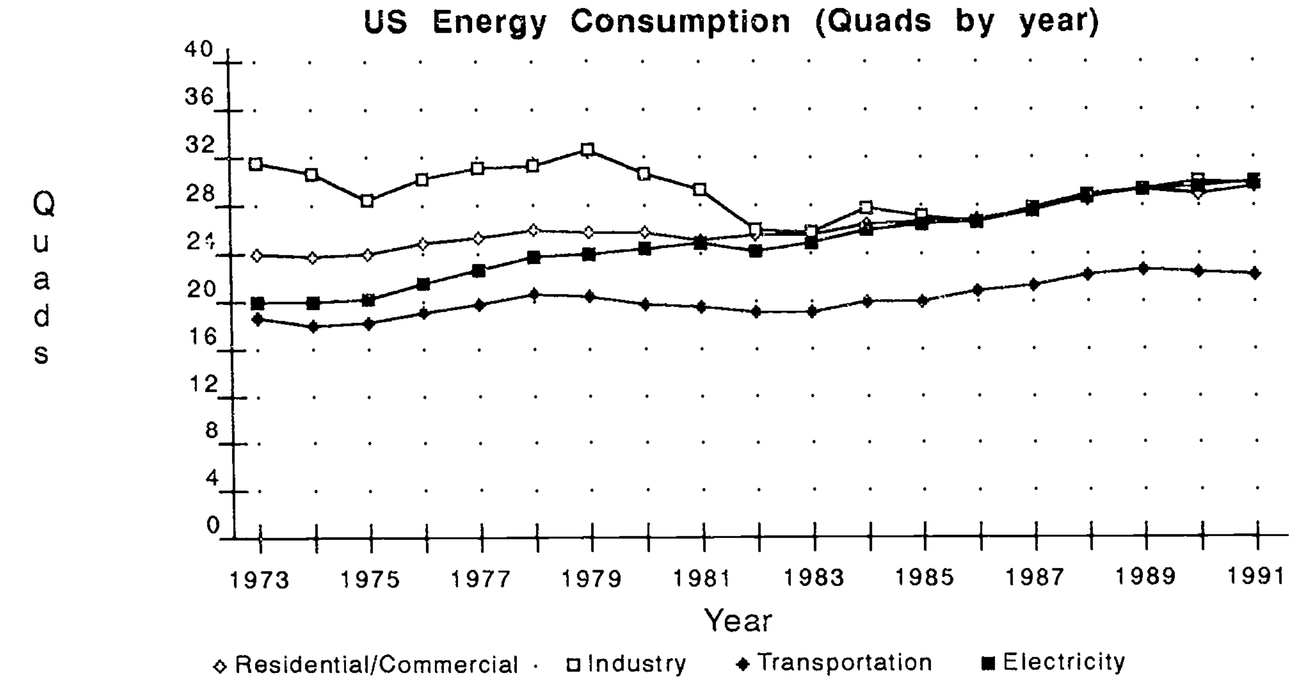

US Fossil Fuels Production
23.0
20.7
18.4
16.1
13.8
11.5
9.2
6.9
4.6
2.3
0.0
Quads
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
Year
◇ Coal Production
□ Nat. Gas Production
◆ Oil Production
■ NGPL Production


US Nonfossil Fuels Production
7.0
6.3
5.6
4.9
4.2
3.5
2.8
2.1
1.4
0.7
0.0
Quads
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
Year
◇ Hydro Production
□ Nuclear Production
◆ Other Production



From the first graph, US Energy Data, we can see that U.S. energy production has shown only a very gentle increase during this time, while consumption conspicuously decreased for the two years following the 1973 and 1979 gasoline shortages. The last graph, US Energy Consumption, shows that the decreased energy consumption is primarily due to the industrial sector, whose energy consumption has been lower than its 1973 value ever since. This is not true for energy consumption in the residential/commercial and transportation sectors, which have shown a gradual increase, while electricity (whose use is actually distributed among the industrial, residential/commercial, and transportation sectors and is also included in their total energy consumption) has shown a much greater increase. The continued increases of energy consumption in the nonindustrial sectors caused total U.S. energy consumption to peak at 81.5 quads in 1991.

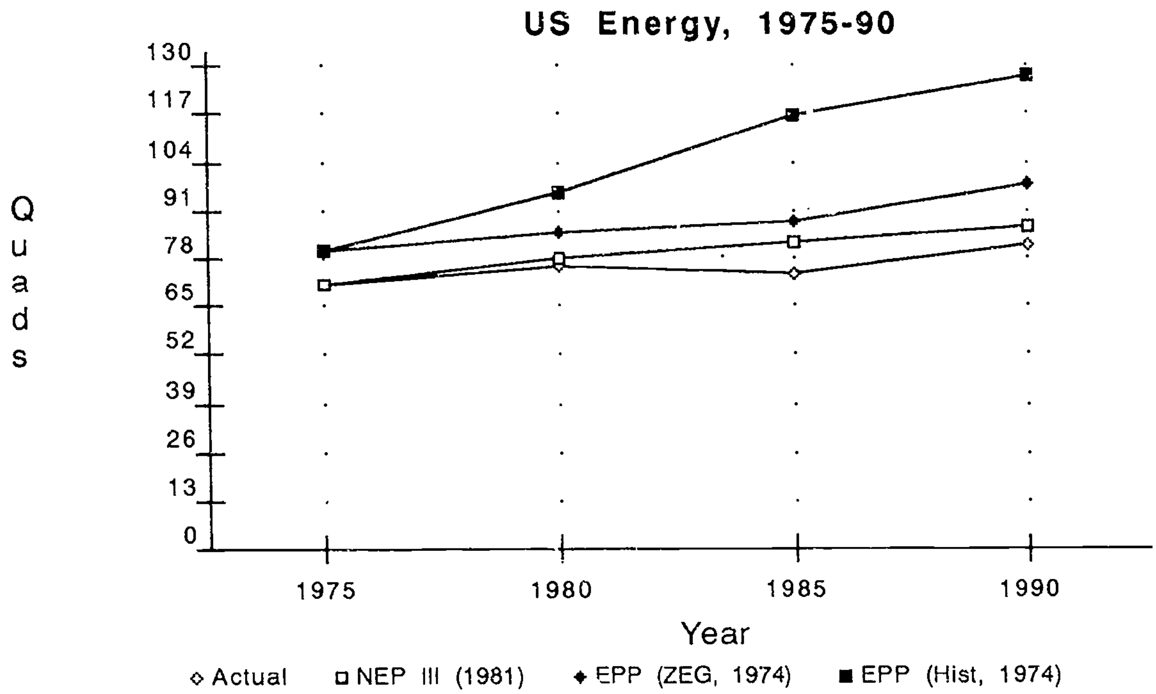
In energy production, the graph of US Fossil Fuels Production shows fluctuating oil and natural gas production and an overall increase in coal production, while NGPL (natural gas propane liquids) production remained virtually constant. The graph of US Nonfossil Fuels Production shows that hydroelectric production has remained relatively constant while nuclear energy production has shown an overall increase (which is soon expected to plateau). Production of energy from "other" sources, which include nonhydroelectric renewables, has not progressed well at all.

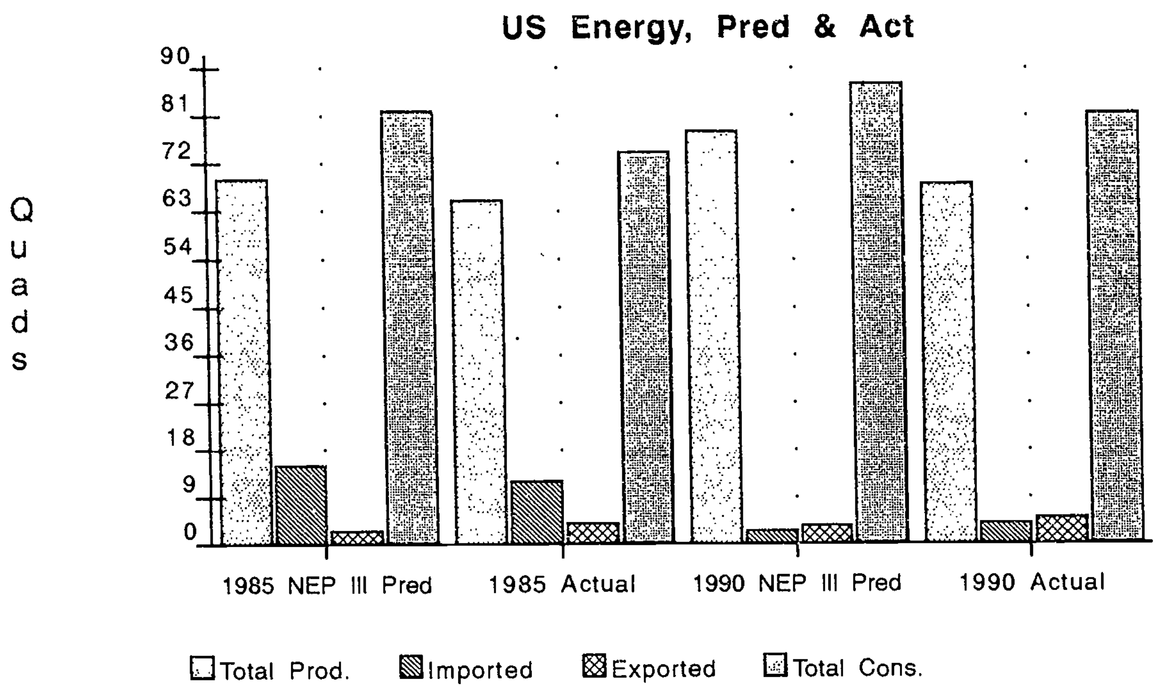
Or at least that's the way it appears until one notices the caveat under production of energy from "other" sources, that only the use of "other" sources to generate electricity is included and that an additional 2.4 quads of energy is estimated to have come from wood in 1987. In fact, further examination shows that over 90% of the "other" sources of production is geothermal, while 3.5 quads of energy have been produced annually for end uses other than electricity in 1988, 1989, and 1990. Of this more than 3 quads were from biomass in the residential, commercial, and industrial sectors.

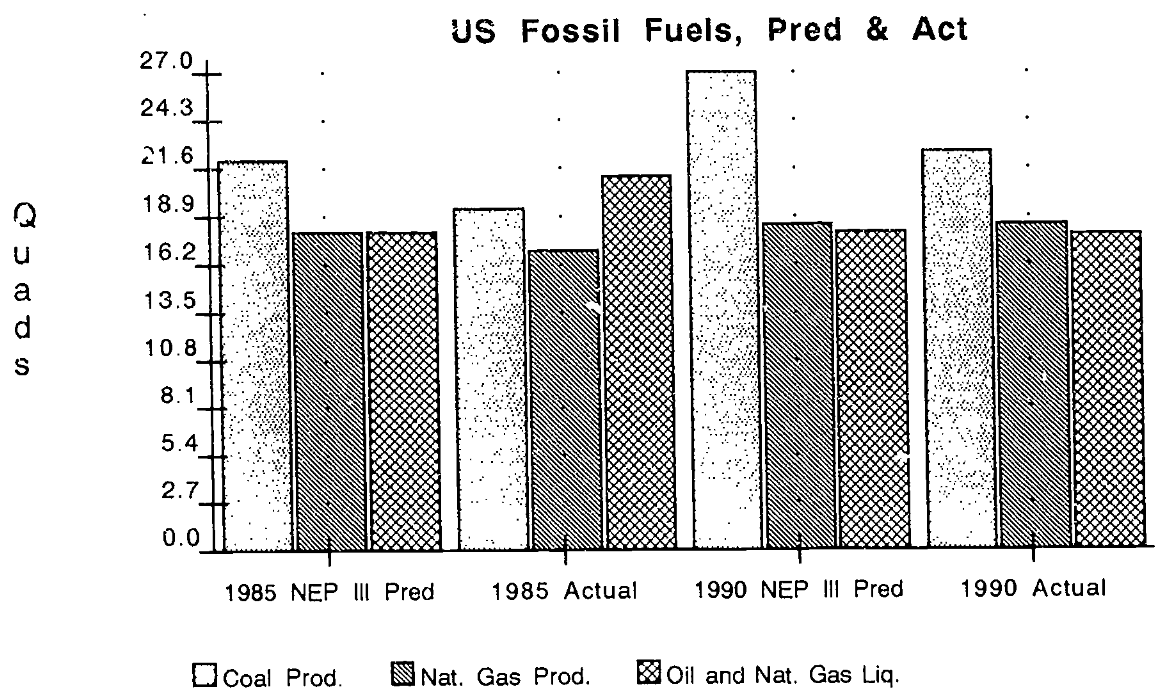
Comparison with Predictions

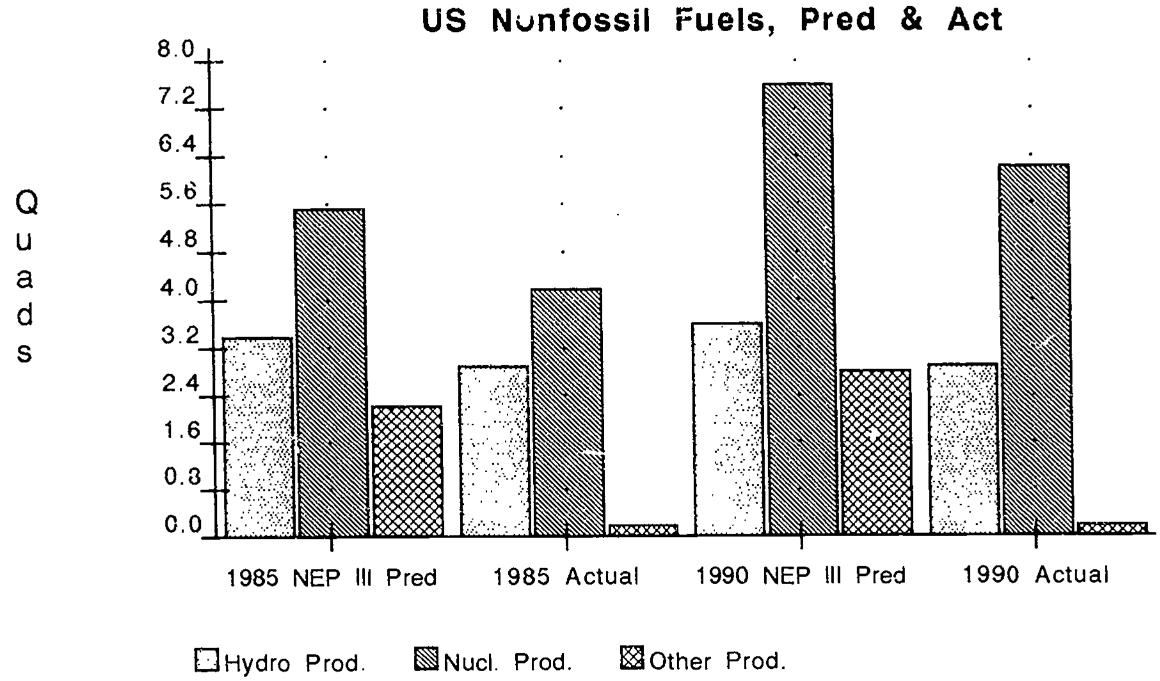
How does all this stack up? The following graphs compare actual U.S. energy consumption with predictions from *A Time to Choose*, published by the Ford Foundation's Energy Policy Project (EPP) in 1974, and the National Energy Plan III (NEP III), published by DOE in 1981. The first compares the total actual consumption with predictions for 1975 (in the case of the two EPP scenarios), 1980 (with preliminary actual values provided by NEP III), 1985, and 1990. Of the two EPP scenarios, the "historical growth" prediction is based on the assumption that no changes would be made from U.S. energy practices in 1974 and the "zero energy growth" prediction envisioned a constant annual U.S. energy consumption of just under 100 quads in 1990. It is striking that actual energy consumption lies below the predictions of *all* the EPP scenarios as well as that of the 1981 National Energy Plan (whose predictions are more conservative, perhaps in view of the leveling trend of U.S. energy consumption in the years between the publication of *A Time to Choose* and NEP III). In fact, U.S. energy consumption since 1974 has fallen below the predictions of *every* scenario of which I'm aware.

The additional graphs provide a more detailed comparison for 1985 and 1990 between actual energy production and consumption, fossil fuels production, and nonfossil fuels production. Like predicted total energy consumption, predicted total energy production also exceeded the actual values, although actual energy exports exceeded their predicted values. While predictions of the combined oil and natural gas produced seem to have been accurate, predictions of coal production appear to have fallen short of the actual values. The same is as true for nonfossil fuels as for coal, although adding the aforementioned 3.5 quads of energy from renewable energy sources for nonelectric end uses would bring the actual amount of nonhydro renewables above the 1990 prediction.




US Energy, Pred & Act
Quads
90
81
72
63
54
45
36
27
18
9
0
1985 NEP III Pred
1985 Actual
1990 NEP III Pred
1990 Actual
Total Prod.
Imported
Exported
Total Cons.


US Fossil Fuels, Pred & Act
Quads
27.0
24.3
21.6
18.9
16.2
13.5
10.8
8.1
5.4
2.7
0.0
1985 NEP III Pred
1985 Actual
1990 NEP III Pred
1990 Actual
Coal Prod.
Nat. Gas Prod.
Oil and Nat. Gas Liq.



Energy: The Next Twenty Years attributed "well over half" the difference between the historically expected energy consumption and actual consumption in 1980 to such energy conservation measures as added home insulation and more efficient automobiles, and the remainder to reduced economic activity. This report also assesses energy intensity of different occupations, with industrial and transportation occupations using hundreds of thousands of Btu per dollar of GNP, while service occupations use less than 20 thousand Btu per dollar of GNP. It would appear that reduced U.S. energy consumption is also partly due to the shift from a manufacturing to a service economy. For example, New Jersey has lost 300,000 manufacturing jobs between 1970 and 1991.

But although both *Energy: The Next Twenty Years* and the CONAES Report expected reduced oil and natural gas use in the 1980s, the United States has not broken away from its traditional diet of these two most convenient fossil fuels. The primary reason for this seems to have been the continued relatively inexpensive price of these fuels. McGeorge Bundy, in his Foreword to *Energy: The Next Twenty Years* states that "The central message of the present report is that energy -- expensive today -- is likely to be more expensive tomorrow and that society as a whole will gain from a resolute effort to make the price that the user pays for energy, and for saving energy, reflect its true value." (Ford Foundation, 1979: xvii) A subsequent analysis, based on gasoline demand and price in a variety of nations, suggests that the gasoline demand per gross domestic product is inversely proportional to the retail gasoline price. The CONAES Report shares the same concern about the negative impact of oil prices that are too low. They also found, in contrast to the recent inability of the U.S. Senate to increase the federal gasoline tax more than 4.3¢ per gallon, that the "effect on GNP of imposing a blanket tax on all primary sources of energy to reduce energy consumption to specific levels" was "surprisingly small, assuming that the economy is given time to adjust . . . ." (CONAES, 1980: 12)

Weaning Ourselves from Fossil Fuels

Foreseeing an era of restricted supplies of oil and natural gas, both *Energy: The Next Twenty Years* and the CONAES Report write about the transition to an era without these convenient fossil fuels and our own ability to decide how smooth this transition will be:

> The fundamental changes we anticipate in the world energy situation over the next twenty years -- such as a relative decline in oil and gas use, rising energy costs and prices, and increased efficiency in energy use -- will occur whether the United States handles its energy policy wisely or foolishly. But U.S. energy policy will be a major factor determining whether the changes will be relatively smooth and easy or will result in unnecessary disruption, cost, or worse. If the required energy adjustments have to be forced by events that have not been anticipated and planned for, the next twenty years could see a series of perpetual crisis-oriented actions. . . . (Ford Foundation, 1979: 6)

> The problem is in effecting a socially acceptable and smooth transition from gradually depleting resources of oil and natural gas to new technologies whose potentials are not now fully developed or assessed and whose costs are generally unpredictable . . . . The question is whether we are diligent, clever, and lucky enough to make this inevitable transition an orderly and smooth one. (CONAES, 1980: xvi)

The CONAES Report (1980: 140) shares the enthusiasm of the Carter Administration for developing a synthetic fuels industry ("up to 12 quads [of fuel from coal liquefaction] could be available by 2010 if environmental problems can be solved"). Both reports are cognizant of the constraints that carbon dioxide emissions could place on the ultimate burning of fossil fuels.

Short of resolving present problems with nuclear fission and fusion, this leaves us with the need to make a transition to strictly renewable energy sources in the long-term future. Excluding about 3 quads of hydroelectricity, the U.S. has thus far progressed to 3.5 quads of renewable energy, most of it biomass fuels with nontransportation end uses -- a far cry from a current annual demand of about 80 quads. These 80 quads must be distributed among end uses of electricity, heat, and liquid fuels (for transportation). The only renewable source of the last of these three end uses is biomass. The other end uses can be met by direct solar and the solar by-product, wind. Wind, the only economically competitive renewable electric energy source in addition to hydroelectricity at present, had a generating capacity of 295 megawatts as of March 1984, with planned expansion to 1894 megawatts (a standard power plant generates 1000 megawatts). Over 90% of this capacity is in California. Even if this expanded capacity generates electricity full time, it will produce only 0.06 quad in a year. (The solar electric generating capacity at the end of 1983, all of it in California, was much smaller -- only 172 megawatts.)

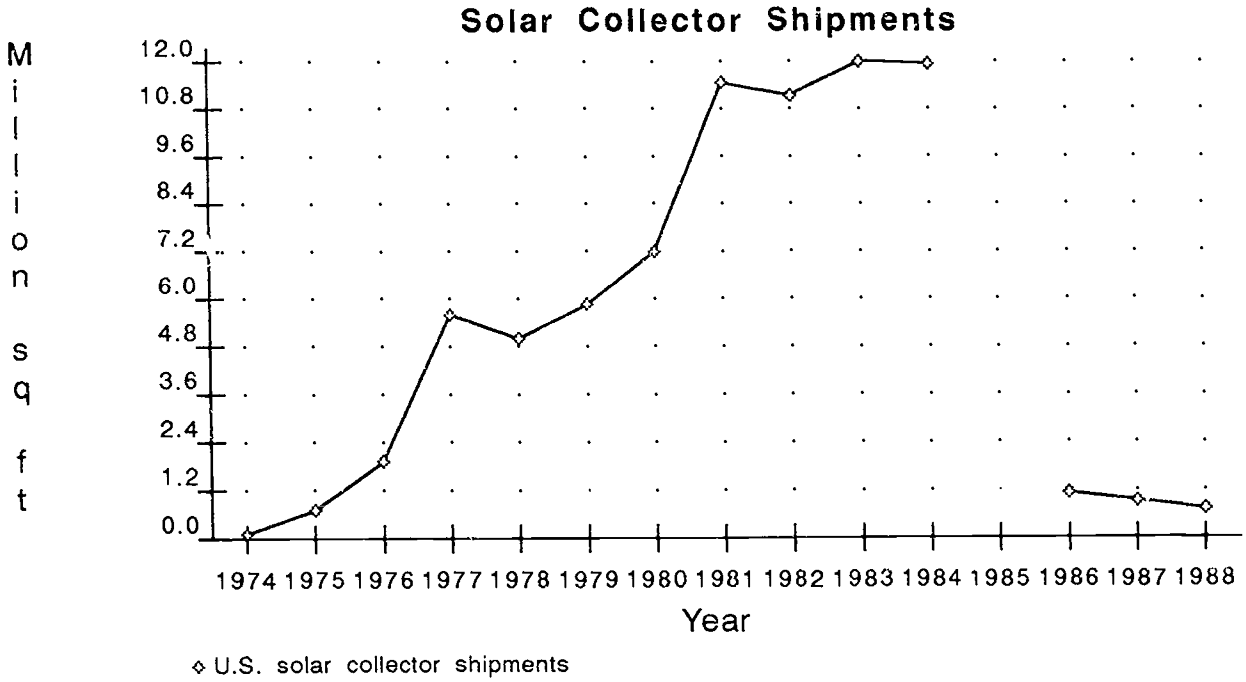
The CONAES Report (1980: xv) states that ". . . solar energy technologies other than hydroelectric power will probably not contribute much more than 5 percent to energy supply in this century, unless there is massive government intervention in the market to penalize the use of nonrenewable fuels and subsidize the use of renewable energy sources." In fact, we have already seen one example of this with the Federal tax credit for installing domestic solar hot water systems. This credit expired in 1985, and the graph below showing the shipments of domestic solar hot water systems makes it clear that with it went what was then a burgeoning new industry, an industry which has suffered further from lack of maintenance of systems already installed. In fact, Stobaugh and Yergin advocated the 55% tax credit implemented in California as a way to stimulate the solar industry all across the country by lowering payback times.

"The Solar Resource Group of CONAES concluded that solar energy technologies could contribute substantially to the national energy system by 2010 if there were purposeful governmental intervention in the energy market. However, with energy prices in the range considered by the CONAES study, market penetration by solar energy (apart from biomass and hydroelectric) would be only a few quads up to 2010. . . . if tax policies and economic incentives were introduced to encourage its adoption in preference to other energy forms, regardless of cost, . . . solar technologies might provide as much as 25-30 quads . . . by 2010, but the total price . . . could be . . . 2-3 times the cost of alternatives." (CONAES 1980: 44)

Except for using less energy than anyone expected, the United States energy situation twenty years after the energy crisis of 1973 seems remarkably unchanged. The first paragraph of *Energy: The Next Twenty Years* needs very little updating, as is indicated by the following (with updating changes underlined):

> Two decades have passed since the oil crisis of 1973-1974 signaled a new era in U.S. and world history. The effort to develop a satisfactory policy response to what was once characterized as the "moral equivalent of war" has stretched out so long that weariness rather than vigor characterizes the national debate . ... energy and environmental objectives seem irreconcilable; . . . a national consensus that solar energy is a good thing has yet to result in significant resource commitments, while support for nuclear energy, yesterday's hope for tomorrow, is eroding; and coal is marking time. Meanwhile, the slow, steady increase in the number of barrels of oil imported . . . provides reminders that much needs to be done. (Ford Foundation, 1979: 1)

When it opened in 1977, the Solar Energy Research Institute's charge was to insure that 20% of U.S. energy was produced from renewable sources by 2000. The Institute was renamed the National Renewable Energy Laboratory in 1991 and is now employing more people than at its earlier peak in 1980. In spite of the time lost during the 1980s, can the U.S. still reach this goal by 2000?



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EQUITY CONCERNS IN U.S. NUCLEAR ENERGY POLITICS: THE NEED FOR ALTERNATIVE ENERGY FOR A SUSTAINABLE FUTURE

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Sustainable development is a process in which policies and programs of energy, environment and development are so designed as to "bring about development that is economically, socially and ecologically sustainable" (Hague Report, 1992). Energy plays an important role in the process of sustainable development. Nuclear power is often cited by its advocates as an alternative energy source for the future because of its relatively benign environmental impacts (IAEA, 1992). As global warming becomes one of the top priorities in national and international policy agendas, advocates are again promoting nuclear power. In this context, it is not surprising to see that the U.S. National Energy Policy Act (EPACT) of 1992 emphasizes nuclear power as one of several important future energy sources.

The nuclear future faces daunting challenges Apart from economic, environmental and technological problems, it has to overcome socio-political dilemmas. Equity and human health issues, stemming from nuclear power generation and nuclear waste disposal, are especially critical concerns for the public as a whole. Among the many possible socio-political concerns, this paper intends to focus on equity issues. No one, no community and no nation wants a nuclear power plant or a waste treatment facility in their backyard (Not In My Back Yard; NIMBY). Equity issues involved in nuclear power deployment and treatment are the major social challenges to the future U.S. nuclear prospect.

This paper argues that nuclear power is not a fuel for our sustainable future. As a means of justifying our argument, the paper first contrasts a conventional energy regime with a sustainable energy regime, characterizing nuclear energy as a product of the former. In this discussion, our focus is on the equity dimension of sustainability. Next, the historical review of the U.S. government's nuclear policies reveals that there was a lack of equity considerations in its nuclear development and nuclear waste disposal management. Finally, this paper explores short-term adjustment strategies that address inequity problems involved in nuclear power and suggests long-term needs for facilitating the transition from a conventional energy to a sustainable energy future.

I. Nuclear Power as a Conventional Energy Regime

In the conventional growth-oriented energy system, energy decision-makers act on the premise that increased energy consumption equals economic growth. Decision-makers tend to emphasize the values of stability, reliability and economic optimization; social and environmental impacts are treated as external to energy decisions. Energy choices are profit-oriented and technology-reliant with a focus on centralized, capital intensive systems of production and delivery capable of providing abundant fuel supplies to meet the requirements of industrial wealth-creation (Byrne & Wang, 1992).

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In contrast, in a sustainable development-oriented energy system, energy decision-makers act on the premise that energy efficiency and renewables support sustainable development. Decision-makers tend to emphasize the values of innovation, flexibility, equity, and social optimization; social and environmental impacts are treated as internal to energy decisions. Energy choices are equity-oriented and community-reliant, with a focus on decentralized delivery of efficient energy services to meet requirements for sustained development (Byrne & Wang, 1992).

U.S. nuclear power is a product of the conventional growth-oriented thinking. It fits well with the characteristics of the conventional energy regime: a centralized technology and a resource-intensive supply-oriented energy system. Nuclear energy started with an enormous expectation that it could offer the prospect of reliable and cheap supplies to meet the constantly increasing demand conventionally associated with economic growth. The U.S. nuclear industry was, and still is, heavily supported by the conventional growth-oriented energy institutions. National policy, market, technology, financial and research institutions have all been supportive of U.S. nuclear energy development.

During the energy crises in the 1970s, nuclear power came to be viewed as a more attractive energy source which could reduce vulnerability to world fuel price changes and sudden supply stoppages (Kruschke & Jackson, 1990: 35). In the context of environmental concerns in the 1980s and the early 1990s, it was considered by its proponents as a sustainable energy source. They tried to recover the lost utopia of nuclear fission by emphasizing the environmental disadvantages of fossil-fuel combustion and the various advantages of nuclear electricity, so-called "clean energy." In spite of the optimism, nuclear energy has been subject to considerable disputes over its economical, environmentally, and technological viabilities. Most detrimentally, however, socio-political viability has been greatly challenged.

Economically, nuclear power is not a cheap source of energy. Its construction costs generally exceed five to ten times as much as originally projected in the U.S. (Flavin, 1983: 12-5). The price of nuclear power is more expensive than the solar power which is currently being sold by a private firm to California utilities (Hall, 1991: 125). The projected dismantlement cost of a nuclear power plant is close to 10 percent of the total construction cost, even without considering the costs of removing nonradioactive structures (Komanoff, 1981; Pollock, 1986). The nuclear industry has been created under heavy government subsidies. As an example, the Price-Anderson Act of 1957 set an upper limit of $560 million compensation for personal damages, but the liability limit per accident was raised to $7 billion in 1988 (Kruschke & Jackson, 1990: 69).

Environmentally, nuclear power has long-term ecological and human health hazards. Radioactive materials harm human health, even at low levels of exposure Burying radioactive wastes (*radwastes*) is not a safe solution. Nuclear advocates argue that levels of "background radiation" (radiation from natural sources) account for a considerable proportion of the total radiation but "it is the concentration of radioactivity that matters" (Blowers, Lowry, & Solomon, 1991: 17). Nuclear power is not a panacea for addressing global warming problems caused by the concentration of carbon dioxide and other gases. As Keepin and Kats (1988) point out in their scenario analyses, even if one-fourth of the global primary energy needs are supplied by nuclear as of 2025, it could not resolve greenhouse gas problems. Further, replacing all fossil-fuel power plants with nuclear plants would reduce the problems by less than 20 percent (Insight, January 15, 1990).

Technologically, safety problems with large nuclear reactors, especially with light water technology, raise great concerns. Most of the existing nuclear power plants were constructed based on the assumption that "you had a mature technology when in fact it was still evolving" (Morone & Woodhouse, 1989). There is no guarantee that "radioactive waste will not someday leak in dangerous quantities from even the best of repositories" (Krauskopf, 1990: 1232). Scientific communities agree that no existing technology can completely solve the radwaste problems by burial, which is considered one of the safest treatments. This is so simply because: 1) possible geological changes lead to possible underground release of radwastes, which eventually will contact the human society, or at least the ecosystem; and 2) the tremendously long half-life[1] of a radioisotope, which is a major component of nuclear waste, may cause radioactive pollution due to unexpected accidents within a long span of time in human society, even though all the best technical and geological treatments isolate them from the present human society.

Socio-politically, the U.S. nuclear industry is facing the most significant challenges. Public opposition, coupled with the environmental movement, is growing stronger, especially after the accidents at Three Mile Island (TMI) and Chernobyl. Nuclear power generates anxiety that is consistent over time and increasing. The evidence of widespread fear is an inescapable constraint for nuclear decision-makers. Utilities tend to favor siting their nuclear power plants near communities to reduce transmission costs, thereby making those power plants more efficient economically. This efficiency orientation raises equity issues in the U.S. nuclear sector. The earlier nuclear power plants were built without a full understanding of the technological and societal requirements (Lenssen, 1992). These equity issues are in part attributable to U.S. nuclear policies.

II. Equity Issues in U.S. Nuclear Politics: Historical Overview

Equity considerations in U.S. nuclear development are examined in a historical context in which the evolution of U.S. nuclear power development is divided into four distinctive periods covering 1939 through 1993: the dawning (1939-53), intermediate (1954-68), peak (1969-79) and struggling (1980-93) phases.

A. The Dawn of Nuclear Development: 1939-53

The year 1939 is very important in the sense that the U.S. government officially launched nuclear weapons construction. Albert Einstein's 1939 letter to President Roosevelt on nuclear physics played an important role in initiating the federal government's nuclear weapons program. Since the launching of nuclear weapons research through the establishment of the Manhattan District Project (1941), U.S. nuclear technology has been continuously advancing, primarily in weapons research and secondarily in nuclear power generation research.

Technological development and congressional and administrative supports eventually gave the U.S. a key to open the door to the nuclear world of electricity generation. In August 1946, Congress passed the Atomic Energy Act, the first Congressional enactment encouraging nuclear energy development. This act established the Atomic Energy Commission (AEC) and the Joint Committee on Atomic Energy (JCAE), which were the first legislative promoters of nuclear energy generation (Kruschke & Jackson, 1990: 32). President Eisenhower's UN speech in 1953 on "Atoms for Peace" was the trigger for the growth of the nuclear energy regime.

During the early years of nuclear development, there were no concerns over ethical and equity issues (or at least no prevalence of those issues) in U.S. nuclear development—neither in technology development, administrative motivation, nor in legislative guidance. Only technological improvement and institutional supports were demanded by the nuclear scientific arena and policy field. The U.S. nuclear energy system was developed from the beginning without having an opportunity to be discussed by the public on ethical and equity dimensions.

B. Intermediate Stage with Private Partnership: 1954-68

The construction of the first commercial nuclear reactor, proposed by the AEC and approved by the JCAE, began at the Shippingport Atomic Power Station (60 MW) near Pittsburgh in December 1954. It began the supply electricity to the Pittsburgh area in 1957 and was shut down in October 1982 (Kruschke & Jackson, 1990: 33-4; Nuclear News, August 1991: 79). As the U.S. nuclear power system approached a national scale, the probability of nuclear accidents increased. The Fermi fast breeder reactor had a partial core meltdown in October 1966 (Kruschke & Jackson, 1990: 34). This incident, however, was easily neglected in the midst of nuclear institutionalization.

Rudimentary studies on nuclear reactor safety were undertaken in this period. The AEC released a report in 1975 entitled, "Theoretical Possibilities and Consequences of Major Accidents in Large Nuclear Plants." The report was intended to relieve fears and anxieties of the American public and the nuclear industry with respect to the possibility of nuclear accidents (Kruschke & Jackson, 1990: 33). The federal government initiated nuclear safety management by imposing costly, technological requirements upon the nuclear industry. At the same time, the government greatly supported the industry by providing financial safety in the event of accidents at major nuclear power plants. The Eisenhower administration's acceptance of the Price-Anderson Act in 1957 was good evidence of the government's real intentions in their promotion of the nuclear industry—financial protection and encouragement of private investment for the nuclear industry.

Public-private collaboration did not fully prepare to address the possible release of radioactive materials into the atmosphere. For instance, the Private Ownership of Special Nuclear Materials Act, enacted under the Johnson administration in 1964, was mainly focused on nuclear promotion rather than reactor safety requirements. In this phase of nuclear development, major nuclear-related institutions in the U.S. were mobilized to build up the nuclear system. Also, decision-makers within the U.S. nuclear sector did not seriously consider the site selection of nuclear waste disposal facilities.

C. Rise of Nuclear Safety and Environmental Issues: 1969-79

The National Environmental Policy Act (NEPA) was enacted in 1969 under the Johnson administration in the wake of possible adverse environmental effects of governmental projects (Kruschke & Jackson, 1990: 35). The American public's awareness of the dubious safety of nuclear reactors was an underlying factor in the enactment of the NEPA. The act required governmental agencies to submit environmental impact statements (EISs) identifying the environmental effects of all proposed public projects.

The AEC established the Atomic Safety and Licensing Appeal Board in 1969 to pursue stricter implementation of safety regulations and more careful license-granting processes. This board was responsible for technical review of the safety systems and measures required for granting construction permits for nuclear facilities. Government studies on nuclear safety issues were frequently conducted. A three-year reactor safety study undertaken in 1974 by the federal government concluded that reactor meltdown would be extremely unlikely (Kruschke & Jackson, 1990: 35).

President Nixon encouraged nuclear technology development by providing financial and administrative supports. He announced nuclear technology promotion as a national goal. The Energy Regulation Act of 1974 reorganized the nation's energy program. The Act established the Nuclear Regulatory Commission (NRC) to replace the AEC. The Energy Research and Development Administration (ERDA) created by the Act was involved in a project of nuclear disposal site selection in 1976 (MRS Commission, 1989: F-2). The reorganization among nuclear regulatory and managing authorities further fortified the growing nuclear regime.

The administrative reinforcement of nuclear promotion and up-to-date technology accumulation reinforced further promotion of the U.S. nuclear system on a large scale and at a fast pace during these years. The growing nuclear regime was large and robust enough to ignore the minor disorders of a few nuclear facilities, such as the mechanical malfunction and release of radioactive iodine in the Dresden-2 reactor near Chicago in 1970. While the nuclear industry was running at full speed in this period, another strong force was rising—an anti-nuclear ideology.

In April 1977, President Carter ordered an indefinite delay of a plan for fuel reprocessing. He signed the Energy Reorganization Act, under which a Federal Department of Energy (DOE) was created and the ERDA was combined with the Federal Energy Administration. DOE initiated a proposal of nuclear waste disposal siting—Away-From-Reactor (AFR) storage of spent fuel[2] (MRS Commission, 1989: F-2). NRC became more strict in reactor safety requirements and its granting of operation permits for existing reactors, as public wariness of the nuclear industry was emerging everywhere, specifically in communities located near nuclear facilities (*nuclear-facility communities*) in the U.S. The NRC ordered the shutdown of twenty-three nuclear reactors in 1975 because of cracking in the coolant pipes. Nuclear accidents were still occurring frequently and were severe magnitude (Kruschke & Jackson, 1990: 36).

A major nuclear accident at the Three Mile Island (TMI) Nuclear Power Plant near Harrisburg in 1979 played a crucial role in the apparent decline of the U.S. nuclear regime. The TMI accident was extremely significant, marking a milestone in the long span of U.S. nuclear development. This accident contributed greatly to the public's reconsideration of not only the safety of nuclear reactors but also the whole meaning of nuclear technology in human society. After the accident, the U.S. nuclear industry faced more rigorous regulation by nuclear authorities and stronger opposition from environmentalists and nuclear-facility neighboring communities. However, no significant equity issues surrounding sitings was raised, while the U.S. nuclear industry, ironically enough, recorded its biggest capacity expansion and its highest growth rate in the history of U.S. nuclear energy development.

D. *Battles on Nuclear Safety and Waste Management: 1980-93*

The most recent phase of U.S. nuclear development (1980-93) is characterized by more intensive and larger-scale concerns about nuclear generation and its waste disposal. No more reactors have been ordered or contracted for since the TMI accident, and safety regulation of existing reactors and waste disposal facilities has risen as an extremely critical issue. The Nuclear Safety Research, Development, and Demonstration Act was enacted in 1980, establishing a program within DOE to improve the safety of nuclear power plants.

President Reag' ı issued the Nuclear Power Policy Statement in 1981, emphasizing the imperative of nucle. ' power as an alternative to meet national energy needs (Kruschke & Jackson, 1990: 37). He also signed the Nuclear Waste Policy Act in 1983. The Act, the first enactment of nuclear waste disposal management, aimed at program development for the disposal of high-level radwaste and spent nuclear fuel from nuclear power plants. Along similar lines, DOE established the Civilian Radioactive Waste Management Office in 1984. Nuclear waste disposal management was emphasized more in this period than in any other. The Nuclear Waste Policy Amendments Act (NWPAA) of 1987 outlines compensation methods for the states and localities where Monitored Retrievable Storage (MRS) or repositories of radwaste locate. Nuclear safety and its accompanying inequity issues were culminated in the enactment of the NWPAA. The existing policy (mainly directed by the NWPAA) is controversial in the compensation assessment because there is usually a significant gap between the compensation amount proposed by hosting states or localities and the Act's specified compensation (MRS Commission, 1989). Whether or not economic disadvantages are appropriately compensated by the government's benefit payments, psychological effects are hardly compensable. Even though "stigma effects" exist, neither an objective nor an agreed-upon method to measure and compensate for them is yet available. Neither is there agreement on whether or not such compensation is necessary or even desirable (MRS Commission, 1989: 78).

One of the most alarming nuclear accidents was an explosion in 1986 at the Chernobyl Nuclear Power Plant in the Ukraine, within the former Soviet Union. Human health destruction and ecological damage were horrendous and are currently expected to be substantial all around the world even after a long span of time (Kruschke & Jackson, 1990: 38). The aftermath of the accident was significant enough to incite the public to rethink the threat of nuclear materials to human health and the global ecosystem.

III. Inequity as Constraints of U.S. Nuclear Development

Inequity emerges as a major policy issue of nuclear energy. Inequity in a cost-benefit context is not comprehensive because social aspects of community anxiety and fear are not considered in the cost calculation. More importantly, this fear plays a significant role in the formation of the sense of inequity, leading to nuclear opposition. Three equity issues—*intraregional, interregional* and *intergenerational inequities*—are involved in the development of nuclear energy and its waste management.

A. *Intraregional Inequity*

The communities in the vicinity of a nuclear power plant or a waste treatment facility are more likely to be exposed to actual and potential health and environmental problems than more distant communities. These communities become sacrificial lambs because they provide a power source for economic prosperity for all surrounding communities but with great exposure to risk themselves. This is an *intraregional inequity*.

The aftermath of the TMI accident in 1979 gave the American public a clear picture of the equity issues involved with a nuclear facility. While the TMI nuclear power plant supplied electricity to Harrisburg, Pennsylvania and its vicinity (at least ten miles away from the plant), about 20,000 community residents living within a five-mile radius of the power plant were evacuated for several days. The accident seriously affected the nuclear-facility communities. Seven cows and thirteen calves were dead within a week after the accident in a dairy farm in Bainbridge township, five and a half miles from the power plant. The deaths were believed to be due to radioactive contamination. An eight-year-old boy developed severe psychological problems after he returned from the evacuation (Tredici, 1980: 28, 33). These ecological effects were only a part of the immediate physical results occurring immediately after the accident. If all long-term human and ecological impacts and their potential were measured, the total damage from the accident would indeed be considerable. The accident was estimated to increase the probability of cancer deaths and major environmental damage in the area.

The overall adverse effects of the TMI accident will affect wider territories than the nuclear-facility communities close to the power plant. These communities, however, suffered local consequences in addition to the widespread effects. In such an accident, no federal siting compensation can either rebuild degraded human health and deteriorated environment or recover the immeasurable and ever-lasting damages to the physical and psychological well-being of the specific community.

A community's response to a nuclear waste disposal site echoes its response to a nuclear power plant. As long as nuclear wastes exist, they will always threaten society, especially nuclear-facility communities, through various forms of environmental degradation. As of 1990, about 21,800 metric tons of irradiated fuel from all U.S. commercial nuclear reactors are stored in cooling water pools within each plant site. This is almost twice much as that of 1985 (12,601 metric tons) (Lenssen, 1992: 51). The probability of radioactive release, caused by various scenarios,[3] imposes social inequity to nuclear-facility community members.

B. *Interregional Inequity*

An *interregional inequity* exists between the South/West and North/East regions in the U.S., stemming from the unbalanced and unfair radwaste management in the nuclear industry. While most high-level wastes (HLW) are produced in the North/East region, where most commercial nuclear power plants are located, most waste disposal facilities are sited in the South/West region (Blowers *et al.*, 1991).[4] The states in the South/West region do not directly benefit from the nuclear power plants whose radwaste comes to their nuclear waste disposal sites, but the citizens of those states inevitably confront health dangers and psychological anxieties associated with nuclear power.

Even though disposal siting reflects the geological nature and population density of each region, the communities in affected regions are facing one of the most sensitive concerns in the nuclear industry. Many scientists and even politicians who are involved in the nuclear industry regard nuclear waste disposal as the *Achilles Heel* of the nuclear industry (Blowers *et al.*, 1991; Blowers & Pepper, 1987). The currently poor management of nuclear waste disposal generates severe inequity issues in the U.S.

When a specific state in the South/West region accepts nuclear waste into its territory in return for economic compensation, residents of neighboring states inevitably confront health dangers and psychological anxieties in their daily lives. There is a tendency that compensation for radwaste-facility-hosting communities and power-plant-hosting localities is apt to be politically manipulated, deterring the promotion of interregional equity.

C. *Intergenerational Inequity*

The domain of equity expands across generation lines because today's decisions affect future generations' ways of life. The current generation's nuclear decisions will play a significant role in the next generations' environmental and human-health conditions because of the excessive length of the half-life of most radioisotopes. If this generation utilizes nuclear technology intensively, whether the coming generations accept the technology or find energy alternatives, they will inevitably have to handle the nuclear waste inherited from their ancestors. The shift of responsibilities for handling nuclear wastes, especially radioactive materials and nuclear power plants decommissioned after full use (over forty years), is a case of *intergenerational inequity* (Kasperson, 1983).

As decisions regarding the present tax system will affect the future generations' burden of federal debt built by current deficits (Frederickson, 1990: 230), so the current generation's decisions on nuclear-related institutions will affect the future generations because of the astronomical length of the half-life of most radioisotopes. The half-life of radioisotopes varies from less than one second to millions of years (*e.g.*, plutonium-239 (24,400 years), uranium-235 (710,000 years), iodine-129 (15.8 million years)), depending upon their internal structure (Lenssen, 1992: 50-2). Once nuclear systems are set in place, regardless of nuclear needs of future generations, they are burdened with considerable costs. These costs include monitoring, surveillance, and potential hazards. Since nuclear-related problems in the distant future have little or no effect on contemporary political perspectives, current nuclear decision-makers tend to heavily discount the needs of future generations (Blowers *et al.*, 1991).

IV. Sustainable Energy as a Remedy for Inequity

The Nuclear Waste Policy Amendments Act (NWPAA) of 1987 provided a legal mechanism to compensate the states and localities in which radwaste facilities and nuclear power plants are located. There is, however, a big gap between the amount of compensation proposed by states or localities for their hosting of nuclear facilities and the act's specified expenditures for compensation. The local estimation is usually five to ten times higher than the NWPAA's stipulation.

The improvement of infrastructure by the public sector has also been made in nuclear-facility-hosting regions. The provision of infrastructure includes road construction, safety service, and emergency shelters. In addition, according to the act, roads surrounding an MRS might have to be upgraded (to ensure radwaste transportation safety), the police force might have to be increased (to ensure safety of the facility), and the school system might have to be enlarged (partially in order to meet the education demand of newly arriving families of facility employees).

In some cases, the economies of affected communities have become more active, and some might even be considered booming. Community economies have taken advantage of the compensation by using it as seed money (leveraging funds) for economic viability. The existing compensation strategy mainly directed by the NWPAA has not, however, been able to compensate completely for the equity loss of the facility-hosting states or localities. Whether or not inequity has been appropriately compensated in an economic term by the government's payments and/or the improvement of infrastructure, psychological effects, or so-called "stigma effects" are hardly compensable.

As a short-term strategy for easing inequity problems associated with nuclear energy, site-selection processes should be opened and include not only nuclear-related agencies and state legislatures but also those communities involved. Nuclear decision-makers should be responsive to the American public's awareness of nuclear-related equity issues. The public's active participation in the decision-making process is critically and urgently required. The extent of the public's participation will affect the quality of their daily lives. The horizontal binding of the nuclear industry, the public and the government can contribute to the growth of equitability in U.S. nuclear power development.

Public hearings at any appropriate stage of nuclear facilitation can be cooperatively undertaken. A public hearing is the only arena in which all competing interests emerge and, therefore, gives a good opportunity to yield all possible considerations in a nuclear project. There should be no predetermined orientation or biased value in the preparation of a public hearing. Only the "neutrality" nature of a public hearing can guarantee expression of the opinions of all concerned parties, making them better understand the situation and problems. Appropriate treatment of equity issues could be brought into the process of the public hearing, producing reasonable policy outputs.

The non-public and non-private sectors could also contribute to the easing of inequity problems. The environmental education conducted by nuclear-neutral environmental organizations could provide useful knowledge necessary for nuclear-adaptive life styles. These organizations should not be influenced by either the public sector or the private sector. The influence-free nature (in terms of organizational linkage or funds, for example) ensures neutrality in delivering appropriate environmental knowledge. This group could also take a watchdog function, indirectly affecting the nuclear industry's attitudes toward safety and equity issues.

The short-term strategies of economic compensation, political participation and public awareness, however, are not capable of eradicating the equity issues coming from the "fear" of radiation. Nuclear power creates greater and more widespread fear than any other form of risk (Slovic, Fischoff, & Lichtenstein, 1979). Although the statistical chances of death and cancer from the radiation are low, public fear of radioactivity has increased. Even public information campaigns often become counter-productive, producing "an inverse relationship between efforts to encourage understanding and public resistance to it" (Goodin, 1980; Blowers *et al.*, 1991).

The risk from nuclear energy is a socially-induced risk which is often irreversible. Once a nuclear reactor is commissioned, risk from radioactivity continues unless decay reaches harmless levels. The half-lives of some radioisotopes extend over millions of years, requiring long-term security and safety. At least any increase in nuclear risk can be avoided by the transition to a sustainable energy regime, mainly composed of energy efficiency and renewable energy (Byrne and Wang, 1992; Blowers *et al.*, 1991). Energy efficiency and renewables could meet the requirements for expected economic development while also providing appropriate amounts of energy for self-reliance and environmental protection. Energy efficiency and renewable energy even have a positive dimension for equity improvement (Byrne and Wang, 1992).

Designing strategies for a sustainable energy future is not a small task, however. The task covers economic, socio-political, technological and environmental dimensions. It needs reorientation from the conventional policy to a new one which calls for drastic changes in values, policies and institutions. One strategy is introduced here to illustrate our point of a paradigm change in step-by-step processes.

The first step would employ an educational campaign to change the value system of citizens from a conventional to a sustainable paradigm. This idea has already developed to some extent and is being largely applied. The formation of social values with respect to sustainability in a society depends upon the extent of the public's awareness of the interlocking nature of energy, environment and development. Leadership by environmentally-active and equity-supportive citizens would also change the social norms of the general public. Consensus would build among citizens. Informed citizens would participate in the political process through the mechanisms of public hearings or elections. They would evaluate the political agendas of candidates and elect those candidates who are in conformity with their orientation.

In the second step, elected representatives, regardless of whether they are congressmen or public officials, would formulate policies which meet the desires of informed citizens. Policies would take the form of providing a sustainable vision for society in the areas of energy, environment and development. Through the alliance of improved social equity and environmental quality, sustainable energy development would also be achievable.

The third step would be institutional changes to reflect the new sustainable policy orientation. The political system, composed of sustainable-oriented policy makers, would be a critically important institution to reflect society's realities and citizens' burgeoning demands for a sustainable energy future. It would also play a major role in the enhancement of socially-accepted values of sustainability and give direction in mobilizing other public resources. Such a change in social values and its political reflection would cause institutional changes in the areas of market, technology, finance and research.

Utilities' adoption of demand-side management (DSM) is a concrete example of a paradigm change from supply-oriented utility resource planning practiced since the birth of the electricity industry. With state utility regulators' encouragement, DSM was originally implemented by electricity utilities in California, New York and Wisconsin in the 1970s. These states' successful DSM implementation, which was also supported by the public, ultimately moved Congress to enact the Public Utilities Regulatory Policies Act in 1978 (PURPA). This act requires all state utility regulators to investigate DSM measures including rate revisions which encourage energy conservation (Rosenbaum, 1987: 38). This policy change in the public sector and legislative adaptation fostered by public support brought about the utility sector's active investigation of DSM alternatives. These changes made utility investment in energy conservation and efficiency competitive with the conventional energy supply options. Without this policy change, an economic bias toward supply would have continued in the utility sector, and the social and environmental benefits of conservation would have been undervalued.

V. Conclusions

The conventional approach to economic growth has assured a high level of energy use. The national (even international) energy system searches for abundant, low-cost energy sources and vulnerability-free energy supply strategies. "Centralized power" (Messing, Friesema, & Morell, 1979) is persistently sustained in U.S. society, providing the prerequisite for an institutional commitment to nuclear power. This is strikingly similar to cases of national promotion of nuclear power in other countries in the early period of nuclear development. Support from long-lasting administrative, congressional, judicial, and techno-economic institutions remains strong.

These institutional supports are, however, challenged. The U.S. anti-nuclear movement is getting stronger, arguing for a nuclear moratorium to avoid the vulnerability of future generations. Public fear of radioactivity has an emotional strength based on the following rationality (Blowers *et al.*, 1991): the statistical chances of radiation accidents are low, but the consequences are catastrophic; radioactivity is invisible and widely dispersed, creating a rational fear of the unknown; risk from radioactivity is extended over a long time-span; and risk is self-ignored by human society.

Nuclear fission is one of several technologies that Amory Lovins defines as *"hard energy path"* (1977: 25). Lovins captures the nature of inequity inherent in the *hard energy path* by indicating that this path is "probably inimical to greater distributional equity within and among nations" and "inequitably divorces costs from benefits" (1977: 148). Under the nuclear system, society depends on huge generation systems financed by huge outlays of capital. Only a few experts can govern high technology, and society is exposed to unimaginable risks. These phenomena can be expected to cause public distrust and alienation, and even deny public participation (Lovins, 1977: 150).

The proponents of nuclear development try to recover the lost utopia of nuclear fission by emphasizing the environmental disadvantages of fossil-fuel combustion and the various advantages of nuclear electricity, so-called "clean energy." They criticize fossil fuels as hazardous methods of generating electricity. They seem to assume that we face a Hobson's choice between acid rain, climate warming and lung disease from fossil fuels and the widespread fear, potentially catastrophic accidents and economic losses of well over $30 billion from nuclear power (Morone & Woodhouse, 1989: x).

Our choice is not limited to either nuclear or fossil fuels. Energy efficiency and renewables are the choices for our sustainable future that can be "locally tailored" both technically and socially. Efficient use of energy and development of renewable energy often make more sense to our communities than building a nuclear power plant with a correspondingly large electricity grid and risking health and public safety. The environmental and anti-nuclear movements have jointly focused to stress conservation and renewable energy.

The realization of a sustainable future depends upon ending social and environmental inequity. This constitutes the basic challenge, and it is a challenge that remains to be confronted. If the U.S. government, the nuclear industry and the public make concerted efforts in the common interest of social and environmental sustainability, we may be able one day to leave to coming generations a common future both they and we can appreciate.

NOTES

1. Half-life is the amount of time it takes for 50 percent of the original activity to decay; after 10 half-lives, one-thousandth of the original radioactivity would remain, an amount that can still be dangerous (Lenssen, 1992: 50).

2. This is a revision of the previously-developed Monitored Retrievable Storage (MRS) approach. According to this revision, the fuel owner would pay the federal government for storage and disposal.

3. There are a number of geological and human-driven causes of radioactive release. Major causes are earthquakes, fault movement, volcanism, rapid ground water movement and degradation, structural problems with tuff rock at high temperatures, the potential for gold and silver recovery at the site, and the repository's incompatibility with the underground testing of nuclear weapons (Blowers *et al.*, 1991: 216-7).

4. For example, Cypress Creek Dome and Richton Dome were built in Mississippi; Vacherie Dome in Louisiana; Deaf Smith and Swisher counties in Texas; Davis Canyon and Lavender Canyon in Utah; Yucca Mountain in Nevada; and Hanford in Washington (Blowers *et al.*, 1991: 207).

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Technology Becomes the Best Weapon for the Government to Defuse an Environmental Movement
—The Case of the Fifth Naphtha Cracking Plant in Taiwan

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Spectacular economic growth in Taiwan for the last three decades has been accompanied by growing environmental pollution. Since the late 1980s, grassroots environmental movements have grown up to challenge the authoritarian state. In 1987, angry residents of Houchin, which is located in the Kaohsiung, the second biggest metropolitan in Taiwan, engaged in strong protests against the plan submitted by its neighbor — Kaohsiung Refinery Plant (KRP) of the Chinese Petroleum Corporation (CPC) — to build a large naphtha cracking facility there. The major reason for the Houchin residents' demonstration was that they would not stand any further environmental pollution coming from the KRP because the village had more than 40 years of pollution experience. This protest continued for three years. Although the villagers did not successfully stop the construction of the naphtha cracking plant, the case of Houchin supplies a precious lesson for us to understand how civil protest was dissolved by the state and technology.

This paper will focus on the case of Taiwan's fifth naphtha cracking plant to demonstrate the environmental roots of civil protest in Taiwan and the formidable challenges it faces in reversing the country's environmental decline. This paper will argue that: 1) an ideology of technological and economic determinism has become a powerful weapon for the government to defuse environmental protest, and 2) environmental pollution is treated as though it is a "normal" risk of development and greater importance is given to expanded production capacity and technological innovation. Political and social values, such as equity, environmental balance and governance are all marginalized. This trend of technological determinism in Taiwan does receive immense opposition from local communities. The deterioration of the natural environment has incited local communities to defy the determinism of technology and to request their rights in the decisionmaking process.

This paper will first briefly scrutinize the relationship between technology and grassroots environmental movements. That technology is not a neutral object and has political features will be examined in the next section. This paper will then offer a brief overview of the economic and political situation in Taiwan. Following is the examination of the metropolitan region of Kaohsiung, where the village of Houchin is located. The case of the fifth naphtha cracking plant will then be explored in detail with a focus on the state's appeal to technological and economic determinism to thwart environmental protest. The conclusion of this paper will discuss the meaning of the Houchin protest for Taiwan's future development.

Technology and Grassroots Environmental Movements

One of the major characteristics of recent grassroots environmental movements in the U.S., according to Freudenberg and Steinsapir, is its "ambivalent attitude toward scientific and technical expertise" (1992: 31). On the one hand, movement activists work closely with scientists and construct positive relationships with them. On the other hand, activists express their total disbelief of the jobs which have been done by the scientists employed by industries or government. The image of technology which has been labelled as a neutral and objective mechanism by the corporations and government is no longer accepted by the grassroots environmental movements. Freudenberg and Steinsapir say "environmental activists reject the image of science as a neutral force that pursues the truth no matter what its consequences" (1992: 32).

Charles Piller agrees with this argument in his research of community defiance in the U.S. He indicates that science and technology are by no means neutral objects because they are controlled by an irresponsible system (1991: 15):

> What does the prevalence of Nimbyism tell us about the way science and technology are administered in our society? . . . It suggests a more fundamental cause — the dominance of an autocratic, profligate, and often irresponsible system for managing the scientific and technological enterprise.

In their study of the Three Mile Island nuclear accident, Goldsteen and Schorr not only confirmed this argument but further identified the deterioration of community values because of citizens being deceived by technology and corporations. The authors found that residents who lived around the TMI nuclear power plant were taught to believe in "rationalism grounded in a belief in science rather than emotion" (1991: xvi-xvii):

> However, this "rational" relationship between community and corporation has not worked for many communities. They have not shared in the rewards; they have been deceived, their rights trampled and their concerns dismissed. Communities are learning that corporations have been allowed to represent their interests without sufficient accountability and social responsibility. They have not considered community values.

The deterioration of the quality of life in communities and the request for a safe and healthy environment draw citizens and environmental activists' ire that technology is not a neutral factor which they can depend upon. Technology, which has been wrongly taken as a neutral actor in industrial and capital society, has profound implications for the value choices that society will make. Through grassroots environmental movements, the environmental activists discover that technology has an inherently political feature.

That technology has political features has been argued by Langdon Winner, Dorothy

Nelkin, and Michael Edelstein, among many others. They indicate that technology not only plays a political role but also helps the industrial and governmental sectors to restrain citizens' participation in the decisionmaking process.

Langdon Winner indicates that technical things have political qualities. He says that the structural implications of technology have not only extended into the technological domain but also extended into social and political realms. Winner says (1988: 42-43):

> The things we call "technologies" are ways of building order in our world. Many technical devices and systems important in everyday life contain possibilities for many different ways of ordering human activity. Consciously or unconsciously, deliberately or inadvertently, societies choose structures for technologies that influence how people are going to work, communicate, travel, consume, and so forth over a very long time. . . . [T]he adoption of a given technical system unavoidably brings with it conditions for human relationships that have a distinctive political cast — for example, centralized or decentralized, egalitarian or inegalitarian, repressive or liberating.

Technologies do not allow flexibility and choices which are different from those of its designers. Winner says "to choose them is to choose unalterably a particular form of political life" (1988: 42). Unfortunately, the power to choose technologies is not equally distributed in industrial society. In fact, most citizens are excluded from the decisionmaking process. Winner says the power is controlled by "an elite of highly trained technicians, planners, and managers. masters of 'state techniques,' who bring the whole into fine tune" (1977: 256).

To preserve the domination of technical value and the efficiency of the economy, Michael R. Edelstein says that state regulators "frequently act to insulate the market from the potentially disruptive and destabilizing effects of full citizen participation" (1986/1987: 89). Administrative procedures "are designed to avoid unfettered citizen involvement" (1986/1987: 89). Even those citizens who are invited to participate are "merely a token part of the process" (1986/1987: 89). Likewise, Freudenberg and Steinsapir also indicate that "government and industry often seek to convert what are fundamentally political issues into scientific and technical questions that require expert study rather than democratic decisionmaking" (1992: 32). Dorothy Nelkin further explains this point (1974: 2):

> Specialized bureaucrats that develop technical projects function according to a formal system of rules and procedures designed to fulfill narrowly defined objectives. Decisions are made on the basis of specialized technical competence, and there is little tolerance for the uncertainties and unpredictability that wider citizen involvement is likely to introduce. Bureaucrats assume that their plans reflect a broad public consensus on the ultimate value of technical progress. They identify their actions with the public interest and seek to maintain their autonomy and remain insulated from the political process.

The administrative procedures are designed to sustain the independence of bureaucrats and to prohibit citizen involvement. The values of liberty, justice, or equality are all excluded from regulators' technological considerations.

The citizens' exclusion from the democratic processes is not accepted by local communities which are seriously polluted by industrial production. Many grassroots environmental movements have emerged since the 1970s and are willing to voice their grievances. In one sense, these movements can be described as one kind of human choice against the authoritarian system or the totalitarian state and a way to bring back the autonomy of community. In their research on the nuclear accident at Three Mile Island, Goldsteen and Schorr concluded (1991: 214):

> The new paradigm accepted by communities states that science and technology will accord communities a better life if people interject their values into the risk assessment and decision-making process. The advances of science and technology have social costs. Consequently, the impact of such advances must be weighed in advance by the people who will feel their adverse consequences. People must take an active role in protecting their communities since industry and government have priorities which are inconsistent with those of the community.

They further indicate that "there should be democratic participation in the decision-making process regarding environmental risks. . . . Technological decisions must be incorporated into the democratic process" (1991: 218). Above all, technology cannot be excluded from political operations and must be decided by democratic participation.

The grassroots environmental movements which took place in Taiwan in the 1980s could be explained as the communities' demand to participate in the governmental decisionmaking process. Citizens who live around the polluted industries do not believe that government and industries act in the communities' best interests. In order to preserve a safe and healthy environment and to maximize the quality of life in communities, civil protests have occurred in many different polluted areas. Citizens do not consider technologies are the best alternatives to resolve the serious environmental pollution problems which they have borne for quite a long time. Among Taiwan's grassroots environmental movements, the protest in Houchin is one of the most important examples.

Economic Background in Taiwan

It is necessary for us to understand the economic and political background in Taiwan before we discuss in detail the case of Houchin because the environmental protest in Houchin was closely connected to these structures.

Economic development in Taiwan has been praised as a miracle because of the high economic growth rates in the last three decades. The growth rates of gross national production averaged 8.7 percent from 1953 to 1982, with a peak average of 10.8 percent for the years 1963-1972. Trade surpluses have occurred nearly every year since 1970, and foreign reserves amounted to US $7 billion in 1980, US $15.7 billion at the end of August 1984, and nearly US $76 billion in 1988.

The high economic growth rate was ascribed to the government's economic policies. Since 1953, central economic planning has been performed, and the government has employed many four-year economic plans to regulate economic activities and to promote economic growth. Two different economic policies have been executed since the 1950s. The first policy was the import substitution policy, which adopted a foreign exchange policy and implemented a pricing policy to encourage domestic production of substitutes for imported goods. After a few years, easy import substitution changed due to the limited domestic market and urgently needed foreign exchange earnings. By 1958, the investment climate was gloomy and more fundamental policy changes were sought. The strategy of development was then turned toward export promotion. Development strategy at that time became entirely export-oriented.

The industrial policy was fully integrated into this strategy. The petroleum industry is among the major industries which have been promoted since this period. Because of funding and raw material shortages, the development of the petrochemical industry was postponed to the fourth four-year plan beginning from 1965 to 1968 (Lin & et al., 1983: 1228). Under government encouragement, the first naphtha cracking plant located inside the KRP was completed in 1968. After the completion of this plant, former Vice Minister of Economic Affairs, Kwang-shih Chang, said "a new era of petrochemical industry began" (1977: 2). In the same period, two petrochemical complexes — Jenwu and Tasheh — which surrounded the KRP had also been constructed by the state. The second naphtha cracking plant was established in 1975 to supply the great demand for petrochemical raw material. This plant was also situated inside the KRP. There were direct transmission pipes to connect these two plants with the complexes.

Many downstream petrochemical plants were constructed inside the complexes. Most of the petrochemical plants were owned by private investors, including foreign and overseas Chinese investors. According to Chang, "among the foreign investors are such well-known multinationals as National Distillers, Amoco, Union Carbide, Gulf Oil, Hercules, Imperial Chemical Industries, Solvay, etc" (1977: 3). There are also joint ventures between domestic and foreign interests. However, Chang says, "the largest single investment in the petrochemical industry is from government funds. State-owned petrochemical enterprises are involved primarily in the production of basic petrochemicals, such as products from naphtha crackers" (1977: 3).

The petrochemical industry is a significant factor in the achievement of Taiwan's economic miracle. According to the government report, thirty-seven percent of total manufacturing production in Taiwan comes from this industry. This industry also contributes thirty-two percent of the total exported products of Taiwan. There are approximately 740,000 people employed by this industry. This is why Chang says "the petrochemical industry is of the utmost importance to the continued economic growth in Taiwan" (1977: 2).

Political Background in Taiwan

The state is a dominant actor in the development of Taiwan. Alice H. Amsden finds that the state in Taiwan has played a leading role in the process of capital accumulation. She argues that "to understand Taiwan's economic growth, therefore, it is necessary to understand its potent state" (1985: 78). Thomas B. Gold has also reached this conclusion. He says "any explanation of Taiwan's growth with stability must start with the National party-state" (1986: 122).

The state in Taiwan was totally controlled by the ruling party — Guomintang (KMT) — which retreated into Taiwan in 1949 after its failed battle with the Communist Party in mainland China. According to one political scientist, the nature of KMT has "shown totalitarian inclination, and the party structure is Leninist" (Moody, 1992: 25). KMT and the state were highly militaristic bureaucracies dominated by a single leader, Chiang, Kai-shek, and his son, Chiang, Ching-kuo. Before the 1980s, this party-state system dominated almost all aspects of the Taiwan society.

While new social groups were emerging and society as a whole was benefiting from economic growth, political development lagged far behind. Beginning in the late 1970s, a few political elites had bravely expressed their grievances and asked for participation in politics. The responses they got from the conservative state were brutal repression and arrests, but the opposition movements did not stop. Since the 1980s both the general public and segments of the governing elite have been increasingly demanding more rapid democratization.

Under comprehensive pressures from civil society, the authoritative state gradually changed its dominating characteristic in the 1980s. Hung-mao Tien, a political scientist, indicates this change in the characteristics of the state. He says "the institutional structures that have helped cement the KMT's authoritarian one-party system are gradually revised, albeit slowly, to accommodate public pressure for more intraparty pluralism and even a representative democracy at the systemic level" (1989: 13).

The major opposition party — the Democratic Progress Party (DPP) — had been established in 1986, and the martial law which had been employed for 38 years was lifted one year later. Lots of political protests against the state had been held in this period. Among these protests, the environmental movement was one of them. The public had recently become highly vocal in its concern about harm to the environment. The residents whose living spaces have been threatened by industrial pollution also uttered their grievances and wanted to protect their communities.

Industrialization and Metropolitan of Kaohsiung

Because of its natural harbor which benefits from importation and exportation, the metropolitan area of Kaohsiung, which includes Kaohsiung municipality (KM) and Kaohsiung county (KC), has been designated by the state as a major industrial area in Taiwan since the 1950s. For example, up to 1981, 30% of developed industrial estates in Taiwan, which accounted for 2,931 hectares, were located in this area (Chang, 1984: 14). Up to 1992, the percentage was 29% (Urban and Housing Development Department, 1993: 68). The CPC refinery was built here. The Kaohsiung Export Processing Zone within which no duties were imposed on imports was set up in 1965. In the 1970s, a large number of capital-intensive industries were established, such as the Kaohsiung Shipyard, China Steel's Integrated Cold-Rolling Mill, and China Petroleum's petrochemical project, including both upstream naphtha cracking facilities and downstream petrochemical production. The government-owned naphtha cracking plants which produce major feed-stock for the petrochemical industry are all located in the metropolitan of Kaohsiung.

Coinciding with the building of industry in Kaohsiung, a large number of people have migrated into the metropolitan of Kaohsiung since the 1960s. For example, 90,000 net migrants moved into this area between 1966-1981. The total population for Kaohsiung metropolitan was 1,698,000 in 1981, 1,908,971 in 1985, and 2,552,487 in 1992, which comprised of 13% of Taiwan's population (Urban and Housing Development Department, 1993: 192).

The metropolitan of Kaohsiung became one of the most heavily populated areas in Taiwan. Accompanying the heavy industries located inside the metropolitan, Kaohsiung has had a long history of pollution problems. According to Michael H. H. Hsiao, a prominent sociologist in Taiwan, Kaohsiung has become the most polluted area in Taiwan (1987: 30).

On July 1, 1968, Kaohsiung municipality was redesignated as a special municipality under the direct jurisdiction of the Executive Yuan, the cabinet of Taiwan. The Kaohsiung municipality government was then headed by a mayor appointed by the President on the recommendation of the Premier. Citizens of KM were deprived of their right to elect their mayor, who thus represented the government, not the people in KM. The village of Houchin was under the jurisdiction of the Kaohsiung municipality government which always played a passive role in the anti-naphtha cracking plant issue.

The KRP and the Case of Houchin

The KRP is located in northern KM and owns 30-40 different small petrochemical plants. It was first constructed in the Japanese colonial period. After the Second World War, Taiwan was controlled by the government of the Republic of China, and the administration rebuilt the plant. The history of KRP is more than fifty years old, and it also has a prolonged pollution tradition affecting surrounding communities, especially Houchin, a village adjoining the north boundary of the KRP. The KRP produces severe air, water, and noise pollution. Sulfur dioxide (SO_2) is abundantly produced in the processes of refining. Black smoke, which includes offensive odors, is frequently discharged from the plant. For example, the KRP received 160 tickets from the KM's EPA bureau in 1989 because of air pollution. In addition, the plant poured black, smelly water into the nearby Houchin River. The groundwater was totally polluted and saturated with oil. The plant also yielded a great amount of noise.

In June 1987, the CPC's plan to build a large naphtha cracking facility inside the KRP, the fifth naphtha cracker in Taiwan, had been disclosed by the mass media. According to the CPC, the reasons for the construction of this plant were: 1) the demand for petrochemical raw materials in Taiwan was greater than the supply; 2) to stabilize the supply of petrochemical raw materials and not to rely on importation; 3) the petrochemical industry was very important for Taiwan's economy; and 4) the government wanted to use this plant to substitute for the first and second naphtha cracking plants because of their inefficiency and heavy pollution.

Economic considerations were cited as the grounds for building this plant inside the KRP. The CPC said: 1) the fifth naphtha cracking plant could get its raw materials and deliver its production to the petrochemical complexes very easily because there were fixed transportation lines among them and 2) to construct this plant in another place would cost the government lots more money than to build this plant inside the KRP.

However, the executing of the building plan had occurred one year earlier than the date when the plan was leaked to the public, June 12, 1987. In February 1987, a contract was made between the CPC and one American construction corporation, and the CPC had paid one million US dollars. Several months later, the residents of Houchin were very angry about the disclosed construction plan not only because the CPC did not ask for their opinions, but also because the CPC had not yet resolved many serious pollution problems. The residents in Houchin had pleaded with the state and the KRP many times about the problems of environmental pollution in their community, but they did not get any positive responses. Although the CPC promised to do a better job on pollution control this time, the villagers could not believe the CPC's guarantee.

Angry residents of Houchin village lodged many strong protests against the construction plan in late 1987. The protesters maintained that they would not stand any more pollution, coming from the KRP, which they had suffered for more than four decades. Enraged villagers demonstrated in Houchin village and protested many times in front of the gates of the KRP. The Anti-Fifth Plant Self Help Committee (AFPC) was formed in Houchin on August 5, 1987, and became the key organization for the protest.

AFPC led its followers not only to protest outside the KRP but to demonstrate many times in front of the Ministry of Economic Affairs and the Legislative Yuan, the Congress of Taiwan. Both of these institutions were located in Taipei, 180 miles north of Kaohsiung. On October 20, 1987, hundreds of Houchin residents demonstrated outside the Legislative Yuan, because one legislator had called the protest activities a riot and asked the government to use force to stop them. The residents wanted an apology from this legislator. One serious conflict erupted between the Houchin residents and the police because the police forbad Houchin residents from going into the Legislative Yuan to urinate.

The anti-naphtha cracking plant movement became a renowned event after the protest in front of the Legislative Yuan received wide media coverage. The protest activities received much support from scholars, students, members of the Democratic Progress Party (DPP), some mass media, and other environmental organizations. For example, on October 27, one explanatory meeting had been held for the public; some legislators, professors, and representatives from environmental organizations accused the police of not behaving well in the clash.

The State's Responses to Environmental Protest

1) Technological Fix

Technology was the best weapon for the government to obstruct environmental protest in Houchin. The government reiterated that the deteriorated environment in Houchin could be well treated by a panacea of newly developed technologies; it also attacked and labelled the civil protest as irrational and anti-progress behavior because the Houchin community did not accept the technologies. In this regard, technology became a neutral, rational, and progressive factor. Any political activities should abide by the decision of technology, and the only way to solve environmental pollution in Houchin was to accept the new technologies.

To reduce the environmental pollution, the CPC promised to implement a three-year pollution control plan from 1989 to 1991, which would cost US$488 million dollars. In this plan, the CPC tried to reduce air, water and noise pollution discharged from the KRP. The CPC dug thirty-one wells and installed seventeen diaphragm pumps around the eastern gate of the KRP. These pumps were intended to pump out polluted groundwater. The CPC also reconstructed the drainage ditches to prohibit the waste water from permeating the soil and becoming a part of the groundwater. In addition, the CPC constructed three new waste water treatment plants inside the KRP.

In order to reduce the emission of sulfur dioxide, the CPC soon changed the fuel for the refinery, and it planned to switched to liquefied natural gas in March 1990. The CPC built a 150-meter stack in April 1988 to spread smoke and dust high in the sky. In addition, the CPC tried to use new technology to reduce the odor coming from sulphur, and also constructed one air pollution monitoring station. With the purpose of diminishing noise, the CPC built a soundproof wall and a 60 meter greenbelt around the northern KRP.

On the one hand, the government tried to improve its image as an environmental vanguard through the installment of new technology inside KRP. On the other hand, it also ruthlessly accused the protesters of exhibiting irrational behaviors because they did not accept the technology. The former chairman of the Council for Economic Planning and Development asked the Houchin residents to act rationally when the KRP's gate was blocked. The former Vice Minister of Economic Affairs also charged that the protest activities were irrational, and he suggested that the villagers needed to talk with the government to solve the problem.

The argument of irrationality put overwhelming pressure on AFPC. For example, two gates of the KRP were barricaded after the conflict occurred on October 20. The KRP shortly announced that it would suspend all works. The decision to shut down the KRP was rejected by the Ministry of Economic Affairs, which indicated that it would hurt the economic development in Taiwan. On October 22, after consultation between the police and AFPC, the latter decided to revoke the blockage in front of the north gate. The reason for this decision was because AFPC received heavy pressure from the government which accused it of jeopardizing the economic development of the entire country. In addition, AFPC wanted to get rid of the image of riot and irrationality.

In August 1988, the environmental impact assessment of the fifth naphtha cracking plant issued by the Environmental Protection Agency concluded that the construction of the plant could be conditionally accepted. The major condition was that the CPC needed to do an extraordinary job in pollution control. This conclusion was not accepted by most of the local residents, who not only believed the CPC would soon forget its promise to the extraordinary condition, but also doubted the EPA had the will to force and to monitor the implementation.

2) Promote Friendly Relationships with Houchin Residents

The strong protest coming from Houchin forced the CPC to promote friendly relations with its neighbor. The CPC soon decided to install free tap water for the Houchin residents and to supply funding for local community activities. It also agreed to repair drainage ditches and roads in Houchin at no cost. In addition, it provided employment opportunities and student scholarships for Houchin's residents. It also planned to construct a local hospital, a swimming pool and a library for the Houchin community. These efforts to promote friendly relationships were not fully appreciated of by Houchin residents. According to CPC's publication, Houchin residents derided these activities by saying that "the CPC just wants to improve public relationship with us, but it does not want to solve the pollution problems" (Lin, 1989: 45).

3) Stimulate Dissensus in AFPC and Support the Referendum Option to Continue Negotiations

In early 1990, internal conflict between two factions of AFPC was surfacing. The two factions were the Eagle faction, which steadfastly opposed the construction of the plant; and the Pigeon faction, which agreed to negotiate with the CPC. AFPC was restructured on April 1, 1990 and the Eagle faction lost power to the Pigeon faction, which subsequently controlled the operation of AFPC.

The Pigeon faction suggested holding a local referendum to decide whether the plant could be built inside the KRP. The background for this suggestion, on the one side, was because the anti-plant movement had gone on for almost three years, and the people of Houchin wanted to settle it so that they could go back to their normal lives. On the other side, the government also anxiously wanted to resolve this problem. The CPC had worked hard to develop friendship with the Houchin residents. With the winning of the Pigeon faction in the reformation of AFPC, the government believed most of the Houchin residents agreed to negotiation at this time. So the government also conceded to have this referendum, and agreed to take the result seriously.

On May 6, 1990, a historic local referendum was held in Taiwan. The atmosphere in Houchin was very calm because AFPC insisted on playing a "neutral" role and rejected any help coming from other environmental groups and DPP. Even the Eagle faction was threatened by AFPC not to have any protest activities. For example, Tian-sheng Hwang, who headed the Eagle faction, was forced to cancel a speech because the Pigeon faction disagreed with his arguments.

With high voter turnout, the result of this referendum showed that 4,499 (60.8%) of Houchin's residents disapproved of the construction plan, and 2,900 (39.2%) residents agreed to negotiate with the government. The result cheered AFPC supporters as well as environmental groups throughout Taiwan. They thought a long fight could be finally closed. On the other hand, the outcome really surprised the CPC and the government, but they soon proclaimed that the referendum was just for consultation and the plant must still be built. The government asked the CPC to continue to negotiate with Houchin residents. This decision shocked Houchin residents who felt they had been cheated by the government and AFPC.

4) Authoritarian Rule and Compensation

On June 3, the cabinet was reshuffled, and the Minister of National Defense, Pei-tsun

Hau, became the new Premier. He maintained the construction of the fifth naphtha cracking plant was the priority job on his calendar. The new Minister of Economic Affairs went to Houchin to communicate with local residents in the following months. The major agenda in their discussions was the amount of compensation, and how to reduce environmental pollution in the KRP.

On October 22, 1990, 6,000 police and ten court prosecutors were stationed at the KRP, and the government proclaimed ground-breaking for the fifth naphtha cracking plant. The government declared that any illegal and irrational protest would be punished by law. The administrator who supervised the ceremony on that day took a helicopter to the scene because he feared the local residents would block the gates of the KRP. According to the government's announcement, the reason for the construction of the plant was that the state had met Houchin's requirements, which were: 1) the CPC promised to move the KRP to another place within the following twenty-five years; 2) the assurance of reducing environmental pollution in KRP; and 3) a compensation of US$60 million to Houchin community. Under comprehensive political pressures, the atmosphere in Houchin was very quiet on the ground-breaking day. The anti-naphtha cracking movement had finally been dissolved.

Cooptation and Taiwan's Environmental Movement

Examining the environmental movement in Houchin, the author finds that an ideology of technological and economic determinism has become a powerful weapon for the government to defuse environmental protest in Houchin. Any protests coming from Houchin's residents were labelled as irrational, anti-technological activities by the giant monster — the state, which also controlled most of Taiwan's mass media. Houchin residents were described as the new Luddites. This bad image gave Houchin's inhabitants comprehensive pressures and stimulated dissension in AFPC.

Gradually, the rational proclamation was accepted by the Pigeon faction which finally controlled the operation of AFPC in 1990 and dissolved many protest activities. At this moment, the issue of the construction of the fifth naphtha cracking plant had been transformed to the issue of how much compensation is enough for Houchin's citizens to accept the plant. Once again, Houchin's citizens were criticized by the state controlled mass media which indicated that the "true" purpose for Houchin's civil protest was because the citizens wanted to have a great amount of compensation. The original goal of stopping the construction of the fifth naphtha cracking plant was obscured by the monetary request. The protest activities gradually lost public support because those people who could sacrifice their living environment in exchange for money were not felt to be deserving of societal respect.

In fact, compensation was not the demand of Houchin residents. The referendum on May 6, 1990, verified that Houchin residents did not want to have compensation; on the contrary, they wanted to have a safe living environment and wanted the government to cancel the construction plan. Unfortunately, this request was refused by the authoritarian state. Without the consensus of Houchin people, the state truculently broke ground for the fifth naphtha cracking plant.

The civil protest in Houchin was defeated by the enormous state, which sought to mute environmental protest in Houchin by promises of new technology to fix the problems of older technology, and by promises to move polluting industries to remote areas in 25 years. Although the state installed many new technologies in the KRP and supplied a great amount of compensation, the Houchin residents did not fully appreciate these activities because they had lost their belief in the government's promises to improve the quality of the environment in Houchin. Their protest activities could not be described as irrational behavior, and could be justified by the political values of democracy and governance.

Conclusion

Under Taiwan's rapid industrial growth strategy, environmental pollution in Houchin is treated as though it is a "normal" risk of development. After the emergence of protest in Houchin, the government reiterated that environmental pollution could be controlled by newly developed technologies, and charged that the village's rejection of the plant was irrational and anti-progressive. The government assumes environmental pollution to be a problem of "social costs" and regards new technology as the most effective means to lower these costs. In this context, greater importance is given to expanded production capacity and technological innovation. Political and social values, such as equity, environmental balance and governance are all marginalized. The powerful and authoritarian state not only restricted citizens' participation in the decisionmaking process, it also rejected the result of Houchin's democratic referendum, which it had supported. Finally, despite the rejection of the Houchin community, the state employed its hegemonic power to construct the fifth naphtha cracking plant.

The environmental protest of Houchin indicates that Houchin's residents were not satisfied with the authority of technology, and were willing to challenge the authoritarian state. They wanted to have a safe and healthy environment in their community, and asked to participate in the decisionmaking process. Although the protest did not prevent the government from the construction of the fifth naphtha cracking plant, it did have significant achievements for Taiwan society. It not only forced the state to make profound concessions but also showed the injustice of the government. This event also displayed the wrongdoing of the ideology of technological determinism, and gave Taiwanese a distinguished opportunity to reconsider development alternatives in their future.

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STS Collegiate Programs

DESIGN METHODOLOGY IN STS PROGRAMS

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1. What is Design Methodology?

Design is a core activity in technology. It is not possible to give a good impression of what technology is without mentioning design. Design integrates the use of natural phenomena, that are studied in (natural) sciences, technological tools and methods and social demands and constraints. Design methodological analyses show how scientific, technological and social factors interact in the creation of new products and processes. According to Bochenski (1965), methodology is the theory of the application of the laws of logic to various fields. Design methodology then is the study of how in design a logically correct use of different types of knowledge takes place or can take place. Although this definition seems rather narrow, it correctly emphasizes that methodology is not only the study of methods in the sense of prescriptive step models.

Design methodology is a rather young discipline (no older than about 30 years; see Cross in De Vries 1993 for a short history of design methodology). Historically, the first concern of design methodology was to produce prescriptive representations of design processes (see for example Pahl and Beitz 1991). Usually, they were based on the following two premises:

- the description of the design process is independent of the technology or product type that is involved,
- the design process contains three steps in the order of analysis of the problem, synthesis of possible solutions and evaluation of the design proposal.

Both premises were challenged by research that showed that there are significant differences between the design of different types of products and that designers, throughout the design process, engage in analysis, and synthesis and evaluation activities. It also became clear that prescriptive design process models can have a negative influence on the design process: they tend to become so autonomous that the relationship with the changing scientific, technological and social context is forgotten during the process, because all effort is put into 'blindly' following the steps in the process.

Still today two 'cultures' of design methodological research can be distinguished (De Vries in De Vries 1993):

- a 'culture' that focuses on the 'internal' design process (i.e. without regarding social factors). Here we find practicioners in particular from construction

engineering and mechanical engineering (who are interested in the design process representations in terms of flow charts and step models), cognitive psychologists (who study the way designers think), business studies experts (who develop methods for relating design to production, logistics, marketing, etc), and computer experts (that work on software for supporting the design activities),
- a 'culture' that focuses on the scientific and social context in which design activities take place, and in particular the various scientific and social factors that influence design. Here we find historians (who study the way designs have evolved during different historical epochs and among different settings), philosophers (who study the nature of the knowledge that is involved in design), (natural) scientists (who study the science-design relationhips) and sociologists (who focus on the social actors that influence the design).

Especially in the second 'culture' we find the science-technology and technology-society relationships, that are the key issues in STS programs (see Staudenmaier 1985 for a survey of the type of studies published in the international journal *Technology and Culture*, that can be seen as representative for this 'culture'). Therefore in this paper this 'culture' will be the one in which we are interested. It should be noted, that this 'culture' often is known better by its broader name 'technology dynamics'. The study by Vincenti in which he characterised the types of knowledge that designers use and the way these types of knowledge are developed (Vincenti 1990), belongs to the field of design methodology (more specifically: design epistemology), but was not qualified as such explicitely. Usually the term 'design methodology' is equated with the first 'culture'. However, the meaning of the term according to, e.g., Bochenski (1965), does not support this equation.

2. Types of STS programs

If we look at the various programs in which scientific-technological and social knowledge is brought together, we can roughly distinguish two types of such programs:
- engineering based programs: these programs educate engineers, that in the first place have a thorough basis of engineering know-how, but in addition to that some knowledge of the social circumstances under which technological developments take place, so that in developing new technologies they are aware of social needs and constraints;
- social science based programs: these programs educate social scientists with a special focus on technological developments.

Usually programs of the first type are concerned primarily with the development of new technologies, whereby social factors form a boundary condition for these developments. The engineers that have been trained in such a program are able to make decisions about possible developments that are based on insights in a combination of scientific-technological and social factors. The second type of programs deals more with the consequences of implementation and diffusion of new technologies in society. Here an understanding of the technology itself is a necessary condition for understanding the way this technology is implemented in certain parts of society. The role of various actors in this process is studied.

Some programs have a hybrid character. The 'Technology and Society' program of the Eindhoven University of Technology trains engineers, that can contribute to policy making with respect to technological developments: these engineers do not develop new technologies themselves, but carry out research that supports technology policy making.

3. The role of design methodology in STS programs

As design methodology deals with the development of new technologies and products, the first type of STS programs, mentioned above, yields opportunities for integrating design methodological studies into the program. Here design methodology could play the role that technology assessment plays in the second type of STS programs. In a way design methodology and technology assessment are analogous: both are aimed at integrating scientific-technological and social know-how for decision making on technological developments. The difference is, that design methodology supports decision making for development of the technology, and technology assessment supports decision making for the implementation of the technology. In fact the boundary becomes blurred when technology assessment moves into the direction of 'constructive' technology assessment, whereby the impact analyses are used to influence the way the technology is developed (Smits, Leyten and Geurts 1987). But even then the technology assessment analysis is on a much more global level than the design methodological analysis, that deals with a specific product in a specific industrial context.

Design methodology can also be regarded as complementary to theories in technology dynamics - like social constructivism - that focuses on social actors, while design methodology focuses on factors or phenomena (natural and social).

4. The current situation in STS programs

At this moment design methodology does not seem to play a vital role in most STS programs yet. Surprisingly this holds for both types of STS programs. One would expect, that in the first type of STS programs, design methodology would be an element already present. The reason for this lacking of design methodology in STS programs could be that there is a general problem in making real integrations of scientific-technological and social know-how in STS programs. Most programs are multidisciplinary rather than interdisciplinary. Several disciplines are represented as separate disciplines, but there are difficulties in obtaining a degree of integration. Design methodology is particularly aimed at making this integration and therefore could make an relevant contribution to STS programs.

These remarks can be illustrated by looking at a number of different STS programs worldwide. The STS program at the Virginia Polytechnic Institute and State University (VPI&SU) in Blacksburg (VA) USA, has three main components: history, philosophy and sociology. The aim of the program is to educate people for advisory positions in science, industry and governmental bodies. Most attention is paid to medium and long term decisions on the diffusion of certain technologies in society, and in some cases the development of the technology itself. This can be seen as characteristic for a social science based type of STS program, that does not primarily train future engineers. Design methodology is not an explicit part of this program.

The same holds for the TEMA program at the Linköping University in Linköping, Sweden. In this postgraduate course we find four themes: communication, health and society, technology and social change, and water in environment and society. Again the focus is more on the consequences of a technological development for society than on the technological development itself. Here too, we find no design methodolology courses mentioned in the program.

A third social science based program of which the content was studied for this paper, is the Pennsylvania State University (USA) STS program. This program recently shifted from being based in a social science environment to an engineering environment. The content of the program still reflects the history of this program with its main focus on policy making for implementing technology in a socially sophisticated way.
The 'Technology and Social Development' program at the University of Toronto (Canada) is an engineering based program. The students that finish the program are engineers with an extra social awareness dimension. They should be more sensitized to the social restraints for technological developments. The program does not contain a course entitled 'design methodology' or anything of that kind. From the program description is it not clear how the necessary integration of technological and social factors is taught to the students without such a course.

The same can be said of the program "Technology and Society" of the State University of New York (SUNY) at Stony Brook (USA). In this engineering based program the focus seems to be management, and Technology Assessment. Both are not primarily concerned with the specific way in which various products are developed, but take a rather overall and long-term view on technological developments. This is illustrated by some of the materials that are used in this course (e.g., the booklets by E.T. Layton on J.B. Francis and by K. Jeffrey on the historical development of pacemakers). These texts clearly combine technological and social (historical) know-how, but do not show in much detail how integration of technological and social factors took place in the design of specific products. The other booklets written for the program are even less technological in nature.

The 'Social Studies of Technology' program at the Manchester Metropolitan University (formerly the Manchester Polytechnic) in Manchester (UK) consists of the following elements: philosophy (of science), economy, sociology and policy. Here too we get the impression that social subjects and philosophy are taught as an extra to engineering students in the hope that it will enable them to combine that knowledge with the engineering know-how they gain from the rest of their engineering study.

The Massachusetts Institute of Technolology (MIT, USA) has two programs: a social science based program ('Science, Technology and Society') and an engineering based ('Technology and Policy'). Although there are courses that belong to both programs, the difference between the programs is evident: the 'Technology and policy' program is much closer to the technology itself than the 'STS' program where history, psychology and politics are the main issues that are taught. In the firstmentioned program we find courses like 'Engineering systems analysis', 'Technology policy

making processes', and 'Strategic planning', specific courses on environmental issues, law and technology and ethics of technology. Again we see a tendency to stay at a certain distance from the most concrete level of engineering work: the product design. Design methodology is not mentioned as an element in the program.
It should be emphasised that this survey is not a thorough and in-depth study of the content of these programs, but a general impression based on descriptions of program structures and courses in the program. Besides that it should be kept in mind that the fact that the phrase 'design methodology is not mentioned does not in itself mean that the concept is not there. But the total impression of the programs of both types is, that the concrete way in which technological and social factors are integrated in product design is not represented very well in the program.

5. Design methodology in the Eindhoven University of Technology STS Program

5a. Design Methodology courses in the EUT STS Program

The Eindhoven University of Technology (EUT) has five engineering faculties: building engineering, mechanical engineering, technical physics, chemical engineering, mathematics & computer sciences and electrical engineering. There is a sixth faculty for engineering business studies. The seventh faculty is called Philosophy and Social Sciences. It is this faculty that teaches the STS program. All students take engineering subjects from one engineering faculty, chosen by themselves, for about 50% of their study. The other 50% they take social science (history, economy, sociology and law) and methodology of technology courses. Design methodology is a main focus of the methodology courses (philosophy of science is another focus).
Design methodology is taught as one compulsory course (Design Methodology for STS) and two electives (Special topics in design methodology, Environmental issues in design methodology). The content of the compulsory course is the following:

- students are acquainted with the basic concepts of experience-based technologies, macrotechnologies and microtechnologies, and the concept of multifactorial design methodological analyses;
- these concepts are illustrated by case studies: bridge design, the Brabantia corkscrew (De Vries 1994), the Philips Stirling engine (De Vries 1993), the Philips Plumbicon (Sarlemijn and De Vries in Kroes and Bakker 1992);
- a brief survey of other approaches in design methodology is given.

The elective course 'Special topics' is an extension of the core course mentioned above:

- the various approaches in design methodology are explored in more detail;
- more case studies are discussed to illustrate the idea of multifactorial analyses in design methodology.

In the other elective course, design for sustainability is the special focus:

- case studies of multifactorial analyses are discussed to show their relevance for 'green design' (e.g., Stirling refrigerating equipment, the three way catalyst),
- new developments in methods for green design are presented (e.g., life cycle analyses, relationships among the design variables of form, material and treatment). These methods are illustrated with case studies that have been reported in some Dutch projects (Eco-design, Milion, see ref.).

This content of design methodology education was chosen to fit the general goal of the EUT STS program: to educate engineers, who are able to integrate technological and social factors into the decision/policy making process for developing and/or implementing technology. In contrast to the more traditional approach that can be found in business studies, with its general schemes for design processes that are independent of the specific technology under consideration, the EUT approach to design methodology is much more focused on the differences between different types of products. This has to do with the fact that the engineers that are educated in the STS program should be able to contribute to the development of the product. To be able to do that, a generalistic approach is too far away from the engineer's daily practice. The multifactorial analyses that were mentioned earlier, comprise Scientific, Technological, Market, Political, Juridical and Esthetical factors (for ease of use abbreviated by the acronym STeMPJE, introduced by Sarlemijn; see Sarlemijn in De Vries 1993). Students learn in a certain product design case that a survey of the state-of-affairs with respect to these factors, followed by an integration of these factors, can lead to a well-defined set of policy recommendations for the design process of that product.

5b. Students' master's theses on Design Methodology in the EUT STS program

In the final part of their study (about six to eight months) the students carry out a case study in an industrial setting. These studies either deal with STeMPJE analyses for certain products that are to be developed (like the redesign of a telephone set for ISDN-supported applications, or the further development of a communication system for electronic road maps in cars) or deal with certain methods for product design (for example Concurrent Engineering, or Quality Function Deployment). In both cases the students look at the way technological and social factors play a role in the design of specific products. Especially in the case of methods for design there is a clear difference with business study approaches to the same issue. Most studies of that type should be seen in the context of the increasing awareness of the need to include considerations of production, assembly, distribution, use, maintenance, re-use and recycling in the design process. Several studies have indicated the role of good communication between design, production and marketing in the success of product design (see e.g., Cooper and Kleinschmidt in Henry and Walker 1991 and Freeman in Roy and Wield 1992). Publications like Hollins and Pugh (1990) focus on the organisational aspects of this issue and do not take into consideration the need to differentiate between different types of technologies. The students in our program always have to include an analysis of the different types of technologies in their research.

A number of master's theses have been written in the context of integrating environmental requirements in design. Here too, we find the two types of studies that were mentioned above: STeMPJE analyses for certain products (e.g., package for semiconductors and components with Philips Package Design and Development) and methods for 'green' design (the application of life cycle analyses in industrial design processes by KEMA, a Dutch organisation for energy research).

The results so far are quite satisfactory for the companies for which the studies were done. The work done by the students was relevant enough for the companies, that several masters' theses could not be published because the information in them was judged too important and viewed as proprietary. One example of this was a study done with a major corporation in the Netherlands, where the design process of a project was analysed in terms of the extent to which STeMPJE factors had been taken into account in the decisions about the design process. It appeared that the design process was so rigid that there was almost no sensibility to the changing world outside (a changing market, actions of competitors) during the design process. Management had introduced the concept of a product manager with the intention to guarantee this sensitivity, but the study clearly showed that the responsibilities of the product manager were insufficient to fulfill this expectation. The results of this study were used when the EUT design methodology group was asked to serve as external consultants for Philips Corporate Design in defining the character of their 'High Design Process'. Philips Corporate Design has gone through several organisational changes already (see Heskitt 1989) and now under the direction of Stephano Marzano seeks new ways for customer values' involvement in the total design process (in fact this very much resembles Bernsen's 11th principle of design management; see Bernsen in Oakly 1992).

5c. Discussions on the future of the EUT STS program

The success of such studies does not mean that there are no problems. In fact the EUT STS program faces the same problems that Cheek (1992) identified for STS programs in the K-12 area (primary and secondary education):

- opposition of the traditional programs (in this case the engineering programs),
- staffing (finding faculty members that in themselves combine a technological and a social science background),
- multidisciplinarity (making a real integration of technological and social know-how).

The position of design methodology is certainly not unchallenged in the struggle for determining a clear profile for the program. A decision to restrict the focus of the program to technological diffusion processes only would solve some of the problems mentioned above (a purely social science based staff would be satisfactory then), but could result in a view that design methodology is no longer relevant to the program. But in that case, as the program is part of a university of technology, the distance to the other (engineering) faculties would increase substantially and the position of the program within the university with its orimarily technological character could become questionable. It would also be the opposite of the increasing role design activities plays in the STS and technology education in the K-12 area, that can be observed in many countries worldwide (De Vries in Gordon 1993). Further international exploration of the possible role of design methodology in STS programs could be useful to support the statement made earlier in this paper, that design methodology offers an almost unique opportunity to make a real integration of the S, T and S in STS programs.

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AUTOMATING A TECHNOLOGY COURSE FOR LIBERAL EDUCATION: A PROPOSAL FOR CHANGE

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As students from today's educational institutions graduate and go forward to business, industry, and other institutions, it is critical that they develop a sense of responsibility to apply technology for the improvement of society. To help prepare college graduates for the technological world market, institutions must help them identify and manipulate those characteristics of technology that can better serve our society. The upper division course being presented here should challenge undergraduate students to apply the theories developed within it and other courses. The students must also be challenged to consider the ethics of situations based on the interdisciplinary nature of their liberal education and the impact of the technology involved.

This proposal was designed to review the content of and develop innovative instructional materials for the course, "Technology Systems in Societies." A brief backgound of the course is presented in the following:

Background of the Technology Sytems in Societies Course

The course, Technology Systems in Societies, has been a part of the liberal education offerings at Bowling Green State University (BGSU) since its inception in 1986. Typically, 150 students are enrolled annually in the course.

During the summer of 1988 Technology Systems in Societies, was offered to approximately fifteen nontraditional students at the Firelands College campus of BGSU, located in Huron, Ohio. The majority of the students were manufacturing technology majors between 25-50 years of age, and full-time employees in various industries in the local area. The majority of these students were 2+2 transfer students entering their junior year of studies at BGSU.

It was during the summer of 1988 offering of the course that the idea for this proposal was conceived. At this time, the course was taught by employing one-way televised media from BGSU with interactive audio teleconferencing. The course was offered during two evening sessions each week over an eight week summer semester with regular reading and writing assignments. The off-campus students were brought together with the professor and on-campus students through an audio link that allowed questions to be asked and answered in either direction. A supporting graduate assistant was on-site with the off-campus students and the professor visited the off-campus students periodically during the semester.

Two major issues became apparent as a result of the experiences in the initial delivery of the course and its presentation off-campus. These are listed in the form of the following research questions for the study:

Research Questions

1. What content should be included in an upper division liberal education technology course?
2. What delivery systems should be used to deliver a liberal education technology course to traditional and nontraditional students in on and off-campus settings?

Rationale

Liberal education about technology is becoming well understoood by some educators. The rationale for pursuing such a project is also based on the belief that while technology and culture have changed, education about technology has not.

Because technology is shaping the way we live, it should be studied and understood by all members of society. A better understanding of the implications of technology can be developed by using careful design, analysis, and applications of the technology itself. It is also important to understand the ethical ramifications that the applications of the technology brings out.

We live in a technological culture that is becoming increasingly complex. As technology is proliferated world-wide, problems and issues associated will increase and become more difficult to resolve. This is true because people from other cultures will attempt to become high technology cultures and the resources required to do that will, correspondingly, diminish. As the transfer of technology occurs, significant issues to be addressed include food production, housing, transportation, environmental clean-up, resource depletion, education and retraining, waste reduction, genetic engineering, energy alternatives and production, medical technology and health care priorities, etc.

<u>Background</u>

But just because we live in a technological society does not mean we understand the technology. And even though we are consumers and users of technology and its products, this does not ensure the technology is under control. This is a particularly worrisome thought if the statements about the proliferation of technology are correct. We must acknowledge the relationship of technology to events of wartime initiatives. Presumably, it was technological issues (e.g., energy resources needed to power our energy-intensive technological culture) that drew us into the recent Mideast crisis. It was clearly strategic technological applications that won the war. The technological strategies used in this wartime effort, more than any time before, required broad knowledge of technological systems including the relationships of technology to people, their cultures, and the environment.

As this may relate to educating post-secondary students it should be apparent that understanding technology is not a simple matter. There are individuals who advocate addressing technological understanding simply by requiring a course in computer science, the hard sciences or mathematics. Although the aforementioned courses and areas of study are important for applying various technologies to improve the human condition, understanding technology goes far beyond this. The computer is one of the most important current and future technologies, and students should be proficient in its use. Students should have a firm grasp of scientific principles and the tools of mathematics. However, it is imperative to understand that these tools may enhance technological understanding, but by themselves they do not accomplish it.

For individuals to be technologically literate and capable of applying and controlling technology, they must understand scientific and mathematical principles as well as computer capabilities. Similar to computer issues, environmental issues require a broader understanding of technology to enable people to apply adequate and appropriate solutions. This necessity is part of the reason why students should study the broader concepts of technological systems, including their components and system-related implications. Issues related to the environment, computers, etc., will be better understood and addressed within the broader context of technological systems.

In order for students to be responsible citizens and productive problem solvers, they must have a reasonable understanding of what makes technology work. Such an understanding encompasses both physical and social experiences. It includes issues or activities such as: costs of technology, physical functioning of technology, problem-solving functions, technology assessment, systems analysis, technology innovation and experimentation, energy resources and the environment, human and social relationships to technology, quality and productivity enhancements, and ethical and moral decision making.

If we consider the technological transfer problems previously identified and the issues or activities that should be studied, it is easy to see that technological literacy crosses many traditional disciplines. Technology as an area of study is more complex than many individual courses and integrates these into a much broader interdisciplinary perspective (Broudy, 1960). Ultimately, the advancement of technology and the myriad choices of study it presents to the academic community will cause educators to consider restructuring the entire educational system so that students will be able to adequately understand and control our technological culture as it relates to the global environment.

The academic community must study issues related to liberal education and needs to contemplate ways to improve liberal education for all undergraduate students (Whitehead, 1932). These could range from refocusing liberal education so that it is more classically-based, to redefining the emphasis and functional understandings so that they relate in a more interdisciplinary way to all areas of study within post-secondary institutions. Such a change must include technological literacy, assuming we wish to improve upon current and past circumstances.

Much healthy discussion and debate is occurring across the country regarding the best approach and content for educating our students (Kanigel, 1986). It is significant to note that we may now have the opportunity to take the bold and necessary steps toward fulfilling the goals of liberal education. If through education we are truly liberating persons for their futures, it would seem that we have a moral and ethical obligation to provide technological knowledge and experience as part of that education. Can students think they are well prepared to function as problem solvers and be viable participants in a technological culture if they are technologically illiterate?

REVIEW OF LITERATURE

In this review of literature, technology is presented as a liberal education topic. Content areas for a technology-based liberal education course are isolated. Finally, educational technology is reviewed for suggestions of possible means to automate the educational process in a technology-based liberal education course.

Technology as Liberal Education

There is some discussion on the integration of technology into liberal education as is described by Kanigel (1986) when he stated that, "The one right way of bringing technology into the liberal arts is a long way off. The field is yet in its infancy-still fluid, still tentative and still sometimes boldly innovative, touching off sparks of creative fire where seemingly alien disciplines touch" (p. 22).

Morton Tavel who was a physics professor and director of Vassar's Science, Technology, and Society program believed that upon the completion of college, graduates should have an understanding of basic concepts of science and technology, as much as they know about English literature (Kanigel, 1986). Another view of this is presented in the statement "The great sin is not lack of brains, but lack of cultivation is a principle and a promise that the science of education is obligated to redeem, and there is reason to believe that it can redeem it" (Broudy, 1960, p. 24).

Preparing Students for Life in a Democratic Society

As indicated by Broudy, liberal education is aimed at preparing citizens for meaningful lives by developing talents directed toward self-realization and self-fulfillment. This development of individual capacities and talents was termed intellectual development by Whithead (1932) and is what he described as making liberal education an important factor in a democratic society. Liberal education must be designed to free humankind from ignorance, prejudice, and narrowness by providing information, awareness, and understanding about various life issues. The purpose of a liberal education is to provide a comprehensive understanding of human knowledge and culture and to develop an orderly mind (Ducasse, 1958).

Greene took a classical view of liberal education and he elaborated on how it influences the body politic and religion in a democratic society in the following statement:

> In proportion as it is truly liberal and vital, all its members, as younger and older scholars will be intensely concerned with the most urgent problems of mankind--with scientific and technological advance, with

political power and social justice, with the multiple moral rights and duties, and with the challenges of religious aspirations and belief. (Greene, 1953; 43)

Since the early 1970's, courses involving the subject matters of science, technology, and cultural issues are regularly included in liberal arts curriculum plans (Kanigel, 1986). Kanigel maintained that the need for students to understand technology, how it affects society, and how society influences the use of technology is based on technological literacy.

Technological Literacy

Technology, as a part of the student's core curriculum, helps to unite different aspects of various courses to better understand their relationships and benefits. Johnson (1992; 271) stated, "When dealing with technological advances and their impacts on society and the environment, an integrated understanding of mathematics, science, and technology is, without question, needed to make quality decisions. Without an explicit attempt to integrate these fields in school, it is doubtful that students will recognize their importance and be able to integrate the subject matter on their own." Waetjen (1987; 13) elaborated further by stating that technological literacy is truly a "legitimate field of liberal education."

Virtually all human functions are affected, either directly or indirectly, by technology. When students graduate and enter the workforce, they must be capable of integrating their knowledge and experience with the technological circumstances they manipulate. Business and industry are looking for workers capable of understanding and manipulating several facets of their work environment. For this, the workers need to possess the ability to mix their work experiences and the pot-pouri of liberal education they have received to think creatively, solve problems, and make decisions. An understanding of technology, combined with well developed intellectual skills, will allow for the workers to make critical issues regarding technological issues (Johnson, 1992).

Technology should be taught as part of the liberal education curriculum to enable students to better understand technological behaviors, technological systems and their complexities. Students in higher education should acquire sufficient knowledge to be able to control technology, both as participatory democratic citizens and for individual control for safety and quality of life. Peterson (1992) helped describe how contemporary technology fits into the liberal education tradition as being "at the core of education" due to its multi-disciplinary nature. He also discussed that it breaks down the barriers between the academic domains--integrating them in the process.

People also need to prepare for the transition from an industrial society to an information society. Individuals must be able to understand this trend if they want to take advantage of the benefits and avoid the problems (Naisbitt, 1982).

Problem Solving

Addressing the needs of undergraduate students in the American higher education institutions, Splete (1986; 21) pointed out that technological literacy is requisite to problem solving:

> Because the technological methods and problem-solving techniques of the engineer are so much a part of our society, we need to educate our undergraduate students about them. This requires much more than simply making our students computer literate. It is time for educators to rethink and defocus the traditional liberal arts curriculum to include study of technology. In addition to introducing them to the traditional methods of inquiry of social sciences, humanities, and natural sciences, we need to help students develop the skills of technological reasoning and decision-making. This is important now, but it will become imperative as technology becomes an increasingly powerful force in our society.

From this it is surmised, that only after becoming technologically literate can the student do a competent job of problem solving.

Mioduser, Venezky, and Gong (1992) described the value of integrating science and technology courses in liberal arts subjects for potential problem solving applications. They implied that it was the application phase of the instructional process where the liberal education content was used to solve sociological and technical problems. Problem solving is a technique that should grow over an individual's lifetime.

Lifelong Learning

The teaching of technology must be interdisciplinary. Furthermore, it should not be restricted to students who will be future leaders as most of our students do not fall into this category. As educators, we hope graduates will contribute to the development of society through their individual creativity, their relations with family and friends, their jobs, and their roles as citizens. In each of these directions, the individual interacts with a highly technological environment. Education should develop capabilities for lifelong learning in all of the disciplines that contribute to that environment (Truxal, 1986).

Since American higher education institutions have traditionally focused on the preparation of liberally educated citizens, shouldn't these citizens have a reasonable understanding of technology in our technological world? The increasing need of our society for individuals who are able to understand, apply, and control technology, mandates that higher education institutions provide students with an opportunity to understand technology and learn how to live in the technology-based environment. However, only selected undergraduate students--students in science and science-related disciplines learn something about the technological world (Westheimer, 1987).

The literature suggested that preparing students for life in a democratic society, technological literacy, problem solving, and lifelong learning are the areas that need to be covered in a technology-based liberal education course. Various forms of educational technology that can deliver those content areas in an automated format are presented in the discussion that follows.

Educational Technology

The literature on educational technology was reviewed as it relates to the delivery of a technology-based liberal education course. The following media areas were isolated as being particularly applicable to the proposed delivery of the automated liberal education-based technology course.

Video Media Implications

Soloway (1991) discussed the use of video discs as an interactive, self-learning multimedia package that promotes user's creativity and self expression. These interactive programs can be fun for the user to participate in and are potentiallyt more acceptable as learning strategies. Soloway also discussed the use of desktop video as it enhances individual thinking skills in educational packages. These game-like qualities were found to be of some use in motivation and simulation that will be developed further later.

Classroom videotaping allows for students to review lectures and student presentations, thus self-analyzing the tactics they took in responding to problem oriented activities. Students progressively get better at identifying and responding to problems in general, whether they are in school, work, or in life itself. While students benefit from visualizing their mistakes on videotape, so willinstructors when they use it as an assessment technique. With the audiovisual record of each student or each group's response to a proposed problem, an instructor is able to guide them for their next presentation and may reference the taped material in the future. The possibility is there to erradicate the memorize-and-forget tactic used for the studying of many tests when appropriate videotaping strategies are employed (Johnson, 1992).

Multimedia Computer Possibilities

Spitz (1994) described the value of computer-based CD-ROM as a means to inexpensively produce multimedia training on IBM-compatible systems. She also described the value of the audio component in such systems as simulating the student being near an instructor. This was particularly true as it related to feedback on the correctness of answers. Spitz also described how "low technology" applications in computer-based training systems may be as appropriate as their high technology counterparts when they better serve the instructional objectives.

Multimedia applications of educational technology often take the forms of video games and experiences. These are powerful bases for delivering instruction in many areas within the liberal education field. When the games and experiences closely simulate the 3-D world they become part of virtual reality which will be disussed later (Lindquist, 1992).

Artificial Intelligence

There are possibilities of using artificial intelligence (AI) as a master guide in the automation of liberal education subject matter. McKenna (1991) discussed the value that artificial intelligence has in interactively ascertaining literacy and then improving students' reading skills. [Here the educational technology is specifically addressing literacy which is a major function of liberal education.] Halff (1986) expanded on that idea by stating that these computer programs are capable of simulating an instrutor in determining that errors were made in a diagnosis phase and formulating plans or strategies to have the student overcome the difficulty.

One of the classical programs that used early developments of artificial intelligence in the learning setting was a program called LOGO (Dennett, 1993). These early programs showed the flexibility that artificial intelligence has in delivering a variety of liberal education subject matter. Artificial intelligence can also be used to simulate the world in three dimensions. It crosses into the world of virtual reality when it does that.

Virtual Reality

Virtual reality involves using the computer to simulate real life situations. Some of these applications approach the very real world of nearly 3-D imagery. Such experiences hold great possibilities in the classroom, but much of their use has been in video games (Lindquist, 1992). As the experience novelty is replaced with well planned subject matter infusion the possibilites for this technology are endless. Wheeler (1991) stated that virtual reality has the ability to simulate areas in Physics, Chemistry, and other scientific areas in higher education. One of the benefits of the virtual reality experience when applied to the scientific areas is the elimination of danger. Students can work with nuclear material or caustic substances virtually and not run the risk of the physical harm that would normally accompany these activities.

The barrier of scale can also be removed via virtual reality. Going into the human body and investigating the interworkings of the immune system can be simulated in virtual reality (Lindquist, 1992). This takes education beyond its traditional dimensional boundaries and limits.

Art is one area where the virtual reality technology becomes the medium of the discipline (Leunfeld, 1993). Art as a subject certainly can include the application of the realistic simulation of virtual reality which would be using the technology as a medium. It also can be used to simulate the imagery of Art, in an art appreciation sense. This artistic media as a form of educational technology makes the application of technology have interesting consequences in the proposed automation of the course.

Distance Learning

Portway (1993) described the advantages of distance learning as costing about half that of traditional classroom training and the use of telecommunications makes it possible to reach diverse geograpically distanced populations that would normally be impossible to reach. The system that Portway described, "Hewlett-Packard's Distance Learning," included networked computer terminals through which both the instructor and the student could have immediate feedback. In this system, there was a keypad form of input used by the student to answer multiple-choice questions. The student ascertained the correctness of the response and this was used to communicate the effectiveness of teaching to the instructor.

After reviewing the literature, video media, multimedia computer possibilities, artificial intelligence, virtual reality, and distance learning technologies were suggested as possible media to present an automated technology-based liberal education course. These discoveries lead to the formation of the following objectives and subsequent project phases to accomplish this proposed study.

OBJECTIVES

In this proposal, several objectives are outlined in the following:

1. To assess the mission, content, and process of a course aimed at understanding technology.
2. To focus specifically on innovative teaching methods, learning strategies, and systems for enhancing the delivery of the course.
3. To develop criteria necessary for the integration of the course as a part of a university core curriculum.
4. To develop the entire course package as a model for distribution in similar circumstances.

In order to accomplish the objectives of this project they have been organized into three proposed phases. The initial phase was designed to start the development of the media for the project on-campus at Bowling Green State University. Phase I is organized as it relates to each stated objective.

PROJECT PHASES

Phase I: On-campus Media Development (January 1994--December 1994)

Phase I was designed to initiate the project over a one year timeframe. The following identifies the benchmarks for the first year of the project:

1. To assess the mission, content, and process of a course aimed at

understanding technology.
   a. Survey on and off-campus graduates.
   b. Receive advisory committee feedback.
2. To focus specifically on innovative teaching methods, learning strategies, and systems for enhancing the delivery of the course.
   a. Develop an abstracted taxonomy of educational technologies.
   b. Select educational technologies from the list that will apply to the liberal education course.
3. To develop criteria necessary for the integration of the course as a part of a university core curriculum.
   a. Establish content required for university acceptance of a liberal arts course.
   b. Determine the criteria necessary for the integration of the course into a university curriculum and assure that it still meets those criteria after being "automated."
4. To develop the entire course package as a model for distribution in similar circumstances.
   a. Break the course into a list of topics that relate to educational technology formats.
   b. Assign educational technologies, as they relate, to each topic of instruction.
   c. Develop a sequence for adapting each topic/unit for application to educational technologies.
   d. Prototype one topic or unit of instruction.
   e. Use the prototyped experience as a model to prototype the other units of instruction.
   f. Package the instruction for duplication and replication on-campus.
   g. Test the package and make changes from the iterations of the running of the course on-campus.

Based on the findings and recommendations found in phase I, and paralleling several of the previously mentioned objectives, the following steps will be taken during phase II which is a second year timeline. The second phase is an application of the media developed in Phase I to off-campus nontraditional students. Phase II is also organized as it relates to each stated objective.

Phase II: <u>Application of the Media in Off-campus Delivery</u> (January 1995--December 1995)

1. To assess the mission, content, and process of a course aimed at understanding technology.
   a. Administer teaching evaluations relating to the teaching methodology (multi-media format) for the course initially on-campus and later off-campus.

b. Tabulate the teaching methodology data from the entire year one experience.
c. Analyze data on the effectiveness of the educational technology used on a case-by-case application basis.
d. Make recommendations for improving the delivery of the course.

2. To focus specifically on innovative teaching methods, learning strategies, and systems for enhancing the delivery of the course.
   a. Develop a summary of the results of the instruction based on the content delivered and the educational technology applied.
   b. Present the results in a narrative format.
   c. Draw subjective conclusions on the applications of the educational technology to the content area delivered.
3. To develop criteria necessary for the integration of the course as a part of a university core curriculum.
   a. Review the criteria required for university acceptance of a liberal arts course.
   b. Reaffirm that the course still meets the criteria necessary for the integration of the course into a university curriculum.
4. To develop the entire course package as a model for distribution in similar circumstances.
   a. Use the prototyped experiences in phase I as a model to prototype all of the units for both on and off-campus presentation.
   b. Package the instruction for duplication and replication on and off-campus.
   c. Test the package both on and off-campus and make changes from these new iterations of the delivery of the course.

In the final phase of the project the findings of the study of the off-campus presentation will be developed into a format that is generalizable to other institutions' technology-based liberal education applications. As done in the preceeding phase, Phase III is organized as it relates to each stated objective.

Phase III: <u>Generalization to other Technology-based Liberal Education Applications</u> (January 1996--December 1996)

1. To assess the mission, content, and process of a course aimed at understanding technology.
   a. Survey recent on and off-campus graduates (after they have undergone the new multimedia instruction).
   b. Receive advisory committee feedback.
2. To focus specifically on innovative teaching methods, learning strategies, and systems for enhancing the delivery of the course.
   a. Develop a summary of the results of the instruction based on the content delivered and the educational technology

applied.

b. Present the results in a narrative format.

c. Draw subjective conclusions on the applications of the educational technology to the content area delivered.

d. Make final changes to improve the instruction after phase II has concluded.

3. To develop criteria necessary for the integration of the course as a part of a university core curriculum.

a. Review the criteria required for university acceptance of a liberal arts course.

b. Reaffirm that the course still meets the criteria necessary for the integration of the course into a university curriculum after final modifications.

4. To develop the entire course package as a model for distribution in similar circumstances.

a. Use the prototyped experiences in phase II as a model to prototype all units for the universal presentation format.

b. Package the instruction for duplication and replication at any institution of higher education.

c. Test the package at several different higher education institutions and make changes from this input.

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POLLUTION PREVENTION ACROSS THE TECHNOLOGICAL CURRICULUM: AN INTERDISCIPLINARY CASE APPROACH

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For the Arts and Humanities, and to some degree for the Social Sciences, the terms postmodernism and poststructuralism refer in part to the blurring, even to the dissolution, of genres and other categories and their subsequent reordering. As Carl Bankston (1994, p.1) writes, postmodernism's view of the nature of humanity:

> offers a stark contrast to the image of "modern man" that has dominated Western thought since the fifteenth or sixteenth century. In place of the modern rational, unitary self dominating a coherent world of discoverable, systematic certainties, the postmodern perspective posits a self emerging from a confluence of diverse experiences, arbitrary forms of social relations, and systems of communication.

Bankston's remark, and the postmodernist impulse itself, are useful if for no other reason than because they force a rethinking of our systems of knowing and education. Whether or not a new and pronounced reverence for the arbitrary is discernible in the social sciences and humanities, what is becoming increasingly clear is that these disciplines are being defined differently than they were a decade or two ago.

In the engineering fields as well, the boundaries of traditional bodies of knowledge are being stretched; and it might not be going too far to claim that these bodies of knowledge may be due for a fundamental restructuring. Such changes are not in the broadest sense unique and in fact they can be viewed to be, especially within the university setting, both normal and necessary. Indeed, if many in these three fields harbor doubts about the changes underway, then comfort might be taken in being reminded of the founding notion of the modern university that began in the Middle Ages. To someone like Thomas Aquinas the Latin verb scire, to know, the root of our modern term science, indicated the activity of acquiring knowledge of a specifically theological nature, for this was knowledge. Yet we already see in Aquinas's thinking the distinct branch of knowledge that came to be called philosophy in the modern world--and in turn the idea of science such as we today think of it, the hard sciences. But of course we need not look back all the way to medieval times in order to present a warrant for today's kinds of activity. Rather, modern developments in mathematics and the sciences--the emergence of particle physics, for example--suggest the limitations and perhaps even the dangers of practicing a single discipline in isolation, as if in a vacuum. The vacuum, the void, by some philosophical lights, is what underlies the manifest world, and so science is science of the world.

The same can and must be said for education. One critical position that underlies the STS enterprise is the assumption that students learn better, learn more, and quite possibly faster, when what they are learning is contextualized within parameters that exceed a single discipline and is integrated with other disciplines--as is coming to be widely recognized in, for example, the engineering field (see, for instance, Mitra, 1992; Robbi & Elliot, 1992; Wyant & Eck, 1992). Embracing an interdisciplinary approach to education, however, will present problems of a practical and otherwise a logistical nature. What, for instance, might be a likely focus for training students to comprehend the engineering impulse and practice within the wider world? On its part, the contextual humanistic-social science approach has given rise to scholarship and fields of study under the general heading of STS--science, technology, and society. Today, the hundreds of participants at this NASTS annual meeting, covering education from elementary school through doctoral programs, and all related fields, are testimony to the interest in the interactions of technology and science with society. STS as a discipline is multifaceted and dynamic. The STS practitioner can focus her or his energies on numerous approaches and projects.

Thus, when we analyze a real-life problem faced by our technological society--environmental pollution, for example--we realize that environmental problems themselves tend to be multi-faceted. Again, they often transcend the scope of any one discipline. Analyzing the environmental impact of a product's package design for instance, requires collaboration of several disciplines: social sciences to provide an economic assessment of the package's life cycle effect on the environment; humanities to evaluate the aesthetics and ethics of design change; natural sciences to provide a toxicological analysis of chemicals in the packaging manufacture and disposal. Interdisciplinary collaboration has therefore become an essential element of any kind of environmental research, planning, and management.

Under an EPA grant, the faculty at the New Jersey Institute of Technology has developed an education plan that addresses complex and interrelated issues in pollution prevention. Since the spring of 1992, it has worked toward the tangible project goal of researching, writing, and assembling a multi-disciplinary textbook that can be used in courses throughout the curriculum of a technological university. Through detailed introductions, case-studies, and interactive student tasks and assignments, the idea of pollution prevention is presented in this book from the perspectives of engineering, social sciences, and the humanities. Chapters include discussions of environmental history, aesthetics, governmental regulation, life-cycle design, philosophy, critical thinking, and international issues--all with a focus on pollution prevention.

The project has now reached the stage where the text with case studies is being implemented in diverse courses throughout major departments of our university. We believe that this multi-disciplinary approach to liberal arts education, as well as to engineering education, in the contemporary university is the first step in a revolution in the technical training of engineers, architects, and other technological professionals. Concern for the environment has proven to be a rich common ground for all these disciplines, where, in fact, the technology of pollution prevention has been an integral part of the New Jersey Institute of Technology's curriculum for several years. Environmental paradigms--of (1) Sustainable Development, of (2) Clean Manufacturing, of (3) Design for the Environment, and of (4) Life Cycle Analysis--have been integrated into existing engineering courses. Now, with the creation of a proto-textbook, these environmental paradigms have been specifically expanded into a framework that includes pollution prevention from a humanities and social science perspective.

The notion of a common (environmental) ground shared by diverse disciplines proceeds, first of all, from the belief that pollution prevention is not just a technical issue. Rather, it is philosophical, ethical, aesthetic, social, political, and economic--thus the development of an interdisciplinary textbook of case studies in which students solve problems that are pragmatic, humanistic, and policy oriented. By employing an environmentally based set of heuristic tools, students complete tasks that emphasize communication skills, research, and critical thinking.

As shown here (in Figure 1, below, the Table of Contents of Pollution Prevention Book), one case study or a number of case studies can be employed in the service of a particular course's ultimate aim.

Figure 1. Contents of Pollution Prevention Book

POLLUTION PREVENTION FROM A HUMANITIES AND SOCIAL SCIENCES PERSPECTIVE

Preface
Introduction: Preventing Pollution at the Source
Chapter 1: From Remediation to Prevention
Introduction
Case Study 1. Understanding the Issues: End of Pipe Strategies Versus Front End Environmental Design
Chapter 2: Definitions and Documents
Introduction
Case Study 2. Developing a Glossary and Writing a Position Paper on an Environmental Issue
Chapter 3: A Critical Thinking Model for Pollution Prevention
Introduction
Case Study 3. Critical Thinking in a Plan for Pollution Prevention

Continued on next page

Figure 1 (continued from last page)

Chapter 4: The Historical Dimension
Introduction
Case Study 4. To Preserve Nature or To Use It? The Story of Hetch Hetchy Valley and the City of San Francisco
Case Study 5. What is the Meaning and Value of "Wild Country"? Robert Marshall, Echo Park and The 1964 Wilderness Act
Chapter 5: The Cultural Dimension: The Visual Imagination
Introduction
Case Study 6. To Live with Nature or to Dominate it?
Two American Architectural Approaches: Skyscraper Versus Adobe and Pueblo
Case Study 7. Exploring the Idea of Nature as a Spiritual Entity: Frederick Church's Nineteenth Century Painting and Ansel Adams' Twentieth Century Photography
Chapter 6: The Cultural Dimension: The Literary Imagination
Introduction
Case Study 8. Exploring the Idea of Nature as a Spiritual and Physical Entity: The Nineteenth Century Writing of Ralph Waldo Emerson and the Twentieth Century Writing of Gary Snyder
Case Study 9. Ethical Science and its Relationship to the Natural World: Journals of Life in the Woods by Henry David Thoreau and Aldo Leopold
Chapter 7: The Ethical Dimension
Introduction
Case Study 10. The Ethics of the Commons
Case Study 11. The Ethics of Restoration and Mitigation
Chapter 8: The Policy Dimension: Economic and Social Context
Introduction
Case Study 12. The Geography of Environmental Policy Decisions
Case Study 13. Overcoming the Car Culture: Developing a Program to Modify Human Behavior
Chapter 9: Policy Dimension: Legal Context
Introduction
Case Study 14. Planning for Ground Water Protection
Case Study 15. Environmental Dispute Resolution: The Phohl Brothers Landfill Case
Chapter 10: The Policy Dimension: Communications
Introduction
Case Study 16. Cutting Through the Red Tape: Reading Environmental Rules
Case Study 17. The Substance and Process of the Pollution Prevention Act
Chapter 11: International Perspectives
Introduction
Case Study 18. International Aspects of Pollution Prevention
Chapter 12: Federal Programs
Introduction
Case Study 19. Federal Government as a Model: Investigating and Implementing Pollution Prevention Practices in Federal Facilities
Chapter 13: State, Local and Small Private Programs
Introduction
Case Study 20. Newark Radiator Repair
Chapter 14: Industrial Programs
Introduction
Case Study 21. Source Reduction Versus Recyclability: The Nine Layers of a Snack Chip Bag
Case Study 22. Industrial Response to Eliminating Halon: An Ozone-Depleting Chemical

A course in manufacturing engineering, for example, might use the book's case study, "The Nine Layers of a Snack Chip Bag," to examine environmental tradeoffs of source reduction versus recyclability in evaluating a design change. Similarly, a course in American literature or in World Civilization might integrate into its syllabus the book's case study entitled "Exploring the Idea of Nature as a Spiritual and Physical Entity: The Nineteenth-Century Writing of Ralph Waldo Emerson and the Twentieth-Century Writing of Gary Snyder."

Even within the confines of a single course discipline, the book might lead students to think of that discipline within a larger field of understanding. For example, several case studies in the book reveal the complexities of ethical decision making. "The Ethics of the Commons: An Examination of the Moral Obligations Regarding Commonly Owned (or Unowned) Resources," and "The Ethics of Restoration and Mitigation: An Examination of the Moral Value of Natural and Restored Environments," ask students to consider their individual conduct as professionals and as citizens within a world of decreasing natural resources and increasing amounts of pollution. These cases and others require students to make ethical, and practical, decisions that impact upon the environment. A case entitled "Ethical Science and Its Relationship to the Natural World: The Nature Journals of Henry David Thoreau and Aldo Leopold," for instance, details the relationship between observation of the physical world and a consequent psychological bond with that world, which leads to feelings of connection and responsibility.

Furthermore, the book provides a pedagogical envelope for existing interdisciplinary curricula within a technological school. NJIT is a participant in an interuniversity, interdisciplinary engineering education project called Gateway. Serendipitously, the book has been and will continue to be applied specifically within the Gateway intiative's parameters. For example, at NJIT a common hour presentation for engineering students on skyscrapers can be augmented by case studies in the book on art and architecture (such as one entitled "To Live with Nature or To Dominate It?: Two American Architectural Approaches, Skyscraper Versus Adobe and Pueblo"). Yet the book can also be used within the context of each Fundamentals of Engineering Design module (which helps to make up the freshman engineering course). And the students in each section of this FED course also take a course called "Writing, Reading, Thinking," which is meant to be complementary. The students discuss poetry in their engineering course. They make oral and visual presentations of their respective engineering teams' individual projects; a group that has been assigned the task of designing and manufacturing a toy, for instance, will have to present its work, not in its engineering but in its English class. Moreover, in conjunction with the FED electrical engineering module, the English class will consider a variety of readings on light--for example, texts like the biblical *Genesis* in which God says "Let there be light," and as well writing by the contemporary poet William Bronk whose poem "The Annihilation of Matter" concludes, "Objects are nothing. There is only the light, the light!" Such classroom activity is enhanced by using the pollution prevention book's case study that compares the use of light in the landscapes of the nineteenth century painter Frederick Turner and those of the twentieth century photographer Ansel Adams. Likewise, with the civil engineering module, whose theme is reservoirs, the English class will discuss and write responses to texts with the theme of water, or employ appropriate case studies from the pollution prevention book. And so on.

While some schools have made successful attempts at integrating social sciences, humanities, and engineering in one course (notable is the Colorado School of Mines' semester-long interdisciplinary seminars that emphasize the role of technology and its impact on social change [Florman, 1992, p.21]), NJIT's focus is to bring pollution prevention into courses across the curriculum. The cases in our volume are subject-related and cognition-related, but they do not include identical tasks. Redundancy, however, is necessary to successful integration of skills. Hence, like the assimilation of writing skills through reinforcement, which occurs in many courses, a holistic awareness of the environment comes from exploring problems and solutions from a variety of perspectives by performing related sorts of inquiry.

Overall we can say that, in solving practical problems, students rethink their personal and civic roles in their world. In our assessment of the field tested volume, students were asked how their concept of pollution prevention had been expanded by using various case studies. One student wrote, "I thought that pollution prevention meant prevention of exhaust from motor vehicles and factories, but now I understand that it can include parts of forests, wetlands, or a valley, such as the Hetch-Hetchy Valley. . . ." Another student wrote, "Until this assignment, I never knew that hospitals produced so much waste and that one patient could produce gallons of waste per day. This case made me more aware." Initial responses of our faculty, as well as faculty from other schools with whom we have spoken, are equally enthusiastic.

Traditionally, people think of the humanities as perhaps a course in American literature, and of the social sciences as a course in, say, child psychology. It would be disingenuous to maintain that these traditional subjects no longer hold sway in our educational and epistemological traditions. Arguably, however, American Literature, as a discipline, thrives when it asserts that there is a place for the appreciation of nature through contemplation of the beautiful, and thereby of the ethical. Likewise, the social sciences may comprise a methodological approach to understanding the environment through empirical data collection. These things should not be otherwise, But what, in fact, requires a deeper appreciation is the potential for these disciplines to adopt environmental paradigms that can create a unique disposition toward pollution prevention and environmental thinking generally, and can deepen and enhance the disciplines themselves.

Finally, our goals are altruistic and pedagogic; technology needs the support of society in order to effect necessary changes for restoring and preserving the natural world. Only when societies, when people, make the effort, can real progress be made. This progress will require interdisciplinary thinking that transcends traditional distinctions and creates new, and in our time, more useful categories of knowledge.

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SHOW ME SOCIAL ISSUES AND TECHNOLOGY

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"Show Me" Social Issues and Technology is a case history of a course at Central Missouri State University. Central is a four-year comprehensive state university located on the western edge of the state, fifty miles east of Kansas City, Missouri. The university serves a defined catchment area of 21 counties plus the rest of the state, the nation, and the international community for specific, premier programs of study. Many of the premier programs are located in the College of Applied Sciences and Technology (CAST).

Social Issues and Technology is a course offered by the Department of Agriculture within the Applied Sciences group of the College. The course was designed to meet the needs of students in the Bachelor's degree programs offered by the department. Because the course draws on material from many fields, it was decided that it should be an upper-division undergraduate course to allow the students to complete their General Education requirements and to be substantially involved in their chosen Agricultural major before taking the course.

There are a number of philosophical reasons for offering this course. Technology, perhaps more than any other single characteristic, has shaped the history, economics, politics, and destiny of the United States. Technology is the basis for, and hopefully will provide a solution to, many of the social issues we face today. For example, environmental degradation, bio-genetic engineering, misuse of computer technology, and preserving the food we eat, produce technology-related social issues that the current generation of college students will have to deal with in the future.

An understanding of the scientific basis and the actual application of technology is an important component of any general education; however, students need to understand the impact of technology on society if they are to develop the vision to be the economic, political, and social leaders in tomorrow's world. The Social Issues and Technology course provides a broad historical background to today's technology as a basis for examining specific technologically-related social issues from a general and/or an economic perspective.

This type of course provides a unique opportunity to integrate material from science, history, economics, political science, sociology, and philosophy in the examination of one of the most pervasive phenomena of our time. The examination of social issues related to technology helps to develop tolerance for other people's points of view, as well as a deeper understanding of one's own point of view.

The course teaching team is comprised of two to four faculty when it is offered. Currently, it is being offered during the fall semester. The five faculty who have taught this course are an agronomist, two agricultural economists, a veterinarian, and a technologist. All professors are present at each class meeting. All faculty members grade all term papers and each faculty member grades his/her own test questions on exams. The presence of more than one faculty member causes a different type of group dynamics within the classroom setting. The faculty at times restrain themselves from dominating the class in order to serve as a catalyst to stimulate discussion or to suggest alternative points of view which may generate questions. After several weeks of faculty involvement, the students become more spontaneous.

The course, in its current makeup, uses two texts that are read by the students as outside readings. One is Technology in America: A Brief History, while th second is the current edition of the State of the World from the Worldwatch Institute. Neither book is lectured from, but both are used as references as appropriate to classroom topics. Exam questions, in the broad generic sense, are taken from the outside readings. The exam questions are always essay in format and require students to present a supportable opinion.

The classroom presentations begin with several class periods devoted to the history of technology. Background material is also presented covering the topics of creativity and innovation, invention, and basic economics. This background material is followed by presentations covering a broad spectrum of subjects as shown in the list contained in Appendix A. At this time the course is primarily for agriculture majors, so much of the material has a direct or indirect agricultural application or relationship; however, a great many of the topics covered are of general interest not only to people working in agriculture, but to everyone who is concerned with the future of our society.

The use of case studies and examples provides students an opportunity to develop their analytical and reasoning skills, while written assignments and oral presentations on group projects develop communications and interpersonal skills. The students, either individually or collectively in small groups of two to four, make oral presentations or form debate teams to report on or to debate subjects such as abortion, NAFTA, cloning, radon gas, or challenged persons. Each student writes a term paper on his/her choice of topics. Examples of topics of past papers are listed in Appendix B. As expected in a group mainly composed of agriculture majors, many of the topics are agriculture-related.

Actual classroom presentations by professors vary in format and style as determined by the professor and his/her topic. For several semesters, the history portion has been illustrated with slides. In the fall, we are planning to use the Ascent of Man video series hosted by the late Jacob Bronowski, to give the students the historical perspective. The computer is used to manipulate the charts and graphs found in the current edition of Vital Signs. We have merged the resulting computer graphics with overhead transparencies to show competing data as well as to project future trends. Many interesting comparisons have been drawn for this class by using a variety of outside references ranging from Preparing for the Twenty-First Century, Beyond the Limits, and The Limits to Growth to "Playboy". By the middle of the semester, the students are beginning to become engrossed in this course and are searching for as much material as possible on the topics presented. The entire classroom is used as a teaching tool as the bulletin boards are used to display social issue topics in a poster presentation format. The poster presentations are, for the most part, self-explanatory.

The students are required to submit weekly annotated bibliography cards on articles, books, magazines, or even newspaper articles about technology and social issues. The faculty encourage the students to direct these readings toward their own term paper topics, but many do not elect to do so. Most students seem to explore their interest of the moment, rather than pursue a single topic for a number of weeks.

Student evaluations of this course have generally been very positive. Students report that the class is interesting, that they like having several faculty members involved in teaching the course, and that they enjoy the class because it is challenging. Criticisms include comments on the State of the World text being too hard or boring, that there is too much work involved in the course, and that the "environmentalist" viewpoint is over- represented.

Some people may think this course is not any different from what you have experienced at your own institution. It may not be. In west central Missouri, this course is unique. The faculty teaching situation is different. The course requirements are rigorous. The students are challenged beyond normal expectations. It is a "Show Me" experience in teaching and learning at Central Missouri State University.

Included after the Appendices are a sample course syllabus from Fall, 1993 and a suggested reference list of books and periodicals available to the students.

APPENDIX A

The Social Issues and Technology course involves an in-depth examination of a number of issues related to technology. Specific issues to be examined are determined in part by the interests of the class. Some examples of issues which have been discussed include:

A. Can we create a "sustainable agriculture"?
B. Gene splicing - man makes himself
C. Acid rain - costs and benefits
D. Electro-Magnetic fields
E. Scientific progress and limits of growth
F. Malthus and population growth - was he right?
G. Computers - yesterday, today and tomorrow
H. The Grand Canyon as a sanitary landfill
I. Radon gas
J. Preservation of species - genetic erosion and endangered species
K. 50 trends shaping the world
L. Earth's greenhouse effect
M. Cows have rights too
N. Technology transfer - the international picture

APPENDIX B

TERM PAPER TOPICS

Birth Control
The Use of Electronics in the Military
The Drug RU 486
Owls vs. Loggers
Soil and Survival
The Study of Modern Cropping Systems and How the Form of Production is Affected
John Deere
Bioengineered For a Better Cropping System?
PETA Under Fire
Earthquake Predictions
Sustainable Agriculture, Fad or Reality
Midwifery
Bovine Somatotropin
The Questionable Safety of Breast Implants
An Agricultural Answer to the U.S.'s Dependance on Foreign Oil
Ozone Layer Depletion above the Arctic and Antarctica
The Greenhouse Effect
Can a Machine Ever be a Mind?
Compact Discs
Ethanol - An Alternative Fuel
Artificial Insemination in Beef Cattle
Conservation Tillage
Henry Ford and the Advancement of the Automobile
The Needs and Benefits of Conservation and No-Till Farming
Technology of Radial Tires in Agriculture
Robotic Technology

Agriculture Department
AGRI 3130
SOCIAL ISSUES IN TECHNOLOGY

INSTRUCTORS:

This course will be team taught by Dean Rosser and Dr. Worman with guest presentations by other faculty. Dr. Worman is responsible for administrative aspects of the class.

TEXTS:

Marcus, A.I. and H.P. Segal, Technology in America: A Brief History, 1989.

Brown, L.R. et al, State of the World: A Worldwatch Institute Report on Progress Toward a Sustainable Society, 1993.

Additional reading material provided as handouts.

NOTE: Specific readings may or may not be discussed in class. Whether or not readings are discussed, students will be held responsible for the reading's content on exams.

PURPOSE:

To impart to the students a historical view of past technologies and the associated precipitation of social changes, socio-economic structures necessary to evaluate the increasing proliferation of technological transformation, and an understanding of how changes promise to affect their lives now and in the future.

OBJECTIVES:

Upon completion of this course, the student should be able to:

1. Discuss the evolutionary process of technology as a result of man's ability to manipulate natural law to his advantage.

2. Evaluate major historical technological advances, their associated resistance, and resulting social adjustments.

3. Analyze the role of the advancement of technology as the critical link in society.

4. Analyze specific topics and studies that relate to current and future social issues both within and among cultures and nations.

COURSE APPROACH:

There are two major components to this course. During the initial component of the course, we will discuss technology in a historical perspective, examining both the process of technology and technology history in the US, particularly in the last 250 years.

The second component of the course involves a more in-depth examination of a number of issues related to technology. Specific issues to be examined will be determined in part by the interests of the class. Some examples of issues which may be discussed include:

A. Can we create a "sustainable agriculture"? - FW
B. Gene splicing - man makes himself - DA
C. Acid rain - costs and benefits - AR
D. Electro-Magnetic fields - AR
E. Scientific progress and "limits of growth" - AR
F. Malthus and population growth - was he right? - FW
G. Computers - yesterday, today and tomorrow - FW
H. The Grand Canyon as a sanitary landfill - AR
I. Radon gas - RT
J. Preservation of species - genetic erosion and endangered species-RT
K. 50 trends shaping the world - AR
L. Earth's greenhouse effect - FW
M. Cows have rights too - DA
N. Technology transfer - the international picture - FW

GRADING POLICY:

4 exams (including final)	400 points
Weekly readings/reports	120 points (10 points each)
Term paper	100 points
Group presentation	100 points
Writing sample	40 points
Participation, quizzes	40 points
TOTAL	800 points

GROUP PRESENTATION:

The class will be divided into small groups of two. Each group will select a topic, based on the available Worldwatch Papers, to research. The group will make an oral presentation of their findings, presenting a balanced picture of the subject. Class members will participate in grading the presentations with an in-class peer grading sheet.

TERM PAPER PROCEDURE:

I. A topic for the paper will be submitted on September 16, 1993.

II. The outline is due on October 14, 1993. It should be prepared on a word processor and should include:
   1. The word processing program which will be used.
   2. Double spacing.
   3. One inch margins.
   4. Four references.

III. The term paper is due on November 23, 1993. It should include:
   1. One inch margins.
   2. Five to ten double spaced pages PLUS a title page.
   3. At least six references.
   4. The style format as defined by The Publication Manual of the American Psychological Association.

IV. Late paper grades will be dropped 5 points per class meeting.

V. Plagiarism will not be tolerated. If you have questions about plagiarism, consult *Form and Style: Theses, Reports, Termpapers* by Campbell and Ballou or ask the instructor.

Term papers may be turned in at least one week before the due date for critiquing prior to final grading.

OUTSIDE READINGS/REPORTS:

Twelve outside readings/reports on Social Issues/Technology are required. These may be taken from journals suggested in class, journals from the library, ones you receive at home; from major newspapers; or from TV reports. One annotated bibliography is due each week at the beginning of the Tuesday class starting September 7 through November 23.

The Annotated Bibliography should be typed using a word processor on standard paper. It should be a minimum of 200 words and include:

1. Bibliographic information on reading/report (Title, Author, Page Numbers, Volume, etc.)
2. Synopsis of the article/report
3. Your opinion on the article/report (i.e., why it caught your attention, how it relates to your life, work, or what we have been studying in class)

These articles/reports may be used as a basis of discussion during class, or students may be asked to discuss their article/report in relation to other topics. Students should be prepared to discuss the articles/reports and their implications.

READINGS

Week of	Chapter Number and Title	Pages
	TEXT: Technology in America: A Brief History	
September 7	1. - Manufacturing America: 1607 to 1800	3-50
	2. - Young America and Individual Opportunity: 1800 to the 1830s	52-86
September 14	3. - America as a Social Unit: 1830s to the 1870s	88-130
	4. - Systematizing Power, Communications, and the Power of Communication	135-178
EXAM I		
September 21	5. - Systematizing the Fabric of American Life: the 1870s to the 1920s	180-217
	6. - Systematizing Workers and the Workplace	220-253
September 28	7. - Technology as a Social Solution: the 1920s to the 1950s	257-312
October 5	8. - Technology as a Social Question: the 1950s to the Present	315-362
	TEXT: State of the World: A Worldwatch Institute Report on Progress Toward a Sustainable Society	
October 12	1. - A New Era Unfolds	3-21
	2. - Facing Water Scarcity	22-41
October 19	3. - Reviving Coring Coral Reefs	42-60
	4. - Closing the Gender Gap in Development	61-79
EXAM II		
October 26	5. - Supporting Indigenous Peoples	80-100
	6. - Providing Energy in Developing Countries	101-119
November 2	7. - Rediscovering Rail	120-138
	8. - Preparing for Peace	139-157
November 9	9. - Reconciling Trade and the Environment	158-179
	10.- Shaping the Next Industrial Revolution	180-200
EXAM III		

Readings will be covered in class discussions, quizzes and/or tests. Any references at the end of each chapter may be helpful for your outside reading assignment.

AGRI 3130
SOCIAL ISSUES IN TECHNOLOGY

Date	Activity
August 26	Introductions, syllabus and writing assignment
August 31	Pre-test, creativity & innovation - FW
September 2	Economics - FW
September 7	Pre-History - AR
September 9	Historical - AR
September 14	Historical - AR
September 16	Historical - AR
September 21	Exam I - FW
September 23	Historical - AR
September 28	Radon Gas - RT
September 30	Historical - AR
October 5	Gene splicing DA
October 7	Historical - AR
October 12	Malthus - FW
October 14	Preservation of species - RT
October 19	Population - FW
October 21	Exam II - FW
October 26	Computers - FW
October 28	Limits of Growth - AR
November 2	Computers - FW
November 4	Landfills - AR
November 9	Sustainable Ag - FW
November 11	Sustainable ag - FW
November 16	Animals rights - DA
November 18	Exam III - FW
November 23	Greenhouse effect - FW
November 25	Thanksgiving - no class
November 30	Small group presentations
December 2	Small group presentations
December 7	Technology transfer - FW
December 9	Trends - AR
December 16	Exam IV-Final 11:00-1:00

SUGGESTED OUTSIDE READING SOURCES

TEXTS:

Brown, L. R., Kane, H., & Ayres, E. (1993). Vital signs 1993. New York: W.W. Norton.

Brown, L. R., Brough, H., Durning, A., Flavin, C., French, H., Jacobson, J., Lenssen, N., Lowe, M., Postel, S., Renner, M., Ryan, J., Starke, L., & Young, J. (1992). State of the world 1992. New York: Norton.

Brown, L.R., Durning, A., Flavin, C., French, H., Jacobsen, J., Lenssen, N., Lowe, M., Postel, S., Renner, M., Starke, L., Weber, P., & Young, J. (1993). State of the world 1993. New York: Norton.

Cutcliffe, S. H., Goldman, S.L., Medina, M., & Sanmartin, J. (Eds.). (1992). New worlds, new technologies, new issues. Bethlehem, PA: Lehigh University Press.

Kennedy, P. (1993). Preparing for the twenty-first century. New York: Vintage.

Markert, L. R. (1993). Contemporary technology. South Holland, IL: Goodheart-Willcox.

Meadows, D. H., Meadows, D. L., & Randers, J. (1992). Beyond the limits. Post Mills, VT: Chelsea Green Publishing.

Meadows, D. H., Meadows, D.L., Randers, J., & Behrens, W. W. (1972). The limits of growth. New York: Universe Books .

Sharp, A. M., Register, C.A., & Leftwich, R.H. (1990). Economics of social issues. Homewood, IL: Irwin.

PERIODICALS:

American Heritage
Audacity
Discover
Invention and Technology
Issues in Science and Technology
Scientific American
Technology Review
The Futurist
USA Today
U.S. News and World Report
Worldwatch Papers #85-112
World*Watch

VIDEOS:

- Seeds of Tomorrow
- Alternative Agriculture: Growing Concerns
- World at your Fingertips
- The Thinking Machine
- Future Quest Series: Science and Society
- Latin American Population Explosion and Industrialization
- Race to Save the Planet: Greenhouse Effect and Preserve the Earth
- Business of Hunger
- Economics USA: Pollution
- Global Warming

SCIENCE, DIVERSITY, AND COMMUNITY: REVITALIZING INTRODUCTORY SCIENCE CURRICULA: AN OVERVIEW

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"Science, Diversity, and Community, Revitalizing Introductory Curricula" is a comprehensive National Science Foundation (NSF)-funded project, the overarching purpose of which is to promote permanent systemic change in the way that science and science education are regarded and carried out within the University of Wisconsin System. It is this goal that makes this project risky and difficult but very exciting and rewarding. If it is as successful as we hope, this project will become institutionalized within our system and should serve as a model for other institutions, large and small.

Within this overreaching framework, the major goal of the NSF-funded project, "Science, Diversity, and Community: Revitalizing Undergraduate Curricula," is to attract and retain qualified female and minority students in science, mathematics, and engineering by improving the quality of undergraduate science education for both women and men. In so doing, the program seeks to reverse female and minority attrition from science at a point at which it is most acute in higher education: introductory courses of the undergraduate science program.

The Women and Science Program is sponsored and administered by the University of Wisconsin System Women's Studies Consortium, which serves as a formal organization of the Women's Studies Programs in all of the degree-granting institutions including the two doctoral, eleven comprehensive, and thirteen freshman-sophomore campuses in the UW System. The Consortium has identified curricular reform as one of its primary goals and, because of the challenges presented by the sciences, designated Women and Science as a focus area within that goal. A systemwide Women and Science Advisory Board, composed primarily of scientists nominated by the Vice Chancellors of each UW institution, also helps to guide the program.

The Women and Science Program is an eight-semester visiting professorship, curricular and faculty development program that brings together students and faculty at UW System institutions with eight Distinguished Visiting Professors (DVP's) of Women and Science, from inside and outside of the UW System, who have successfully implemented teaching innovations at their home institutions. By the conclusion of the project period, each of the eight DVP's will have visited a "science community" made up of one or more science departments in one or more UW institutions; they will work with a total of at least seventeen Faculty Fellows in the Host Communities. The program is designed to reform introductory curricula and increase female and minority representation in science by: a) increasing faculty expertise in gender and science scholarship and pedagogy; providing role models of professional women scientists; c) improving classroom and campus climate; and d) creating "science communities" that will promote effective learning. Since these innovations have been shown to be attractive to white men as well as to women and people of color, this project should gradually effect an increase in the total number of students majoring in the science.

The typical DVP spends a full semester at a UW science community, teaching a model introductory science or mathematics course, holding seminars on the incorporation of the new scholarship on gender and race-related content and pedagogy into introductory science teaching, and working closely with Faculty Fellows from the Host Communities to develop new course materials and syllabi. (Each Faculty Fellow is expected to develop a new and/or revised course and teach it within two years). The program will also develop a Cadre of Faculty Development Experts, made up of Faculty Fellows and other participating faculty, some of whom will serve as DVP's and others who will facilitate workshops on other UW campuses. A systemwide Women and Science Advisory Board helps to guide the direction of the project.

Building Science Communities

Building interdisciplinary science communities has been an organic process, beginning with a nucleus of science and women's studies faculty and extending to include many other faculty, staff, and students from a variety of disciplines as well as administrators. In fact, the process has involved defining and redefining just what is meant by such a community.

Responses to a kickoff conference, attended by one hundred and fifty faculty from across the UW system, held in the fall of 1992 were an early indication that faculty and staff interested in science education welcomed a rare opportunity to network and discuss reform of the science curriculum with a wide spectrum of colleagues from across the state. Interestingly, an overwhelming majority of participants identified improving the climate and developing a sense of community as the most important elements in attracting more qualified students -- including women and minorities -- to the science; this initial judgement has been reiterated and underlined by faculty on host campuses.

Professor Ethel Sloane (Biology, UW-Milwaukee) was the first Distinguished Visiting Professor in the spring of 1993. Sloane visited the University of Wisconsin Centers and taught her course, "The Biology of Women," at UWC-Waukesha. Professor Sloane also worked with Faculty Fellows from three UW-Centers campuses to prepare new or revised course syllabi. Faculty mini-conferences were conducted by Sloane, the Faculty Fellows, and members of a Centerswide science improvement group for the science faculty of all the UW Centers. Evaluations were positive with participants saying that they appreciated the opportunity to discuss and share ideas on the topic of science curricula reform. Again, the need to the improve climate and the sense of community was identified as most critical to success.

While Sloane's visit to the UW-Centers was called for as a part of the Women and Science Program's initial proposal to the NSF, subsequent Distinguished Visiting Professorships of Women and Science have been allotted to UW System institutions by a competitive internal proposal process conducted during 1992-93 and the spring semester of 1994. Awards are based on the institution's level of commitment to curriculum reform: a "critical mass" of host participation in faculty development activities, institutional support for curriculum reform, as demonstrated by institutional matching funds and other resources, and evidence of commitment to collaborative activities within or between institutions.

A total of four Distinguished Visiting Pro ssors of the Women and Science are scheduled for the 1993-1994 academic year and fall semester 1994, three of whom spend a full semester at a UW System institution. Two of these DVP's, Sherrie Nicol (Mathematics, UW-Platteville and Cheryl Ney (Chemistry, Capitol University), have been based at a Collaborative Community -- comprised of UW-Eau Claire, UW-River Fall, and UW-Stout -- during this academic year. The UW-Madison Chemistry Department will be host to Vera Kolb (Chemistry, UW-Parkside), the third DVP, in the fall of 1994.

The fourth DVP, Sue Rosser followed a different model, as requested by the Consortium Executive Committee and designed by her in collaboration with participating institutions who submitted successful proposals for her visit. Professor Rosser circulated among nine UW institutions, initiating faculty development activities. She spent an average of two to three days at each of these campuses, giving workshops and talks attended by faculty and administrators. She also met individually with faculty particularly interested in curricular revision. From all accounts, these events were well attended and received.

The program, pending final approval by NSF of its concluding phase, will continue through the 1995-96 academic year. We are currently requesting nominations and/or applications for DVP's, and the call for proposals has been distributed. At the conclusion of the project, we are planning for its institutionalization through the Cadre of Faculty Development Experts and other strategies. We also intend to create a number of "products," including a comprehensive project which will describe how our collective applied theories of women and science have been evolved, what we have learned, and how to go about doing what we have done -- this should serve as a kind of blueprint for others hoping to form science communities with similar goals. Other products, in addition to the revised courses, include laboratory manuals, handbooks, articles, and conference presentations within the state and nationally. While we recognize that the culture of each department, college, and institution is different, we believe that the commonalities -- manifested in attitudes and practices that present both barriers and opportunities -- we have experienced in the course of this project will ring true in a wide variety of situations.

The Collaborative Community

Rebecca Armstrong, the Project Administrator, will focus on the Collaborative Community, referred to above, which has turned out to be challenging and innovative. Professor Sherrie Nicol will relay her experiences in that capacity last semester. Loretta Thielman, who has been a Faculty Fellow in the program, will talk about how her perspectives on science education in general and science communities in particular have evolved. I use the term "evolve" frequently in speaking of this project because, as it has progressed, all of us have been in a process of learning, hence frequently effecting alterations in how we carry out our roles in the community.

Since she is not here today, I want to quote briefly from Cheryl Ney, our current DVP in the Collaborative Community, who is involved in a wide variety of activities, ranging from formal to informal at all the campuses. These activities include teaching at UW-River Falls and facilitating, with the Faculty Fellows, colloquia on such topics as epistemology and teaching practice, the discovery/hands-on, learning by inquiry approach to teaching, and "contextualizing the discipline: the interdisciplinary field of science and technology in society." Commenting on her role, Professor Ney says, "Faculty development activities have traditionally focused on curriculum and teaching strategies. This often translates into the expectation that a Faculty Development Expert will provide faculty with the "right" knowledge in teaching, usually in the form of content/curriculum suggestions and teaching methods. However, if one believes that knowledge is socially constructed, then faculty development activities become the facilitation of this process of knowledge-building among faculty." Through these means, this project will result in the establishment of a distinctive paradigm of an organic learning community which includes a faculty development model based on a socially constructed, interdisciplinary understanding of knowledge. And it is this distinctive characteristic that faculty involved with (or even having contact with) this project find either exciting and promising or threatening.

Program Evaluation

The purpose of the evaluation is twofold: 1) to assess whether the program has met its original goals, 2) to determine what methods have been successful in implementing it and, relatedly, how in the course of the project the design of the project should be altered. Since the program should serve as a national model, the evaluation is formative, providing insights and information for other institutions that might replicate some or parts of it.

Two evaluators were contacted, Judith Levy, head of the Department of Chemistry at Eastern Michigan University, and Gloria Rogers, Dean for Academic Advising at Rose-Hulman Institute of Technology. The plan for evaluation includes the following:

- Extensive quantitative and qualitative data collection, which will offer accountability and facilitate the possibility that the program will serve as a national model.

- Multi-group evaluation of students, Distinguished Visiting Professors, Faculty Fellows, and campus administrators in order to completely measure and analyze the outcomes of the program.

The evaluators will report on their findings periodically and contribute to the final comprehensive document at the end of the project period.

<u>What We Have Learned Thus Far</u>

The program has already begun to have what we consider an impressive impact, reaching several hundred faculty and staff as well as students on UW campuses. What we have learned is that what we have set out to do is more complicated and challenging than we had anticipated. As I implied earlier, this project is larger than the sum of its parts. We are trying to do more than develop new courses around the state. Rather we are trying to build interdisciplinary science communities within and throughout the state where the ways in which knowledge is transmitted and where the learning climate is significantly different from now. In effect, we are trying to transform the culture from, as one or our Advisory Board members put it, a caste system to one where education is conducted through collaborative, creative approaches.

In the process, we have learned a great deal. For one thing, each department and each institution has its own culture which must be taken into consideration in the planning of each host community -- especially complicated in the CC. It is important to be flexible and to involve faculty and administrators (support from both top and bottom are essential) at every step of the way in order to build a sense of ownership. It has also become clear to me, at least, that faculty development is the most important component of this project -- someone in a meeting a few days ago asked how we could encourage students to collaborate and participate in these new strategies -- but students aren't the challenge here; I'm convinced that they will be excited by challenging teachers; it's the faculty we need to hook).

As a result of what we've been learning, we're making adjustments both in the theoretical base and the nuts and bolts of the program as we've gone along. For example each of the campuses in the CC has a Coordinator whose work has turned out to be more time-consuming than we had anticipated; as a result, we've squeezed out some additional funds to provide them with release time. While it seemed as if we had a great deal of money, we have been aware of additional needs that we didn't anticipate -- some of which require funding (although not all). On a larger issue, we also have come to realize, as a result of the observations of our DVP's, evaluators, and others, that the project must add to its goals the increase in recruitment and retention of women and minority faculty members.

On a more positive note, our creative DVP's, Faculty Fellows, and Coordinators have taken the program in new directions, providing unanticipated insights as to the greater possibilities of this project -- how to make it work and institutionalize it. For example, at our most recent meeting in the Collaborative Community, I was delighted to find that the Fellows have become a community within the community -- this will surely contribute to long term project goals. It was gratifying to hear very positive comments from faculty and administrators alike, some of whom had previously seemed somewhat skeptical about the project. These words are being translated into deeds as they have initiated discussions of ideas and plans for continuing and even expanding the project to other collaborative communities.

Future Plans

As indicated above, the project will continue to evolve through the 1995-96 academic year, becoming gradually institutionalized and eventually affecting many more hundreds of faculty and thousands of students statewide.

Because of the structure of the UW System, we have the unique opportunity to experiment with faculty and curriculum development in a wide variety of settings. Moreover, the Consortium's experience with collaborative initiatives and our resources, such as the Women's Studies Librarian's office, has been very helpful in implementing this project.

We anticipate that the project will serve as a model for other academic programs facing similar challenges regarding science education in the midst of problems in staffing and resource development in financially difficult times -- both within our system and across the nation. We hope that the outcome of the project evaluation and our products will help to shape other faculty development and pedagogical and curriculum reform initiatives for years to come.

STS in K-12 Education

TRENDS AND DILEMMAS IN SCIENCE, TECHNOLOGY AND SOCIETY EDUCATION WITHIN K-12 SCHOOLS IN THE UNITED STATES

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Science, technology and society (STS) education is a burgeoning movement in K-12 schools across the United States. While the number of teachers involved in STS education within K-12 schools is unknown, a number of indicators demonstrate the widespread and growing acceptance of this movement. These indicators include:

* a growing number of workshops and presentations at major annual educational conventions such as the Association for Supervision and Curriculum Development, National Science Teachers Association, National Council for the Social Studies, National Council of Teachers of English, National Middle School Association, and International Technology Education Association;

* an increasing number of STS curriculum materials produced by educational publishers, state departments of education, and local school districts;

* specific mention of STS education within official position papers of professional associations such as the National Science Teachers Association and the National Council for the Social Studies

* an expanding number of STS workshops for classroom teachers offered by colleges universities, state intermediate service units, and museums;

* increased mention of STS education within educational periodicals, particularly in the areas of science and technology education, and the establishment of several publications for teachers exclusively focused on this arena;

* explicit mention of STS in the standards documents of various national projects, including Project 2061 of the American Association for

the Advancement of Science (1993), the draft national science standards from the National Research Council (1994), the draft national standards for the social studies from the National Council for the Social Studies (1994).

The Goals of STS Education

While K-12 schools devote increasing attention to STS teaching and learning, there is little agreement on a working definition. A study of 15 recent statements contained in curriculum documents or presented by STS practitioners found little overlap (Cheek 1992a). Out of thirty descriptors used to describe STS education, only the following six features of STS education found widespread agreement:

* emphasize the general interactions between science, technology and society

* raise levels of awareness regarding STS issues

* incorporate ethics and values considerations

* increase student understanding of the applications of technology

* promote decision making skills

* involve students in local community action

These six features form the core of what STS education is seeking to accomplish.

Despite the lack of a well-formulated definition, STS education has found a disciplinary home within science education (Bybee 1992, McCormack 1992, Fensham 1992), social studies education (Marker 1992, Splittgerber 1991), and technology education (Fensham 1992, Zuga 1991). An Assembly on Science and the Humanities has recently been formed within the National Council of Teachers of English and has engaged in an active publications program (Cheek 1992a, Cheek 1993a).

Some environmental educators also have embraced STS education, although there is still considerable disagreement about the exact relationships between these two movements (Cheek 1992a, Hungerford, Volk, and Ramsey 1989, North American Association for Environmental Education 1990). Clearly there are close conceptual ties and allied aims among STS education, environmental education, and global education (cf. Cheek 1992a, Smith 1992, Tye and Tye 1992). A major focus for all of these movements has been the desire to more adequately prepare students for participatory democracy in the 21st century, rather than leaving technical decisions solely to the experts. This emphasis is in line with the reemerging civics movement within American elementary and secondary schools (Quigley and Bahmueller 1991).

The Content of STS Education

K-12 STS education in the United States has usually been mediated via one of two approaches (Rosenthal 1989): 1) a focus on STS issues (modeled after the field of science policy studies) or 2) a focus on the social aspects of science (modeled after disciplines like the sociology and philosophy of science). The first option engages students in the study of global, national, or local STS issues such as solid waste management, acid rain, deforestation, rising health care costs, and energy conservation. The choice of topics is generally determined by what is "hot" in the national media or of current concern within local communities.

Sometimes exploration of STS issues is limited to students developing position papers or taking a stand on an issue within the classroom. Increasingly, STS teachers are providing opportunities for students to not only explore a local issue but also to engage in some form of informed local community action regarding the issue (Hungerford, Volk, and Ramsey 1989; Ramsey, Hungerford and Volk 1990; Lewis 1991). The STS issues approach requires a constant updating of course materials and can lead to a fragmentary understanding of science, technology and the social sciences since relevancy is the guiding criterion. Exposing the student to the formal structure of a discipline is also frequently lacking in this approach (Krumhout and Good 1983).

An STS approach that exposes students to the social aspects of science has a large following outside the United States and has found wide acceptance and support from members of the philosophy, sociology, and history of science and technology communities (Biological Sciences Curriculum Study and Social Science Education Consortium 1992, Hills

1992, Solomon 1993). The focus of materials developed under this rubric is on fostering student understandings of the nature and culture of science and technology. While the approach has much to commend it, tracing the history of the growth of scientific thought or an emphasis on the sociology of science and technology may prove more interesting to the specialist than to the student. There is also the problem that most science and technology teachers have no formal background in the history, sociology, or philosophy of science or technology (but see Duschl 1990).

These two main approaches are not necessarily antithetical as a number of actual materials demonstrate (Cheek 1992c, 1992d, 1993b, 1993c, Aikenhead 1993). Either approach requires additional inservice training for classroom teachers in appropriate instructional techniques and content knowledge related to STS studies (Rubba 1991).

New challenges also must be faced in the area of assessment of programs and evaluation of individual student learning. Fortunately, many techniques have already been applied in STS education within and outside the United States so that useful models exist for school districts (Cheek 1992b). An increasing number of formal assessment instruments are being developed to aid the classroom teacher (e.g., Cheek 1992a, Crelinsten, deBoerr, and Aikenhead 1992).

Contemporary K-12 STS Education Materials

A wide range of STS materials for K-12 classrooms has appeared in recent years, too voluminous to mention here (Cheek 1989, 1992a). More recent products which have appeared include STS materials for elementary schools (Zaner-Bloser, Inc. 1990, Biological Sciences Curriculum Study 1992), middle schools and junior highs (Biological Sciences Curriculum Study 1993; Cheek 1992c, 1992d, 1993b, 1993c; McFadden and Yager 1993; Eannance 1990), and high schools (Christensen 1991, Solomon 1992, Aikenhead 1993, Globe Book Company 1993, U.S. Department of Energy 1992). The National Science Foundation (NSF) and the U.S. Environmental Protection Agency have funded a number of recent projects which are developing STS materials to add to this growing collection. NSF is also funding an increasing number of teacher enhancement activities which purport to prepare teachers for STS education efforts.

Challenges Facing K-12 STS Education

Statewide systemic change (SSI) initiatives funded by NSF and statewide curriculum frameworks projects increasingly mention STS education as one of several major educational goals for all students (Cheek 1989, 1992a). Preliminary indications from the work of committees within the national science standards project coordinated by the National Research Council portend that STS content understandings will figure in the final set of curriculum, assessment, and teacher preparation standards.

There is a growing awareness on the part of educational policy makers that there is a basic level of scientific and technological literacy that should be possessed by all graduating seniors. The annual technological literacy conferences sponsored by the National Association for Science, Technology and Society in collaborations with other professional associations, have given national visibility to the K-12 STS education movement (e.g., Cheek 1993a).

Despite the obvious need for attention to STS education in K-12 schools, there are still a significant number of barriers which have to be surmounted if STS education is to be more than a passing educational fad. Foremost among them is the capacity of classroom teachers to engage students in STS issue investigation and the development of informed plans for personal action (e.g., Rubba 1991). Sustained STS education within the classroom setting requires a teacher orientation to instruction where active student framing of issues to be explored is encouraged. Exploration of issues and information that lie outside the traditional subject matter purview of science, technology, the humanities, or the social studies (depending upon which class is the venue for STS education) has to be permitted. This wide-ranging, interdisciplinary approach to learning raises significant questions about teacher evaluation of student learning since the teacher is often called upon to make judgments about subject matter understandings of students for which the teacher may lack relevant knowledge (Cheek 1992b).

A movement away from a textbook toward more active forms of student learning is required if STS education is to succeed in the classroom. Time and opportunities must be provided for students to construct knowledge and meaning for themselves about relevant scientific, technological, social, and ethical aspects of STS issues (Cheek 1992a, Driver 1994). The "less is more" aphorism must prevail within K-12 classrooms if we are serious about student construction of knowledge. There is an emerging body of evidence that when teachers adopt such an approach to STS, the learning curve of students increases dramatically (Rubba 1991, Cheek 1992a, Hungerford, Volk, and Ramsey 1989).

Another major barrier has been the form of teacher preparation employed in the United States and the certification process of state departments of education. Most programs and state certification requirements mandate the preparation of subject matter specialists rather than the creation of subject matter generalists. STS education, by its very nature, is interdisciplinary. Many science teachers, however, have never been exposed to coursework in technology, philosophy, economics, and sociology. (Compounding the problem in many states, science teachers are even further specialized by separate certification programs to teach a particularly science subject such as biology, chemistry or physics along with "general" science.) A social studies teacher feels uncomfortable in the realms of science and technology and the technology teacher possesses an inadequate knowledge base in the realms of philosophy, economics, sociology, and even sometimes in the sciences.

Middle schools, as advocated by the National Middle School Association, have adopted a team approach to classroom instruction (National Middle School Association 1992). This approach enables teachers from various disciplines to meet together regularly and for substantive periods of time to plan instruction with an assigned group of students. The schedule and assignment of teachers can be arranged to suite the instructional needs. Such an approach holds great promise for STS education and is being advanced by materials produced explicitly for middle schools (e.g., Cheek 1993b, 1993c). However, the greater challenge will be how to foster interdisciplinary teaching within junior highs and high schools where compartmentalized approaches to instruction predominate. This significant barrier is the primary reason why the majority of high school STS instruction takes place within the classroom of isolated STS teacher-advocates rather than being widely institutionalized across an entire school district. The situation is not dissimilar to the problems that STS programs have faced in finding a permanent "disciplinary" home within colleges and universities (Cheek

1992a).

Conclusion

STS education must compete in the K-12 arena with a wide variety of other agendas for educational reform. The degree to which the movement can address the fundamental challenges of adequate teacher preparation in STS studies, a constructivist approach to STS education, and teacher certification and scheduling barriers to interdisciplinary teaching and learning, will determine the success of the movement. Grassroots educational reform movements never outlast their proponents unless structural changes occur with the K-12 educational system which institutionalize those reforms. The movement as a whole must engage itself more effectively in educational policy discussions to the point where technological literacy in its broadest sense, is seen as essential education for all teachers and students in contemporary society.

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STS AS AN ORGANIZING PRINCIPLE IN ELEMENTARY TEACHER PREPARATION: UNIFIED STUDIES

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Pre-service teachers need an action-based, interactive, integrated, and meaningful approach to teacher training that provides them with the knowledge, skills, and strategies they will need to work and be successful in America's changing schools. This approach should emphasize "connections" in education through the integration of teaching and learning skills, the implementation of key educational principles, and the development of STS - centered ideas.

Over the past several years, Utah State University has taken numerous steps to make STS a key principle in its Elementary Teacher Preparation Program. This has included the restructuring of teacher education "core" subjects with a "multi-college" approach, modifications to methods courses and practicum experiences, and the establishment of a "Unified Studies - STS" framework. Utah State's "Unified Studies" approach has its roots embedded in ideas and philosophies common to Science / Technology / Society , Holistic Education, and Integrated / Transdisciplinary Education. This paper will review the basic structure of "Unified Studies" as an STS organizing principle for teacher preparation.

Unified Studies and Holistic Education

As Unified Studies was being developed at Utah State University, the ideas about its framework and organization came from current literature, innovative programs found around the world, and our intuitive feelings about how teacher education should be. Since its initial beginnings, we have found that Unified Studies has many connections with the holistic education movement.

Miller (1988) defines holistic education as the following:

"The focus of holistic education is on relationships - the relationship between linear thinking and intuition, the relationship between mind and body, the relationships between various domains of knowledge, the relationship between the individual and the community, and the relationship between self and Self. In the holistic curriculum, the student examines these relationships so that he/she gains both an awareness of them and the skills necessary to transform the relationships where it is appropriate." (Miller, 1986: 3)

The "real world" of teaching requires a self-motivated, self-directed teacher who is capable of inquiry, analysis, synthesis, evaluation, resourcefulness, intuition, and creativity. This is what is hoped for in educating all pre-service teachers. Holistic education and Unified Studies are ways to help pre-service teachers deal with several topics, skills and concepts and transfer learning in more meaningful ways.

In Miller's book , The Holistic Curriculum (1988) he notes that holism is based on the perennial philosophy which states that all things are part of an invisible unity or whole. Its basic principles are as follows:

1. There is an interconnectedness of reality and a fundamental unity in the universe.
2. There is an intimate connection between the individual's inner or higher self, and this unity.
3. In order to see this unity we need to cultivate intuition through contemplation and pondering.
4. Value is derived from seeing and realizing the interconnectedness of reality.
5. The realization of this unity among human beings leads to social activity designed to help others.

Interwoven within holistic education is the idea of cultivating one's intuition and individual insight to enhance learning and education. Intuition has been referred to as that : "still small voice within" that prods one into action. Through Unified Studies it is hoped that pre-service teachers can learn how to culture their own personal intuitions and make the connections necessary in education and life to make learning meaningful.

In holistic education there is the belief that the teacher has an integral part in making connections for students, not only in subjects, but in life. Steiner (1976) who developed the first Waldorf School, told his teachers before his school opened the following:

The teacher must be a person of initiative in everything they do, great and small.
The teacher should be one who is interested in being of the whole world and of humanity.
The teacher must be one who never makes a compromise in their heart and mind with what is untrue.
The teacher must never get stale or go sour.
I do not want to make you into teaching machines but into free independent teachers (Steiner,1976: 199-201).

The holistic approach also states that in order to facilitate learning, student dialogue must be promoted through six conditions. Freire (1956) lists those as being:

1. **Love** - dialogue cannot exist in the absence of love for the world and human beings.

2. **Humility** - dialogue cannot exist without humility. Dialogue as the encounter of human beings addressed to the common task of learning and acting is broken if parties lack humility.
3. **Faith** - dialogue requires an intense faith in people, faith in the power to make and remake, to create and recreate, faith in their vocation to be more human.
4. **Trust** - founding itself on love, humility and faith, dialogue becomes a horizontal relationship of which mutual trust between the dialoguers is the logical consequence.
5. **Hope** - as people seek to be more fully human, dialogue cannot be carried out in a climate of hopelessness.
6. **Critical thinking** - finally, true dialogue cannot exist unless the dialoguers engage in critical thinking.

In support of the holistic philosophy, we believe that the ideal teacher training setting should be a cross between Harvard and Disneyland, an atmosphere that provides for educational excellence and rigor yet is viewed as being "the happiest place on earth!" We believe that the precepts of Invitational Education (Purkey, 1984) establish the base from which such a climate and positive learning atmosphere can develop.

Unified Studies seeks to exemplify the four key principles of Invitational Education which are:

1. People are able, valuable, and responsible, and should be treated accordingly.
2. Teaching should be a cooperative activity.
3. People possess relatively untapped potential in all areas of human development.
4. This potential can best be realized by places, policies, and programs that are specifically designed to invite development, and by people who are personally and professionally inviting to themselves and others.

Holistic approaches to education are essential both philosophically and practically in terms of "Unifying" the teacher education process.

The Science/Technology/Society Connection

From all the reform and restructuring movements over the past decade, the one that has had the most profound impact in terms of the development of USU's Unified Studies Model has been the Science/Technology/Society movement.

While the information age continues to descend upon us, we are also faced with issues that affect our lives, both positively and negatively, and all those who live within our society and world. Issues such as:

- The effect of technology on society as a whole.
- The effect of new advances in science on human health and life.

- The effect of a changing world population on earth resources and the environment.
- The effects of rapid change on our lifestyles and the ways we participate in decision making.
- The effects of a changing world on human values.
- The effect education has in allowing people to take appropriate actions in relation to "real world" problems (Iozzi, 1987).

The goals of STS are many. Hurd (1986) reported several of these goals and how they would affect education in our transitional society. He stated that the STS movement could do much to enhance our national unity, the strength of which depends in no small measure upon individuals' civic consciousness and the ability to participate effectively in resolving social conflicts and in directing courses of action. The educational advantages of an STS context in USU's teacher preparation programs include the following:

1. The pre-service teacher actively participates in exploring problems by processing information, formulating options, and making personal judgments on real-world events. Pre-service teachers may then develop an awareness of their own purposes, beliefs and ideals, as well as those of others.
2. An STS context provides a richer framework for the development of such intellectual skills as problem solving, decision making, ethical judgment, and knowledge synthesis.
3. Because STS problems are current, personal, and of the real world, motivation is enhanced. Pre-service teachers must consciously apply their knowledge in planned and purposeful actions. The emphasis is on developing a working knowledge of integrating skills, judgments, and abilities.
4. Today's high technological society needs knowledgeable citizens with a modern outlook and developed intellectual skills. More than ever pre-service teachers need an education that equips them to handle changing knowledge and fields of study.
5. The STS context is designed to make learning productive for pre-service teachers by encouraging them to examine real phenomena around them and to connect these happenings with personal and "real- life" student educational experiences.
6. The STS context provides an authentic view of science and technology as a functioning research agenda and its application to human affairs. Pre-service teachers gain the understanding that all things are connected and linked.
7. The STS context widens the scope of learning by providing connections with many school subjects, including other sciences, the social and behavioral sciences, the humanities, arts, and others. In addition, a stronger bond between school life and the outside world can be established.
8. An STS context changes the focus from isolated, meaningless topics, towards the use of knowledge and skills that enable pre-service teachers to plan and work in the future.

Bugliarello (1991) suggests some other important advantages of STS education. They are as follows:

1. Technological literacy is meaningless without basic literacy. The ability to communicate knowledge and concepts is essential if we are to function in our technological society.
2. The road towards technological literacy must start by simplifying and demythologizing the teaching of science and technology. The attempts of Project 2061 are aimed to do just this.
3. Technological literacy as a practical tool is meaningless without also focusing on personal habits and attitudes. Accuracy, reliability, punctuality, etc. are essential in enabling us to function successfully in a complex socio-technological environment.
4. Technological literacy is above all the development and the empowerment of a new set of ethical concerns and responsibilities.

Project 2061: Science for All Americans, a set of recommendations established by the National Council on Science and Technology Education and a distinguished group of scientists and educators appointed by the American Association for the Advancement of Science, as critical implications for teacher education. Project 2061 is based upon the convictions that:

1. All children need and deserve a basic education in science, mathematics, and technology that prepares them to live interesting and productive lives.
2. Sweeping changes in the entire educational system from kindergarten through twelfth grade will have to be made if the United States is to become a nation of scientifically literate citizens.
3. World norms for what constitutes a basic education have changed radically in response to the rapid growth of scientific knowledge and technological power (AAAS, 1989).

Utah State's Teacher Education Program supports many of the key findings reported in Project 2061 and has modified them to relate to pre-service teacher training. They include the following areas:

What pre-service teachers learn is influenced by their existing ideas.

Marcia Linn (1986) reported there is agreement that learners actively construct an individual world view based upon personal observation and experience and that they respond to formal instruction in terms of this preexisting intuitive perspective. Research has also revealed that learners construct a sense of themselves which guides their learning behavior. This consensus about the nature of the learner has increased our awareness of the complex nature of education.

Pre-service teachers must not only gain access to new information, they must also integrate this information with naive, perhaps erroneous, intuitive ideas. The new consensus about the learner also respects the complexity of pre-service teachers' conceptual frameworks and illustrates the powerful thinking tools they use to form their ideas. It also places greater importance on what pre-service teachers already know and what the pre-service teacher can learn.

One major implication for teaching is that it is inappropriate to assume that pre-service teachers simply absorb information. It appears, that pre-service teachers constantly interpret new information based on their particular world view. Their misconceptions, therefore, do not arise merely from failure to absorb information, but rather from erroneous interpretation based on intuitive perceptions that must be overcome.

Progression in learning is usually from the concrete to the abstract.

Pre-service teachers can grow in their ability to understand abstract concepts and reason logically when they learn about things that are tangible and directly accessible to their senses. These skills, however, develop slowly and many times there is a dependence upon concrete examples. Concrete experiences are most effective in learning when they occur in the context of some relevant conceptual structure. College professors sometimes overestimate the ability of their pre-service teachers to handle abstractions. Teacher training and development must progress from the concrete to the abstract at many levels.

Pre-service teachers learn to do well only what they practice doing.

If pre-service teachers are expected to apply STS ideas in novel situations, then they must practice applying them in novel situations. Pre-service teachers cannot learn to think critically, analyze information, communicate ideas, work as part of a team, and acquire other desirable skills, unless they are permitted and encouraged to do those things over and over in a variety of contexts.

Effective learning by pre-service teachers requires feedback.

Repetition of tasks by pre-service teachers, whether manual or intellectual, is unlikely to lead to improved skills or insights. Learning takes place best when pre-service teachers have opportunities to express ideas, and get feedback from their peers, and instructors. For feedback to be effective, it must consist of more than just the provision of correct answers. Feedback should come at a time when pre-service teachers are interested in it, and should be in terms of not only cognitive, but affective actions. Pre-service teachers must also have time to reflect on the feedback they receive, and to make adjustments and have the opportunity to try again when required.

Expectations affect performance.

Pre-service teachers respond to their own expectations of what they can and cannot learn. When they lack confidence, learning eludes them. Pre-service teachers grow in self confidence as they experience success in learning, just as they lose confidence in the face of repeated failure. It is essential that teacher training programs provide pre-service teachers with challenging, but obtainable tasks.

Teaching should be consistent with the nature of good inquiry.

Research has shown that there are components which can help promote improved teaching and enhance learning. In training pre-service teachers, professors should engage students actively, concentrate on the collection and use of evidence and data, provide historical perspectives, insist on clear expression and communication, use collaborative and cooperative methods, avoid dogmatism, and promote aesthetic responses.

Teaching should aim to counteract learning anxieties.

College professors should recognize that for many pre-service teachers learning involves feelings of anxiety and fear. Professors can help overcome such feelings in pre-service teachers if they build on successes, provide abundant experience in using tools, model how to deal with anxieties and fears, and emphasize cooperative and group learning processes.

Teaching should take its time.

Pre-service teachers need time for making observations, for taking wrong turns, for testing ideas; time for building things, collecting things, constructing models; time for asking questions, reading, and arguing; time for wrestling with unfamiliar ideas, and for coming to see the advantage of thinking in a different way. Moreover, any topic that is taught only in a single lesson is unlikely of being remembered. Teaching and learning should be an interactive endeavor undertaken by teacher and student.

In conclusion, our research has shown that integrating teacher education through a Unified Studies - STS approach has proven to be very successful.

Utah State University's Unified Studies - STS Teacher Preparation Framework

Acquisition of Teaching /Learning Skills

Related to

LIFE, LEARNING & INDIVIDUAL EMPOWERMENT

in 6 areas of emphasis (Capacitive Teaching)

1. Content: ("The What")
2. Attitude: ("The Way")
3. Process: ("The How")
4. Application: ("The Why")
5. Creativity: ("The Wonder")
6. Integration: ("The Big Picture" - Metacognition)

Implementation of Key Principles

Based on

INQUIRY AND INVESTIGATION

utilizing the principles of

1. Subject integration
2. Depth vs. breadth
3. Teacher as facilitator
4. Character development
5. Technology integration
6. Balanced, multi-dimensional assessment

by active participation in

- Foundational skills
- Hands-on experiences
- Real life problem solving
- Enrichment activities

Development of STS Ideas

About

PEOPLE, SOCIETY, & OUR DYNAMIC WORLD

Using a "Unifying " Matrix of Six Concepts

1. Elements
2. Systems
3. Diversity
4. Changes/Cycles
5. Connections
6. Communication

and seven Topics

1. Symbols
2. Living Things
3. Society
4. Earth/Universe
5. Aesthetics
6. Beliefs
7. Technology

(Klag, 1990)

The model illustrated, Utah State University's Unified Studies - STS Teacher Preparation Framework, was developed as a way of organizing and implementing meaningful change in the teacher preparation practicum experience at USU's Edith Bowen Teacher Education Laboratory School.

While space and time do not permit further description of this model, we believe that its implementation has dramatically improved the quality of pre-service teacher training in terms of STS integration. The ultimate success of STS as an organizing principle in teacher preparation programs depends in no small measure upon a reconceptualization of the entire process of teacher training. The STS approach is designed to put knowledge into action through the application of what is learned.

One key principle holds true: in all things we either progress or we digress. We either move ahead, or we fall behind; we either grow, or we deteriorate. In teacher education, one must always be open to new ideas and learning. Malcom Forbes was once quoted as saying, "The true goal of education, is to replace an empty mind with an open one." So it is with the establishment of Unified Studies and STS in teacher education.

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THE LEARNING CYCLE: A VEHICLE FOR CHANGE IN TEACHER EDUCATION

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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.

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 the 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 instigated 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 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

Inquiry requires a hands-on approach (Lombard, Konicek and Schultz, 1985) since 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 these elements.

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's discovery of penicillin as indicating that visual and creative thinking (right side of the brain) are instrumental in problem solving.

The Sample

The teacher sample for 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.

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. Student science attitudes were analyzed using the Pearson Product-Moment Correlation Coefficient. The learning styles were tested through the use of the one-way analysis of variance (ANOVA).

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 multiple regression 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 most 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 (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 statistical relationship (i.e., probably not due to chance alone) between elementary grade students process skills and their exposure to Learning Cycle Strategies as mediated by the National Resource Module. After exposure to the

Learning Cycle students took primary and secondary process skills tests, outscoring their pre-process skills tests.

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.

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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ELEMENTARY SCHOOL TECHNOLOGY EDUCATION

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In several countries around the world, technology is a school subject required of all students, much like English is required of all students in the United States. Although most people realize that modern society is dominated by technology, and despite a movement in this country to gain support for teaching it in US schools, relatively few students graduate with a competence in technology. This is partly due to a lack of agreement on the meaning of the term "technology" among educators. For the purpose of this paper, technology is the knowledge and processes people use to make material changes.

Technology and technology education. Although computers and lasers are often thought of as the best examples of technology, any time people change the forms of materials, they are participating in technology. Cooking food, making clothing, building a shelter, and preparing medicine are all good examples of technology. For the purpose of this paper, technology education is teaching people about technology and its social impacts.

Usually, technology education is a hands-on course of study in which students gain an understanding of and competence in technical processes by designing solutions to technological problems. In technology education, students also learn about the impacts of technological change on society. While all of those educational terms sound good, where does teaching technology fit into the elementary curriculum?

A starting point may be to recognize that much of what we call "hands-on science" in our elementary classrooms involves children changing the forms of materials constructively. Take, for example, making paper or constructing simple machines. Both are examples of children doing technology, but neither is complete without a consideration of their larger meaning. What was the world like before the wheel and axle? What was the impact of the production of paper upon societies which developed it?

What if we, as an elementary class, built a simple, working printing press, and produced our own weekly newspaper? Would that be a science lesson? After all, we'd be applying what we learned about simple machines. Or would it be a social studies (current events) project in which we investigated and reported what was going on around the school? Or perhaps, writing a newspaper article is really a language arts exercise, while designing the newspaper is an art project. However you see it, there's certainly a lot of technology being learned.

Unfortunately, few in the elementary teaching profession include constructive activities such as these in their curricula. And few in the technology education profession include the elementary grades when they consider what students need to learn about technology.

A consideration of the problems of teaching elementary students about technology.

Technology educators are beginning to realize that the elementary school is a formidable but essential frontier. Like the Western frontier of the 1800s or the "final frontier" of outer space, it is mysterious and quite unlike anything we're familiar with. And it is populated by strange creatures we don't understand and are quite frankly a little afraid of: kids!

We don't understand why a first-grader will walk away from us while we're trying to talk to her. We can't figure out why we can't seem to get a third-grader to ask his classmate before borrowing a pencil or a ruler. And we're not sure what to teach them in technology education.

After all, they don't seem to understand us when we try to explain to them how lumber is made, or how an internal combustion engine works. So should we simply conclude that technology education is something that elementary children are not ready for—that it should remain strictly a secondary subject? Before we draw that conclusion, perhaps we should look a little more closely at the psychology of the elementary child.

There are at least two major differences between elementary children and technology teachers. First, many technology teachers are very interested in the technical details of industry and technology. We like to be able to change the oil in our cars and fix our own leaky faucets. Meanwhile, most elementary-aged kids couldn't care less about faucets or motor oil. This brings up a second point: unlike most technology teachers, children tend to be very *egocentric*. They are concerned with things of immediate interest to themselves.

Once we begin to see how children view the world, teaching them technology quickly becomes more straightforward. This paper addresses the psychological considerations of elementary students and reviews technology content and methods from this point of view.

A brief review of the psychological considerations.

For those of us who are a little rusty on the material in our Psychology 101 courses, here's a quick recap of Freud's components of personality. The following is not meant as a definitive description of the drama that is actually played out in the human psyche. It is merely meant as a thumbnail overview.

The id. A newborn baby has only one developed part of her or his personality: the *id* (Latin translation: "it."). This unconscious part of the personality is comprised of an individual's desires and the instincts and methods used to satisfy those desires. If unchecked, the id will use the most direct methods to achieve basic needs like food and oxygen, as well as other natural desires (Freud used aggression as an example), with no regard for propriety, ethics, laws, or conscience. Freud called this operational philosophy the "pleasure principle."

The ego. Clearly, adults do not operate on the basis of the id alone. Another operational phase in effect is the "reality principle." Desires can be satisfied in a realistic manner if time and thought are put into a solution. The id, however, does not want to wait—or even to waste time thinking. From very early in a person's life, the *ego* (Latin for "I") serves to balance the id by employing the reality principle. Wittig and Williams (1984) noted that Freud likened the ego to the horse rider who guides and controls his steed (the id). Often, the rider finds himself safely guiding the horse where it already wanted to go.

The superego. The ego's continuing efforts to find practical solutions to the demands of the id represent an attempt at survival. The ego and id, operating as an internally-balanced entity, prefer actions which will increase the likelihood of survival over actions which are ethical or otherwise considered good (Bernstein, Roy, Srull & Wickens, 1991). As the ego balances and holds in check the id, the *superego* exercises conscience-based control over the ego-id. And while the ego finds practical solutions for the desires of the id, the superego finds ethical solutions for the demands of the ego-id (Lahey, 1989).

Egocentrism. The superego is developed by learning a set of morals or ethics, usually from parents or others. Elementary schoolchildren have a developed superego; it just doesn't always appear to be as developed as their teacher might wish! Watching a third-grade boy shove another child out of the way in an attempt to get outside to recess (apparently without considering the consequences), an observer might wonder if elementary schoolchildren even have a developed ego—perhaps the id in some children is reigning supreme. But upon further inspection, it becomes clear that the ego is in full effect. In fact, *the most practical method* for that third-grader to get out to recess was to push the other child out of the way. If the id were fully in control, the child would have used *the most direct method*—probably jumping out of the classroom window to get outside.

The real difference between this third-grader and the average adult is not the balance between the id and the ego; it's the *egocentric* nature of the child. "Egocentrism…is the inability to distinguish between one's own perspective and someone else's perspective" (Santrock, 1990, p. 267). Santrock (1990) noted that by the time a child begins elementary school, she or he may have developed some ability to take another's perspective, but that this development is not uniform.

It is possible that the third-grader was trying to be malicious when he shoved his classmate aside. But it is more likely that he simply never considered what it would be like to be shoved aside himself. That wasn't his concern.

Implications for elementary technology education.

Savage (1990) called the division of technology content into major US industries (communication, construction, manufacturing, and transportation) "industrial technology." While this industrial perspective may function well at the secondary level, perhaps there is another way of organizing our content for elementary schools. Recognizing elementary children as more egocentric than older students, we may find that a self-centered, personal view of technology may be appropriate for them. In fact, we may find two perspectives through which to learn technology: industrial technology, which involves other people, and personal technology, which involves *me*.

Industrial technology. For example, manufacturing is an industry which young children might enjoy learning about. Engaging them in a production line to let them experience "how they do it in industry" can easily be a source of excitement and genuine learning, as can short filmstrips, show-and-tell, industrial field trips, or demonstrations. But when the unit on industrial manufacturing is over, students may still not be able to identify how manufacturing affects *them*. Manufacturing remains part of the realm of the outside world which is interesting but very confusing. Most adults only peripherally understand how the manufacturing industry operates and where it fits in society. So why should second-graders be expected to comprehend such things?

Personal technology. That's not to suggest that we should shelter children from the realities of our industrial society. But a second-grader might also benefit from a more personal treatment of manufacturing.

How about making a box? A big box or small box, round or square, padded or decorated. Are there any boxes around the room? What do you suppose their use is? How do you think they're made? Do you think *you* could make one? To most of us, a rectangular box is easily made of corrugated cardboard with a knife and some glue. We know that we can quickly custom-make boxes from readily-obtainable materials. But what third-grader knows this? What third-grader wouldn't benefit from having a box she made herself? A jewelry box, or a box for marbles, or for baseball cards or colored pencils. Or maybe a box for other boxes!

Another appropriate project involves having the children build a dollhouse. That's right: a dollhouse. Girls and boys delight in fantasy play (Santrock, 1990), often involving miniatures of people and objects, such as dolls and toy soldiers. 1/4" plywood is a good material for the walls, and the use of thicker wood for the floor improves assembly with nails and glue. For older students, stud construction might be modeled, but generally, construction principles can be integrated into any form of this project. The social-studies component of dollhouse construction activity is probably as great as the technology component, and can easily be emphasized as well. Finally, cooperative learning, problem solving, research and experimentation, and many other contemporary learning methods can be a part of such a unit.

The industrial technology content conflict. It should be remembered that a dollhouse (or toy soldier bunker, or space station headquarters) is a *manufactured* product, as well as a replica of a *constructed* shelter. But is this a construction activity or a manufacturing activity? If we are designing a sequence of industrial technology experiences which includes communication, construction, manufacturing, and transportation, this should be a very important question.

But who cares? Certainly not the children engaged in the activity. However, they do care that someone is trusting them with the responsibility to use tools and materials like grown-ups do. They do care that they get to build something in school. And they do care that they're learning while doing something they enjoy.

In the realm of industrial technology, this activity may fit into one of two content subdivisions: manufacturing and construction. This conflict is of little consequence in a personal view of technology.

A consideration of technology education content in the elementary school.

The content of technology education is relatively well-defined. "As a subject for educative purposes," Bonser and Mossman considered technology education (industrial arts) to be "a study of the changes made by man in the forms of materials to increase their values, and of the problems of life related to these changes" (1923, p. 5). Industrial education historian and longtime AIAA Executive Secretary Kenneth Brown wrote that this was the first and only definition of the subject (1977).

At the elementary level, this content may be divided into two wholly inclusive sets: "the knowledge and processes *I* use to make physical changes," and "the knowledge and processes *other people* use to make physical changes." To simplify, then, technology can be viewed either egocentricity or from the point of view of society.

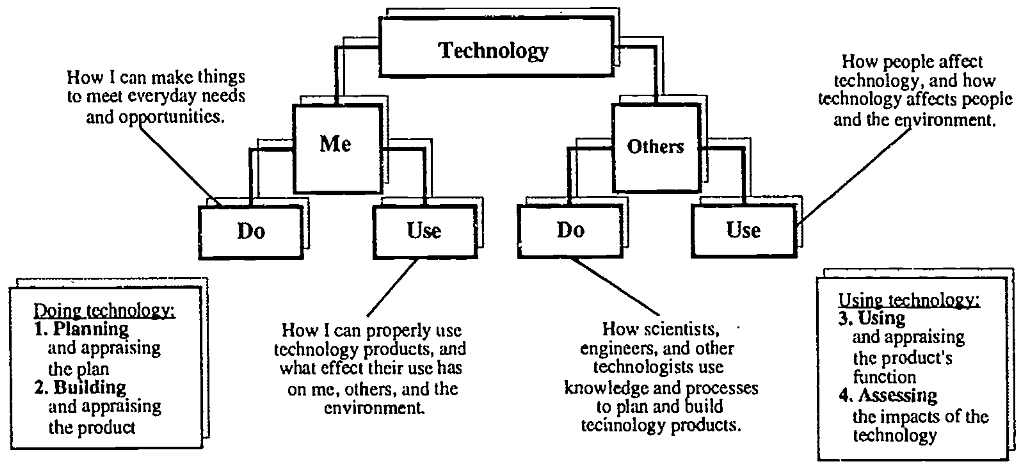
Technological Actions. When studying the human, technological response to a problem, we find that it contains a sequence of three major actions (from Wright, 1992): designing, producing, and using. *Designing*, or more generically, "planning," is a preparatory stage in which one or more responses to the problem are developed theoretically. *Production*, or "building," is the physical realization of the design. *Use* is the application of the product to the situation which induced the technological action. Products, of course, may be used for reasons unrelated to their intended use. Some common applications of technology are improvements to human communication, construction, manufacture, and transport.

Ideally, a fourth action, assessment, takes place after the use of the product. Here the impacts of the product's application on individuals, society, and the environment are evaluated.

At the elementary level, the actions of technology may be divided into two wholly inclusive sets: *Doing*, which involves planning and building, and *Using*, which investigates how technology is applied and what effects such application has (use and assessment). This hierarchy is summarized in figure 1 below.

Figure 1:

PERSONAL TECHNOLOGY CONTENT DIVISION



A consideration of technology education methodology in the elementary school.

Technology education at the elementary level usually involves, in large part, student activity. This is due not only to the nature of the subject, but to the belief, attributed to Comenius, that activity precedes concept learning (Nelson, 1981). Another consideration is the attention span of the children. Expanding on Santrock's (1990) discussion: attention span is not always shorter for younger students; however, children are much more selective about what they'll pay attention to for longer periods of time. For an elementary school student, an enjoyable activity can easily consume a half-hour or much more (Santrock, 1990). Generally, when students are "doing technology," they are engaging in technology activities.

Methodology for "doing technology." While there is no strict set of criteria which can be used to determine what is—and what is not—a technology activity, most technology activities feature all or most of the following characteristics. These characteristics—construction, problem solving, feedback, redesign, content, authenticity, and impact consideration—are intended as guidelines only.

- *Construction*. A technology activity is constructive. The student changes the forms of materials constructively; otherwise the student is not participating in technology. "Elementary schoolchildren," Santock pointed out, "are far from having physical maturity, and they need to be active...physical skills are a source of great pleasure and accomplishment for children" (1990, p. 348).

- *Problem Solving.* In a technology activity, a solution to a problem is designed. The result of the changes the student makes in the forms of materials must be in response to a specific need or "problem." Sometimes a child will enjoy working with materials without an apparent aim or goal. There is nothing the matter with this! While this isn't usually part of a technology activity, it can be valuable in teaching children the *use* of tools, a methodology described in the next section.
- *Feedback.* In a technology activity, feedback is provided to the student as to the strengths and weaknesses of the solution. Otherwise the student is solving the problem in a vacuum.
- *Redesign.* The opportunity for improving the solution is available to the student in a technology activity. Otherwise the student cannot take advantage of the feedback provided.
- *Content.* Some general concept related to technology is reinforced in a technology activity. The activity may be part of an overall sequence designed to teach students some area of technology. In the example of making a box, students might learn about fasteners and adhesives, when to use reinforcement during construction, and how to accurately cut material.
- *Authenticity.* The importance of this was emphasized by Scobey (1968): a technology activity for elementary school students can and should have practical and authentic qualities. The student can often use the same principles that a technologist would to solve the problem.
- *Impact consideration.* Because the students should be solving a real-world problem, the impacts of the problem should be investigated in a technology activity. Of course, in a personal consideration of technology, this can only succeed if the students are able to put themselves in the place of others. To some degree this is possible (Bernstein, et al., 1991), but will vary greatly from student to student in the typical elementary classroom.

Methodology for "using technology." While students are "doing" technology (i.e., planning and building), they are likely to be "using" technology as well. For this reason, much of the content about the use of technology may be presented when appropriate during technology activities.

For example, if a technology activity students in which are engaged involves wood as a material, content relative to the use of the saw, hammer, and abrasive paper might be presented during the "doing technology" activity. Similarly, if students were publishing a book, they might receive instruction in the use of the word processor, photocopier, and side-stitch stapler.

"Using technology" content which the teacher wishes to present, but which does not relate directly to "doing technology" content, may be introduced using several methods in addition to oral instruction. Here are some examples.

- *Demonstration and practice.* There are many technological products students may need or desire to use in school, at home, or in other places. Some of these may be electronic, such as a computer or VCR in the classroom; others may be manual, such as a coping saw or a pair of scissors. Each of these technology products—tools—has a proper and safe method of use. Such use can be demonstrated by the teacher and practiced by the students.

- *Engaging in common use.* Many technologies are in common use around the home each day. Examples of this include the use of a fork, an egg beater, or a microwave oven to prepare food; or a needle and thread to repair clothing. Students themselves can engage in these everyday activities to gain competence and confidence in using technology products. The major difference between this and the "demonstration and practice" method is that "engaging in common use" and its results are authentic.
- *Research.* The proper use of some products might not be known to the teacher. In fact, one unifying characteristic of many manufactured products is that they are distributed with instructions for use. If students do not know how to use a computer program, battery-powered screwdriver, or vacuum cleaner, they may be encouraged to read the instruction manual, or otherwise engage in research to determine the proper and safe use of the product.
- *Exploration.* The use of many products may be best learned by exploration and experimentation. This is particularly true of computer software, especially in creative applications.

There are many totally inclusive schemes for dividing technology content into areas of study. For the senior and junior high schools, teachers apparently have found that the Jackson's Mill organizers (Snyder & Hales, n.d.) of communication, construction, manufacturing, and transportation to be effective. But at the elementary level, other methods of content division may be equally valid.

Using an appropriate filter through which to view the content of technology, and being aware of appropriate teaching and learning methodologies, technology educators may have the tools to make inroads into the elementary school. Once we begin to understand elementary school children, we should also have the confidence to use those methods to teach that content to children.

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Young Children and Science:

Can You See Inside Me....Me and My Skeleton Frame?

Imagine a classroom where children are excitedly hypothesizing what will happen if they were to change the materials, and/or the structure for their own bodies.

Now imagine a group of young children constructing a chicken skeleton out of bones buried in sand. 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. Often educators and teachers lament the shortage of time, meager resources and lack of confidence as reasons for not "teaching" science to young children. Hopefully, this presentation will demystify science experiences for young children, by providing new curriculum approaches, suggesting different teaching strategies, and by supporting an integrated broad-based interactive program. It shores up the teacher's self-confidence while permitting flexibility in styles of learning and teaching. It further provides the stimulus and framework for converting explorations into skills, knowledge, concepts -- into a process or way of thinking about science. Always the focus is on the children doing an activity or project, and/or engaging in an experience or exploration.

The plethora of exploratory activities and approaches designed to permit these young children to actively experience and interact with the question at hand, and to develop a course of action which impacts positively upon it, provides the spark that ignites the interest of both teacher and student. For example, young children assemble themselves into a small group and dramatize The Scarecrow, The Tin Man (Wizard of Oz), Raggedy Ann. They actually "construct" a puppet of straw and blow it down (a puppet of wool, of wood and of clay, of cardboard and clay). Questions follow...what could we have done to make it better....could we try it....did it work....can we improve on it? Thus all of the activities are directed toward developing an understanding and awareness of their skeletal system, while reaching out to children for their creative solutions and abounding energy. Not only do the children find themselves empowered through their impact and involvement, but the teachers feel empowered also - they become catalysts for change. Their view of the role of science in young children's lives is dramatically altered. Their view of how young children learn science is reinforced and supported. Their view of themselves as agents of change is incredibly strengthened.

The purpose of my presentation is to stimulate thought among my colleagues in early childhood and primary education about the scientific possibilities inherent in the materials they teach. I hope to walk them through some possible approaches and activities, to suggest some applications and to engage them in active discussions. I would like to think of this presentation as seeding, or a greenhouse for their own innovations or ideas to come to fruition. I will draw upon a wide variety of material -- children's literature, technology, history, surveys, critical thinking activities, artistic culminations and poetry.

I believe teachers can encourage and assist children to develop a lens through which they can view themselves and the world around them, making sense of this world. Teachers can create a climate in which children can freely explore their own questions, take risks and make mistakes.

I hope this presentation will encourage a free-flowing exchange of ideas, so that each of us will be recharged to DO SCIENCE - Science in which process and content are given equal importance - SCIENCE in which children excel and succeed!

Important points to note in working with young children:

1. They cannot recognize cause and effect easily. They need repeated experiences to take the "magic" out of the effect. (It's still okay to keep some magic in!)

2. They focus on the beginnings and endings of experiences, leaving out the middle section.

3. They need to probe, question, discuss, handle things - in short, they must have hands-on experiences in order to formulate ideas and concepts.

4. They are still at a concrete stage of thinking about things.

5. They cannot yet distinguish clearly between fantasy and reality.

6. They are holistic and egocentric in their approach to explorations - how does the exploration affect their senses, their bodies, their belongings? Usually their questions focus around these themes:

   What is it?
   What is it like?
   What does it do?

7. They need repeated experiences and explorations to arrive at understandings.

8. They are curious and should be encouraged and supported in their quest for information. They should ask questions, questions, questions.

Isidor Rabbi once shared these insights with a friend upon being asked why he became a scientist.

"My mother made me a scientist without ever intending it. Every other mother in Brooklyn would ask her children after school....'So! Did you learn anything today?' But not my mother. She always asked me a different question. 'Izzy,' she would say, 'Did you ask a good question today?' That difference -- asking good questions -- made me become a scientist!"

The presentation about the human skeletal system is based on explorations carried out by children ages four through seven years old in response to questions posed by them and to them.

The following sampling of projects, activities, and discussions are those successfully adapted, incorporated and utilized by teachers to initiate interest in the children's own skeletal systems. As you will see, the approaches differ. Teachers should select those projects and explorations consonant with their style of teaching and with their children's style of learning. Of course, any of these projects can be amended in order to meet both the individual and collective needs of the children at hand.

APPROACH #1 Read <u>Why Can't I,</u> by Jeanne Bendick

Discuss contents of the book with the children.

Query: I wonder why we can't fly like a bird?
Document all comments, acceptable responses, place on experience chart

<u>Seven-year olds and their responses:</u>
Noah: We have no wings
Laura: Gravity keeps us on the ground
Matt: We're not the right shape
Sue: We're too heavy to fly

Discuss the various responses, e.g., an airplane is heavy, but it flies.
Query: What gives the bird its shape?
(Again, utilize experience charts) Record all comments
Noah: A bird has bones like a chicken
Laura: I don't think a chicken flies
Hmm, I wonder, does a chicken fly?
Matt: Let's cut open a chicken....
Laura: Gross - I'll look for a book about chicken bones in the library
Noah: My dad x-rays people and looks at their bones....Can we x-ray a bird, a chicken?

Preparation:

1. Enlarge and photocopy the skeletal system of birds (Reference: <u>Anatomy & Physiology for Children Through the Dissection of a Chicken,</u> by Ashton)

2. Try to borrow a stuffed bird from a museum

3. View specific videos relating to structure and form of birds; show to group

4. You might wish to order (purchase) commercial kit-building skeletal model of birds

5. Have your favorite butcher bone two or three chickens. Follow the attached sheet of instructions for the cleaning of the bones.

6. Vocabulary and discussion of work of scientists:

Anatomist	Archeologist	Orthopedist
Paleontologist	Structure	Bone
Skeleton	Vertebrae	Leg Bones
Wing Bones		

One teacher cleaned all the bones in soapy water, then reused the water and added 1/4 cup of Clorox, allowing the bones to soak for a day. Rinse them, allow them to dry for a day, and they are ready to use.

Concepts:

- Bones of a chicken weigh very little
- Bones of a chicken are arranged in a specific order
- Bones give the chicken its shape and form
- Bones are different sizes
- Bones are different shapes
- Bones are hollow
- Bones support the frame of the animal
- Bones keep the chicken functioning

Activity (7-year olds) Group of 6-8 children

FIRST SET OF CHICKEN BONES

1. Tack up large skeleton of chicken to tack board, chalk board.
2. Hide cleaned chicken bones under sand in sand box. Children are scientists, looking for clues as to the inhabitants who lived in this specific habitat.
3. Children tape or place the bone they "found" onto the skeleton of the chicken. (They discuss the dinosaur exhibit at the Museum which they had recently visited.)
4. Have children observe the skeletal system. Does the shape of the chicken follow the skeletal system?

SECOND SET OF CHICKEN BONES

Activity (7-year olds)

1. Distribute chicken bones to students
2. View under microscope; students draw their observations, view under magnifying lens; view with naked eye
   Paper divided into three sections - drawings or sketches under appropriate headings. Do they appear the same?
3. Students weigh collectively the bones of a chicken, then singularly weigh one bone. Document the weights in sheets for their portfolios with sketches of bones they chose to weigh - also measure the same bone, again document findings.

4. Arrange bones sequentially, or according to some classification - weight, length, type, location, function.
5. Plan a Chicken Bone Mini Museum - Cardboard from recycled material - choose one bone, put in Ziploc bag - using the enlarged x-ray photo of chicken, label Ziploc bag, get Museum board ready.
6. Wear goggles - Place bone under toweling, papers - break it apart - crush it - discuss bonemeal for plants, etc. Bring in bonemeal for class to see.

Activity

Does form follow skeleton structure? Compare skeleton of chicken with skeleton of a house, yurt, tent, human skeleton. Have students use toothpicks or tongue depressors, clay, to form structures. Cover with transparent paper -

Discuss the importance of the skeleton frame to the structure - talk about skyscrapers, bridges, human skeleton. Place human skeleton picture alongside chicken skeleton picture.

Dissect fish in class, or have students look at boned fish with skeleton intact for them to examine and discuss

Activity

Have photographs or sketches of animals available to students. Have them superimpose skeleton structure onto animal - Have them compare their sketches with actual x-rays of the animals. (Have books and references available for the students.)

Thumb Test - Have students tape their thumb across their palm - leave other fingers free.

a) Can they hold a glass?
b) Can they play marbles?
c) Can they draw a picture?

Discussion and Comments -

Do animals have thumbs?
If they do, do they use it like we do?

Activity:

Fingerprint everyone's thumb
Discussion; Comparison

Enrichment

a) Research limbs of animals
   Paws, claws, fins, wings
b) Research animals who have no

bony structures

c) Research animals who carry their bony skeleton externally

d) Press bones into clay or plaster of paris to form an impression. Impressions can be made of single bones or entire skeletons (small fish, for instance).

e) Get other animal pictures and try to visualize bones below the skin, feathers or furs.

f) Use creative movements:
Strut like a peacock
Prance like a monkey
Hop like a frog
Run like an ostrich

g) Experiment:

a) Hold arm outright, bend wrist
b) Hold arm outright, bend at elbow
c) Hold arm outright, roll at shoulder
d) Hold arm outright, bend arm between wrist and elbow
Are you able to do all these movements?
e) What if you had no knees, no joints - would you be able to kick, hop, sit?

h) Compare bodies to machines
a) Arms are like levers; compare them to seesaw, crane, fishing rod

Alternate Approaches

1. View the <u>Wizard of Oz</u>, dialogue on the Scarecrow, on the Tin Man, on Dorothy - Could a scarecrow really walk? If he could, how? What makes us able to walk, crawl, move? (most students say our muscles) How would the Tin Man walk?

2. Have students draw a person, or hand out a sheet - like the one attached. Have students fill in every part of the body they are familiar with.

<u>What We Know About Our Bodies</u> - Experience Chart
Noah: I know we have a heart because the doctor listens to it with a stethoscope.
Laura: I know we have bones because I can feel my elbow.
Matt: My father has an x-ray of my hand. Can I bring it in to show you all - I saw my bones.

Give additional sheet of an outline of a person to the group. Have them pinch themselves, feel themselves - place bones or structure on to sketch of person.

Extension - How did people long ago know where their bones and/or organs were? History of medicine, use of dead bones, customs, dissections, drawings, statues, traditions, myths.

Compare their outline sketches with a published sketch of a skeleton of a human being. Borrow x-rays of bones from physicians. Have students note the sizes and shapes of the bones. To explain the spinal cord, students can hook together empty spools and move them in unison to see how they react.

a) Students of this age love to learn the true names of their bones - see students' sheets attached. (From Kid Science, March 1991)

Chart: What Do We Want to Find Out About Our Bones?
Important Concept: Help students to discover that bones do not move themselves. Muscles from other parts of the body move them.

1. What part of the body has the longest bone?
2. What part of the body has the smallest bones?
3. Are bones living?
4. Can bones grow?
5. Can broken bones get better?
6. Why are bones important?
7. Are there parts of your body that you use that you cannot see?
8. Are there parts of your body that are always working - even when you are asleep?
9. What happens when a bone really gets hurt or dies?
10. What if we had no bones....?
11. Are people born without bones?

Circle Time - Activity

Read The Magic School Bus Inside the Human Body, by Joanna Cole
Make a Class Book - Bone Trivia
Include interesting facts that the students have learned from reading and listening to stories.

BONE TRIVIA EXAMPLES

1. Your bones are alive; they take in food through the blood. They grow, they can usually repair themselves.
2. A baby has more bones than an adult. As it grows, some of its bones join together to make one bone.
3. An adult person has 206 bones.
4. About 25% of a human bone is water.
5. Most of the bone is made up of calcium.
6. When you are born, your bones are soft and made up of a rubbery substance like cartilage (like the tip of your nose).
7. You can change the size of your bones -

some athletes who run have very large leg bones and muscles.

8. Half of your bones are in your hands and feet.
9. Bones fit into four basic groups.

Extensions:

Writing Exercises:

Analogy: An elbow is to an arm like a ________ is to a door (hinge).

For 7-year olds:

Footprint Patterns:
Have each student put their feet into washable tempra paint - walk across the room - note that each child has his individual pattern. Some swerve to the left, some swerve to the right.

Write a Mystery:

The Case of the Missing Dog Bone

Bring in articles of Bone Replacements

1. Students can summarize article
2. Students can engage in writing exercise such as below:

FACT	COMMENT (OPINION)
Mrs. Brown had an artificial hip to replace her diseased hip bone.	I wonder what the artificial hip is made of?
She will need some physical therapy to help her strengthen her leg muscles.	What happened to her muscles? Where are these muscles anyway?

Other Extensions if age-appropriate:

1. Books about handicapped individuals.
2. Books dealing with customs of other countries - Indian burial customs, Eskimo scrimshaw, tools, Egyptian burial customs.
3. Art - Leonardo DaVinci sketches of the body, Greek and Roman statues.
4. Have students bring in other (cleaned) bones.

Examining bones:

Ask your butcher, or parents, for soup bones. Tell him the children and you are interested in learning about bones. A cylindrical bone like the shin is an excellent one for students to study. (Try to saw it lengthwise, so they can look inside.)

If you wish to do a joint dissection, obtain beef knuckles. Get one with most of the tissue left on it.

Exploring with the students:

a) First look at the ends of the bone.
b) Smell the bone.
c) Weigh the bone.
d) Bang the bone against something.
e) Hit the bone with something light - something heavy.
f) Draw the bone - describe what the different parts look like.
g) Is the bone similar to a part of the body you have studied?

Hints:

1. Have children observe muscles and/or tendons. Name: Marrow, calcified Bone, spongy bone (Young children need not memorize words, but get familiar with them.)
2. Separate halves and talk about the function of the bone marrow.
3. Pull away the covering skin (periosteum). If the bone is fresh, you will see small red dots where blood vessels enter the bone.
4. On the surface, you will see tiny holes. Bone breaks down and will renew itself by growing back in a constant cycle.
5. Scoop out marrow. Boil bone to get it really clean. Inside you will see the braces, or struts that grow along lines of stress.

Note: Young students like using the magnifying lens.

Extension: Read: Bony Legs, by Joanna Cole
Make: Bone Soup
Read: Stone Soup

Activity: To show how bones can be made to move.

The places where bones come together are called joints. Since bones are rigid, joints are crucial to our being able to move. Any place we want to bend must have a movable joint there.

a) Cardboard puppets with fasteners
b) Styrofoam hand strips with plasticene to make a simplified model of a human skeleton
c) Or, as younger children do after exploring their bodies, connect toothpicks (they break easily to assorted sizes). Toothpicks are the bones - with small balls of clay to represent joints. Emphasize that they must put a joint wherever the skeleton is to have mobility.
d) Are all the joints equally mobile - elbow versus shoulder, knee versus ankle?

Activity: Trace baby's hand on graph paper. Calculate area, measure a certain finger, calculate hand spans - trace students hand on graph paper (area). Do comparative measurements. Trace adult hand on graph paper. Contrast, compare, document measurements.

a) Ask physicians for x-rays of various hands, note patterns of growth, discuss how companies come up with statistics. Do the x-rays differ, where, how?

Enrichment:

Which would take longer? .....

- to walk up a hill or down a hill?
- to brush your teeth or floss your teeth?
- to write your name with your left hand or your right hand?
- to ride to the store or to walk to the store?
- to go up a pole, or to come down a pole?
- to lace up a shoe, or to use velcro tabs?

Initial Activities for Young Children:

1. Read Curious George Goes to the Hospital. Discuss why George had to go to the Hospital. What did the doctors do to make him better? Discuss what x-rays are. (Have some x-rays available.) Ask if anyone in the group has had a broken arm. Have them describe the incident and what occurred.

Query: George has bones....we saw that in the x-rays. Do you think we have bones inside our bodies? How can we find out?

- Have children feel themselves, their rib cages, their elbows, their ankles. Have them wriggle their toes, turn their heads, bend their wrists, kneel down

- Experience Chart:

Ann: I can kick the ball with my foot
Bob: I can draw a picture with my hand
Tim: I can wink my eye

Alternative: Have children create a Class Book utilizing a rebus-like approach with their illustrations.

Another approach: The adult can also take Polaroid photos of the children at play, or at work. Have them illustrate the photo.

- I am sliding down the chute: (Bob)
- I am pushing a wagon: (Ann)
- I am painting a picture: (Tim)

Query: Ask the children to think what works together inside their bodies that enables them to get up and sit down. Ask what gives their legs, arms, and fingers their shape. Ask them what they think they would see if they could look underneath their skin.

- Record their comments onto an Experience Chart
- Using their fingertips, can the children feel a bone inside their arms or legs? Can they feel their wrist bones, their skulls, their spines?

All of the above activities should lead the children into examining their own body structure.

Activity: Lie down on paper, and ask a friend to trace you. Feel your rib cage, neck bones, arm bones, leg bones, head bones. Place them on the traced body outline. Have children label all the bones they know.

- Make sure new vocabulary words are listed on an on-going chart placed at eye level of the children.

- Acting without words (Pantomime) is another way to reinforce a child's concept formation. Here are a few examples:

  - Show us how a baby would get from one part of the room to another
  - Discussion about crawling or wriggling across the room. Why does a baby crawl on his hands and knees? Accept all reasonable responses
  - Show us how a rabbit would get from one part of the room to another part
  - Show us how a worm would get from one part of the room to another part. Children can add their own versions -- can leap, jump, slide, etc.

Activity: Bring in chicken bones for group. (Work with group of 6-8 children). Give each child one bone.

- Have children compare the bones, classify the bones, trace the bones, smell the bones
- Have children drop each bone to the ground - time how long it took to hit the ground - drop bones of different sizes to the ground, which one hits the ground first? - Drop bone and a block to the ground. Which one hits the ground first? I wonder why?

Writing Activity:

Tape bone to construction paper. Write sample like the following:

Ann: My chicken bone is bigger than an ant, but smaller than my pencil.

Extension: Have children take any number of bones and clay - create a new animal skeletal structure.

1. Tell us what your animal is
2. Tell us where your animal lives
3. Tell us what your animal eats
4. Tell us what your animal says
5. Tell us what your animal likes to do

Concepts for Younger Children:

1. The Human Body contains many bones
2. They help to give the body shape
3. They hold the body up
4. They protect what is inside

Read: Why Am I Different, by Norma Simon, to the children. Discuss the story with the children. Query whether all of us look alike. Make a collage of people; include all ethnic groups, all types, thin, fat, small, large, tall, short, etc. We are alike; we are all different. In what ways?

Extensions:

- Puppets with fasteners to show joints - Read Pinocchio. Go to Puppet Show.
- Shadow Puppets - If structure determines shape, children can make shadow shapes with their hand - rabbit, duck, etc.
- Demonstrate material for a cast, a sling - ask children how it feels to wear a sling.
- Discuss people who use crutches, canes, leg braces, artificial limbs, walkers, hearing aids.
- Learn three stretching exercises to do before walking.
- Plan and take a well-balanced, easy-to-carry snack for an extended walk.

(For 7-year olds:)

- Draw or make a model of a futuristic technique used for someone who has a broken leg. Describe all its new features.
- Visit several stores that sell walking shoes. Ask a salesperson what to look for in a walking shoe. Compare several brands.
- Prepare a simple First Aid Kit to take on walks.

Activity:

HOW TO TAKE CARE OF OUR BONES

- Do wear a helmet when you ride a bicycle
- Do wear eyeglasses with unbreakable glass
- Do wear proper shoes or sneakers
- Don't put things in your ears or up your nostrils
- Don't play with sharp things
- Don't walk barefoot in the classroom, in the street, or on the sidewalk

Games to Reinforce Concepts:

Loopey Loo.....
Simon Says.....
London Bridge is Falling Down.....

Songs:

Them Ther' Bones
Children make up their own bone songs

Movement Activities:

Strut like a Peacock
Run like a Zebra
Hop like a Frog

Story Time:

Read Raggedy Ann and Andy
How would they move?
Make your own dolls, straw puppets
Move like a yarn doll, a stuffed bear, gingerbread boy (in story)

Arms or Legs?
In which of these activities are your arms used most? In which are your legs used most? Which activities need the use of both your arms and legs?

Swinging
Roller-skating
Playing baseball
Carrying a large pail of water
Peeling an apple
Running
Eating
Swimming
Climbing a tree
Jumping rope
Playing checkers
Making a pie
Seesawing
Raking leaves

Activity:

- Time line sequence
  - Photographs of children

1 year 2 years 3 years 4 years 5 years

  - Put captions underneath photos

Add any relevant data

Activity:

- Clothes line sequence
  Place clothing of a one-year old, two-year old, three-year old, etc. on clothes line. See sequential changes, plus growth. Discuss why the clothing got larger. Place all comments on experience chart.

Activity:

- Writing Experience
  Class Book: The important thing about my hand is.......

Activity:

- Footprints: Have each child put his/her foot into water, make footprints on butcherblock paper. Measure footprints, place in sequence across the room. Graph how many footprints it takes to go from place X to place Y. Graph how many <u>jumps</u> it would take to go from place X to place Y. Compare and discuss data.

Activity:

- Make handprints in clay
- Make footprints in clay
- Make fingerprint on wrapping paper
- Create a sequence story with illustrations
  When I was born, I could wriggle my thumb.
  When I was one, I could not run
  When I was two, I could really move
  When I was three, I could climb a tree
- Invite nurse/doctor/scientist to class
- View select videos on athletes, dancers; how they use their bodies

Extensions and Follow-up:

- Safety issues
- Nutrition and Food
- Your senses
- Other body systems, especially the muscular and digestive systems for these ages
- Health issues
- Handicapped people
- Inventions and patents

Enrichment: Visit Dinosaur Exhibits, Zoos
Discuss what scientists do
Collage of scientists at work. Include women, multi-ethnic groups. Help children discover the inclusive work of scientists.

Resources:

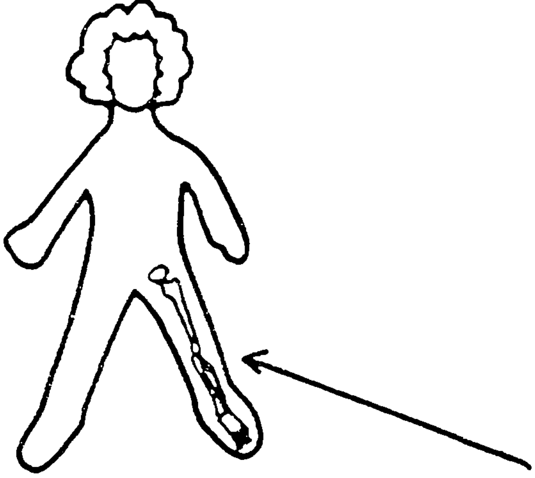
Non-Fiction

Joanna Cole: The Magic School Bus Inside the Human Body
Alice Hinshow: Your Body and You
Ilse Goldsmith: Human Anatomy for Children
Castle Books: The World of the Human Body
Susan Meredith: What's Inside You
Rosemary Althouse: As We Grow
Jeanne Bendick: The Human Senses
Gwen Allen/Joan Denslow: Bones
Philip Balestrino: The Skeleton Inside You
Ruth Brunn: The Human Body
Ruth Gross: A Book About Your Skeleton

Fiction

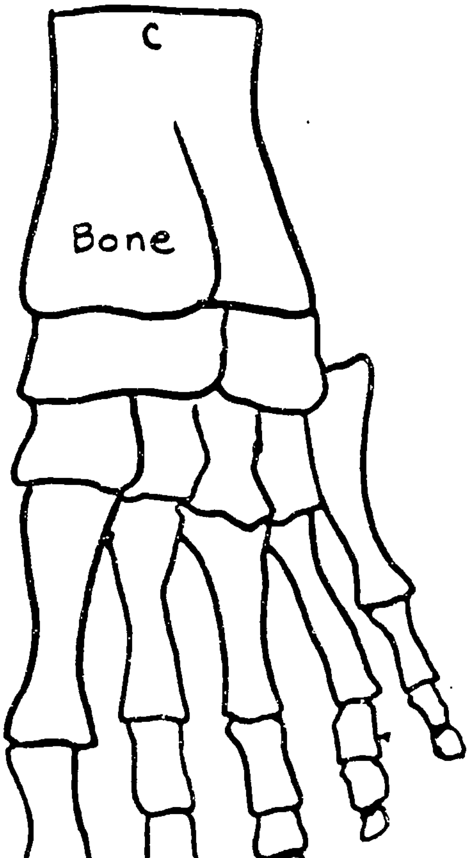
The Clifford Series: e.g.,	Clifford Follows His Nose
	Br'er Rabbit and The Tar Baby
	The Gingerbread Boy
	Raggedy Ann & Andy
	The Wizard of Oz
	Pinocchio
	Curious George Goes to the Hospital
Maurice Sendak:	Mili
Nursery Rhymes:	Jack and Jill
Shirley Hughes:	Alfie's Feet
Patricia Machachlan:	Through Grandpa's Eyes

"My Skeleton" (My Bones)



My bones go here.

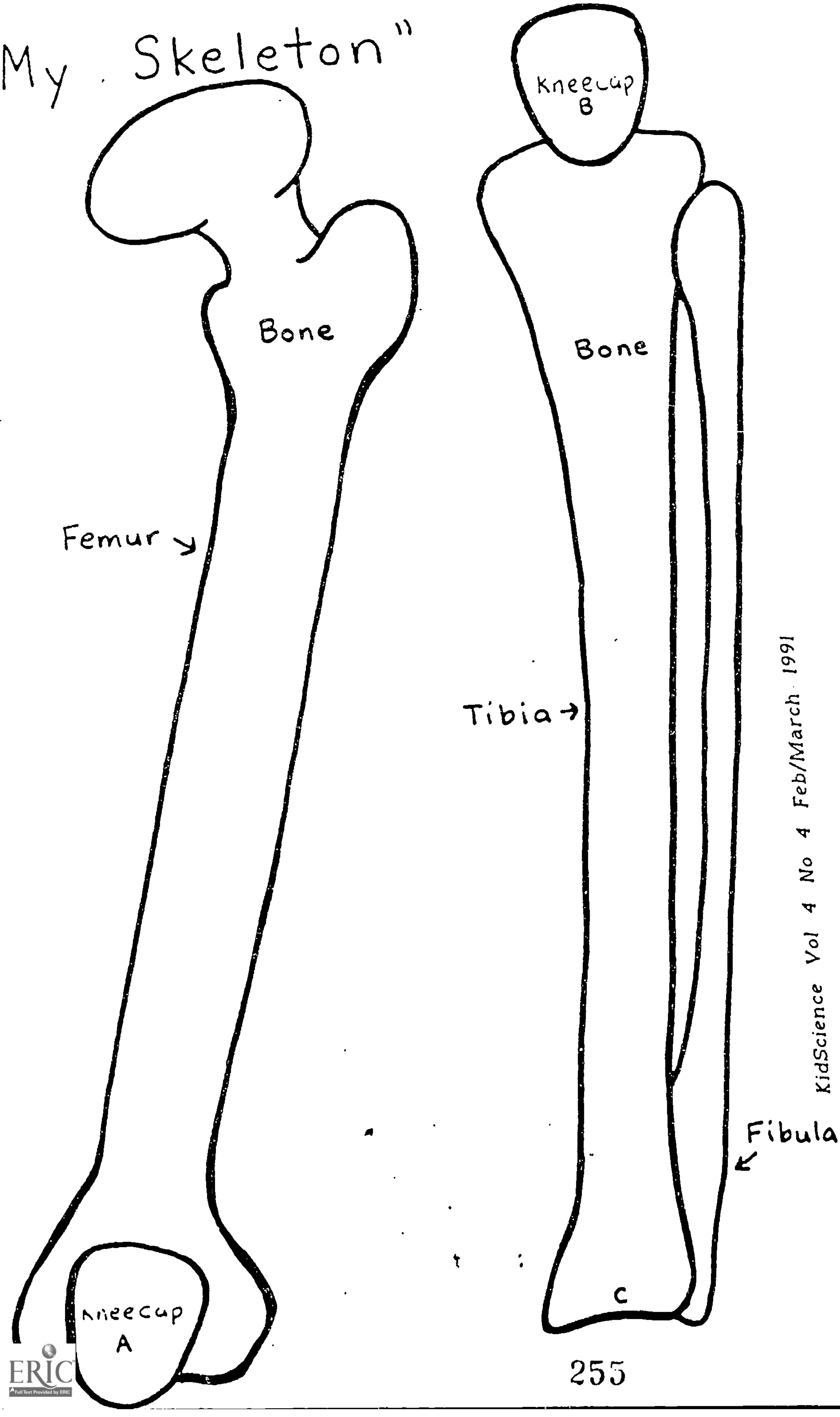
- Run on white or off-white (ivory) paper.



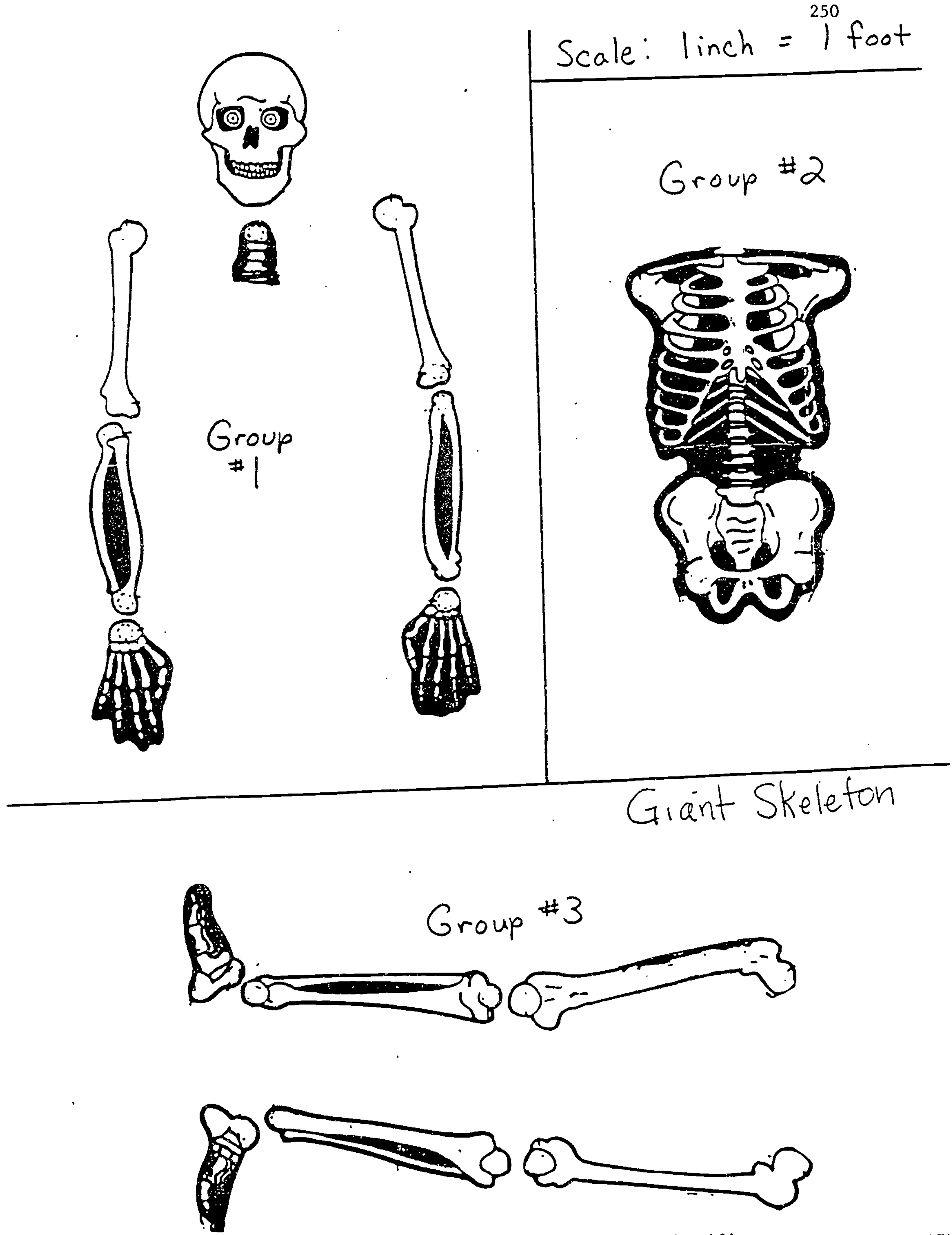
- Cut out bones of leg. Arrange the bones of the leg inside the left leg. (Big toe should be on the inside as in diagram.)
- Paste on leg. The foot joins at "C." The two kneecaps are "combined." (Paste Kneecap "A" over Kneecap "B.")

"My Skeleton" by Doreen Fuller will help little kids understand that there are bones inside their bodies.
KidScience Vol 4 No 4 Feb/March 1991

"My Skeleton"

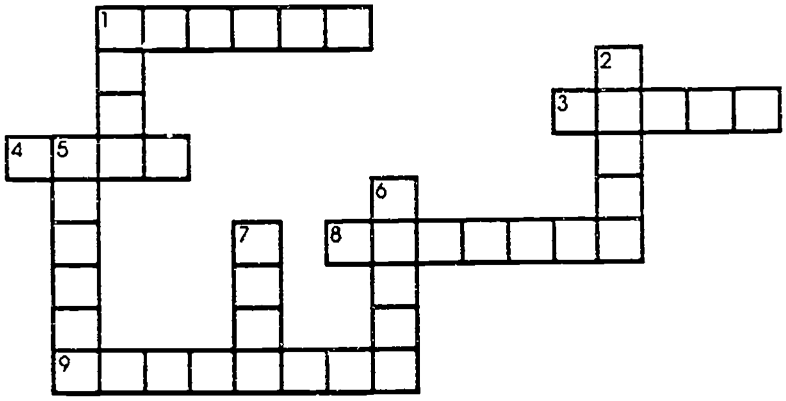


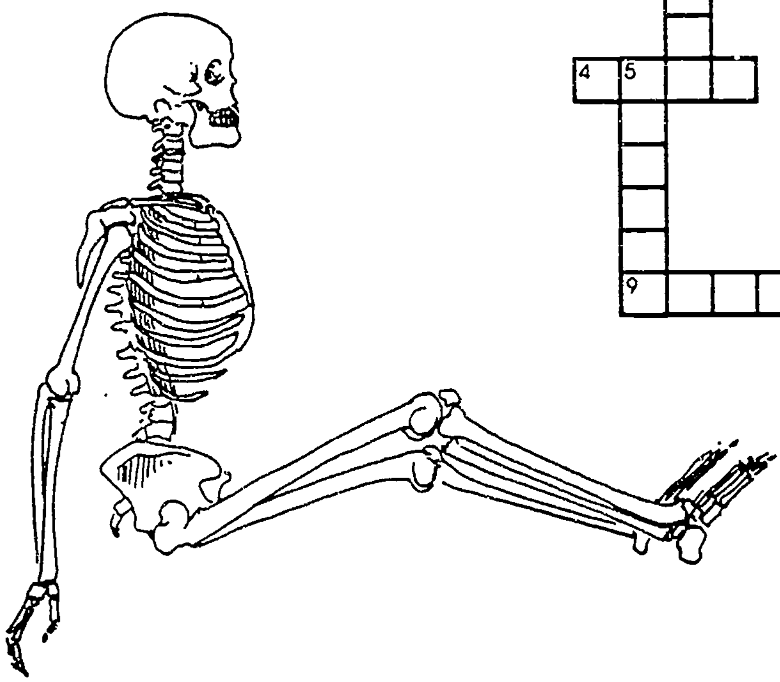
KidScience Vol 4 No 4 Feb/March 1991


Scale: 1inch = 250 1 foot
Group #1
Group #2
Giant Skeleton
Group #3

Skeleton

The skeleton is the bony framework of the human body. It is made of 206 bones of different sizes and shapes. The skeleton plays a role in determining how the body moves because most of the muscles and bones of the body are attached to it. In addition, the skeleton provides protection for many of the body's important organs such as the LUNGS, HEART and BRAIN. The skeleton also acts as a storehouse for the minerals that the body needs to stay healthy.





ACROSS

1. Skeleton bones are different sizes and ________
3. The skeleton plays a role in determining how the body ________
4. Some bones are ________ and some bones are short
8. They attach to the skeleton
9. Framework for the body

DOWN

1. Covering for the body
2. The skeleton is made of 206 ________
5. The skeleton protects the ________ of the body
6. The skeleton is the framework of the ________ body
7. The skeleton plays a ________ in determining how the body moves

Name ______________________________

HANDS UP

Find words that are things you can do with your hands. Draw a line around each word. Use the Clue Box to help you.

	R	Z	O	I	
	R	U	B	T	
X	S	L	A	P	
W	E	S	A	E	
A	W	C	W	X	
V	D	R	A	W	V
E	P	A	I	N	T
Z	E	T	A	P	T
F	C	C	D	N	I
G	L	H	I	T	C
P	A	O	Q	U	K
G	P	O	K	E	L
	J	B	O	X	E

CLUE BOX

SLAP
WAVE
PAT
RUB
DRAW
PAINT
BOX
TAP
SCRATCH
HIT
TICKLE
POINT
POKE
CLAP

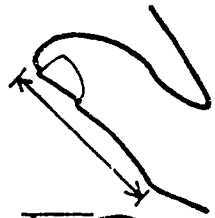
Name ______________________________

HOW BIG AM I?

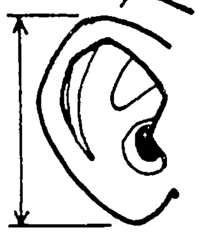
You will need: a metric tape measure or one meter of string and a metric ruler.

Measure these parts of your body with the metric tape measure. If you do not have a tape measure, measure with the string. Then lay the string on the ruler. Write each measurement on the blank.

1. How long is your right thumb? ____________

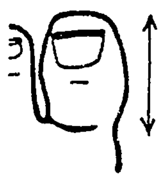


2. How long is your left ear? ____________

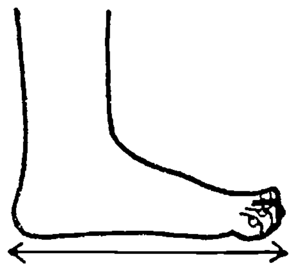


3. Make a muscle. How big around is your upper right arm? ____________

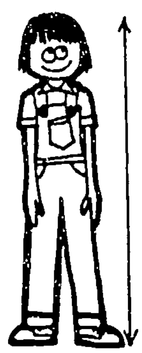
4. How long is the big toe on your left foot? ____________



5. How long is your right foot? ____________



6. How tall are you? ____________



MINDS 2000+, INTERNET AND GLOBAL CHANGE

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January 1994

NASA'S MINDS 2000+, INTERNET AND GLOBAL CHANGE

by

James L. Barnes

The Nature of MINDS+

MINDS 2000+ is a NASA funded global change curriculum development project. The project utilizes innovative Internet and CD technologies to study global change issues associated with NASA's Mission to Planet Earth and the U.S. Global Change Research Program. This pre-service and in-service project will enhance middle school instruction through its integration with technology, space science and global change education. It is designed to improve the skills of teachers and instruction in these areas and to increase the access of all students to this instruction. A spin-off of this project will be an increased interest in a holistic approach to technology, space science and global change education at the middle school level. The project will focus on the use of technology to study global change and space science as an integrator of the existing middle school curricula to promote learning and to develop problem solving and creative and critical thinking skills. All project activities are built upon real life context scenarios that actively utilize Internet gophers for data acquisition. The hands-on/minds-on learning experiences are coded to the national standards for mathematics, science and technology to ensure a seamless curriculum transition for students from elementary school to middle school to high school.

As a result of the project, a proposed pre-service course will be implemented at Eastern Michigan University which will in-service teacher educators and middle school teachers. A permanent laboratory will be established for technology and space education. Support pre-service and in-service networks will be established to provide continued implementation and improvement of the quality of teaching and instruction at the middle school level. Through the established course and other products of the project, teachers, teacher educators and students will develop problem solving, creative and critical thinking skills that will provide them a means to transfer knowledge to solve tomorrow's problems, thus producing a more scientific and technologically literate citizen.

Learning Experiences

Based on the national standards for science, mathematics and technology the following global change themes have been selected for MINDS 2000+:

- Global Change
- Satellites and Remote Sensing
- World Food Problems
- Weather
- Deforestation
- Technology Management: Urban Growth and Planning
- Technology Management: Nuclear

The curriculum map used for MINDS 2000+ is highlighted in Figure 1.

Insert Figure 1 about here

Deliverables

- Teacher's Guide (University Pre-Service and Middle School)
- Student MINDS-On Manuals (University Pre-Service and Middle School)
- Interactive Tutorial (Macintosh Hypercard)

The Goal of MINDS 2000+

The goal of MINDS 2000+ is to develop scientific and technological literacy by focusing on science, mathematics, technology and space science as integrators of the existing middle school curriculum. MINDS 2000+ will use this relationship and its interactions to have students develop an greater understanding of global environmental change through the concept of Earth as an entire system. Students will explore how its components and their interactions have evolved, how they function, and how they may be expected to continue to evolve. In order to accomplish this goal, students will use remotely-sensed satellite and earth probe data. Thus the ultimate goal is to develop in students the capability to predict environmental changes, both natural and human-induced, that will occur in the future. By providing students with this capability they will be able to answer many fundamental unresolved questions about their constantly changing global environment, thus improving their quality of life.

The Objectives of MINDS 2000+

To accomplish the intended purpose of MINDS 2000+, the project will focus on the development and implementation of pre-service and in-service activities that foster the integration of technology and space science with the existing middle school curricula for all students. More specifically, the objectives of this project are:

- to develop problem solving and creative and critical thinking skills through the integration of science, mathematics, technology and space science with the existing middle school curricula.
- to assess pupil's academic performance and teacher's instructional skills in science, mathematics, technology and space sciences as a result of their exposure to this program.
- to in-service teachers and teacher education personnel through staff development workshops and to establish a national in-service network model to enhance the transferability of the program.
- to develop an interdisciplinary model that can be easily transferred and adapted in teacher education institutions and in the nation's schools and one that enhances and facilitates the development of transferable concepts, skills, and knowledge, while enhancing attitudes and self concept.

The Benefits of MINDS 2000+

MINDS 2000+ fosters the following benefits to students:

- National Standards for Science, Technology and Mathematics
- Interdisciplinary Approach
- Systemic Approach
- Innovative Teaching and Learning Practice
- Use of Internet and other databases
- Problem Solving and Problem Finding
- Creative Thinking
- Critical Thinking
- Collaborative Learning
- Interpersonal Skills
- Real World Context
- Environmental and Social Awareness

Internet and Learning Experiences

Students work in groups to solve global change design briefs. A sample design brief is illustrated in Figure 2. Groups are organized based on student interest and learning style. Learning experiences involve the interactions among natural science, physical or biological sciences, information technology and social sciences. This interaction is diagramed in Figure 3.

Insert Figure 2 about here

Insert Figure 3 about here

In order to solve the global change design briefs, students use Internet as an integral component of their learning process. They use primarily the Consortium for International Earth Science Information Network's (CIESIN) gopher, the University of Michigan's Underground Weather database (Blue Skies), NASA Spacelink and Internet resources. Through these resources, students are able to capture key governments documents, articles, demographic information, and images. In order to gain a better understanding of the type of research categories available to students, see the menus of the Eastern Michigan University NASA gopher and web, which is highlighted in Table 1.

Insert Table 1 about here

Students begin MINDS 2000+ by studying general concepts of global change. As part of this study they go on to a scavenger hunt of the CIESEN gopher. The scavenger hunt enables them to learn about Internet and to become familiar with what data are available to them on global change. They also explore ftp's (file transfer protocols), E-mail, telnets and other Internet resources. Once students complete this learning experience they explore satellites and remote sensing. They study the Earth Observing System and Earth Probe satellites. In this learning experience students use Internet to collect data on each satellite as to its operation, platform, resolution, swath and purposes.

With this background students embark on a study of world food problems. Students are divided into the UNESCO geographic regions in order to study a particular region's food problems. Besides the CIESIN gopher, students use the geographic server (martini.eecs.umich.edu 3000) to gain information on cities, latitude/longitude, food resources, imports, exports and the like. They also access map data through ftp spectrum.xerox.com and the CIA World Data Bank through ftp gatekeeper.dec.com and ftp ucsd.edu. An example of a image capture is found in Figure 4.

Insert Figure 4 about here

Students then go through a series of weather-related activities. In this learning experience students learn basic weather concepts, capture weather images, and study disaster management of weather catastrophes. There are at least 40 ftp's and telnets for weather information and images. Among the most useful are Blue Skies (University of Michigan Underground Weather), NOAA, NCDC Weather Data, ftp uriacc.uri.edu for weather images, ftp unidata.uarc.edu for weather images and aurelie.soest.edu.au for sea-surface-temperature.

In the learning experience on deforestation, students are divided into two groups: (1) loggers and (2) environmentalists. Students will study deforestation from the viewpoint of their group. They will access CIESIN's gopher, use the Carbon Dioxide Information Analysis database and other Internet databases. Students will use the data accessed to design a case for their viewpoint. They will end the learning experience by E-mailing their class discussion to their representative and the White House.

Students wi'' study the global change problems associated with the urbanization of large international cities through the problem on Technology Management: Urban Growth and Planning. They will use the geographic server (martini.eecs.umich.edu 3000) to gain information on cities, latitude/longitude, food resources, imports exports and the like. They also access map data through ftp spectrum.xerox.com and the CIA World Data Bank through ftp gatekeeper.dec.com and ftp ucsd.edu. Besides these Internet resources, they will access reports and articles from libraries, such as the Library of Congress.

Finally, students will study Technology Management: Nuclear. This learning experience explores the energy component of global change. Students will access the CIESEN gopher, the National Nuclear Center database, the CIA Data Bank and other necessary telnets and ftps. They will capture images over time, i.e., 1986, 1988, and 1992 to examine the changes that have occurred around Chernobyl.

Summary

MINDS 2000+ provides an innovative vehicle to addressing the national standards for mathematics, science and technology. It incorporates an interdisciplinary approach through hands-on/ minds-on uses of technology. By using Internet and other technologies we can provide real world applications to the existing curriculum. Students will be able to access the most current data by which to examine global change problems which affect the social process. By doing this they will be able to make key connections among related subject concepts and thereby enhance their ability to transfer knowledge.

CURRICULUM MAP

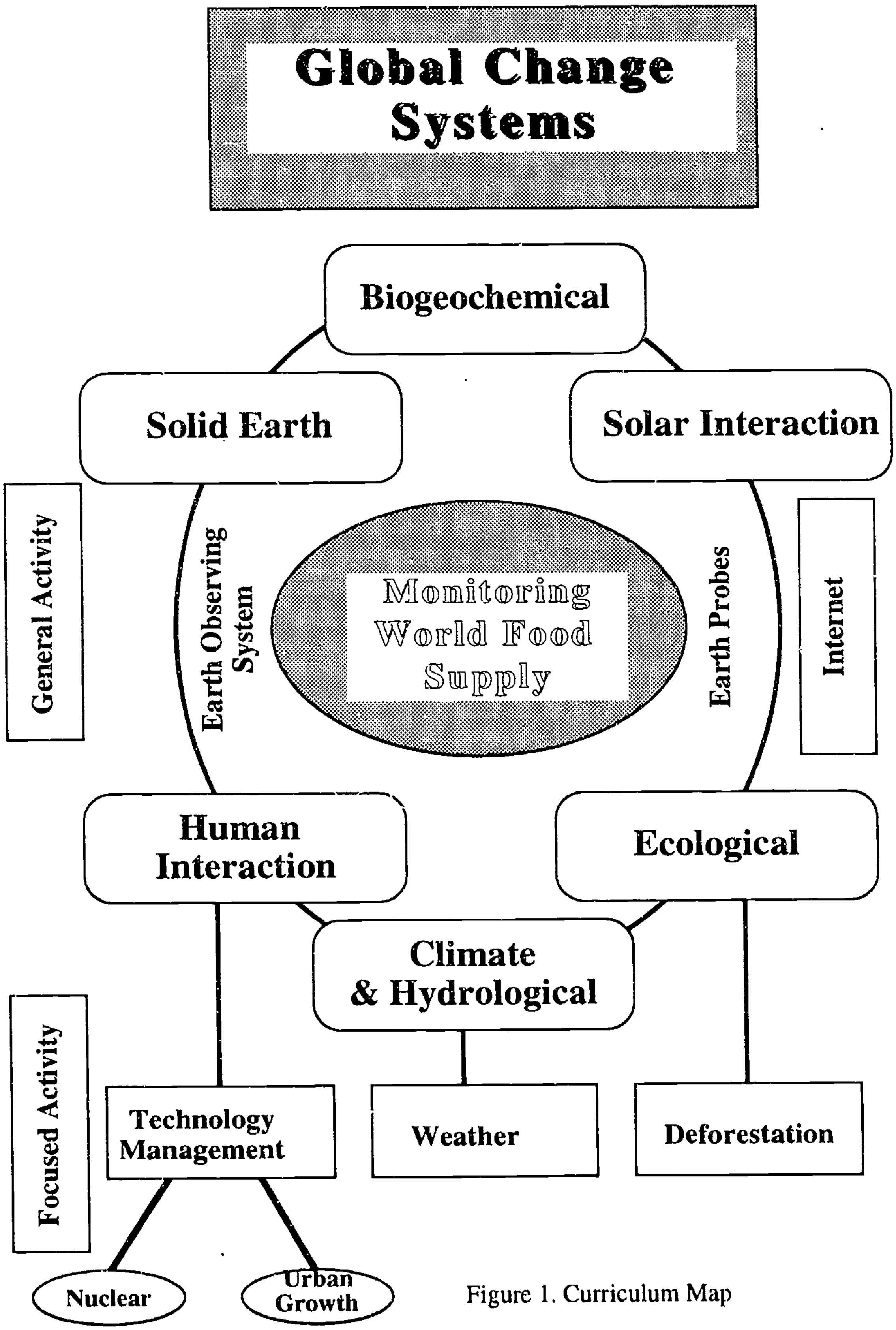


Figure 1. Curriculum Map

Design Brief

Deforestation

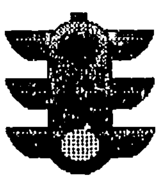
People are creative because they make a conscious effort to think and act differently. All people have the ability to be creative.

The problem outlined below provides the bare minimum of information you need to proceed with the design process. While you must think about the actual implementation of your design, you are only asked to complete a model which represents your solution. It is important that you plan a strategy, and consider many alternative designs before working on the one you think most appropriate. Let your minds go free, and try not to be too bound by rigid thinking.

PROBLEM SCENARIO: Over the last several decades increased pressure has been placed on the world's forest resources. The cry has been for more effective forestry management. One of the areas most affected by this demand is the Pacific Northwest. The Pacific Northwest is in the midst of a battle between the timber industry and the environmentalist. Questions are being raised by the timber industry for rights to clear cut forest areas, especially public forest, in order to protect the industry's jobs and to lower the cost of building materials due to a greater supply of lumber. Among the leaders in this effort by the timber industry are the Northwest Forestry Association, the lumbering communities, and the companies. Environmentalist are trying to block the efforts of the timber industry in order to protect the decreasing amount of old growth forest, the global carbon cycle and endangered species, such as the spotted owl. Among the environmentalist groups are the U.S. Forest Service, the Bureau of Land Management, the Wilderness Society, the Oregon Natural Resources Council, the Audubon Society and the American Forest Service Employees for Environmental Ethics (AFSEEE). Who is right? Can a forestry management plan be developed and implemented that will bring a balance between the spotted owl, old growth forests and the timber industry's need to harvest trees on public land?

Genius is one percent inspiration, and ninety-nine percent perspiration.
Thomas Edison

DESIGN BRIEF: The class will be divided into two groups: timber industry and environmentalists. Each group will create a forestry management plan in the form of a report that will allow the timber industry to be productive and at the same time be environmentally sound. In order to accomplish your task, each group will be subdivided into the following groups: natural scientists in charge of observable elements, physical scientists and technologists in charge of atmospheric transmission, sensors and satellites, information technologists in charge of data and information processing, and local, state and national social scientists in charge of creating policy. All work will be recorded in the group's portfolio. Group members will record all their work in their design log. Each group will construct a model to depict their solution. Once each group has completed their research and produced their model and report, the groups will debate their findings and viewpoint. This debate will be judged by local community experts.



You may now proceed with wild abandon.............

Figure 2. Deforestation Design Brief

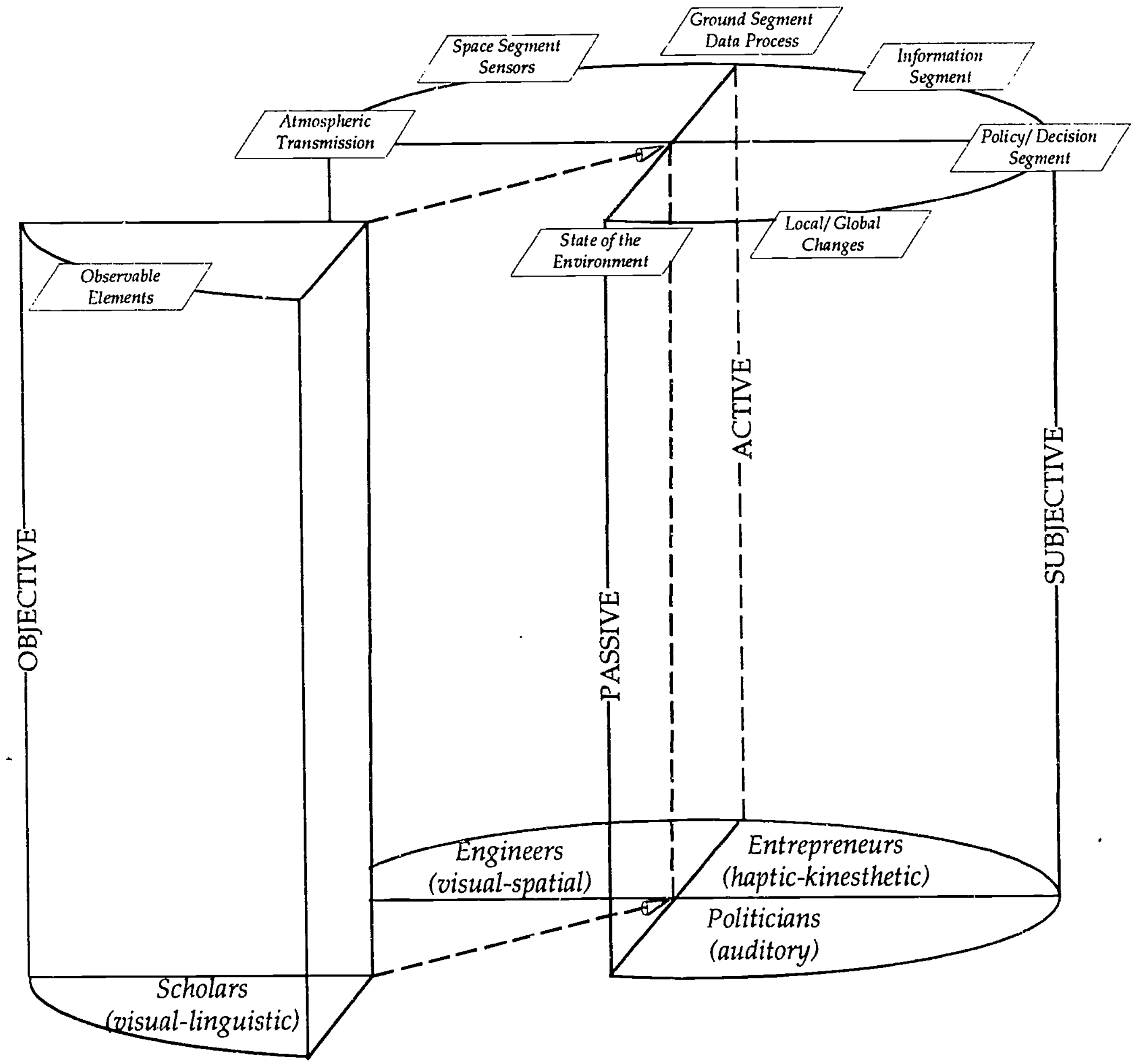


Figure 3. Systemic Global Change Model

Table 1. Eastern Michigan University's NASA Gopher

1. About NASA Research Center
2. Blue Skies (U of Michigan Weather Underground) <TEL>
3. NASA
4. NASA MINDS 2000+/
5. CIESIN Global Change Information Gateway/
6. EMU NASA Space Grant/
7. Subject Resources/
8. Curriculum Center/
9. Teaching and Learning/
10. Global Change/
11. K-12 Network/
12. Other Gophers/
13. NASA Internet Resources/
14. Suggestion Box.

Figure 4. Image capture example.

TAKING ACTIONS ON GLOBAL WARMING: WHAT MIDDLE SCHOOL STUDENTS HAVE DONE

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This paper originated from a panel discussion (Session 8.4) presented at the Ninth National STS Meeting and Technological Literacy Conference in January of 1994 in Arlington, VA by participants and staff members from the Leadership Institute in STS Education (Rubba & Wiesenmayer, 1991). The body of the paper originates from remarks made by the three Institute participants on the panel. The introductory and closing sections of the paper originate from those portions of the panel presented by the Institute staff members.

Leadership Institute in STS Education

The Leadership Institute in STS Education[1] is a three-year teacher development and research project in STS education for middle/junior high school teachers from rural school districts in central Pennsylvania and northern West Virginia. It is sponsored by Penn State University and West Virginia University, and funded by the National Science Foundation.

Project activities, begun in August 1991 and extending 36 months through August 1994, were based at the University Park campus of Penn State University and West Virginia University in Morgantown. The Institute was established to develop a cadre of two-dozen science teacher-leaders within central Pennsylvania and northern West Virginia. An extended program of professional development activities in STS education was offered through two workshops offered in the Summers of 1992 and 1993 with follow-up support activities during each of the following years.

[1] The Leadership Institute in STS Education is supported by the National Science Foundation under Teacher Education Grant TEP-9150232, Teacher development and research in STS education for rural middle/junior high school science teachers from central Pennsylvania and northern West Virginia, Peter A. Rubba, Project Director, and Randall L. Wiesenmayer, Sub-Contract Director.

The Summer 1992 Workshop included three components: 1) Sci-Tech Minicourses on Global Warming, the STS theme of the workshop, 2) a review of the research on effective STS instruction that leads learners to take action on STS issues, and STS unit development work, and 3) electronic mail (e-mail) instruction and practice. The workshop met over the three-week period between June 15 through July 3, 1992 on the University Park Campus of Penn State, Mondays through Fridays, from 8:00 a.m. through 4:30 p.m., with both required and optional evening sessions.

Six Sci-Tech Minicourses on Global Warming were offered to give the teachers a multi-disciplinary understanding of global warming. The minicourse included: The Meteorology of Global Warming, Variations in Carbon Dioxide and Climate through Earth's History, Fossil Fuel Burning and the Carbon Cycle, BioDiversity and Global Warming, The Social and Political Impact of Global Warming, and The Economics of Global Warming. These were taught by Penn State faculty known internationally for their research and scholarly activities in areas related to global warming. Each minicourse was 8 to 12 hours long, involving both classroom and field instruction.

Concurrent with the Sci-Tech Minicourses on Global Warming, the teachers examined the research on effective STS instruction that leads learners to take action on STS issues (Rubba & Wiesenmayer, 1985, 1988, 1991, 1993; Wiesenmayer & Rubba, 1990, Wiesenmayer, Turpin & Arguello, 1988) and worked on the development of an STS unit on Global Warming to be integrated into one of the science courses each taught. The four-phase STS issue investigation and action model was adopted as the organizer for STS unit development. The teachers organized themselves into teams of four or five by grade level and science course taught for the STS unit development work. Each team worked with a project staff member. The initial drafts of the STS units were about 60 pages in length and included detailed lesson plans for four to six-weeks of instruction. With reference to the four phases of the STS issue investigation and action model, approximately five to seven days/periods of instructional time were dedicated to STS issue foundations and STS issue awareness, eight to ten days/periods to STS issues investigation skill development and concurrent investigation of global warming, and eight to ten days/periods to STS issue actions. Resource materials (videos, booklets, journal articles, data sheets) were referenced in the text and/or appendices.

The titles of the STS issues investigation and action units, the names of the teachers on the team that developed the respective units, and the science course into which each unit were integrated are presented below:

Is Global Warming a Threat to Our Society?
Lenker, B., Ramirez, J. Schechterly, D. & Wilcox, C.
(A STS issues investigation and action unit designed for integration into 5th and 6th grade science)

How Does Our Use of Landscape Impact Global Warming?
Fleagle, S., Laskowski, E., Owings, M. & Yukish, D.
(A STS issues investigation and action unit designed for integration into 5th and 6th grade science)

Global Warming: Electricity and Carbon Dioxide
Keplinger, W., Slenker, F. & Thompsen, J.
(A STS issues investigation and action unit designed for integration into 7th grade physical science)

Global Warming: Are Rising Carbon Dioxide Levels Harmful or Beneficial to the Earth?
Barley, J., Keely, M., Kuskoski, J., McLaren, M. & Rothacher, D.
(A STS issues investigation and action unit designed for integration into 7th and 8th grade science)

A Unit for Exploring the Impact of Our Lifestyles on Global Warming
Anderson. S., Conway, P., Jarosick, J. & Sillman, K.
(A STS issues investigation and action unit designed for integration into 7th and 8th grade earth science)

The Impact of Global Warming on Plants and Animals
Ditty, T., Milam, E. & Yorks, K.
(A STS issues investigation and action unit designed for integration into Biology)

Each teacher implemented the STS unit he/she helped to develop during the 1992-93 academic year.

To facilitate communications among the teachers and the project staff at Penn State and West Virginia Universities, an electronic mail (e-mail) link was established on BITNET using an 800 phone number. Use of e-mail in the project was reported on at the 1993 TLC by participants and staff members (Ditty, T., Jarosick, J. Milam, E., Rubba, P., Rye, J., Wiesenmayer, R., & Yorks, K., 1993).

A second summer workshop was offered during the Summer of 1993 at West Virginia University. The instructional program for that workshop focused on global warming, cooperative learning, and authentic assessment delivered by the project staff and faculty members from West Virginia University. The teams of teachers spent extensive amounts of time making revisions to their respective STS units based upon workshop instruction and 1992-93 field test results. The revised STS units averaged over 100 pages. Additionally, the teachers planned short-term dissemination activities (e.g., inservice workshops) and long term dissemination activities (e.g., mentoring another teacher as he/she implements the mentoring teacher's STS unit) for implementation during 1993-94. The revised STS units were again implemented by the teachers during the 1993-94 academic year.

STS Issue Investigation and Action Instruction

From a social responsibility perspective (Waks & Prakash, 1985), citizens in a global society have an obligation to help resolve the myriad of STS issues that humankind has created and now threaten the world. These include STS issues such as, acid rain, global warming, ozone depletion, overpopulation, species extinction, water quality and quantity, and waste management. Consistent with the social responsibility perspective, the Institute was founded on the premise that the goal of integrating STS into school science is to help learners/citizens develop the knowledge, skills and willingness to take responsible actions on STS issues based upon informed decisions (Rubba & Wiesenmayer, 1985). Hence, the STS issue investigation and action instructional model was endorsed.

STS Issue investigation and action instruction originates from work in environmental education on teaching for responsible citizenship action. The environmental education research on responsible citizenship action, which is summarized elsewhere (Rubba & Wiesenmayer, 1988, 1993), and more recent work in STS itself (e.g., Ramsey & Hungerford, 1989; Simpson, 1990; Wiesenmayer & Rubba, 1990) shows that learners/citizens take action on societal issues and continue to take action when the instruction helps them develop: 1) an awareness of societal issues, b) knowledge about actions that might be taken to resolve the issues, c) the ability to carry out or take informed actions on the issues, and d) certain personality and affective characteristics that dispose one to act (e.g., a somewhat questioning attitude toward technology, an internal locus of control, efficacy perception). STS issue investigation and action instruction comprises four-phase units (i.e., STS issue foundations phase, STS issue awareness phase, STS issues investigation skill development phase, and STS issue action phase) that incorporate these four factors research has shown are requisite to citizen action on societal issues (Rubba & Wiesenmayer, 1985).

The focus in this paper is on the issue actions phase of the STS issue investigation and action units developed by the Institute participants. In the action phase, learners developed an understanding of various types of actions that might be taken in support of the answer they formulated to the focusing questions. A tentative action plan is composed and the pros and cons associated with each action examined from a number of perspectives. Lastly, learners decide which action(s) they are willing to take as individuals or as members of a group, implement the actions, evaluate the results and report on their efforts. All six of the units developed by the participants in the Institute have strong action components. Three of the teachers/participants -- one an elementary teacher, one a middle school teacher, and one a high school teacher -- have implemented those action components in an exemplary manner. The teachers' descriptions of how they implemented the action components of the STS units they helped develop are presented below.

Implementation of the Action Component from *How Does Our Use of Landscape Impact Global Warming?* in Fifth Grade Science -- Dorothy J. Yukish

My students and I are currently in the actions phase of our STS unit on global warming. Both last school year and this one as we approached the action phase I knew that regardless of what actions my students chose to take, I wanted there to be a community education element to their actions. I knew that by the time they were done with the investigations phase of our unit, my students would be more knowledgeable about the issues surrounding global warming, the greenhouse effect, and the thinning of the ozone layer, than the average adult in our rural community. I also wanted my students to be able to go home and discuss what they were learning with their parents, family members and friends. A community education component to the action phase was important. Last year my students made presentations to parent groups, civic organizations, and church groups. We are at about that place in our unit this year. My students soon will begin preparing for this year's presentations.

The presentation involves a script my students prepare. We also use a story board that my students and I constructed last year, to show in concrete visual form what greenhouse enhancement is and what kinds of activities enhance the greenhouse effect. At the beginning of the presentation, the story board shows a completely natural environment with nothing but trees, grass and animals. As the students talked about settlement by man, industrialization and production of waste, and population growth, trees are physically removed from the storyboard and the trappings of our society are added, changing the picture on the storyboard. At the end of the presentation we give everyone in attendance a brochure which the children designed called, "We Are the Caretakers." The brochure lists a number of suggested actions that can be taken at home by individuals to help our environment. Also at the end of the brochure we have included this statement: "We have a rule in our sixth grade classroom. If you helped make a mess then you help clean it up. We think that rule also should apply to our planet."

Last year we also participated in a debate as part of the action phase of our STS unit. The debate question was, "Should there be laws regulating land use as a means of impacting global warming?" We had five different points of view represented in that debate. In the mountains of western Pennsylvania where my school is located we have a large ski resort industry. That was one point of view represented in the debate. Also, the positions of our lumber industry, the Department of Environmental Resources, West Penn Power Company, and a local citizens environmental group were represented. My class was divided into five committees, and representatives from each of these five agencies came into the classroom and worked with the students, helping them prepare their debate argument from that point of view. The students in each committee then selected a student speaker who represented their committee in the debate, presenting the argument and doing the rebuttal. The debate was presented in front of the upper elementary grades in our school and a panel of twelve judges comprised of the five agency representatives, school district administrators, community leaders, and students. That was a very successful activity. The people who came in and worked with my students were great. The students enjoyed the exposure to other people and it helped them see that when you are dealing with an issue such as global warming there are so many different points of view to consider.

This year our actions are more varied then they were last year. We are going to do the presentations and the brochure again. But my students decided that this would not reach enough people. They came up with the idea of videotaping the presentation and adding at the end of the presentation some of their own, personal comments and concerns about the global warming issue. We will make several copies of the videotape and have it available through our school library so other students can check it out, take it home, and share it with their families.

Prior to the holidays we got involved in a really interesting action. We had a lot of discussion about our use of electricity and decided many people think we need a lot of electrical appliances and gadgets, which in actuality we really do not need. The students worked in committees to make lists of household gadgets that unless we are physically handicapped we really could live without; we could do the activity by hand. They listed, for example, table top potato bakers, salad shooters, electric pencil sharpeners and electric can openers. Making the lists made them very conscious of these things as they were doing their holiday shopping, and they did their best to persuade their parents to avoid gadgets as gifts. Students also became very conscious of the gadgets that were being presented in the deluge of television advertisements right before Christmas. One day one of my students came in and he said, "Ms. Yukish, did you see that ad on TV last night for that potato chip maker?" He said, "Now who needs a potato chip maker? At my house we're lucky if my mom has time to make dinner let alone make her own potato chips." Some students, in fact, became quite intrigued with the idea of going back and living like the pioneers lived. They thought it would be neat to try that for a while.

We also got involved in making posters that suggest actions everyone should take to help resolve global warming. These will be put in community businesses and around the school. This is a sampling of the slogans on the posters: "Don't cut down the rain forest." "Replant a tree when you cut one down." (This especially applies to our local lumber industry in which a lot of our parents are employed.) "Carpooling -- If you're going the same place, why not go together?" And finally, "Cows produce four pounds of methane a day, so don't eat a lot of beef. Methane makes the greenhouse effect worse."

The children also got involved in a letter writing campaign in which they wrote to local and state lawmakers and federal government officials. I would like to close by sharing two of these letters with you.

> Dear Vice President Gore,
> Hello. I'm a fifth grader at Springfield Elementary School. My science class is learning about the greenhouse effect and the ozone layer. We humans do lots of things that are bad for the environment and if we don't stop doing these things the environment isn't going to be a healthy place to live. When I grow up I want to live a healthy life. Maybe if we humans stop polluting, cutting down trees, and putting chlorofluorocarbons into the atmosphere, the earth might be a better place to live in years to come. I wish everybody cared about the environment as much as I do. I know you're interested in saving the earth. That's why I chose to write to you. I know you will read this and not just throw it away. I know you will do something about this problem.
>
> Dear President Clinton,
> Hi. My name is C____ S_____. I'm a fifth grader at Springfield Elementary School in a small town in the state of Pennsylvania. It is a place where people help pick up litter and recycle. Some people buy products that have less packaging and wrapping. We buy what we need, not unnecessary gadgets like the salad shooter. I really care about my environment. So do kids in my class. We're going to plant a tree at the school in the summer. You have a daughter. Do you want her to live in a healthy or a bad environment? If you or all of us do not do something about this, we're going to die. Please help by making sure more money is given to environmental research and development. Thank you.

Implementation of the Action Component from *Global Warming: Are Rising Carbon Dioxide Levels Harmful or Beneficial to the Earth?* in Eighth Grade Science -- Martha G. McLaren

I teach eighth grade science. Often it is difficult to get eighth grade students' attention, but our STS unit on global warming was something with which they automatically identified. We approached the unit from the perspective that there is a body of scientific information on enhanced global warming. Some scientists interpret this information to indicate that global warming is a problem needing immediate attention. Other scientists do not view it as something that requires immediate action. Let's look at it; let's analyze the information and data; and let's decide where we would come down on the issue. We actually ended the unit with a pro and con debate where the students were assigned the opposite position they hold, so they get to understand global warming from different aspects.

When we got to the action part of the unit, overwhelmingly my students came down on the side of the issue that it requires action on their part, now. There were a few students that felt it was not a significant concern. To those students I said, "That's fine. Explain to me why you believe that." So the student who did not see global warming as a concern had to justify their views. Also, I ask them to take an action for any environmental problem that they felt strongly about. They were very comfortable doing that. Many of the students chose to plant trees and their documentation to me was a series of pictures. Some of them also decided to kept a journal about the trees they planted. One girl named her tree and got really attached to it. Interestingly, my students began to see trees as something more; they began to see trees as they fit into the rest of the environment.

A lot of kids started car pooling. We are a rural community and there are no activity buses after school. The kids on athletic teams and in other after school activities made a real effort to carpool -- I know this from their journals. A lot of kids started recycling and a very intense competition started to the point of weighing the recyclable materials to see who had collected the largest amount.

I finished teaching my unit near the end of October. Most student actions are on-going projects. When we talked about consumerism some of the students decided that they were really interested in the financial angle of global warming. We came across the book, *Students Shopping for a Better World* (Dellabough, Hollister, Marlin, Swaab, Rose & Will, 1992). The kids really got excited about this and started looking up the environmental record of companies like Nike and Wendy's. I had a number of students go through the book making sure that the items on their Christmas wish lists came from companies that had good environmental records.

One young man got really interested in consumerism. His family was buying a new automobile. He insisted that he be involved in the family decision and the analysis of what car to buy based on it's gas efficiency. Also, the whole area of safety came up. I teach physical science and we were studying Newton's laws of motion. STS became a wonderful vehicle—no pun intended—to get into lots of safety issues too. So one area of science really led into another through STS.

One brave soul approached the head of the school cafeteria to inquire about the Styrofoam containers that were being used. Another group asked that same question four years ago and they were told that the school was using up the supply that had been purchased. Well, four years later it appears that we are still using up the supply. This young man was thrilled that he was confronting the cafeteria staff about this. The head of the cafeteria armed herself with reams of information about the environmental friendliness of the containers. The young man is very methodically going through calling and checking data and sources. One source gave him a big spiel about recycling Styrofoam, but he realized that there is no place in central Pennsylvania that has the facility to recycle Styrofoam. So he caught on to the propaganda quickly.

We hold a fund raiser every year to get money for a field trip, because like most schools our budgets have been cut drastically. In previous years we have made hoagies. This year the students decided they wanted to sell T-shirts. We found a company called Humani-Tees that sells very high quality T-shirts with environmentally friendly logos and slogans. Parents were thrilled that this was our fund raiser and that we would have kids running around school with positive slogans on their shirts. This company, in addition to being very nice to work with, gives 20% of their profit into agencies that take environmental actions. The students were pleased that they could take persuasive and consumer actions at the same time they were raising funds for a field trip.

My students also took persuasive actions through projects they had to complete in visual communications class. This was arranged with the visual communication teacher. For one project the students must design a computer graphic. My students were asked to design a computer graphic that illustrated a fact that they had learned in the global warming unit. We are in the process of getting these together to make an informational book about global warming that can be shared with the students at the elementary school, which is on the same campus as our middle school. For another project the students make buttons in visual communication class. Last year each student made a button with an environmentally friendly slogan. The buttons were given to me. I wore one every day and on Earth Day we gave one to every teacher in the building. This year the students are cranking out buttons in mass quantities. We plan not only to give one to every staff and faculty member in our building on Earth Day, but to sell them to other students in the cafeteria and donate the money to an environmental organization that the kids decide they would like to support.

Also associated with visual communications class, one of my students developed a computer cartoon about global warming complete with computer animation. Three young ladies have written a play. They have had try outs and are busily making props. The play is based on recycling and peer pressure. It will be presented at the elementary school. Another group of students is working on 30 second public service announcements about global warming that are informative and persuasive. The visual communications teachers is trying to arrange for these to be shown on our local public access cable station.

Yet another group of students was interested in using the computer program Pagemaker to take action. They are making tri-fold brochures. I am checking their factual material for content. The English teacher that works with me is checking their grammar and spelling. The visual communications teacher is working on layout formats and how to use the program. We have a tentative agreement with the company that produces our yearbook to print hundreds of the brochures so on Earth Day everybody that has a mailbox in the district will get a brochure about global warming. We also plan to put piles of the brochures out in different places in the community.

We have had some letter writing. A group of students wrote a letter to the Editorial section of our local newspaper. One student wrote to the President. Talk about excitement, wait till your kids get a response from the President. They were so excited that it came back on official White House stationery. As a result the kids have gotten really interested in whether the politicians that they have written to will actually take the time to respond.

My students constantly are bringing me articles that they have read and saying, "What do you think about this? Do you really believe everything in here is true?" So they are continuing to question what they read. The study of global warming has generated a great deal of interest in other environmental topics. They are fascinated by ozone. One student brought me Echo Writers—pencils that are made not from wood but from recycled paper. We spent a whole period discussing all sides of the question, "What is the environmentally correct writing utensil?" -- "Are we saving the trees? What about the water that it took to recycle the paper? Is there another angle that we need to look at and maybe we should go with plastic refillable pencils?" The kids are now to the point that they question everything. I think it is absolutely wonderful. One young man's father owns the local restaurant. He took the CFCs free tag off of a carton of Styrofoam cups and asked me, "Can we call this 800 number? Can we talk to these people and see if that is true?"

We have a very large deer population, over 1000 deer on the Gettysburg Battlefield which should sustain only about 150 deer. There is a continuing debate within the community on what to do. Some of my students have gotten involved in this and other local issues, such as the proposed solid waste composing facility, by going to meetings and finding out what is going on through the newspaper. Of course, they want to discuss most of these happenings in class.

There have been a number of unplanned effects on other parts of the curriculum from the global warming unit. One of the reading teachers has worked with this little book called, *Four Against the Odds* (Krensky, 1992). It's a wonderful biography of four different people that are involved including Chico Mendez, which was significant for us because we are an apple growing section of Adams County. We have a number of migrant students and this was a real role model for them. The English teacher worked up a whole unit that went along with and supported the environmental interests that my kids were developing.

Our students do debates in English class. Last year and this year many of them selected environmental issues. The English teacher told me environmental issues were not selected before I taught the global warming unit.

I contacted the electric company for resources. They sent the Metropolitan Edison Electric Company (Met-Ed) van, which is an electrically-run van, to our school. The folks at the electric company were thrilled to get this van out where it could be seen. My students were fascinated with it. Our school superintendent happened to stop by the day the Met-Ed van was here. He had a job fair for the adults in the community coming up within a few days and was able to arrange for the Met-Ed van to be at the job fair along with a natural gas powered vehicle. I also tried to get General Motors to send the Impact. I called every General Motors dealer within about a hundred miles, but none of them could help me.

I have a nucleus of three students that I had last year that came to me the beginning of this year and said, "We want to start an environmental action club. Will you be our faculty advisor." The name they selected was "Cool It." They have started an aluminum can recycling center in the school and are constructing a chain from the pop-tops. They want to see how long it will take to get a million pop-tops. A million is probably not a realistic figure for one year but we will keep going and see how far they get. I was impressed that their interest in environmental issues was sustained enough that they came back a year later and wanted to continue it.

I have seen three tremendous changes resulting from teaching the global warming unit and the actions the students have taken. My students no longer see science as separate and as black and white. Science is interconnected with other areas and those interactions have shades of gray; there is no one right answer. They also see that the answers are constantly changing and they need to stay updated. The learning environment has expanded far beyond my classroom to the community and beyond. My students have gone out and made contacts, and are continuing to go out and reach out to other people. They are not afraid to pick up a phone and call an 800 number to ask an environmental question. I have never seen that happened before. STS has made a tremendous impact on the way my students look at the environment, the way my students look at science and technology interactions within society, and the way they look at learning and sources for learning.

Implementation of the Action Component from *The Impact of Global Warming on Plants and Animals* in High School Biology -- Kathy A. Yorks

Biology students in our high school are homogeneously grouped, thus we have academic students and non-academic students together. The non-academic students take an STS course in 11th or 12th grade, while the academic students take chemistry and then perhaps physics or some other advanced science elective. My concern has been that our academic students are not getting

STS education; that their studies in science are not issue-oriented; that they are not developing the skills to investigate issues (from all sides) and make informed decisions. So, my orientation is perhaps a little different than that of some of the other teachers in the Institute who teach middle school science.

I believe there is another difference in my orientation. It is very challenging to fit a five to six week unit into a high school biology course where the curriculum is already overflowing and the teacher has little freedom to make adjustments. What portions of the course can I sacrifice? Botany? Dissections? Those decisions were very difficult to make the first year, but easier the second. Looking back, I can say with all honesty that I truly believe that the information and the skills that my students obtained from our STS unit on global warming were much more valuable than, for example, knowing the anatomy of a crayfish or the scientific name of a white pine tree. Of course, we can debate that, but I believe that the time that we have spent on STS is time that was very well spent.

My unit is not continuous because of the way I fit it into my biology course. We cover the foundations and awareness sections at the very beginning of the school year, and write to various organizations for information at the end of the awareness section. While we wait for the mail to come back we study biology topics that will serve as a basis for the investigation phase -- the cell, photosynthesis, and ecology. In February we return to the STS unit, to analyze our mail and investigate global warming using many resources. Then the students decide what actions they are willing to take. The action segment continues as we return to our study of more "traditional" biology topics

I think there are two reasons why my students go to such lengths at taking action. One is that the actions phase follows the investigation of the STS issue. I do not stand in front of the students and tell them to do X, Y and Z. They are involved in investigating the issue. In order to investigate global warming, my students choose from different organizations and write to them for information. We write to environmental organizations; we write to governmental organizations; we write to conservative organizations, liberal organizations, all kinds of different organizations, and ask them to send us information about global warming. We try to get the most up to date information. The students love getting mail -- even cool tenth graders really like getting mail from people. We have gotten information from some real wild organizations. There is one organization called Earth First that is pretty left-wing. But the kids love it and I make sure that we have a representative sample of different opinions.

The other reason my students go to such lengths at taking action is, and it was not something that I would have predicted, that as we proceed through the unit, even though it takes a fair amount of time, a momentum builds and becomes very powerful. The students come to some consensus. They believe global warming is a problem. The students tend to vary as far as how big a problem they believe global warming is, but they really get caught up in a "What can I do about this?" perspective. I was surprised at the level of concern, at the commitment, and at what the students were willing to do. They were willing to do things that I...well, I really had to lift my energy level to keep up with them. It takes a lot of energy to take action, but I think it is well worth it.

How were the actions my students took a little bit different than those taken by students of the other teachers in the Institute? We are dealing with high school students. High school students are very grade conscious and we have to have ways to keep them accountable. My students were required a) to choose an individual action that they could take, b) to choose a group action that they were willing to take in their cooperative groups, and c) to choose a family action. A plan outlining all three actions had to be submitted to me. I reviewed it, made sure there was some way of verifying the actions, approved it or made suggestions. I stressed to the students that they should choose actions with which they felt comfortable. It might have been a small action, but they had to choose an action, even if it was something as simple as making sure to turn off the TV before going to bed at night. Parents had to provide the verification the actions were taken. That was one of my links with the parents.

Did they all do what they said they were going to do? I don't know. But I did get a lot of positive feedback. There was a lot of family involvement, or at least, the parents were verifying that their son/daughter was taking some appropriate actions. One family substituted all of the light bulbs in their homes with more energy efficient light bulbs. I was truly amazed at the number of families that made a commitment to take action and that gave me positive feedback. Several families started compost piles.

The group actions were great. A group could be as small as two or as large as six. I allowed them to get together with their friends and decide what group actions they wanted to take. The group actions included things as simple as planting trees, helping with paper recycling in our building. We had a group of girls decide they wanted to go to the local elementary school and make a presentation about global warming. When they came back I asked, "How did it go?" They said, "They knew more than we did." They were just amazed that fourth grade students knew as much about as they did about global warming.

The cafeteria sells Sunny Delight in small plastic bottles. We had a group of students decide that the cafeteria should start recycling the plastic bottles. That may not seem like a big deal, but it is very hard to find somebody to take your plastic for recycling in central Pennsylvania. So it involved quite a bit of work to carry out that action. Another groups of kids made posters on global warming that they hung on walls and flyers that we distributed to homerooms.

Probably the biggest effort was they decided to have a bake sale to raise money for a rain forest organization. When the students suggested this, I started thinking, "I don't want to be s tting down in front of J. C. Penny's on a Saturday morning trying to sell cupcakes that nobo ly wants to buy. They're going to raise $30. This is going to be a lot of wasted effort." But I kept my opinions to myself—thank goodness—because the students said, "Well, maybe there's a way we can do it in school." I said, "There's no way our principal is going to allow us to sell junk food in the cafeteria or brownies in the hallway." Finally we thought of the school-wide art show that would be held in the gymnasium. We got permission from the art teacher to set up a couple of tables. The s.udents raised $170 selling cookies and cupcakes. They made up little slips of paper that had information on it about global warming and gave those out with the baked goods. A lot of the faculty donated things. It was a wonderful effort and the kids were so proud of themselves. It was very impressive.

Last year's students continue to give me positive feedback. The kids continue to drop in and talk to me about things that they see. I have not gotten to the investigation and action portion with this year's biology classes, but I am very anxious because in the fall a new paper recycling plant went on line at Hammermill Paper Company, which is located in Lock Haven. The plant is one of only five currently on-line recycling facilities that recycle newspapers and magazines into copy quality paper. I foresee this year's students collecting newspapers or magazines within our building or their families or the community as group actions. We should be able to get some of the folks from Hammermill to come to school to talk to the kids about the plant. That will be great addition to the unit for us this year.

High school kids can get passionate about topics they study. I think that we are giving them in our global warming unit skills that they will continue to practice in life. We had students write letters to companies and letters to the editor. Through some of the resources we used, the students identified some companies they identified as environmentally irresponsible. One student wrote a letter to Mitsubishi that said, in essence, "I'm 16 years old. Some day I'm going to be buying a car. I'm never going to buy a car from you because I understand that your company supports organizations that cut down the rain forest." He firmly believed that the people at Mitsubishi were going to take his letter seriously and there was no way he was ever going to buy any of their products. STS is one of the topics that can get high school students excited.

Summary

It is the action phase that differentiates STS issue investigation and action instruction from awareness-type STS instruction, that aims merely to make learners aware of major STS issues facing humankind. The research on citizenship action in environmental education clearly shows that awareness of issues and knowledge about what actions might be taken is not sufficient to move individuals to action. Learners also need to come to understand that they have the capabilities to take actions and develop the belief that they can have an effect. It can be argued that the action phase is the capstone component in the STS issue investigation and action instruction model. It is the action phase of the STS issue investigation and action model that helps learners develop the skills to take action and belief that they can have an impact.

Additionally, the action phase is the climax of STS issue investigation and action instruction. Throughout the course of the initial three phases of a STS issue investigation and action unit, learners study typical interactions among science, technology and society that result in STS issues; identify a locally relevant STS issue that has global consequences; and investigate the science, technology and society aspects of the issue. In the action phase these activities culminate as learners make decisions about resolution of the issue under study; plan group and individual actions that might be taken toward the resolution of the STS issue, weigh the possible consequences of each action; move forth to take actions; and evaluate the effect of those actions.

This paper has included an overview of a science teacher enhancement Institute in which teachers from rural central Pennsylvania and northern West Virginia are involved in the development of STS issue investigation and action units on global warming, and descriptions by three Institute participants of how they implemented the action phases of the particular STS unit each helped to develop. These were presented as a panel discussion at the Ninth National STS Meeting and Technological Literacy Conference. In responding to questions from the audience during the panel discussion, each of the three teachers indicated that their students also saw taking action as a rational consequence and culmination to their study of global warming:

> For my students taking action was a logical consequence of the STS unit. Even if it wasn't a goal of the unit, I believe they would have come up with the idea on their own because a lot of what they read in the investigation phase focused on what you could do and many of those suggested actions are things they've already heard. They've heard people say, plant a tree. They've heard people say you should recycle. The unit helped them made a connection with that prior knowledge about action and the possible consequences of those actions. As I said, I think they would have been inspired on their own to take actions even if it had not been part of the unit. (MGM)

> My fifth graders really jumped the gun on me in terms of actions even though they were not aware of all four phases of an STS unit. We were only about halfway through the investigations phase when they started saying, "I think we ought to do this. I think we ought to do that." They didn't know that taking action was a part of the unit. It came about naturally. (DJY)

> I think the action phase added a rationale for the students to study Global warming. Early in the STS unit my students could have listed actions that people have proposed as "good for the environment." They might even have listed the same actions they listed at the end of the unit. But at the end of the unit they had a rationale and an understanding of why the actions were good. Also, they were able to connect that action with their understanding of the global warming issue. This made taking action a natural thing for them to do. (KAY)

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"HOW A CITY WORKS"

A Professional Development Institute for Teachers

by

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For the last six years, the MIT Council for Primary and Secondary Education (CPSE), has led MIT's efforts to contribute to the improvement of science and technology education in US schools. It has focused on the professional development of presently active teachers and on the training of new teachers. This paper describes one major program created by the Council.

We felt that city children might be attracted to the study of technology and science if they saw it as a way to understand their social and material surroundings and eventually as a way to control them. We therefore tried to prepare some of their teachers to examine "How a City Works"; to define the resources locally available to them for that purpose, and to encourage them to design open-ended interdisciplinary hands-on projects suitable for their students. We discovered that it was also essential for us to develop the teachers' leadership abilities and their teamwork skills. Finally, we concluded that the teaching and learning styles required by this approach would not fit comfortably in the current institutional and schedule mold of most American Public Schools, and we were therefore led to include the need for systemic change (and some ways to achieve it) in our message to the teachers we worked with.

Our strategy in 1993-94, was to invite the participation of teams from particular schools and school districts. A team generally consisted of five teachers drawn from one school

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- occasionally a High School or a Vocational School and one of its feeders - teachers of math, science, vocational skills, social studies or English; in addition, the team included one school administrator and one lay person drawn from the Community served by the school - a parent, an academic or an engineer, a businessperson, occasionally a School Board member .

In 1992, participants included 25 teachers each from Boston and Cambridge; the notion of structured teams followed from our analysis of the 1992 workshop. The 1993 workshop was attended by Teams from the following schools:

Dallas-Edison Middle School	Boston-Madison Park HS
Dallas-Stockard School	Lowell, MA-School System
New York-Sarah Hale HS Brooklyn	Lowell Reg. Voc. HS/Middlesex Comm. College
Falmouth, ME-School System	Framingham-Keefe Voc. HS
Yarmouth, ME School System	Lexington-Minuteman Regional Voc. HS

and observers from North Shore Community College in Lynn, MA and Bridgeport Engineering Institute, Bridgeport, CT.

Ten teams attended a three week residential workshop at MIT on July 12-30, 1993 and then participated in a follow-up program which included particularly the organization of an activity on their home turf in Spring or Summer 1994 to share their new wisdom with colleagues and lay plans for local school reform.

The Summer Program

During the first week of the Summer Program, the teams performed a series of simple tasks designed to get them to work together as a unit; for example they built a bridge out of wrapping paper and tongue depressors, which spans 18 inches and supports a 12 ounce robot vehicle six inches wide; the materials were assigned a price and a prize was awarded to the team who built the cheapest bridge able to carry the load.

They also brainstormed to create a "wish-list" of changes which would improve the operation of their school - they returned to that list in the third week of the workshop.

In the latter part of the first week, they participated in field trips to see for themselves how a central telephone switchboard works; how the Massachusetts Bay Transit Authority schedules and maintains its trains and buses or how a water treatment plant works; they also heard several background lectures given by MIT faculty or engineers practicing in the urban technologies.

They became familiar with the notion of "webbing" or creating visual models of how the physical and institutional components of an urban system interact. Actual examples of such "webs" are shown on Figs. 1 and 2; these webs were created by groups of participants individually calling out important components and suggesting where they fitted in the system.

At the end of Week One, the participants were ready to undertake technical assignments; these focused on the supply and treatment of water and on mass transit in 1992; on the construction of public facilities and the workings of an urban telephone system in 1993; they will concentrate on electric light and power networks and on public health and health delivery services in 1994. In 1993 the teams undertook the following projects:

Construction projects

1. Concrete Technology
2. Zoo design
3. Providing handicapped access to an old MIT building
4. Transitional housing for the homeless
5. Design of a solar house

Telephone Projects

1. The AT& T "500" Telephone
2. Telephone Switching
3. Telephone Security
4. Cellular telephones
5. Fibre optic transmission

In each case, the participants researched the technical and societal background of their project, acquired some understanding of the underlying science and technology, built a working model (or a mockup in the case of the zoo design project) and wrote a report of their activity. Early in the third week of the workshop, each team displayed their project in the style of a "science fair". In carrying out their work, each team had the support of an advising group consisting of an MIT faculty or staff (or a local senior engineer) and an MIT undergraduate; the senior advisor was not a specialist in the field of the project, so that he/she was also learning as the project went on.

It turned out in fact that the advisors' main task was not to guide team members in the intricacies of the technologies involved, but rather to facilitate teamwork, to moderate arguments among team members and to give everyone a chance to contribute to the common work.

An example of a project is illustrated on Figures 3, 4 and 5 which display the team strategy and the construction of background for their project. The technical part of the exercise included floor plans of several alternative temporary buildings and a scaled down plywood model. Observe that the technical design teams consist of teachers from different systems - in this case from Boston, Yarmouth, ME and two schools in Dallas. The practice was to keep geographical teams together the first week to discuss <u>their</u> school system; to shuffle the teams for the technical projects both to encourage exchanges of views and to give teachers a chance to pick their project; then to reassemble the geographical teams in the third week so that they could compare notes and draw conclusions appropriate to their circumstances.

Indeed, the third week was devoted to group discussions of the dynamics of systemic change in schools, to the stresses and insecurities which result from doing things in a new way, particularly when the teacher sees her/his role shifting from that of the ultimate authority to that of a fellow-investigator. Some time was also spent in starting the planning of the local follow-up activities which each team was committed to undertake.

We emphasize that our goal has not been to produce curriculum materials or to encourage teachers to produce such materials. It was rather to introduce them (or re-introduce them) to the examination of their school as a system (and a component of a larger system), and of urban technologies as systems, in the hope that they would see useful analogies as a result, and that this would color their subsequent planning. In fact, the participation of administrators and community representatives was essential to that process.

The follow-up Winter 1993-94

The follow-up activities during the school year were designed in the light of these expectations. They include a hot line and the opportunity to network by e-mail (America Online) and by telephone conference; the option of school systems to invite their advisors (particularly the MIT undergraduates) for visits in January 1994; and the use of materials developed in Summer, where teachers find it comfortable. We visited classrooms where the teacher took advantage of the "webbing" technique, and classrooms where the students built models of cities which emphasized their technical underpinnings. But the main business of the teams' follow-up was the planning of "their" activities in 1994.

This included some system-wide discussions to define the target participants - teachers at other schools in the system usually - and the format and topic of the planned activities. One school system is using their local resources and some support from MIT to collect materials and ideas for a set of curriculum units on health care in a broad context (e.g.; what is "illness" in various cultures; how are epidemics handled - and on what basis-; and how does the public health system work in their community and provide jobs in health related industries).

Another has scheduled a three day "Team Works" activity which stresses team-building activities with a technical focus: building a bridge, playing (and discussing) the Sim City Computer Simulator Game, designing a collaborative learning experience.

Yet another is organizing a three day workshop entitled: "Opening the Door-Educators Exploring a Factory Environment"; it is open to any team of two or more teachers who work together; aims to improve collegiality within the school community and between school and business communities, to develop a better understanding of systems, to see how a factory works and how to design demonstrations which can be used in the classroom.

Altogether, six participating teams have shown us plans for their follow up activities for Summer 1994 and two others have discussed theirs informally. The original hopes for follow-up and diffusion appear to be realizing themselves and will be amplified with the class of 1994. The general plan of action is outlined on Fig. 6.

Evaluation

How does one evaluate this program? Its goal is to change the attitudes of the participating teachers in the expectation that in due time that change will have consequences on the learning of their students and on the operating style of their systems. It is much too early to measure such consequences, which will emerge slowly over a number of years; but it is possible to get a sense of the teachers' reactions, from a combination of questionnaires and of free writing exercises done over the first year of their participation, and from observation of their actions during the year.

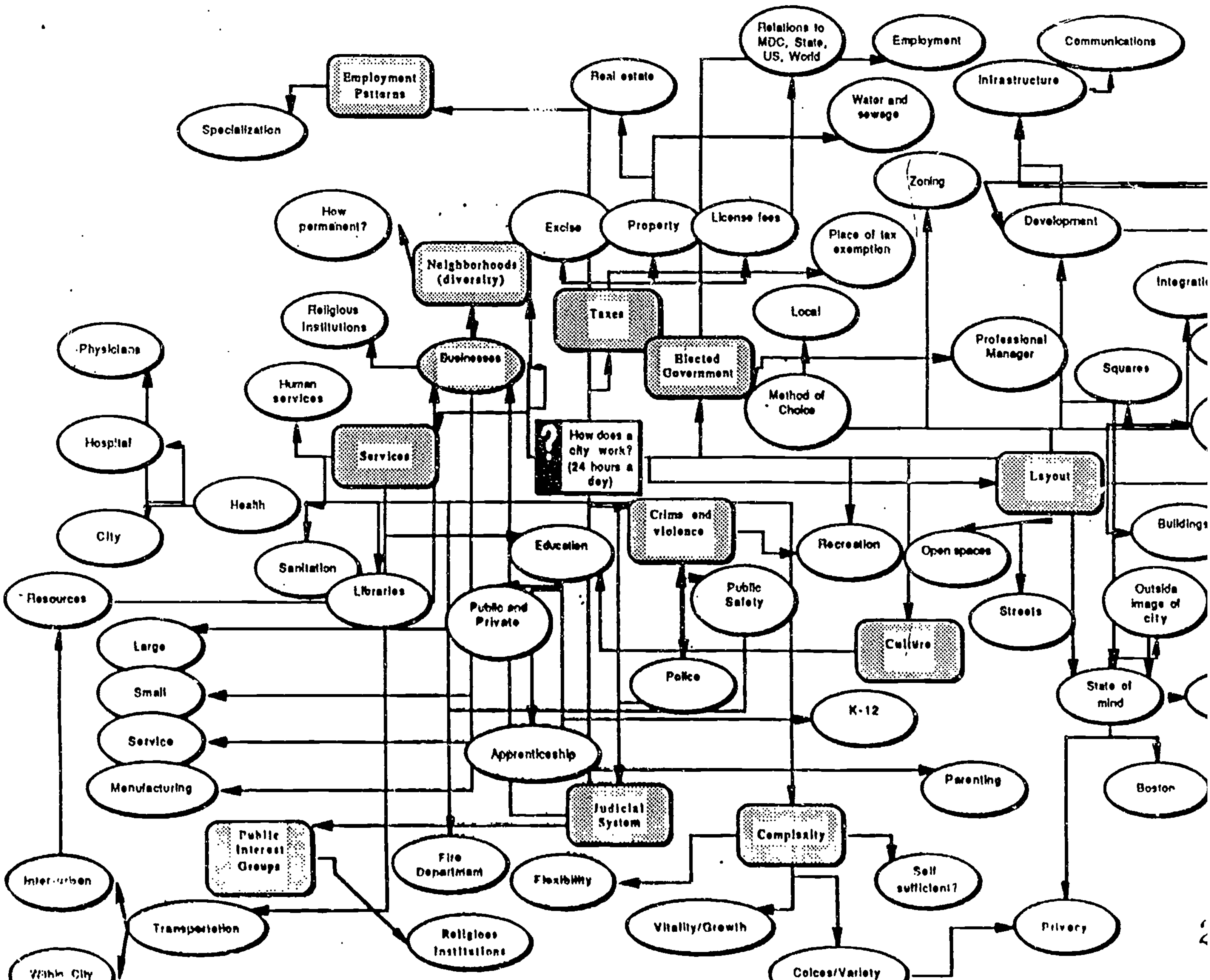
We found that most of the teachers liked their experience on the whole; they realized that they could understand technology in a societal context, and most of them thought that what they discovered was fascinating and appropriate in some form for their students. They also concluded that learning to work in teams and undertaking projects without knowing the outcome in advance called for difficult personal adjustments - they were forms of risk taking both exhilarating and slightly frightening. Predictably, most teachers claimed that the agenda was too charged and did not leave enough time for personal thought; and that the way their projects were organized and displayed overemphasized competition between teams - a somewhat unintended reflection of the MIT style on the workshop activities.

But the most directly observable effect of this program lies in the degree of enthusiasm and skill with which the participants organize their own workshops and work at changing their immediate surroundings and their personal learning and teaching style. So far, with much encouragement, they are beginning to change.

(Fig. 1)

How does a City Work?
Room 34-301

July 13



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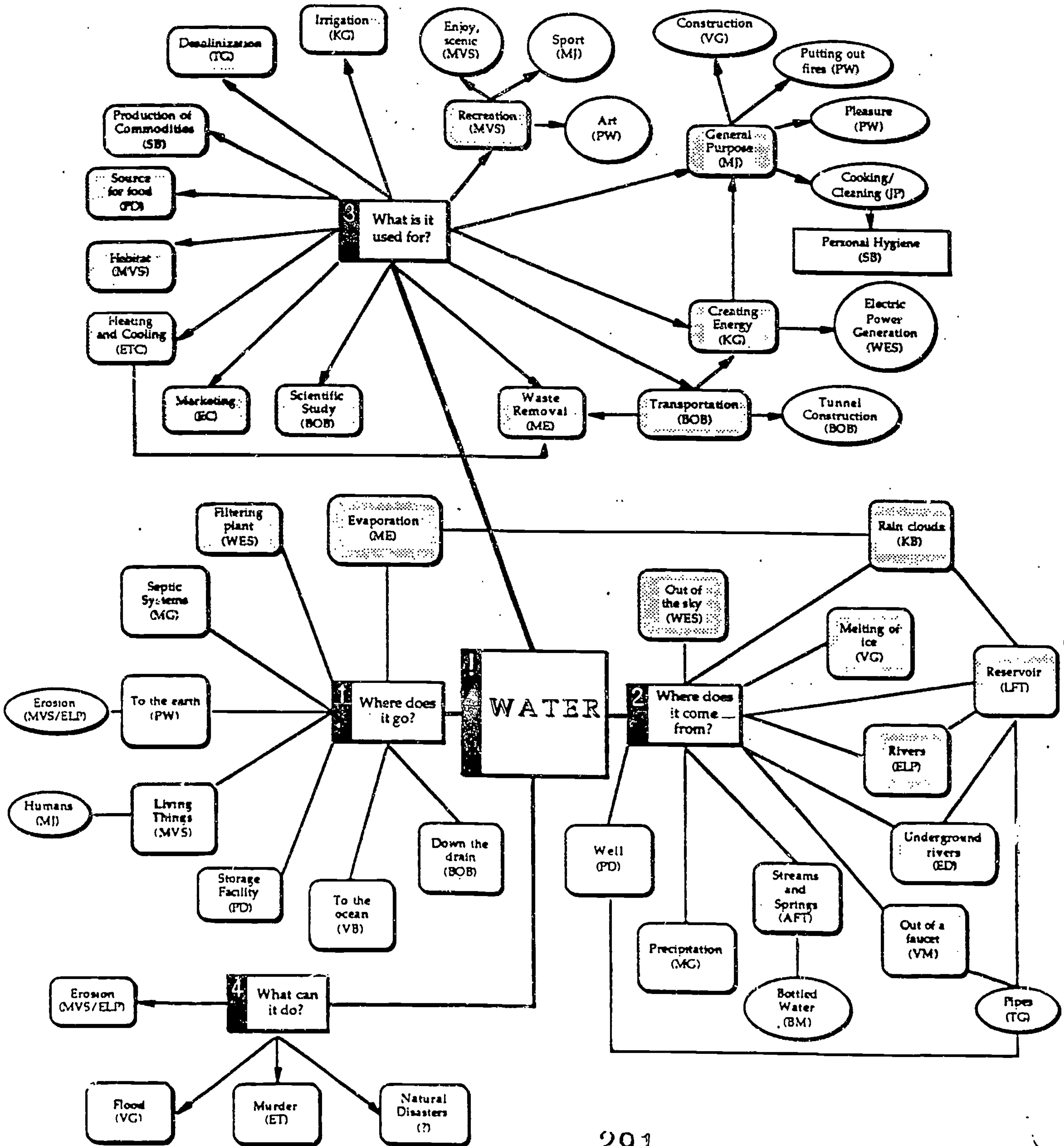
Water Web

Alan Dyson's Group
July 14, 1992



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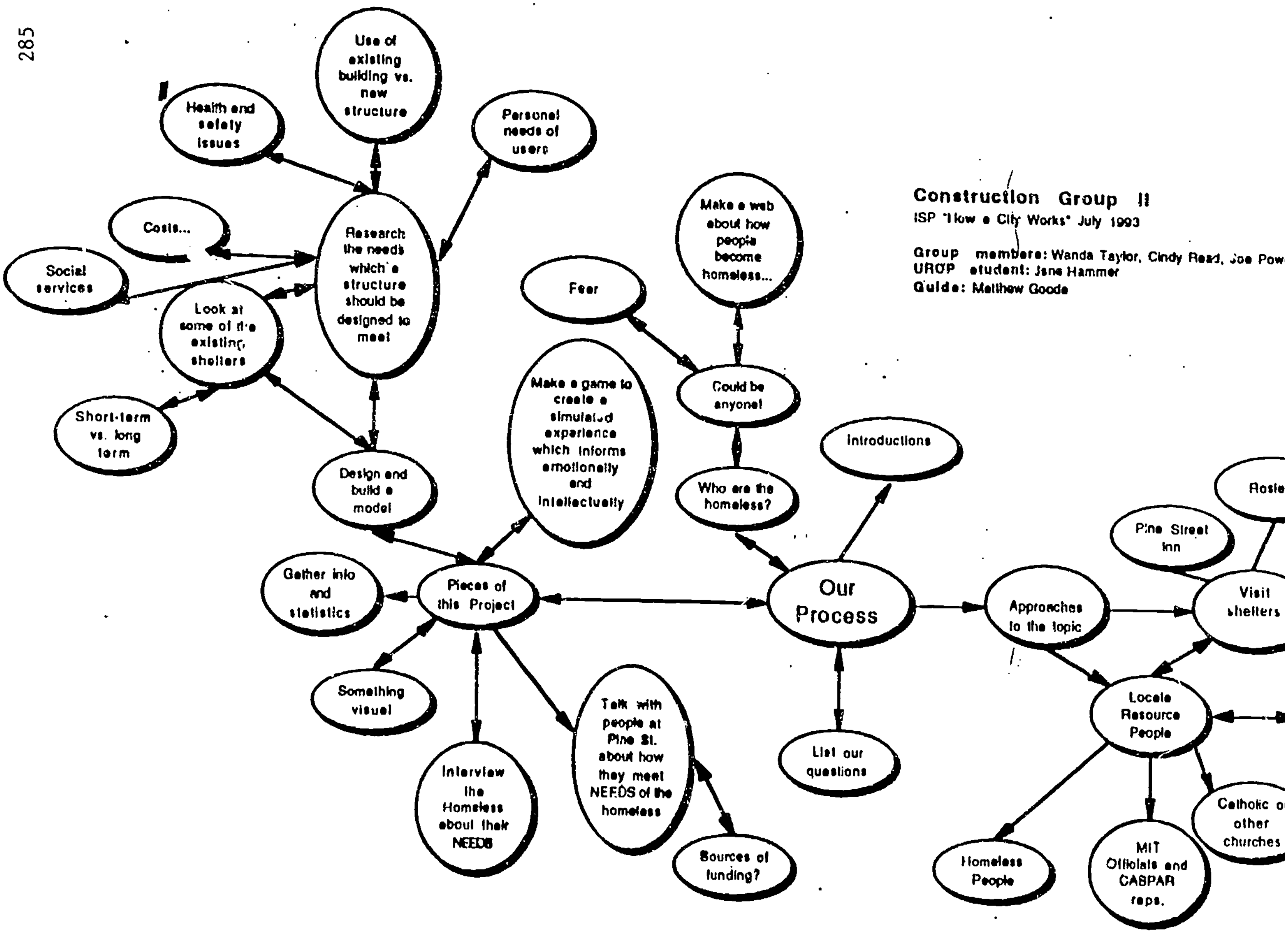
(Fig. 3)

285



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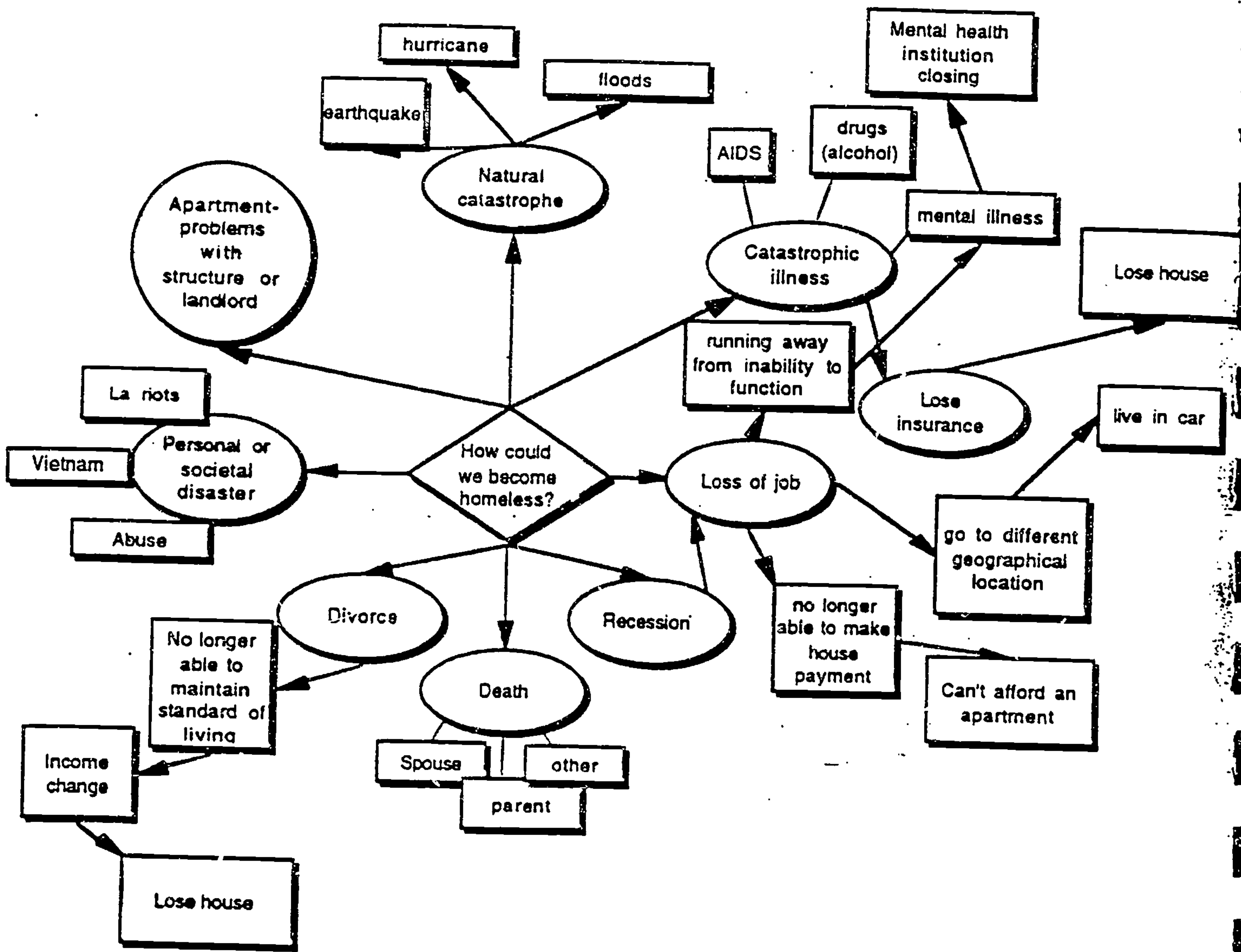
HOW DO PEOPLE BECOME HOMELESS?

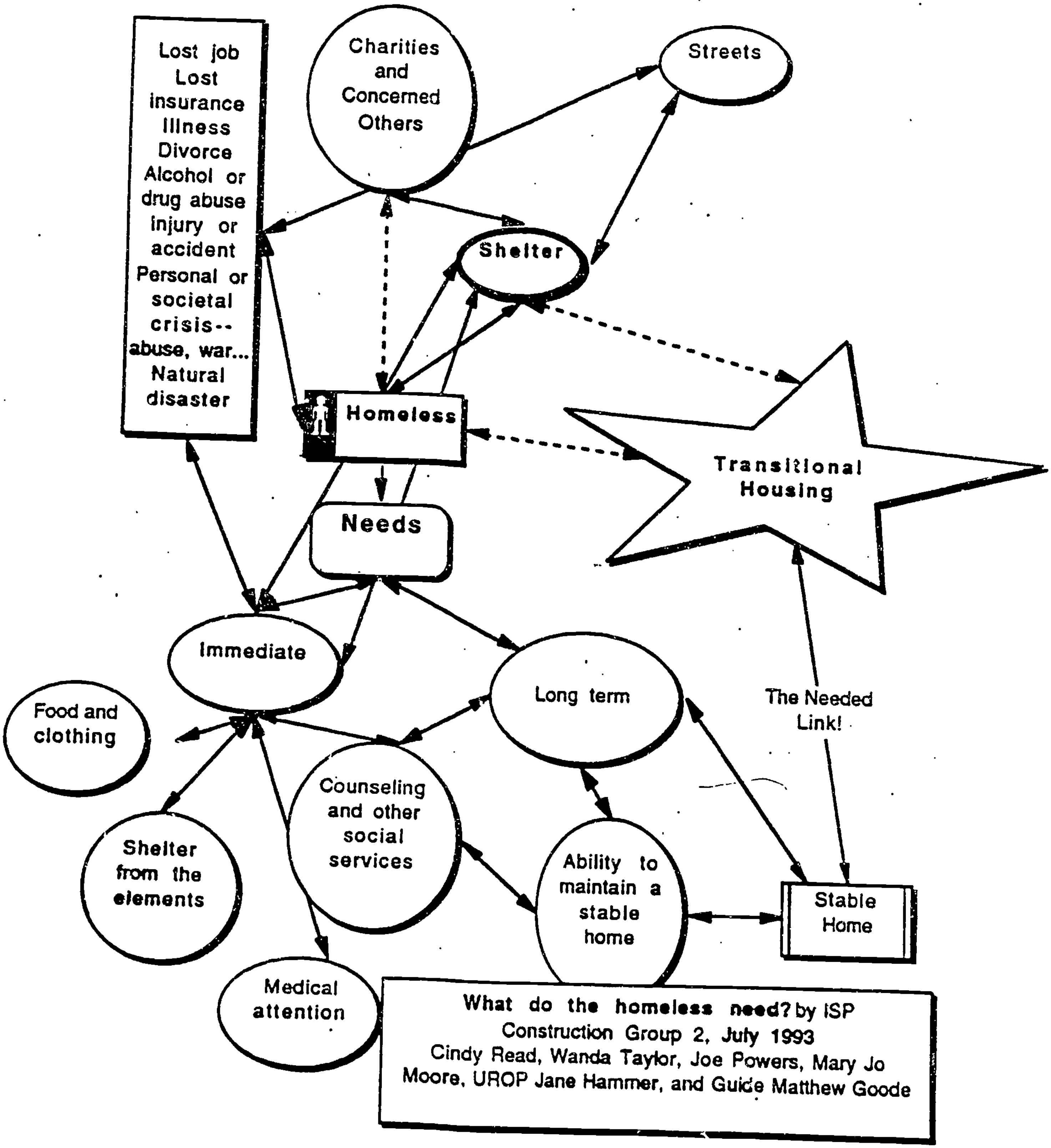


Construction Group II

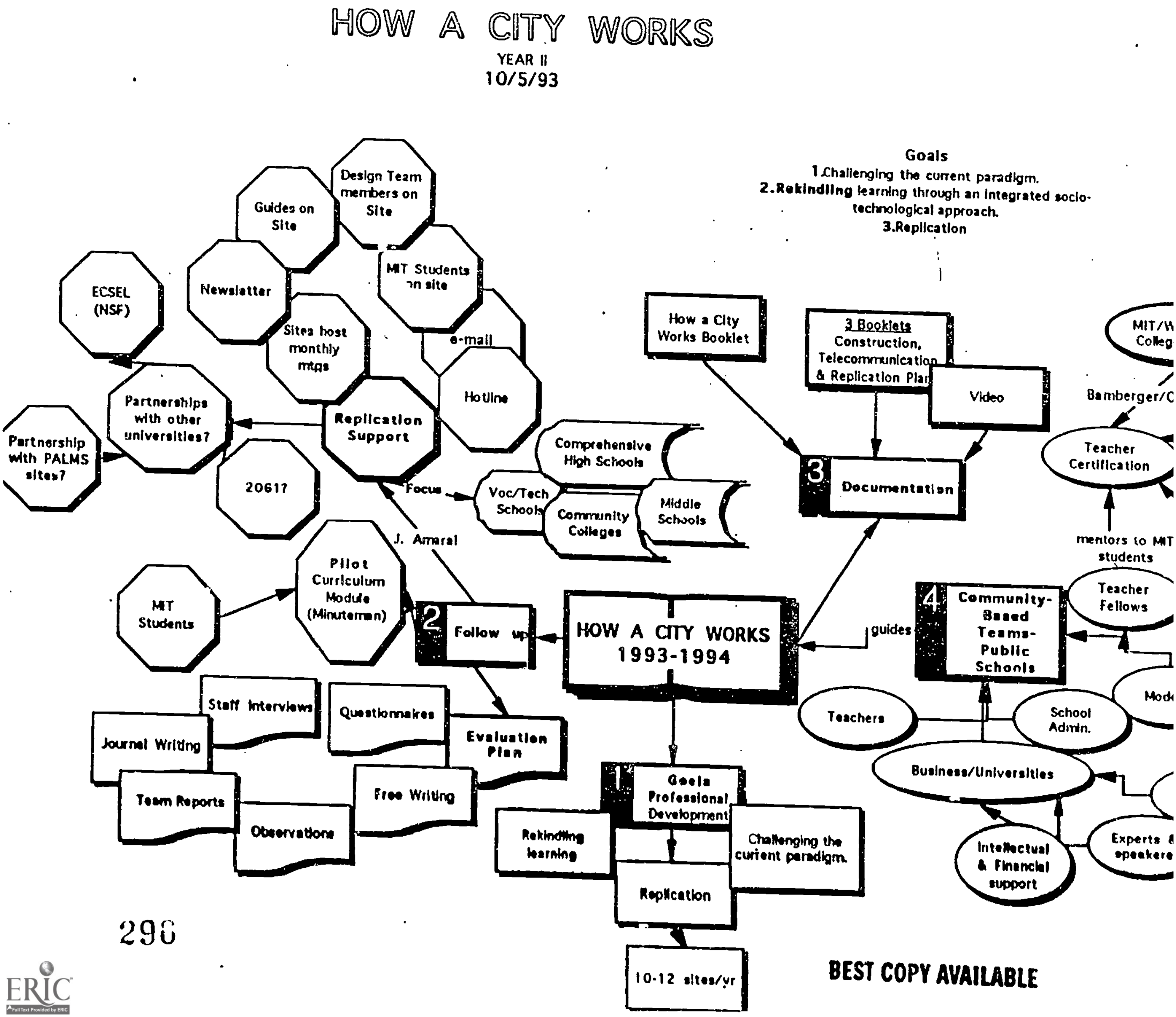
ISP "How a City Works" July 1993

UROP student:Jane Hammer
Guide:Matthew Goode
Group members:Wanda Taylor, Cindy Read, Joe Powers, and Mary Jo Moore

(Fig. 5)


Lost job
Lost insurance
Illness
Divorce
Alcohol or drug abuse
Injury or accident
Personal or societal crisis--abuse, war...
Natural disaster
Charities and Concerned Others
Streets
Shelter
Homeless
Transitional Housing
Needs
Immediate
Long term
The Needed Link!
Food and clothing
Shelter from the elements
Counseling and other social services
Ability to maintain a stable home
Stable Home
Medical attention
What do the homeless need? by ISP Construction Group 2, July 1993
Cindy Read, Wanda Taylor, Joe Powers, Mary Jo Moore, UROP Jane Hammer, and Guide Matthew Goode

(Fig. 6)



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Ninth National STS MEETING and TECHNOLOGICAL LITERACY CONFERENCE

NASTS

National Association for Science, Technology and Society

Co-Sponsored by:
American Federation of Teachers
American Vocational Association
Association for Women in Science
Epsilon Pi Tau
Institute of Electrical and Electronics Engineers (IEEE)
International Technology Education Association
National Council for the Social Studies
National Education Association
Student Pugwash USA
Teachers Clearinghouse for Science & Society Education
Triangle Coalition

SPECIAL EVENTS FOR 1994

THE SECOND INCOGNITI TRUST LECTURE

"Falsified National Academy of Sciences Report Resulted in Hundreds of Unnecessary Drowning Deaths"
Henry Heimlich, Director of the Heimlich Institute
Sunday, January 23, 1994, 11:00 AM
Support by The Incogniti Trust

THE THIRD ROBERT RODALE LECTURE

"Living Machines and Ecologiocal Design: A New Synthesis"
John Todd, President, Ocean Arks International
Saturday, January 22, 1994, 4:45 PM
Support by Calvert Social Investment Fund

A Workshop

NETWORKING K-12 ACTIVITIES APPLIED ENGINEERING AND SCIENCE SOCIETIES

Saturday, January 22, 1994
Support by MASCO Charitable Trust

SPECULATIONS IN SCIENCE AND TECHNOLOGY

Saturday, January 22, 1994, 1:00 - 3:15 PM

January 21-23, 1994
Crystal Gateway Marriott Hotel
Arlington, VA

FINANCIAL SUPPORTERS OF THE NINTH NATIONAL STS MEETING

We wish to thank the following organizations for their financial support of this year's conference:

Calvert Social Investment Fund, specializing in socially responsible investments, for their support of the Rodale Lectureship for the past three years

Hoosier Magnetics, Inc., manufacturer of magnetic raw materials (ferrites) used in refrigerator door closure magnets, advertising magnets and other products, for their support of the Engineering and Applied Sciences Symposium

Incogniti Trust, a private foundation supporting various educational causes, for their sponsorship of the Lectureship in Science, Technology and Religious Values

MASCO Charitable Trust, for their sponsorship of the Engineering and Applied Sciences Symposium

The Issues Laboratory Collaborative, an association of science museums, for their general support of the conference and the conference reception

NATIONAL ASSOCIATION FOR SCIENCE, TECHNOLOGY AND SOCIETY

PRESIDENT:

James J. Murphy, Iona College

STS-9 CONFERENCE COMMITTEE:

Alice Moses, Conference Chair and NASTS Vice President, NSF
Ann Mintz, Conference Co-chair, Orlando Science Center
Warren Rosenberg, Exhibits, Iona College
Victor A. Stanionis, Exhibits, Iona College

STAFF:

Rustum Roy, Corporation Chair
Eugene Bazan, Member Services Director
Richard Deitrich, Conference Site Logistics
Betsy Held, Staff Secretary
Kathy Moir, Publications/Conference Registration
Jan Leslie and **Lisa Moir**, Registration Staff

BOARD OF DIRECTORS

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Curtis J. Tompkins, President, Michigan Technological University
Virginia Wilson, North Carolina School of Science and Mathematics
Karen Zuga, Dept Educational Studies, Ohio State 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's 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 15-member board of directors, elected by the membership, guides a staff consisting of a Corporation Chair, Members Services Director, and Support Staff. Its address is 133 Willard Building, University Park, PA 16802, Phone 814/865-3044, FAX 814/865-3047.

STS-9 REGISTRATION AND INFORMATION
Conference Registration Desk, Arlington Foyer, First Floor

Thursday, January 20	6:00 PM - 9:30 PM
Friday, January 21	7:00 AM - 5:00 PM
Saturday, January 22	8:00 AM - 12:00 PM

ADDITIONAL NASTS EVENTS

Friday January 21:

NASTS COMMITTEES (lunch) 12:30-1:30 PM
Regional Chapters and Conferences [Jefferson]
Publications [Jackson]
Position Paper [Fairfax]
Community College STS [McLean]
College/University STS [Alexandria]
Community Awareness [Lee]

NASTS MEMBERS MEETING 8:15-10:15 PM, Salon 2

Saturday January 22:
NASTS COMMITTEES (breakfast) 7:00-8:00 AM
Institutional Members Advisory Council (Reynolds), Lee

NASTS COMMITTEES (lunch),12:30-1:30 PM
Pre-School/Elementary STS [Jefferson]
Middle School STS [Madison]
High School STS [Jackson]
STS Assessment and Evaluation [Farifax]
K-12 Educational Organizations Linkages [McLean}
International and Foreign Organizations Linkages [Alexandria]
Corporate Linkages [Terrace Restaurant]

NASTS DESSERT RECEPTION
Open to all conference attendees 8:30-9:30 PM
Salon 1 & 2

Sunday January 23:
STS-10 Planning Meeting (Konrad)
Open to All Interested NASTS Members
12:30-3:30 PM, Alexandria Room

SPECIAL ACTIVITIES

Exhibits:
Friday-Sunday, January 21-23
Grand Ballroom Foyer

ANNUAL MEETING OF NASTS MEMBERS
Friday, January 21, 1994
8:15 PM, Salon 2

1. Welcome and Presidential Address by James J. Murphy
2. Open Invitation to NASTS Members to Attend:
   a. Dessert Reception, Saturday 8:30 PM
   b. NASTS Committee Meetings
   c. Planning Meeting for STS-10, Sunday 12:30 PM
3. Honorary Membership Award
4. Election Results for Board Members and Vice-President and Introduction of Board
5. Proposed Changes to Constitution
6. Committee Reports
7. Report by Corporation Chair Rustum Roy on Status of NASTS
8. Open discussion on initiatives and projects members would like to undertake through the association during the coming year.
9. Discussion of STS-10
   a. Overarching theme
   b. Suggestions for main speakers
   c. Location

Breakfast, Lunch & Dinner Suggestions

In the hotel, the **Terrace Restaurant** (level 1) serves breakfast, lunch and dinner. The **Atrium** (foyer level) has a buffet lunch.

There is an underground mall at the hotel, "The Crystal City Underground," where you will find seven fast food lunch and early supper places at the **Food Court.**

SUBMISSION OF PAPERS

All presenters are urged to place 2 copies of their papers in the box near the registration table marked "STS-9 Proceedings." One copy will be given to the editor of the *Bulletin of Science, Technology and Society.* The other copy will go to the editor of the Annual STS Proceedings which are submitted to the ERIC documentation and retrieval system. Papers not ready at the Conference can be mailed to the appropriate editors.

Hotel Services:

Shuttle Service: Complimentary van service is availableevery 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 the undergound.
Indoor pool: Located on the lobby level of the hotel and is open from 6:30-9:30 daily.

CONFERENCE EVE PLENARY:
Thursday, January 20
7:30 PM
Location: Salon 2

"Reinventing Research After the Supercollider"

Wil Lepkowski, Chemical and Engineering News
Rustum Roy, NASTS Corporation Chair

PLENARY 1:
Friday, January 21
8:30 – 10:00 AM
Location: Salon 2

Welcome: **James J. Murphy**, NASTS President
Introduction: **Alice Moses**, NASTS Vice President & Conference Chair

* * *

Introduction: **Rustum Roy**, NASTS Corporation Chair
Speaker: **Maxine Green**, Professor of Philosophy and Education, Teachers College, Columbia University

"Equity and Diversity: Opening Doorways to Learning"

SESSION 1: Friday, January 21
10:15 - 11:15 AM

1.1 Panel — Minorities in S&T — Jefferson

Science and Diversity: Two Systematic Approaches to Curriculum Changes

Description and preliminary results from NSF funded, system-wide projects in two states, contrasting approaches now being tried involving changes in the science curriculum and how science is taught in the classroom to make it more attractive to men of color and women.

Sue Rossen (moderator), University of South Carolina and **Jacqueline Ross**, University of Wisconsin System

1.2 Roundtable — Teacher Ed — McLean

Global Warming: Middle School Students' Conceptions Following STS Instruction

Effects of STS units covering global warming in students subsequent conceptions and misconceptions. Report on interviews with 60 middle school students of teachers participating in NSF-funded Leadership Institute in STS Education.

Randall Wiesenmayer, W. Virginia University; **Peter Rubba**, Penn State University; and **Thomas Ditty**, W. Virginia University

1.4 Paper — Ethics — Fairfax

10:15-10:45 **James R. Gray**, Northern Kentucky University, Highland Heights, KY, *Technological Literacy and Professional Ethics*

10:45-11:15 **Richard A. Deitrich**, Penn State University, University Park, PA. *STS Pedagogy and Wholistic Motivation*

1.5 Paper — Ethics Course — Madison

10:15-11:15 John Karsnitz, Mort Winston, Keith Finkral and **John Hutchinson**, Trenton State College, Trenton, NJ, *New Society, Ethics and Technology Course as College-Wide Requirement*

1.6 Paper — Course Structure — Jackson

10:15-10:45 Jeffrey Collins, *Designing the Science and Society Course for Art/Anthropology Majors*

10:45-11:15 Arthur J. Rosser and **Fred Worman**, Central MO State University, Warrensburg, MO, *"Show Me" Social Issues and Technology*

1.7 Paper — Environment — Alexandria

10:15-10:45 Steven E. Letendre, Center for Energy and Environment, University of Delaware, Newark, DE, *Incorporating Environmental Externalities Into Electricity Markets: Methods and Policies*

1.8 Panel — Gender Equity — Lee

Connections to Gender Equity Resources

Numerous reports have recommended a variety of steps for achieving gender equity in education. Along with curricular reform, we must educate and support teachers in locating and using resources and role models to help develop more equitable classrooms. Panelists will offer information about a multitude of resources from a variety of sources. Plenty of time for questions.

Jane Konrad, Pittsburgh Regional Center for Science Teachers; **Irma Jarcho**, Teachers Clearinghouse, New York; and **Rosiland Eannarino**, NASA Teacher Resources Center, University of Pittsburgh

SESSION 2: Friday, January 21
11:30 AM - 12:30 PM

2.1 Panel — Technology & Democracy — Jefferson

Technological Citizenship and Future Generations: The Simple Gifts Ethic

Concept of Technological Citizenship (TC) and the new social contract of complexity as a participatory model for STS. Other panelists will present case studies of TC.

Philip J. Frankenfeld, University of Chicago, Milwaukee, WI; **Sandra O. Archibald**, Hubert H. Humphrey Institute of Public Affairs, Minneapolis, MN; **DeWitt John**, National Academy of Public Administration, Washington, DC; **Jonathan Bender**, Carnegie Commission, Washington, DC; and **Paul Locke**, Environmental Law Institution, Washington, DC

2.2 Workshop — Elem. Education — Fairfax

A Perfect Place to Live

Hands-On Science Lessons for the young child, helping her/him cope with the complex issues and learn to appreciate the marvelous would she/he will inherit. These lessons unitize cooperative learning strategies and decision making skills for the young learner.

Beverly Nelson, Science Education Consultant, Ridgewood, NJ

2.3 WorkshopTeacher Techniques McLean

Role Playing As An S-STS Teaching Tool

Role-playing can be an effective way to get across STS concepts. After a brief introduction, the attendees will have the opportunity to take on one of four roles (industry, scientist, government, and environmentalist) in a simulation exercise whose objective is to formulate a law dealing with ozone depletion. Handouts.

Al Costa, Worcester Polytechnic Institute, Worcester, MA

2.4 Paper Teacher Education Alexandria

11:30-12:00 **R. Hudspith** and **H. Jenkins**, McMaster University, Hamilton, Ontario, *Using Inquiry & Inquiry-Based Approaches in STS Courses*

12:00-12:30 **Leon Trilling**, Massachusetts Institute of Technology, Cambridge, MA, *Learning and Teaching Science & Engineering in Social Context*

2.5 Paper Environmental Ethics Lee

11:30-12:00 **Pat Mundav**, Montana Tech, Butte, MT, *Mining Culture & Mary Cults: A Case Study*

12:00-12:30 **Richard Simonelli**, Winds of Change Magazine, Boulder, CO, *Sustainable Science*

2.6 Paper Energy Policy Jackson

11:30-12:00 **John L. Roeder**, The Calhoun School, New York, NY, *Twenty Years After the Energy Crisis*

12:00-12:30 **In-Whan Jung**, Center for Energy and Environmental Policy, University of Delaware, Newark, DE, *Equity Issues of the U.S. Nuclear Energy Industry: Is Nuclear Power an Option for a Sustainable Energy Future?*

2.7 Paper K-6 Technology Ed Madison

11:30-12:00 **Pat Foster**, Ball State University, Muncie, IN, *Societal and Egocentric Elementary Technology Education*

NASTS COMMITTEE LUNCH MEETINGS I: Friday, January 21 12:30 - 1:30 PM

All listed committees convene in Salon 2

The following committees shall convene in Salon 2 to set meeting and lunch plans. You may wish to repair to the Terrace Restaurant or the Food Court to eat and discuss ideas and agenda for the coming year. Alternatively, you may wish to return after lunch or bring food to one of the assigned meeting rooms below. Charges to committees are noted following the committee list. Send roster of attendees and copy of minutes and planned activities to Gene Bazan at NASTS.

See Saturday lunch for additional Committee Meetings.

Regional Chapters and Conferences - [Jefferson]. Stimulate regional chapters and regional conferences to promote STS initiatives. Coordinate with existing groups and meetings while stimulating new ones wherever possible.

Publications - [Jackson]. Committee shall work with Association President and editors in monitoring quality and format of current newsletter and magazine. May also consider other Association publications.

Position Papers - [Fairfax]. Prepares positions for the STS community. Identifies important issues, finds interested authors, edits, and recommends adoption of positions meriting acceptance by the Association.

Community College STS - [McLean]. Identifies issues, challenges and opportunities within the community colleges as they relate to STS science. Promote NASTS membership, react to and formulate policy and position statements.

College/University STS - [Alexandria]. Identifies issues, challenges and opportunities within the college/university audience as they relate to STS science. Promote NASTS membership, react to and formulate policy and position statements. Update directory of institutions with STS programs.

Community Awareness - [Lee]. Establish a long-term mission regarding STS awareness efforts for community organizations, identify such organizations, undertake outreach and involvement in such organizations

SESSION 3: Friday, January 21
1:45 - 2:45 PM

3.1 Panel Tech. & Democracy Jefferson

Putting Technological Democracy Into Action

Panelists will discuss three new developments which foster democratic involvement in technology decisions. Participants will speak for ten minutes, leaving plenty of time for discussion from the audience.

Susan Cozzens (moderator), Rensselaer Polytechnic Institute, Troy, NY; **Gary Chapman**, 21st Century Project; **Richard Sclove**, Loka Institute; and **Franz Foltz**, Rensselaer Polytechnic Institute.

3.2 Panel STS Education Madison

The Earth Summit Two Years Later: Teaching Science & Technology Policy

STS often ignores policy issues. The Earth Summit was an important STS policy development. Knowledge about the background and consequences of this summit can provide useful context for many STS topics from global warming to energy options.

Carl Mitcham (moderator), Penn State Univ., University Park, PA; **John Bryne**, University of Delaware, Newark, DE; **Leonard Waks**, Temple, Philadelphia, PA; and **Cyril Ponnamperuma**, Pres. Third World Foundation, University of Maryland.

3.3 Workshop Techniques Fairfax

Courageous Risk Taking as an Attribute of Administrative Leadership

The purpose is to improve the competence level of the participants in using courageous risk taking as an attribute of leadership. Several research studies will be cited. Participants will be actively involved in several experiences designed to facilitate the development of risk taking behavior.

Donald J. McKay, Iowa State University, Ames, IA and **Dean E. Easler**, NE Iowa Community College, Calmar, IA

3.4 Roundtable STS Education Lee

Does Technological Literacy Really Matter? Part I

Reflections on a decade-long series of student projects conducted at WPI. Focus on question: What is the relationship between knowledge and opinion in public understanding of technology society debates and policy controversy? Includes panel discussion and short presentations followed by discussion. Issues include nuclear power and manned/unmanned space policy debate. Covers range of students from grades 6 - junior year in college.

Eveleen Deloria, Student Pugwash USA, Washington, DC and **John Wilkes**, Worcester Polytechnic Institute, Worcester, MA

"Nuclear Knowledge and Opinion: Are They Related?" **John Wilkes**, Worcester Polytechnic Institute (WPI), Worcester, MA

"Reaction to Critiques of NASA's Manned Space Mindset," **Jeff Gorczynski**, **Robert Owen**, **Michael Rider**, WPI

"Student Response to the Nuclear and Space Policy Debate Units From the WPI 6th Grade STS Curriculum Development Project." **Brion Keagle** and **Yiannis Syrigos**, WPI

3.5 Paper Univ. Ed./Sci. & Soc. Alexandria

1:45-2:15 **Sharon L. Chapin**, Washington State University, Pullman, WA, *Biotech or Biowreck? The Implications of Jurassic Park and Genetic Engineering*

2:15-2:45 **R. Eugene Mellican**, University of Massachusetts Lowell, Lowell, MA, *Jurassic Park: Life as a Theme Park & Other Scientific Amusements*

3.6 Paper Public Policy McLean

1:45-2:15 **Glen J. Ernst**, University of Delaware, Newark, DE, *Confronting the Racial and Economic Exploitation of Toxic Waste Disposal*

2:15-2:45 **Shahid M. Shahidullah**, St. John's University, New York, NY, *US Science and Technology Policy: Managerial and Organizational Reforms*

3.7 Paper Univ. Course Structure Jackson

1:45-2:45 **Eric Katz**, **Nancy Coppola** and **Burt Kimmelman**, New Jersey Institute of Technology, Newark, NJ, *Pollution Prevention Curricula at Technological Universities*

SESSION 4: Friday, January 21
3:00 - 4:00 PM

4.1 Panel — STS Education — Madison

STS as the Re-Construction of Knowledge

Collaborative, cooperative, interdisciplinary, multi-disciplinary, multi-cultural, multi-voice, and integrative ways of knowing will be discussed. Will explore how STS challenges what knowledge is. Exercise and discussion.

Robert A. Walker and **Daniel Walden**, Penn State University, University Park, PA, and **Gwen Blair Frazier**, State Department of Education, Concord, NH

4.2 Roundtable STS Education — Lee

Does Technological Literacy Really Matter? Part II

Continuation of WPI Roundtable from Session 3.4

4.4 Paper — Science & Society — Jefferson

3:00-3:30 **E.W. Jenkins**, University of Leeds, UK, *Inarticulate Science? Science for Public Use.*

3:30-4:00 **Mark G. Miksic** and **A. Scott Currie**, Queens College of CUNY, Flushing, NY, *Awareness of the Nature of Science in an Urban College*

4.5 Paper — Women in S & T — Fairfax

3:00-3:30 **Bev Sauer**, University of Maine, Orono, ME, *Sex, Language & Safety: A Feminist Analyzes Liability Cases*

4.6 Paper — Energy Policy — McLean

3:00-3:30 **Kofi Berko, Jr.**, University of Delaware, Newark, DE, *Electric Utility Energy Conservation Programs and the Equity Problem*

3:30-4:00 **Chandrasekar Govindarajalu**, University of Delaware, Newark, DE, *Critique of Renewable Energy Technology Evaluations of the OTA*

4.7 Paper — Public Policy — Jackson

3:00-3:30 **Anita Eide**, University of Delaware, Newark, DE, *Cooperation or Aid: International Development Policies for Sustainable Development*

4.7 Paper — HS Teach. Techniques — Jackson

3:30-4:00 **Robert G. Meeker**, SRC Education Alliance, Research Triangle Park, NC, *Exploring "Real-World" Science and Math*

4.8 Paper — Tech Assessment — Alexandria

3:00-3:30 **Salah M. Al-Mazidi**, Kuwait Institute for Scientific Research, Safat, Kuwait, *Implementation of Technology Assessment Investment Techniques*

3:30-4:00 **Khaled A. Al-Issa**, National Committee for Technology Transfer, Kuwait Society of Engineers, Safat, Kuwait, *Business Development for Technology and Research Projects*

COMMUNITY BREAKOUTS: Friday, January 21
4:15 – 5:15 PM

The community breakouts provide an occasion to meet with peers to discuss key STS issues raised in the Plenary, committee meetings and other sessions of the conference with members of your own interest group. These sessions are self-organized.

Education K-8	[Fairfax]	Business and Industry	[Alexandria]
Education 9-12	[Madison]	Public Policy & Ethics	[McLean]
Education Post Secondary	[Jefferson]	Environment	[Lee]

DINNER BREAK: Friday, January 21
5:30 - 8:00 PM

NASTS MEMBERS MEETING: Friday, January 21
8:15 - 10:15 PM

Open to all NASTS members. See page 4 for agenda.

INSTITUTIONAL MEMBERS ADVISORY COUNCIL BREAKFAST MEETING:

Saturday, January 22, 7:00 - 8:00 AM

Location: Lee

Institutional Members and Contacts

Chair: Terry Reynolds

Babson College: David Adams
Central Missouri State University: Arthur J. Rosser
Colby College: James Fleming
IBM: Carol Bernstein
Lehigh University: Stephen H. Cutcliffe
Michigan Technological University: Terry S. Reynolds, Chair

Montana Tech: T. Lester
New Jersey Institute of Technology: Eric Katz
North Shore Community College: Robert E. Baker
Notre Dame: Vaughn R. McKim
Pennsylvania State University: Carl Mitcham
Purdue University: Leon Trachtman

Rensselaer Polytechnic Institute: Shirley Gorenstein
Stanford University: Robert E. McGinn
Texas Academy of Math and Science: Richard J. Sinclair
University of Delaware: John Byrne
University of Minnesota: Fred Amram
University of Nevada: Michael Robinson

University of Toronto: Willem H. Vanderburg
Utah State University: Prent Klag and Donald Fusinger
University of San Diego: Mitchell Malachowski
Wayne State University: Don Cattle
Worcester Polytechnic Institute: John M. Wilkes

SESSION 5: Saturday, January 22 8:00 - 9:00 AM

5.1 Workshop Techniques Jefferson

Making the Familiar Curious: Inquiry Into Inquiry

Workshop explores how knowledge comes into being and the value of interdisciplinary approaches to study in both the humanities and the sciences. Participants will experience the "Interdisciplinary Non-Trivial Pursuit Game," where people design questions on what they regard as significant issues and other exercises.

Stephen Lafer and **Stephen Tchudi**, University of Nevada, Reno, NV.

5.2 Workshop Elementary Ed Fairfax

Water Education for Elementary Grades

Workshop will share a variety of activities from *The Comprehensive Water Education Book: K-6*. Workshop components will include activities on physical and chemical properties of water, the water cycle, water needs of living things, water management, and potential field experiences. Participants will receive handouts and equipment.

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

SESSION 5: Saturday, January 22 (continued)
8:00 - 9:00 AM

5.3 Workshop — Women — McLean

A Gateway for Girls Into Science and Technology: An Interactive Design Curriculum

Examples of students work, curriculum activities, and reflections from the research and development of the *Imagine* project, to explore pedagogical issues that arose in our classroom research with girls. Hands-on exploration of the design curriculum included in an interactive, computer-based teacher's guide.

Dorothy T. Bennett, **Theresa Meade** and **Margaret Honey**, Center for Children and Technology, New York, NY

5.4 Workshops — Computers — Madison

Teaching Science Using Multimedia

Workshop on "visual learning" will explore use of digitized slides, full-motion video, digital audio, scanned images, and compact disc audio clips in classrooms. Demonstration of Podium software.

Victor A. Stanionis, Iona College, New Rochelle, NY

5.5 Paper — Technology & Work — Jackson

8:00-8:30 Michael Drohan, Penn State University, McKeesport, PA, *Technological Change, Automation and Unemployment*

8:30-9:00 R.T. McCutcheon and **M.B. Van Ryneveld**, University of the Witwatersrand, Johannesburg, South Africa, *Development Engineering Education: Progress and Problems*

5.6 Paper — Ethics — Manassas

8:00-8:30 Ronald M. Uritus, Barry University, Miami Shores, FL, *Henri Bergson on Technology and Society*

8:30-9:00 Mick Lantis and **Marilyn Sulewski**, Purdue University North Central, Westville, IN, *Overcoming Computer Anxiety in Adult Learners*

5.7 Paper — Middle School — Alexandria

8:00-8:30 Jim L. Barnes, NASA Research Office, Eastern Michigan University, Ypsilanti, MI, *NASA's Minds 2000+: An Internet and Global Change Curriculum*

8:30-9:00 Gary Varrella, University of Iowa, Iowa City, IA; **Scott Hoegh**, Hampton Middle School, Hampton, IA; and **Curt Jeffryes**, Jones Middle School, Creston, IA, *Going School-Wide with STS: The Need for an Organizing Framework*

PLENARY 2: Saturday, January 22
9:15 – 10:15 AM
Location: Salon 2

Introduction: **Rustum Roy**, NASTS Corporation Chair
Speaker: **Rebecca Adamson**, President First Nations Development Institute, Falmouth VA

Address by Rebecca Adamson: "Indigenous Economic Technology"

SESSION 6: Saturday, January 22
10:30 - 11:30 AM

6.1 Panel Special Session Madison

The Next Techno-Economy

Special post plenary panel with Rebecca Adamson, Terry Mollner and selected respondents who will explore the trends, issues, and shaping constraints and opportunities of the economy emerging out of the chaos of global transformation: fall of the Soviet Union, massive movement of capital and jobs to other locales, an increased technicization of production.

Rebecca Adamson, President, First Nations Development Instutite and **Terry Mollner**, Chair, Trusteeship Institute, a think tank and consulting firm specializing in conversions of companies to employee ownership.

6.2 Workshop Computers Fairfax

Turn on the Video Spigot to Learning

Hands-on workshop will demonstrate the use of a video spigot to import live and taped video images into an animated or computer generated video program. Emphasis will be placed on using these techniques to create interactive video presentations suitable for classroom or other instructional settings. A team of NORSTAR students who use these techniques will mentor the participants with a demonstration program on the interaction of robots in health care and other settings.

George Skena, NORSTAR Student Research Institute, Norfolk, VA

6.3 Workshop HS Curriculum McLean

The Math/Science/Technology Integration Dream: Is the Emperor Wearing Any Clothes?

Audience will be organized into small groups to discuss the validity of four positions on the optional approach to the central question in science and technology education.

Michael J. Dyrenfurth, University of Missouri-Columbia, Columbia, MO

6.4 Panel Technology Assess. Jefferson

Recent Technology Assessments by the Office of Tech Assessment, US Congress

Vary **Coates**, OTA (moderator); **Linda Garcia**, OTA. Information Technology & the Economy: Electronic Enterprise. **Karen Bandy**, OTA. Potential costs & benefits of more intensive use of information technology in health care delivery. Perspective of patients, health care professionals, payment systems. **Emilio Gonzales**, OTA. Opportunities for electronic delivery of government services and its contribution to "reinventing government."

6.5 Workshop Elementary Ed Alexandria

Building Science Equipment in Elementary Classrooms: Empowering Women and Connecting Technology and Science

Predominately elementary school teachers construct science equipment which they could construct with their own students. Participants in this workshop will simulate this activity by building and then discuss the benefits.

Paul Jablon, Diane Varano, and **Andrea Egitto**
Brooklyn College, Brooklyn, NY

6.6 Paper Women & Minorities Jackson

10:30-11:00 **Sara F. Anderson**, No. Virginia Community College, Annandale, VA, *When 'Outsiders' Challenge the Scientific Community: Case Study of Three Women, Carson, Jacobs, Freidan*

11:00-11:30 **Warren Rosenberg**, Iona College, New Rochelle, NY and **Bernard Listwan**, New Rochelle High School, New Rochelle, NY, *A Science and Technology Entry Program For Minority Youth*

6.7 Paper STS Ed/Biotechnology Manassas

10:30-11:00 **Leonard J. Waks**, Temple and Penn State Universities, University Park, PA, *Beyond the Limits of Schooling in STS Teaching*

11:00-11:30 **S.A. Hagedorn**, VA Tech, Blacksburg, VA, *NBIAP and Public Perceptions of Biotechnology*

6.8 Symposium Lee

Engineering and Applied Science

Presentations by members and education directors of national engineering and applied science societies on latest programs, teaching materials, videos, and other initiatives to improve technology and applied science instruction in K-12. Show and tell for teachers and educators with opportunities for discussion. This is an extended session through lunch.

Rustum Roy (moderator), NASTS Corporation Chair and **William F. Williams** (co-moderator), The Pennsylvania State University, University Park, PA

BEST COPY AVAILABLE

LUNCH MEETING ROUNDTABLE
Location: Manassas

Women Networking in Science & Technology

Janice Koch (moderator), Hofstra University

NASTS COMMITTEE LUNCH MEETINGS II:
Saturday, January 22
11:45 AM - 12:45 PM

All listed committees convene in Salon 2

The following committees shall convene in Salon 2 to set meeting and lunch plans. You may wish to repair to the Terrace Restaurant or the Food Court to eat and discuss ideas and agenda for the coming year. Alternatively, you may wish to return after lunch or bring food to one of the assigned meeting rooms below. Charges to committees are noted following the committee list. Send roster of attendees and copy of minutes and planned activities to Gene Bazan at NASTS.

Pre-School/Elementary STS [Jefferson]. Identifies issues, challenges and opportunities within the pre-school/elementary school teacher audience as they relate to STS. Promote NASTS membership, react to and formulate policy and position statements. Network with existing science associations' pre-school/elementary committees.

Middle School STS [Madison]. Identifies issues, challenges and opportunities within the middle school teacher audience as they relate to STS. Promote NASTS membership, react to and formulate policy and position statements. React to policy statements and projects as they impact STS science in the middle school.

High School STS [Jackson]. Identifies issues, challenges and opportunities within the high school teacher audience as they relate to STS. Promote NASTS membership, react to and formulate policy and position statements. React to policy statements and projects as they impact STS science in the high school.

STS Assessment and Evaluation [Fairfax]. Develop a position paper on assessing student learning in STS classrooms. Promote the use of such methods. Seek ties with other groups involved with assessment.

K-12 Educational Organizations Linkages [McLean]. Identify, undertake linkages with professional science societies; collaborate on common goals.

International and Foreign Organizations Linkages [Alexandria]. Identify, undertake linkages with international and foreign STS-related organizations; develop collaborative projects; encourage NASTS members to make presentations at international conferences; work toward joint meetings.

Corporate Linkages [Terrace Restaurant]. Identify, undertake linkages with corporations regarding joint initiatives, participation in NASTS and STS education, and formation of a Corporate Advisory Council.

SESSION 7: Saturday, January 22
1:00 - 2:00 PM

7.1 Panel — Women in S&T — Madison

Transforming Science Pedagogy

Attracting females to physical science, mathematics, and engineering requires changes in teaching techniques. Panel will discuss work of a group of scientists preparing a new book, "Teaching the Majority: Science, Mathematics and Engineering that Attract Women."

Connie Sutton and **Darlene Richardson**, Indiana University of PA, Indiana, PA; and **Sue Rosser**, University of South Carolina, Columbia, SC

7.2 Workshop — HS Curriculum — Alexandria

Ford Academy of Manufacturing Sciences: An Integrated Curriculum

Presentation on *The Ford Academy of Manufacturing Sciences* (FAMS), an interdisciplinary secondary school curriculum for students to learn science, math, technology and communications in rigorous real life context. FAMS reflects the best of the national agenda for school to work classroom instruction and workplace involvement.

Patricia Davis Austin, The Network, Inc., Andover, MA

7.3 Workshop — Elementary Ed — Jefferson

Out of the Rock Mining

Workshop presented from the perspective of an elementary teacher who has implemented a new K-6 interdisciplinary, earth science program that the National Energy Foundation and United States Bureau of Mines have developed titled *Out of the Rock*. Hands-on experience of a sample lesson. Participants will receive a lesson outline and curriculum materials.

Rachel Daugs, Roosevelt Middle School, Roosevelt, UT

7.4 Paper — STS Education — McLean

1:00-1:30 **Michael J. Dyrenfurth**, University of Missouri-Columbia, MO *International Initiatives Towards Scientific and Technological Literacy*

1:30-2:00 **John Schumacher**, School of Humanities and Social Sciences, RPI, Troy, NY, *University-Level, Multi-Disciplinary Science and Technology Studies*

7.5 Paper — Technology & History — Jackson

1:00-1:30 **Elva Kathleen Lyon**, RPI, Troy, NY, *Early Multicultural Technology Transfer into the American Colonies*

1:30-2:00 **Dennis Rohatyn** and **Mitch Malachowski**, Univ. of San Diego, San Diego, CA, *The Alchemical Bond: STS and the Chemical Revolution*

7.6 Paper — Public Policy — Manassas

1:00-1:30 **Shih-Jung Hsu** and **John Byrne**, Univ. of Delaware, Newark, DE, *To Defuse An Environmental Movement—The Case of the Fifth Naphtha Cracking Plant in Taiwan*

1:30-2:00 **Martin L. Sage**, Syracuse University, Syracuse, New York, *Gamma Irradiation of Food: Boon or Bane?*

7.7 Symposium — Fairfax

Speculations In Science
Part 1

Intriguing ideas from avant-garde science and scientists.

Greg Kunkle (moderator), Lehigh University, Bethlehem, PA; **James Worthey**, National Institute of Standards and Technology, *Lighting as an Optics Problem;* **'Majenta Yglesias**, *Does Color Effect Heart Rate and Blood Pressure in Normal Humans?*; and **Charles Brownstein**, NSF, Electronic Communications Network

7.8 Workshop — Materials Science — Lee

Our Material World: A Solid Approach to STS
Part 1

Three hour workshop for teachers in HS, Community Colleges and Universities interested in materials sciences. Using such solids as plastic, wood, ceramic, and composite materials, we will explore concepts that turn the abstracts of math, chemistry and physics into understandable and useful knowledge for lifelong learning. Social issues involving consumerism, environment, and conservation will be folded in.

Workshop leaders will share ideas, provide you with experiments, demonstrations and resource materials to help you put some "solid material" into your curriculum.

James A. Jacobs, Norfolk State University; **Thomas F. Kilduff**, Thomas Nelson Community College; and others from technical societies.

7.9 Poster — Exhibit Area

1:00-2:00 **Ronald A. Palmer**, West Valley Nuclear Services, West Valley, NY, *Team Learning: A Novel Approach to Teaching STS*

1:00-2:00 **Todd C. Waggoner**, **Ahmad Zargari**, **Ross Corbett**, **John W. Sinn**, and **Edward Kennedy**, Department of Technology Systems, Bowling Green State University, Bowling Green, OH, *Automating a Technology Course for Liberal Education Offering*

7.10 Workshop — Middle & High School — Salon D

Introduction to Model Rocketry for the Classroom

Teachers will construct a model rocket and learn how the fundamentals of modern rocket flight can serve as a rewarding framework for such topics as Newton's Law of Motion, Basic Aerodynamics, etc.

Representatives from **ESTES Model Rockets**, Penrose, CO

SESSION 8: Saturday, January 22
2:15-3:15 PM

8.1 Roundtable Broadening Partic. McLean

The Atypical STS Student

Roundtable discussion for students and faculty to discuss concerns, necessary institutional constraints, and strategies to help alleviate the special burdens on professionally established, male or female students who have family and job responsibilities.

Susan A. Hagedorn, VA Tech, Blacksburg, VA

8.2 Workshop Tech. & Democracy Madison

Technology, You and the Law

This presentation/workshop will examine current technological issues/events and their impact on the Constitution, actual court cases involving freedom of speech, right to assembly, and unreasonable searches will be examined by several judges in the audience. Through this presentation, an entertaining strategy for educators to actively engage students in an analysis of science, technology and social impacts is demonstrated.

Ken Volk, East Carolina University, Greenville, NC

8.3 Workshop Women in STS Alexandria

Encouraging Women in Science and Technology

This session is designed to elicit participants' own experiences with STS education, girls and young women. The goal is to establish a working agenda that overtly addresses the ways in which pedagogy and STS curriculum may be constructed to ensure an equitable and "girl-friendly" environment. This presentation reviews the recent research on the education of girls and young women in science and technology education.

Janice Koch, Hofstra University, Hempstead, NY

8.4 Roundtable Middle School Jefferson

Global Warming: Middle School Students

Reports by teachers of actions taken by their students outside class subsequent to implementation of STS units on global warming. Units developed in conjunction with NSF funded Leadership Institute in STS Education.

Thomas Ditty, (moderator); **Randall Wiesenmayer**, West Virginia University, Morgantown, WV; **Peter Rubba**, Penn State University, University Park, PA; **Dorothy Yukish**, Middle School Science Teacher, Normalville, PA; **Martha McLaren**, Junior High Science Teacher, Gettysburg, PA; and **Kathy A. Yorks**, High School Science Teacher, Lock Haven, PA

8.5 Paper Computer Tech Jackson

2:15-2:45 Mark G. Miksic and **Al-Karim Gangji**, Queens College of CUNY, Flushing, NY, *Learning Enhancement of the Physics of Waves*

2:45-3:15 Arnold R. Spokane and **Judith A. Bazler**, Smart Center, Lehigh University, Bethlehem, PA, *The Jason Project Evaluation Methodology*

8.6 Paper Elem Ed Manassas

2:15-2:45 Jane A. Berndt, George Washington University, Alexandria,VA, *The Learning Cycle and Natural Resource Science*

2:45-3:15 Bernice Hauser, Horace Mann School, Bronx, NY, *Can You See Inside Me?*

8.7 Paper Course Structure Salon D

2:15-2:45 David L. Adams and **James Philips**, Babson College, Babson Park, MA, *Competency-Based Introductory College Science - A Progress Report*

2:45-3:15 Marc J. de Vries, Eindhoven University of Technology, Netherlands, *Design Methodology in STS Programs*

8.8 Symposium Fairfax

Speculations in Science
Part 2

Intriguing ideas from avant-garde science and scientists.

Al Wurth, (moderator) Lehigh University, Bethlehem, PA; **Louis Rodriquez** (moderator), Lehigh University, Bethlehem, PA ; **Beverly Rubik**, Center For Frontier Science, Temple University, Philadelphia, PA, *Three Frontier Areas That Challenge the paradigm: Consciousness Research, Bio-electromagnetics, and Complementary Medicine;* **Joseph Coates**, Coates & Farratt, Washington, DC, *The 2025 Forecast: A Survey of Predictions For the Year 2025;* and **Michael Brill**, Science Applications International Corp., *Geomorphology of the Ninety East Ridge.*

8.9 Workshop Materials Science Lee

Our Material World: A Solid Approach to STS
Part 2

Three hour workshop for teachers in HS, Community Colleges and Universities interested in materials sciences. See Session 7.8 for description.

BEST COPY AVAILABLE

SESSION 9: Saturday, January 22 3:30-4:30 PM

9.1 Workshop High School Ed Jefferson

STS, Constructed Understanding and Alternative Assessments: Natural Partnerships

Using examples from participating secondary teachers in the Iowa Scope, Sequence, and Coordination Project, we will explore the use of ongoing alternative assessments in extended constructivist learning experiences. The focus will be on collecting and evaluating assessment information to see how students construct meanings over time and how their ideas are interconnected into a web of understandings. Participants will split into small groups to make an assessment plan, develop goals and context around an STS framework.

Chris L. Lawrence and **Sandy Enger**, University of Iowa, Iowa City, IA

9.2 Workshop Teacher Training McLean

A National Diffusion Network Model for Restructuring Science Inservice Education

Tired of the same old approach to inservice education? Attendees will become involved in the process of identifying special needs and creating a preliminary plan for strengthening science inservice experiences using the key elements of the Iowa Chautauqua Model. This workshop will inform attendees on how to get started with a Chautauqua program in their area/school/state.

Susan M. Blunck and **Maxwell Dass**, University of Iowa, Iowa City, IA

9.3 Workshop Elem Ed Alexandria

Technology and the New Way to Teach and Learn at the Elementary Grade Level

Technology Learning Modules (TLAs) are a new format of lesson presentation and student learning. The TLA places the student in the role of technological innovator. During this hands-on workshop the participants will transform traditional elementary classroom activities into TLAs.

Vincent Walencik, Montclair State, Upper Montclair, NJ

9.4 Workshop Middle School Madison

The STS-Constructivist Classroom-Relevant Activities that Work!

Each of the presenters has been using the STS approach in their classroom for the past 10 years. In this workshop, activities will be presented for the participants which highlight use of STS and constructivism. Materials will be available for those attending this workshop.

9.4 Workshop (cont.) Middle School Madison

Scott Hoegh, Hampton Middle School, Hampton, IA; **Larry Kimble**, Mt Ayr Community Schools, Mt. Ayr, IA; and **Curt Jeffryes**, Jones Middle School, Creston, IA

9.5 Paper HS Curriculum Fairfax

3:30-4:00 Kenneth A. Dahlberg, Western Michigan University, Kalamazoo, MI, *Trying to Teach the Invisible: Local Food Systems*

4:00-4:30 John G. Wells, West Virginia University, Morgantown, WV, *Biotechnology in Technology Education: Determining an Instructional Taxonomy*

9.6 Paper Tech & History Jackson

3:30-4:00 June Mack, Independent Filmmaker, Bradenton, FL, *The Technology of Filmmaking & Its Impact on Society*

4:00-4:30 Leonard S. Reich, Colby College, Waterville, ME, *The Spirit of St. Louis to the SST: Lindbergh, Technology, and Environment*

9.7 Paper Teacher Training Manassas

3:30-4:00 Daniel J. Brovey and **Mark Miksie**, Queens College, Flushing, NY, *Preparing Science Specialists for the Elementary School*

4:00-4:30 Prent Klag and **Donald Daugs**, Utah State University, Logan UT, *STS as an Organizing Principle in Elementary Teacher Preparation*

9.8 Workshop Materials Science Lee

Our Material World: A Solid Approach to STS Part 3

Three hour workshop for teachers in HS, Community Colleges and Universities interested in materials sciences. See Session 7.8 for description.

9.9 Workshop Environmental Ed. Salon D

New Materials for Environmental Education: Teacher Trainers

This workshop will introduce participants to the EE Toolbox, a collection of resources to enhance teacher workshops. Participants will work with sample materials and review draft activities. Handouts will be available.

Martha Monroe, The National Consortia for Environmental Education and Training, University of Michigan, Ann Arbor, MI.

PLENARY 3: Saturday, January 22

4:45 – 6:00 PM

Location: Salon 2

The Third Rodale Lecture

Supported by the Calvert Social Investment Fund

Introduction: **Rustum Roy**, NASTS Corporation Chair
Award Presenter: **Wayne Silby**, Calvert Social Investment Fund
Recipient: **John Todd**, President, Ocean Arks International, Falmouth, MA

Address by John Todd: Living Machines and Ecological Designs A New Synthesis

DINNER BREAK: Saturday, January 22

6:00 – 8:00 PM

NASTS BOARD MEMBERS DINNER:

Saturday, January 22
6:30 - 10:00 PM
Location: Alexandria Room

For Board Members Only

NASTS DESSERT RECEPTION:

Saturday, January 22
8:30 – 9:30 PM
Location: Salon 1 & 2

THE social occasion of the evening for all conference registrants!

Hosted by: The Issues Laboratory Collaborative, an association of science museums, with support from NSF

SESSION 10: Sunday, January 23
8:30-9:30 AM

10.1 Panel Techniques Jefferson

Case Studies in STS Education

Full length case studies of particular incidents involving scientific or technological developments, with a significant impact on the public, are beginning to appear in greater numbers than before. This session is devoted to a discussion of the utility of such detailed case studies in teaching various courses related to STS and importance of scholarship. The scholarship involved in putting together really good, full-length STS case studies.

Paul T. Durbin (moderator), University of Delaware, Newark, DE; **Bernard Den Ouden**, University of Hartford, West Hartford, CN; **Steven Goldman**, Lehigh University, Bethlehem, PA; and **Robert McGinn**, VTSS/Stanford University, Stanford, CA

10.3 Workshop High School Jackson

Implementation of Performance Assessment

Assessment continues to be a major focus in education. Performance assessment is being addressed b, testing corporations like ACT and ETS. Focus on the design, use, and scoring of performance assessments in STS & SS & C classrooms.

Sandra K. Enger and **Chris Lawrence**, University of Iowa, Iowa City, IA

10.4 Rountable Environment Alexandria

The EPA Journal: Resource for Classroom Teachers

The EPA Journal, published by the Environmental Protection Agency, provides classroom resources through an integrated set of articles, e.g., indoor air quality, risk assessment, pollution prevention. Journal also contains lesson and unit plans for teachers.

We will provide copies of journal, discuss the published lesson plans, and invite participants to discuss their ideas on how the EPA Journal might be used in the classroom.

Stephen Tchudi, Department of English, University of Nevada, NV and **Nancy Stearns**, EPA, Washington, DC

10.5 Paper Public Policy Fairfax

8:30-9:00 **Willem H. Vanderburg**, Director, Center for Technology and Society Development, University of Toronto, Canada, *Auditing the Social Performance of Technology Related Professions: A Topic for STS?*

SESSION 11: Sunday, January 23
9:45-10:45 AM

11.1 Panel Ethics Madison

Modern Technology: The Double-edged Sword

Panel discussion on a variety of dichotomous questions concerning the upside and downside of technology, and whether this mode of inquiry illuminates.

Doris Fleischer, **Lisa Novemsky**, **Ron Gautreau**, and **Frieda Zames**, New Jersey Institute of Technology, Newark, NJ

11.2 Workshop Middle School Jefferson

Pedagogical Growth Through Video Taping: A Model of Self & Peer Improvement for STS-Constructivist Teachers

Discussion of a new method of peer and self observation/evaluation for STS teachers used in Iowa (the ESTEEM model). Reports and discussion of application in Iowa's SSC Project. Participants will have an opportunity to use the classoom observation rubric on a short segment of video tape from an Iowa STS classroom and to discuss applications to their own classrooms.

Gary Varrella, University of Iowa, Iowa City, IA; **Judith Burry-Stock**, University of Alabama, Tuscaloosa ..., and **Sharon Irelan**, St. Malachy School, Creston

11.3 Workshop Middle School Fairfax

Issue-Oriented Modules and Course From SEPUP

Workshop will discuss and update SEPUP's year-long Issue-Oriented Science course, and several activities and/or discussion of two recently published instructional modules, "Household Chemicals" and "Investigating Hazardous Materials." Workshop features both discussion and hands-on activities.

Richard A. Duquin, Kenmore-Tonawanda Schools, NY

11.4 Workshop HS Curriculum Jackson

Bioethical Issues: Organizers for High School Biology Instruction

Presents ideas about designing biology instruction around the bioethical issues arising out of the technological applications of modern scientific discoveries as a way of making biology more relevant to the students. After initial presentation, attendees will be divided into small groups to consider the feasibility of using a selected bioethical issue to organize biology instruction.

P. Maxwell Dass, University of Iowa, Iowa City, IA

11.5 Roundtable Lee

Stars of Science Education Reform Movement

Review of science education reforms over past five years, including Project 2061, NSTA's SSC, National Research Council. Examination of these in terms of STS principles. Open discussion to follow.

Robert E. Yager (moderator), NASTS past President, University of Iowa, Iowa City, IA.

11.6 Paper Computers McLean

9:45-10:15 Robert Novak, Iona College, New Rochelle, NY, *Spreadsheet Model for the Spread of HIV*

10:15-10:45 Juan D. Rogers, Virginia Polytechnic Institute, *The Implementation of an Information Infrastructure: Players and Interests in the Deliberations over the National Research and Education Network (NREN)*

11.7 Paper Tech & Democracy Alexandria

9:45-10:15 Jeffrey L. Newcomer, RPI, Troy, NY, *The Shaping and Uses of the NASA - CIRSSE Two-Arm Robotic Testbed*

10:15-10:45 Jesse S. Tatum, Michigan Technological University, Houghton, MI, *Technology Policy and Civil Liberty*

PLENARY 4: Sunday, January 23
11:00 – 12:00 PM
Location: Salon 2

The Second Science, Technology and Religious Values Lecture
Supported by The Incogniti Trust

Introduction: **Rustum Roy**, NASTS Corporation Chair
Award Presenter: **Elizabeth O'Conner**, Incogniti Trust
Speaker: **Henry Heimlich**, Director of Heimlich Institute, Cinncinati, OH

Address by Henry Heimlich: Falsified National Academy of Sciences Report Resulted in Hundreds of Unneccessary Drowning Deaths

CONFERENCE CLOSING
Following the Plenary

James J. Murphy, NASTS President
Alice Moses, Conference Chair, NASTS President-Elect
Jane Konrad, NASTS Vice President-Elect

STS-10 PLANNING MEETING:
Sunday, January 23
12:30 – 3:30 PM
Location: Alexandria

Open to interested NASTS Members

EXHIBITORS

Bioscience Education, Training and Research Initiative
Bethesda, MD

ESTES Model Rockets
Penrose, CO

Edvotek
West Bethesda, MD

Guilford Publications
New York, NY

Proed, Inc.
Bethesda, MD

SAIC
Reston, VA

Teachers College Press
New York, NY

Virginia Section of the American Nuclear Society
Charlottesville, VA

TLC-9 CONFERENCE EVALUATION FORM

Please complete and return to registration table (boxes labeled "STS-9 Evaluations") or mail before February 15, 1994 to NASTS, 133 Willard Bldg., University Park, PA, 16802.

1. With which one sector do you most closely affiliate?

   _____ Science and Engineering
   _____ Print and Broadcast Media
   _____ Public Interest Sector
   _____ K-12 Education
   _____ Post-Secondary Education
   _____ Museums, Science Centers, Other Informal Education
   _____ Profession Pertaining to Values, Ethics, or Religion
   _____ Science and Technology Policy Making
   _____ 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 do you think about the Crystal Gateway Marriott as a conference site?

10. What additional comments or suggestions do you have?