Appropriate Technology for Sustainable Living

Editor

Robert C. Wicklein
The University of Georgia

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Philosophical Rationale for Appropriate Technology

Robert C. Wicklein
The University of Georgia
Athens, Georgia

Charles J. Kachmar
South Gwinnett High School
Duluth, Georgia

During late night television it is common to have the following scenario depicted to the viewer.

Announcer: It is a land that time seems to have forgotten. (Sympathetic pan flute music in the background. The camera shows a desolate land cleverly capturing the sweltering waves of heat rising from the earth.)

Announcer: Scorched in the equatorial sunlight, the small spring is the only source of fresh water available to the population of this harsh land. (The camera now pans to a small fresh water spring, which is mostly mud. People are drawing vessels of water in the midst of an array of cattle. Insects are plentiful.)

Announcer: This spring is the only promise of relief of thirst available for human, beast, and insect. Human consumption of this water will result in illness, amebic dysentery, and ultimate death. This is 'Nailone', a four year old child sent by her mother to retrieve water from this spring for drinking. (Presentation of a short clip of a beautiful child in tattered clothing, barefoot, obviously malnourished, and in desperate need of medical treatment.)

Announcer: Nailone is the fifth child in a family of six children who inhabit a one-room dwelling made of the most primitive building materials available. (Camera pans to a picture of a thatched hut.)

Elizabath Trailer: (A famous American film and television personality is seen playing with Nailone and her family and taking "red-cross-like" packages off a late model flat bed truck.) You can make a difference in the life of Nailone and her family for only $22 a month. This would provide drinking water, food, clothing, adequate shelter, and medical attention that children like Nailone desperately need. For your $22 a month you will receive a picture of the child that your donation has assisted. Won't you call the toll free number below and give children like Nailone a fair chance at life?

The above mentioned scenario is a form of technology that is very successful here in the United States. Telemarketing has revolutionized the way we do business. It relies on immediate action to address a need or to solve a problem. The consumer picks up a phone, the operator takes the information, the transaction (transfer of money) is done electronically in most cases, and the product is shipped to the consumer. In the case described above, we must examine the appropriateness of this technology as a solution to the problems facing Nailone and her family. Through understanding the background, philosophy, and design criteria for Appropriate Technology (AT) this 'help' campaign can be identified as an example of exploitative capitalism disguised as assistance.

What is Appropriate Technology?

Perhaps the best place to begin a discussion on the topic of AT is to provide a working definition that will serve as the foundation for all future thoughts and deliberations in this book. Appropriate Technology concepts have been discussed throughout this past century by notable leaders and scholars such as Gandi and Julius Nyerere; however, the undisputed founder of the AT movement was E.F. Schumacher, a British economist who worked extensively in India and Burma during the 1950s and 60s. Schumacher encapsulated the philosophy of AT in his book, *Small Is Beautiful,* (1973) where he described the central doctrine of AT as (a) simple, (b) small scale, (c) low cost, and (d) non-violent. The U.S. Office of Technology Assessment has further refined these tenets by describing AT as (a) small scale, (b) energy efficient, (c) environmentally sound, (d) labor intensive, (e) controlled by the local community, and (f) sustained at the local level (Office of Technology Assessment, 1981). Many definitions of AT have spawned from these criteria; however, when the scope and focus of technology education is considered, the following explanation incorporates the core of the AT thrust with the fundamental base of technology education. The following working definition of AT will serve as the foundational base for this book.

> *Appropriate Technology seeks to aid and support the human ability to understand, operate, and sustain technological systems to the benefit of humans while having the least negative societal and environmental impact on communities and the planet.*

Concept and Rationale for Appropriate Technology

A central concept of AT is that technology must match both the user and the need in complexity and scale (Hazeltine & Bull, 1999). With this as a base concept, let us consider the world we live in. World population passed 6 billion humans in 1999. If current growth rates continue the planet's population will be in excess of 9 billion by the turn of the next century (Brown, Flavin, & French, 1999). The majority of this growth will take place in developing countries where resources are currently being stretched to the breaking point and will surely be exceeded in the future. The question of creating a reasonable standard of living that can be sustained for this many people is critical to the very survival of the planet. No amount of foreign aid or advanced technology from industrialized countries will be able to provide for the basics of life for all these people. The only real chance for any type of quality of life must be found by people of the industrialized and developing worlds working together to utilize all of their resources in the most effective and efficient ways possible. This will absolutely require the inclusion of the most abundant and powerful resource available: *Human Beings*.

The philosophical foundation for AT is found in a number of political, religious and grassroots (community) level movements. No one focus or theory can be attributed to the whole of AT, therefore, the philosophical foundation is an eclectic mix of a number of issues that when combined form the essence of AT. The primary forces and theories behind AT are found in the following movements and worldviews:

- European Socialism (working together for the common good)
- Entrepreneurial Capitalism (supply & demand)
- First Century Christianity (The Golden Rule)
- Non-Violence Peace Movement (working for change in peaceful ways)
- Freedom & Equality (failure of western aid projects)
- Decentralized Marxism (non-authoritative collective support)
- Feminist Movement (encouraging women through self-help)
- Breaking of the Technopoly (loosing the hold of high technology on humans)
- African Communalism (supportive of local cultures and customs)
- Environmentalism (considering the planet's ability to sustain life)
- International Labor Movement (empowering the common person)

In each of these paradigms, the central condition of empowering people to develop to the best of their abilities and to have freedom to succeed or fail based on their own efforts is critical. The appropriate technology movement has at its philosophical heart the desire to capacitate people of all walks of life to create (1) *Meaningful Employment*, (2*) Comprehension of Technology*, (3) *Self-Reliance*, and (4) *Reduced Environmental Impacts.* These represent the application of the philosophical basis for AT and are described below.

Meaningful Employment

Appropriate Technology, by design, seeks to be inclusive of people by providing opportunities for meaningful employment. A significant benefit of AT is the creation of employment and service options that would not exist without this form of development. In addition, the types of employment associated with AT often lead to self-employment or small-scale business operations where the opportunities for interesting and challenging work environments are more possible. Modern high technology industries seek to provide maximum output of product while limiting human involvement. The efforts to achieve uniformity of product quality using high tech systems often leads to the creation of dull, boring, and monotonous work. Appropriate technology concepts seek to accomplish the absolute opposite effect: maximum human involvement with reasonable product output. The result of this approach would stimulate growth at a level that could be sustained locally and provide jobs which are considerably more interesting than what is typically found in many high tech manufacturing facilities.

Comprehension of Technology

The incremental steps to progress associated with AT provide a reasonable basis for people and communities to understand the technological processes being employed, therefore, helping to ensure that the technology can be sustained at the local level. This concept is also very different from high technology applications, where technological complexity is far beyond the comprehension levels of the majority of the users of the technology and requires highly-trained technicians using sophisticated equipment to keep the machines and systems operating correctly. The lack of application of this concept has led to a broad range of failures in international aid efforts resulting in a high degree of wasted resources for all individuals and groups involved.

Self-Reliance

Sustainability is a central concept of AT and is essential for the success of a device or system being developed. The only way that sustainability can be achieved is by the end-users of the technology taking responsibility for all facets of the system. Therefore, the development of self-reliance in creating and maintaining AT devices is fundamental to the overall success of the system. Key to this concept is the availability of materials and equipment used to create the AT devices that are within budget of the end-users. The infrastructure required for this process should be limited to what exists at the local level. Again, this concept is philosophically different from modern high tech industries that rely upon a strong external infrastructure that is independent from local conditions and environments.

Reduced Environmental Impacts

After decades of mechanized industrialization, enormous pollution has had a significant impact on the planet, some of which may not be repairable. In many geographical regions around the globe, large-scale destruction of the biosphere has resulted from over population and poor planning. With significant population increases anticipated within the developing world during this century, the chances of more momentous, broad-ranging environmental problems will surely increase. A key concept of AT is the design and function of devices that cause minimal negative impact on the environment. Success of AT is directly measured with regard to its ability to operate and meet human needs without causing undo pressure or stress on the local environment. Appropriate technology could provide a workable alternative with regard to environmental issues for the developing world.

These concepts provide the philosophical underpinnings for AT and are fundamental for all future discussions of this subject. By considering these concepts the reader will begin to grasp the importance of AT to all aspects of life, even if they never plan to leave the boundaries of the United States. Appropriate Technology may play a significant part in the future of our planet and, therefore, should be an integral part of our knowledge base. With these concepts as the basis for our understanding of AT we can better plan for meeting and solving the problems of the future.

Goals of Appropriate Technology

The following basic goals represent the intended focus of Appropriate Technology.

- Aid humankind at the grassroots level
- Provide employment for the average citizen
- Sustainable/durable over time
- Utilize locally available resources
- Promote self-reliance
- Encourage self-supporting processes
- Low cost
- Limit cultural damage
- Limit environmental damage (Hazeltine & Bull, 1999)

Contemporary Trends and Issues in Appropriate Technology

There are many factors effecting the development of AT worldwide. From its historical roots, the developers of AT have sought to design and use technology to help solve human problems at their most fundamental levels. Various technological devices have been created and used extensively throughout the world, some with high degrees of success and others as dismal failures. The process of developing successful AT requires depth of knowledge in a wide variety of areas. Developers must consider sociological and anthropological issues along with engineering and technology concerns. Economic and dissemination factors must be weighed as well as training, education, and maintenance procedures. The seemingly simple AT devices that have been successful in the past represent deep thinking and significant hard work by all those who have contributed in the development process. As the population on the planet continues to rise and as the resources needed to sustain life for all inhabitants of the planet are stretched the need for applying AT techniques and devices will increase dramatically. This will apply to people living in developing countries as well as those in industrialized countries like the United States. The impact that AT can have on people has the potential to make the difference between prosperity and poverty, even between survival and death.

Limitations of Appropriate Technology

By design, AT seeks to down scale, to be small and controllable at the local level. Because of this basic characteristic, production capability will always be limited and, therefore, inhibit the overall potential of the people using AT devices. As Richard Critchfield (1977) stated, "Small is beautiful, but it's still small." (p. 5). Critchfield was referring to Schumacher's seminal writing on AT in his book *Small is Beautiful* (1973). By this he meant that even though some AT devices were successful and sustainable over time they were still too small in scope to play a significant role in improving conditions for the great masses who were in need. Typically, a large-scale high technology application is introduced within a developing country through an outside source (e.g., Intel's Microchip Production Plant in Costa Rica) and are not controlled at the local level nor provide a sustaining redistribution of capital for the common people. Appropriate Technology seeks to restrain radical high technology applications like Intel's, having a limiting effects on the potential growth and impact of developing nations to compete in world markets. Therefore, there are serious concerns by many country leaders with regard to the transferability of knowledge gained from AT applications to higher technology operations.

Another potential problem with AT approaches is that even if a device is effective and meets all the design criteria it still may not be acceptable to the end-users. Sociological and anthropological issues play a significant role in the overall success of AT. A technological device can only be effective if it fits within the societal constraints of the people who are using it. Many quality AT devices have ended in failure because they were not acceptable within the customs of the people for which they were designed to be used.

Appropriate Technology and the Technology Education Curriculum

A major thrust of technology education is to instruct students on the processes needed to solve technological problems. To accomplish this we often focus the majority of our instructional time on the use and application of a few high tech tools and applications (e.g., robots, CAD, CNC). We then conclude that this helps our students to become technological problem solvers. This approach may be particularly interesting to technology teachers; however, it does very little to help students to develop the thinking skills needed to solve problems within the broad field of technological applications. By focusing the majority of our instruction on specific technical applications and procedures (e.g., programming robots to pick and place objects, creating unrelated world wide web based pages, following step-by-step procedures in designing electrical circuits, etc.) we often limit the beneficial results of our field of study.

The field of technology education must heal itself from this myopic condition and see the world in a broader sense if it is to be a significant participant in the educational arena in the 21st century. The majority of *real world* technological problems and their plausible solutions do not require complicated “high tech” applications. The technological problems that most of us face on a day-to-day basis are best solved by employing much lower levels of technology than what is currently presented in the technology education laboratory. This is especially true for the majority of people outside of the industrialized countries. Approximately 80% of the earth's population live and work in environments where high tech solutions would be inappropriate when solving technological problems. Therefore, the need exists for technology education to address technological problem solving from a more holistic and appropriate level; that is, less high tech, more thoughtful problem solving using available resources.

But what would this form of technology education really look like? What would be different about this curriculum than what is currently being used? What would be the benefit of this type of program for students and the profession? Possibly, this form of technology study would lend itself in helping students learn to analyze and solve problems within a more realistic context. Starting with their own school and community and then progressively moving out to the state, region, nation, and world students could benefit by developing a focus on learning that reflects the application of AT solutions within a problem-solving environment which effects them directly; for example, addressing environmental recycling within their own school, planning and designing recreational facilities for their school or community, or designing a special effects scene for a school play. The difference this form of technology education takes is that the students are given more opportunities to be creative, to think logically, and to act responsibly as they work to solve problems that are important and intrinsic to them. The use and application of tools and other technological devices within this context are studied and used as they apply rather than in a narrowly-defined construct of a typically-prescribed technology education classroom activity.

The problem-solving opportunities could also move beyond a local concern to address problems or opportunities that go outside the boundaries of the school, community, or even the state and nation. By continuing to focus the student on broader topics that are based in reality and important for humanity the learner is able to grow and develop as a human and to understand that he or she can make a difference in the world. This form of technology education would be uniquely different from existing models; students would begin to see themselves as part of a solution in helping humanity. They would begin to understand how technology fits into the overall plan of creating a better world for everyone and how they can be a part of the solution, not just an observer that has little control or influence in the overall scheme of things.

The learning contexts associated with AT and problem solving are critical to both framing important technology and scientific concepts and enlightening students as to everyday meaning of erstwhile inert knowledge. In this approach the learning is situated in the context of a global concern or issue. Students could work towards solutions based on criteria that is pertinent to a given situation (e.g., problem scenarios embedded in real world conditions and environments, social/cultural factors integrated as part of the problems). One way of situating this for students is to use current or relatively current news stories into which key technological concepts could be anchored. For example, contexts can be selectively induced or pulled out to amplify circumstances where technology has been associated with dire consequences (e.g., the influence of clear-cutting Brazilian forests on soil erosion and air quality, drinking water contamination in Honduras following recent flooding from a hurricane). This format may stimulate students to engage in real-world events and employ technological problem solving to develop plausible conclusions where there is not a clear-cut answer. Through these types of learning environments students become immersed in research, analysis, exploration, manipulation, and informed experimentation to provide workable solutions. At the same time, they become aware of people and places that they may have never been aware of before.

The potential impact of this approach to technology education could be profound. First, it would be a radical departure from current practices of piecemeal exposures to select technologies and focus in on real-world situations where appropriate forms of technology will be studied and employed to solve problems. A primary goal in this form of technology education will be on understanding real-world environments and determining plausible solutions while considering the impacts on people. Students and teachers will be required to consider a variety of human conditions and developmental criteria in designing and developing appropriate solutions to problems. Second, this approach will require that students and teachers begin to address human conditions outside of the typical school classroom. As this approach is developed over the course of a school term, students will have opportunities to experience how people from diverse backgrounds around their communities, across the nation, and around the globe could benefit from appropriate technological solutions. In short, this is a much more comprehensive approach to knowing and doing technology education, it's technology with a human face. The consequences for not considering this form of technology education will be the continuation of the status quo.

As we enter the 21st century radical changes will continue to take place in the forms and uses of technology. Our current practices of picking and choosing a few types of high technologies to study and experience may impress school administrators and politicians. However, the educational effect on students will be minimal, leading to a very skewed perspective of what technology is and what it can do. The end result will continue to be unreflective students with minimal problem-solving skills.

If we are serious about our instructional content and want to prepare our students for real-world futures then we must help them to see how technology can be used to solve problems in realistic ways. Our planet needs more thoughtful humans that care deeply and can think and solve problems appropriately. *Technology with a human face* should be at the forefront of the technology education movement for the 21st century.

Summary

The concerns and issues that AT addresses are important for all people on Earth. Regardless if we live in industrialized countries like the United States or in developing countries like Guatemala, AT can play a significant role in our lives. At the center of AT is the concept that wise use of our resources will yield positive benefits for people. Whether we are using sophisticated, advanced technologies to produce highly-precise laser measurement equipment or using simple hand tools to produce an uncomplicated water pump for irrigating crops, concerns for effectiveness and efficiency are integral for both processes and products.

Competition for all resources around the world will increase drastically within the next decades and the necessity to effectively meet human needs must be carefully examined, designed, and implemented if we are to maintain or improve the standard of living for people groups around the globe. Appropriate Technology techniques enable people from different walks of life to be more self-reliant and less dependent on centralized systems that may not be the best providers of their basic needs. In addition, AT allows the common person to have a greater involvement and understanding of the technological systems that surround them. Another benefit of AT is its ability to provide sustainable employment opportunities and be less culturally disruptive at the local level.

Educators within the field have only briefly examined the significance that AT has on the technology education curriculum. Because of the designed simplicity, AT concepts and techniques have typically been overlooked by the majority of technology educators in lieu of the more advanced technologies associated with high tech systems (e.g., robotics, lasers, computers, etc.). Although it is understandable that technology education programs in the United States would focus and concentrate on high tech systems, it is regrettable that the field has not taken advantage of this valuable opportunity to address technological content and problem solving. Appropriate Technology topics provide teachers and students with unique ways in which they can learn about technology, its role in societies, its ability to solve human problems, and its impact on people. The International Technology Education Association document, *Standards for Technological Literacy,* (2000) submits that the overall purpose of technology education is to develop broad conceptual understandings of technology. It states:

> Because technology is fluid, teachers of technology tend to spend less time on specific details and more on concepts and principles. The goal is to produce students with a more conceptual understanding of technology and its place in society, who can thus grasp and evaluate new bits of technology that they might never have seen before. (p. 4)

This goal is noble and worthy of continued teaching and learning efforts; however, the reality for most technology education programs is that they do not focus on the broad concepts of technology but rather on the particulars of a few randomly-selected technological tools and equipment. Lewis (1999) stated that:

> As we look at technology education and the perennial, almost ritualistic quest for structure, it should be sobering that a cost of such quest might be the neglect of the needs and experiences of children. Perhaps it is because the field is highly masculinized and is consequently taken in by technological gadgetry. But especially in the U.S. context, where the subject is rarely taught in the elementary grades, focus on children and on learning is minimal in our discourse. Technology *per se* has been our consuming passion and we forget that the enterprise we are about is schooling. (p. 51)

The tendency of technology educators is to be enamored by the gadgetry of technology. This propensity has often prevented the profession from moving to the higher intellectual grounds of developing a "more conceptual understanding of technology and its place in society" as per the goal in the *Standards for Technological Literacy* (2000, p. 4). By design, AT requires that the human users of the technology be placed at the very forefront of any effort to design and construct a technological device. Therefore, AT as a curriculum topic or component would be ideal to help the field of technology education to address the deeper conceptual issues called for by the *Standards for Technological Literacy*.

The study of AT topics within a technology education program will require students to address world issues. This format of instruction is visionary for integrating technology education content with other school subjects. In order for AT devices and systems to be successful they must consider numerous issues and factors from a variety of academic disciplines. For example, if AT was taken into account when it was determined that a given community could benefit from the redesign of a water distribution system for irrigating crops then it would require that AT design and construction methods be utilized. This design and construction process would require the use of aspects of the following academic disciplines:

- Biology in conducting an environmental impact analysis
- Sociology in understanding the structure of the community
- Anthropology in evaluating the interactions of people
- History in determining what had been done before and with what degrees of success
- Geography in the study of the topography and location of the irrigation system
- Mathematics in calculating the volume and flow of the water
- Language Arts in providing written and oral instruction on the use of the irrigation system
- Trade and Industrial Education in the construction of various devices for the irrigation system
- Business Education in determining budgets and planning procedures
- Agricultural Education in determining irrigation needs and plans for various crops
- Technology Education in the design, organization, engineering, and construction of the entire project

School subjects using this form of integration process provide a valuable educational experience for students, allowing them realistic opportunities to put knowledge into practice when solving problems. Integrating student learning has been advocated by numerous educational groups (International Technology Education Association, 2000; Bodelly, S., Ramsey, K., Stasz, C., & Eden, R., 1991; Stasz, C. & Grubb, W. N., 1991) in order to reinforce and complement the materials that students learn. The *Standards for Technological Literacy* supports the integration function of technology education and states, “When taught effectively, technology is not simply one more field of study seeking admission to an already crowded curriculum, pushing others out of the way. Instead, it reinforces and complements the material that students learn in other classes” (p. 6). When AT components and issues are connected with the technology education curriculum, the opportunity for integration is open wide to many rich experiences that can benefit all, students, teachers, users of the technology, and the planet as a whole.

In conclusion, AT as a concept and application can offer the people of Earth a viable alternative to the development strategies that have been used in the past. By focusing on people first and their needs, followed closely by a deep concern for the natural environment, AT can contribute to long-term improvements for everyone, people living in developing countries and those in industrialized countries. Most of the technological applications that have been employed throughout history have come in the form of tools and equipment used to solve existing problems. This reactionary process has stimulated the creation and refinement of multitudes of devices and systems, some of which have been very helpful to mankind (e.g., printing press) and others have been incredibly destructive (e.g., nuclear weapons). Appropriate Technology provides people with a proactive technological option which can empower them in development while protecting their culture and the natural environment. The strategies and tactics utilized in AT offer viable alternatives to the high tech approaches employed in many locations world wide because they are sustainable over time, and they fit the culture and society in which they are being used. In the future, the solutions to our problems will not necessarily be found in the high tech fixes that we are accustomed to experiencing. In the future, it may be just as likely to solve problems using a form of Appropriate Technology that is smaller, more sustainable, less complicated, and more environmentally friendly. Exploring AT as a viable technological option is the theme, goal, and purpose of this yearbook.

Review Questions

1. Compare the international aid programs of the United States with the concepts of Appropriate Technology. What are benefits and shortcomings of each?
2. Discuss the relevance and value of Appropriate Technology within the modern world. Does Appropriate Technology really have a chance to improve the lives of people worldwide?
3. What would you consider to be the strongest reasons why Appropriate Technology concepts, techniques, and practices should be considered for developing countries?
4. What would you consider to be the strongest reasons why Appropriate Technology concepts, techniques, and practices should be considered for industrialized countries?
5. How would you justify the applications of Appropriate Technology in light of the potential limitations that it may bring to the people that use it?
6. Do the concepts of Appropriate Technology have a legitimate place within the curriculum of technology education? If so, on what do you base this?
7. Discuss the benefits and shortcomings of employing Appropriate Technology concepts and applications in the technology education curriculum?
8. Develop a teaching and learning scenario where Appropriate Technology concepts and applications can be utilized within your technology education program.
9. Identify ways in which you could use Appropriate Technology techniques to integrate other school subjects with your technology education program.
10. Why do we not hear more of Appropriate Technology strategies in the United States and world wide?
11. Based on the definition of AT provided, discuss how British colonization of India assisted in the development of the Ghandian theory of appropriate technology.
12. How does fundamental needs assessment contribute to the development of AT?
13. Appropriate technology uses local resources to solve local problems. Explain the economic benefits of this ideal as it pertains to employment, productivity and self-reliance.
14. Appropriate technology uses local resources to solve local problems. Compare and contrast the differences between using imported goods and local resources.

15. Technology attributes to changes in societal values and customs (i.e., drive-through technology). AT attempts to lessen these changes. Is it important for developers of technology to understand the disciplines governing the culture of a given community (i.e., religion, customs, etc.)? Explain why.
16. Is it possible to limit the negative impacts of environmental manipulation while advancing technologically?
17. Site an example of how the concept of AT can be used to integrate the Technology Curriculum with the following academic disciplines:

    Language Arts
    Science
    Mathematics
    Social Studies/Anthropology
    Art
    Music
    Religious Studies/Philosophy.
18. Discuss how a technology education curriculum centered on the study of AT can assist the learner to develop critical thinking skills.
19. Although teaching for transfer cannot be predicted, discuss how you would use a technology education curriculum centered around the study of AT to integrate technology education with academics.
20. How does a study of AT satisfy the national goal of developing a technologically literate society?

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Chapter 2

Economics of Appropriate Technology

Stephen Petrina
University of British Columbia
Vancouver, British Columbia

Patricia O'Riley
York University

Our task is to look at the world and see it whole.
— E. F. Schumacher

Ecology is permanent economy.
— Slogan of the Chipko movement among women in Himachai Pradesh, India

When E. F. Schumacher was agitating for humane, economic practices as alternatives to state and corporate capitalism during the 1960s and 1970s, he was not merely providing models for what he called an "Economics as if People Mattered." He was also expressing the political principles and practices of an economics as if animals, plants, and the ecology of Earth mattered. Like Marx, Schumacher located structural inequities and injustices in systems of economic production. But unlike Marx, Schumacher accounted for "cultural" and "natural" capital in his economics. He emphasized the importance— to people and to nature— of technological practices that were cheap enough for common use, were simple enough in technique for common use, and relied on local knowledge, labor, and materials for the production of things for local maintenance and use. Indebted to the work of Gandhi, Schumacher (1973, p. 161) referred to this as "Intermediate Technology" which was qualitatively different from the poverty-reinforcing tools in much of the southern hemisphere and the large-scale, power-hungry tools of the northern hemisphere. Eventually Intermediate Technology was popularized as "Alternative Technology" and "Appropriate Technology" (AT) in India, North America and various parts of the world (Carpenter, 1988; Kumar-Reddy, 1986; Pursell, 1993; Rybczynski, 1980; Willoughby, 1990; Winner, 1978). From its very beginnings, AT meant that we account for "natural capital" as well as capital equipment, infrastructure, knowledge, and labor in decisions "economic" (Schumacher, 1973, p. 14). In this regard, an economics of AT can also be read as an economics of ecodesign, green design, sustainable design, and ecology— practices that share the roots and branches of AT (Madge, 1993; Scott, 1996).

This chapter is intended to provide an overview of the economics of AT. Principles of accountability, participation, and sustainability are used thematically as AT practices are described as decentralizing alternatives to large-scale and global, market economies. We argue that over the past three decades, the economics of AT has expanded to encompass both the design of sustainable or "green" technologies and the design of sustainable lifestyles. With foci now on changing qualities of technological practice as well as reducing quantities of consumption, design education and technology education are part of a complex political ecology *and* economy (O'Riley, 1999; Petrina, in press).

Economies of Appropriate Technology

Schumacher's model for an alternative, sustainable economics was based on Buddhist values of simplicity and non-violence. Instead of belaboring choices between "modern growth" and "traditional stagnation," or between "materialist heedlessness" and "traditional immobility," Schumacher used the Buddhist value of the Middle Way to position AT as a middle or intermediate path between distinctly different styles of technological practice. Schumacher situated the political economy of AT between capitalism and socialism, as he advocated both a nationalization of small, semi-autonomous industries and small scale private enterprise to assist in creating work. The end was not profit for some and poverty and the elimination of work for most, but rather a "Right Livelihood" for all (1973, p. 58). An economic system based on these values would aim for the "maximum of well-being with the minimum of consumption" and oppose the maximization of consumption and production (p. 54).

In Buddhist economics is a concern for simplicity and non-violence in both material means and ends (Mendis, 1993; Schumacher, 1973, pp. 50-58). If a desired end is an attractive jacket to wear on a cold winter day, then the desired task is to create a garment with the smallest destruction of material and natural resources and with a design that required the smallest input of toil and import of capital. Designing a complex labor-saving machine to perform complicated tailoring with large swaths of imported cloth is a folly and contradiction of the value of simplicity. At the same time, designing for a maximization of production and complicated tailoring which invariably result in an exploitation of resources is a barbarity and contradiction of the value of non-violence. In conjoining the values of simplicity and non-violence, Buddhist economics encourages a reverence for and celebration of all sentient beings and inorganic matter.

For Schumacher and AT practitioners, these values were at the core of AT. This translated into popular and specific economic policies and practices shaped to:

1. create jobs in rural areas (to oppose migrations to over-populated cities);
2. maximize employment by keeping unit investment low;
3. support relatively simple production methods (to use local knowledge and avoid expensive training periods);
4. make use of local raw materials to produce goods that were actually in demand on local markets;
5. make use of decentralized, renewable energy resources whenever possible;
6. promote collective work and political action;
7. promote education for self-sufficiency in developing, using, and managing AT projects;
8. support the sharing of knowledge, resources, and skills outside of import, patent, and royalty systems; and,
9. have a benign or no effect on local, natural ecologies (Darrow & Pam, 1981, p. 11; Schumacher, 1977).

AT in practice and theory was and is a marked contradiction of conventional economics.

In the United States (USA), especially after the second World War, conventional economic principles translated into investments to increase the scales of electrical power generation plants, extractive engineering, factory automation, mechanized agriculture, private utilities, and urban infrastructure. Assistance agencies, such as the World Bank, for dollar-poor countries supported programs that followed a pattern of industrialization set by countries like the USA. Markets for what had become typical of capitalist expansion were strengthened through governmental and international aid subsidies. There was a false assumption that a social contract translating economic growth into well-being would be upheld. Symptoms such as cultural and ecological degradation, monopolization, structural unemployment, and political instability in “developed” and “developing” countries made AT somewhat appealing during the 1960s and 1970s. In the mid 1970s in California, the Office of Appropriate Technology (OAT) was established and at the USA federal level, mandates of four agencies were turned toward AT through policies of President Jimmy Carter. For example, in 1975 the USA Agency for International development was appropriated $20 million to establish an AT program and $3 million was granted to establish the National Center for Appropriate Technology (NCAT). Institutions to spur investment in alternative markets were short-lived however and both OAT and NCAT were disbanded early in President Ronald Reagan’s first term in the 1980s. Some technologies advocated by NCAT, such as solar power, were appropriated by industrial corporations with notions of market control and centralized, large scale development (Pursell, 1993; Willoughby, 1990, pp. 191-196).

There is a general skepticism in AT toward “free enterprise markets” and competition, and a support for public, market intervention to create a climate of choice. Markets with a large number of small, competing businesses, or markets *without* monopolistic control propped up with governmental support, would actually be compatible with AT. A number of small-scale businesses in industries such as cotton-weaving, maize-milling, and sugar-processing have been found to generate between three and fourteen times as much employment with more income per unit of capital than similar large-scale businesses (Stewart & Ranis, 1990, p. 9). AT is not a rejection of market economies, but rather makes a case for small-scale markets that support the forms, patterns, practices, and products of AT (Kumar-Reddy, 1986, p. 299). Practitioners have countered competition and efficiency criticisms by leaning toward markets <u>and</u> state intervention for creating economies conducive to choice (Jackson, 1984, pp. 79-86; Willoughby, 1991, pp. 309-330).

With principles of accountability, participation, and sustainability, markets for AT were and continue to be based on small scale exchanges and decentralized, local control. Hence, much of the work in AT over the past four decades was done in either the non-profit sector or through non-market and unpaid labor and volunteerism. Bartering, international volunteer programs (e.g., Volunteers in Technical Assistance), self-sufficiency homesteads and villages, and self-employment for-profit account for a large share of the market economy of AT. Much of this is done informally and unregulated by accounting procedures. With *laissez-faire* capitalist markets dominated by private control, AT necessarily demands that technological practice be done both outside of, and within, conventional economic relations and in a parallel economy based on labor and a low volume of capital infrastructure (Ekins, 1986; Jacobs, 1991; McRobie, 1981; Schumacher, 1973, 1979; Schumacher & McRobie, 1977). For instance, a survey of funding for AT activities in “developing” countries in the late 1970s indicated that one-third of all funds were voluntary and self-generated and one-half came through governmental assistance (Jequier & Blanc, 1983, p. 84). But there have also been a range of appropriate technologies that have relied on market forces (Willoughby, 1990, pp. 185-209). Whether informal or market-driven, AT demands that unpaid labor and its division around the home for family and personal health— work unaccounted for economically in most countries— be configured into economic decisions. However vital unpaid work is to local and national health, it has remained invisible in conventional economic accounting schemes and policy.

Conventional arrangements of economic and social power militate against the recognition of unpaid work, specifically women’s work. Reflecting a division of labor in nearly all countries, women perform a majority of unpaid, technological work related to domestic child and elderly care, cleaning, food preparation, and subsistence production within systems of unpaid work. In conventional economic terms, this amounts to “between 25 and 30 per cent of any country’s current and future output” (Appleton, 1995, p. 6). Resource allocation based on conventional accounting has meant that unmeasured or “invisible” work was not invested in. Appleton has argued that AT is an opportunity to redefine what is domestic and what is technical in a way that women’s expertise is recognized to contribute to economic intervention (Appleton, 1993a, 1993b, 1995; Hazeltine & Bull, 1999, pp. 296-314; Wickramasinghe, 1993).

> AT practices have favored health over financial wealth, poor people over rich, rural residents over city dwellers, self-reliance over economic dependence, and the unemployed or unpaid over employed. In this regard, AT favors a political economy that mitigates against monopolistic control of market and wealth (Willoughby, 1990, pp. 228-234). These types of commitments have proven effective in the Prato region of northern Italy, where small-scale wool textile manufacturers have won support over large-scale, capital-intensive businesses (Willoughby, 1990, p. 206). Most contentiously, AT also suggests a radical political economy of equitable distributions of income within and between countries, realignment of foreign aid policy toward supporting the principles of AT, and the creation of new political agencies to regulate distributions of wealth and waste. Within a current economic system of state and corporate capitalism, AT and similar practices are typically marginalized at the expense of ecology, equity, and social justice. Skeptical of the power of financial elites, the political economy of AT has developed around grass-roots distributions of power and alliances with diverse political groups such as environmental justice workers, human-rights organizations, organic farmers, post-colonial feminists, and sustainable energy activists (Gedicks, 1993; Knudson, 1992; McGowan, 1984).

The political economy of AT has helped challenge patriarchy which sanctions, maintains, and perpetuates domination through practices such as child labor and gender-stereotyped divisions of labor between men and women. For some ecofeminists, “environmentally and ethically appropriate technology is a precondition for the liberation of women” (Warren, 1993, p. 14). AT is “appropriate” insofar as it is appropriate for females, or meets the local needs of females “in ways that do *not* contribute to the continued inferior status or condition of women’s material lives cross culturally” (p. 23). Within the political economy of AT are possibilities of confronting environmental sexism and racism by confronting patriarchal control of and power over females through technological design. In AT, one cannot afford the "privilege or luxury of talking about women, nature, or technology separately, as if issues of women, nature, and technology are not intimately related" (p. 26).

This political economy of AT is underwritten by a moral economy whereby a web-like interrelation of values lends a logic to the composition of its economics and politics (Daston, 1995). Normative principles such as accountability, participation, and sustainability are defined in relation to values such as access, affordability, conservation, equity, justice, non-violence, prudence, self-reliance, simplicity, and smallness of scale. This moral economy provides a framework for AT practitioners to make judgements on specific technological decisions and policy directions. Clearly, cultural relativism plays a role in this moral economy but does not determine judgement on appropriateness. It can be argued that nuclear power is appropriate for a technologically sophisticated, dollar-rich culture, but this judgement is made outside of the moral economy of AT. Within this moral economy AT practitioners have been able to remain sensitive to cultural and racial differences while attending to an international effort of a common future for the collective good (Hazeltine & Bull, 1999; McRobie, 1981; Mollison, 1990, pp. 1-9, 507; Porter, 1995; Reddy, 1986; Schumacher, 1973, 1979; Schumacher & McRobie, 1977).

Market, political, and moral economies operate in tension with each other and in tension with a global racial economy and international division of labor (Bandyopadhyay & Shiva, 1986; Harding, 1993; Sardar, 1986). State and corporate capitalist economics have managed to maintain historical inequities generally between the southern and northern hemispheres. Countries in Africa, South America, and southeast Asia have been subjected to high levels of indebtedness (i.e., capital, finances, labor) and poverty mainly through exploitive, economic relations with particular countries in Europe and North America. "[T]he haves can only *have*" noted Kumar-Reddy (1986, p. 297), "only if the have-nots do *not* have, in the sense that the affluence of the elites can be preserved only at the expense of the masses." She elaborated:

> Such disparity cannot be associated with stability; it can be maintained only by force. Thus the exploitation, injustice and misery inherent in duel societies implies the immorality of the western pattern of technology. Thus not only is the western pattern not feasible, it is also immoral....what is immoral cannot be sustained.

Throughout this past century systems of child labor, colonialism, environmental racism, indentured labor, and slavery have operated as functions of this global political economy. Panjabi (1997, pp. 5-6) summarized this interdependence as follows:

> In the process of creating today what is called the developed world, the European and American governments, driven as they were by an ethic that is not regarded as favorably now as it was then, destroyed the self-sufficiency of Asian and African countries under their control; converted varied agricultural systems into a precarious reliance on cash-crop production (rubber in Malaya, cotton and tea in India); forced colonial

> exports to bow to the dictates of fluctuating world trade pricing; and all but wiped out local crafts and ancillary production which provided supplementary income for hard-pressed farmers.

He could have added that imperialist practices were not without violent resistance as indigenous peoples were killed, raped, or moved to reservations as their land was taken for production (Gedicks, 1993). The racial economy of AT, however, remains sensitive to how this history has shaped perceptions of colonized and colonizers, acknowledges racial inequities within and between countries, and supports grass roots action for combating economic racism. In fact, there has been a systemic inclusion of justice within this racial economy and disenfranchised individuals and groups are valued for their knowledge and skills and provided with techniques to explore and expand their strengths for economic or political power. The success of AT actually depends on the increased ability of Africans, East Indians, Indigenous peoples, Latin Americans, and southeast Asians to mobilize for economic and political power. AT rests on potentially powerful alliances of aboriginal and immigrant, black and white, and poor and rich peoples in resistance against economic imperialism and supremacy (Kumar-Reddy, 1986). This practice depends not on the promise of participation and racial cohesion, but on the act of solidarity in good faith. In other words, a reduction of "free-market" practices of habitat destruction, non-renewable resource exploitation, and endless material growth is directly tied to the financially poor countries' search for alternative technologies for sustainable livelihood and development. As India's Prime Minister, P. V. Narasimha Rao said at the Earth Summit in Rio de Janeiro in 1997,

> We inhabit a single planet but several worlds. There is a world of abundance where plenty brings pollution. There is a world of want where deprivation degrades life. Such a fragmented planet cannot survive in harmony with Nature and the environment, or indeed, with itself. It can assure neither sustained peace nor sustained development. We must, therefore, ensure that the affluence of some is not derived from the poverty of the many. As Mahatma Gandhi put it with characteristic simplicity, our world has enough for each person's need, but not for his [or her] greed. (quoted in Panjabi, 1997, pp. 96-97)

Accountability, Participation and AT

When Lawrence Summers, chief economist of the World Bank, legitimized the toxic industry and dumping policies of his agency, he touched off a global scandal and demand of accountability in 1991. "Just between you and me," said Summers, "shouldn't the World Bank be encouraging MORE migration of the dirty industries to the LDC's [Less Developed Countries]?" "[H]ealth impairing pollution," he continued, should be done at low costs and confined to countries with low wages. "I think the economic logic," he reasoned "behind dumping a load of toxic waste in the lowest wage country is impeccable and we should face up to that" (quoted in Bullard, 1993, p. 20). To critics, logic suggesting that pollution be generated and dumped at sites of least resistance was typical in an agency that had been accused of "bankrolling disasters" through its commitment to "technocratic export-led" development models that favored the rich and undermined equity and sustainability (Fox & Brown, 1998, p. 1). For managers of the World Bank, arguably the world's most influential agency for assistance in "development," this crisis in the bank's accountability was turned to reform. In 1994 a relatively autonomous Inspection Panel was established to investigate claims that the World Bank was not accountable to grass-roots problems related to development projects. Criticisms, from people ill-effected by the bank's projects, were mobilized to hold the World Bank accountable for its practices; this was an indicative sign of the times. The World Bank was among the first international aid agencies in the early 1970s to declare that development and sustainability were necessarily compatible, yet its practices had come to contradict this declaration. There exists a crucial and delicate relationship between accountability, participation, and sustainability in AT.

In 1971, the World Bank formulated its first policy commitments to AT, generally responding to the agitation and success of Schumacher and the Intermediate Technology Development Group (ITDG) (McRobie, 1981, pp. 19-71). From that time the World Bank has financed an increasing number of AT projects, mostly in poor, rural areas of financially poor countries (World Bank, 1976, 1978). AT practices funded by the World Bank were to be consistent with the host country's national development policy, useful and affordable to consumers, fit the host's socio-cultural setting, make efficient use of local resources, and develop a local capacity for the planning, designing, implementing, and managing of AT. But unlike Schumacher in his economics, the World Bank envisioned AT as a stage in a longer process of full development and industrialization. Nevertheless, the ITDG, like other AT groups, were valuable assets to agencies wanting to link development and sustainability such as the United Nations Industrial Development Organization, World Health Organization, and World Bank. ITDG consultants were hired in the early 1970s to help turn the World Bank's $1.67 million rural road building project in India toward AT practices. The challenge was to innovate with appropriate technologies as complements to the labor-intensive practices advocated by the World Bank (World Bank, 1978). A similar road construction project was supported by the World Bank and ITDG consultants in rural Kenya (McRobie, 1981, p. 50; Schumacher & McRobie, 1977). Yet while bureaucratic agencies such as the World Bank were focused on funding and economic bottom lines, local beneficiaries were interested in participation and improved conditions. Similarly, the ITDG and Schumacher were interested in participatory action and accountability in results. In large-scale enterprise, accountability is necessarily compromised or sacrificed.

> Whereas capitalism is dependent on high rates of participation in the consumption of goods and services, AT depends on high rates of local participation in design, planning, production, and politics (Knudson, 1992; Prey, 1994). At its base, broadened participation in design tends to issue a wider range of alternatives and possibilities. In addition, a practice inviting broad participation functions on a safe assumption that users or the "affected" are best placed to choose what technologies to adopt and redesign. Projects that are based on simple, low-scale, and non-violent technologies tend to enable and sustain high rates of participation in choosing emphases and directions. And social participation and control tend to strengthen self-reliance from within. Schumacher loathed large-scale, political hierarchies and advocated low-scale, information-centered, open, practical systems for political decision-making. He was obsessive about broadening opportunities for disenfranchised people to access money, resources, and time for their economic livelihoods and production processes. One project that Schumacher and the ITDG were fond of noting was the Sarvodaya Shramadana Movement in India. "People's participation is the cornerstone of the movement," McRobie wrote in 1981, which involved over 5,000 village level workers and one million participants (p. 220). Decision-making was done at the local level where village industries were producing for a village market and economy. This was consistent with Gandhi's notion of "production by the masses," and Schumacher defined the technology necessary to support this practice as: "self-help technology, or democratic or people's technology— a technology to which everybody can gain admittance and which is not reserved to those already rich and powerful" (1973, pp. 145-146). Nevertheless, with assumptions on gender norms, opportunities have not always translated into women's participation in technological affairs for either financially rich or poor countries (Appleton, 1995, p. 7).

These notions of accountability and participation were embedded in AT through the early work of the ITDG and Schumacher, who saw accountability as a factor of trust. Simply put, accountability means that people and agencies participating are held accountable for practices that mitigate against achieving sustainable results. Accountability, participation, and sustainability are core principles in <u>practice</u>. To economically participate is to be held accountable to sustainability.

<u>Sustainability and AT</u>

While Schumacher and other advocates of AT did not refer specifically to sustainability in the 1960s and 1970s, their practices were attuned to the necessities of sustaining natural ecologies. For Schumacher, the technology necessary to support "production by the masses" made use of local knowledge and experience, and was "conducive to decentralisation, compatible with the laws of ecology, gentle in its use of scarce resources, and designed to serve the human person" (1973, p. 145). In *Small is Beautiful* as well as *Good Work*, Schumacher began by describing the delicate interrelations between economics and ecology. Through mass production, consumption, and waste, he argued that "developed" countries were squandering the world's "natural capital," or in base economic terms, liquidating these "capital assets" (1973, p. 14). Natural capital refers to renewable (e.g., living species and ecosystems), replenishable (e.g., surface and ground water supplies), and non-renewable (e.g., fossil fuels and minerals) resources. He used the examples of fossil fuels, "tolerance margins of nature" in composting new chemicals, and the "human substance" or psyche (p. 19). AT represented the possibility of a "new lifestyle, with new methods of production and new patterns of consumption: a lifestyle designed for permanence" (p. 19). Permanence of natural capital was sustainability. Of course this notion of *economic* sustainability in AT was more an exception rather than the rule. Practice tended to emphasize *technological* sustainability where "green" or eco-technologies were developed and disseminated to reduce energy or waste.

Agencies such as the World Bank and United Nations also tuned into the politics of sustainability, but it wasn't until the late 1980s that sustainability was placed alongside development on a global agenda. "Sustainable development" was popularized through circulation of the World Commission on Environment and Development's (WCED) report titled *Our Common Future*. Sustainable development was "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (p. 43). The WCED or Brundtland Commission began by arguing for the need to live equitably within a delicate ecosphere.

> The Earth is one but the world is not. We all depend on one biosphere for sustaining our lives. Yet each community, each country, strives for survival and prosperity with little regard for its impacts on others. Some consume the Earth's resources at a rate that would leave little for future generations. Others, many more in number, consume far too little and live with the prospects of hunger, squalor, disease, and early death. (p. 27).

The economics of maximum production and consumption had to be, as many had argued before, reconsidered in the face of an ecological imperative of conservation and a social imperative to minimize human suffering.

The notion of sustainable development has had a number of conflicting interpretations and even within *Our Common Future* there are contradictions (Wackernagel & Rees, 1996, pp. 32-40). Some interpretations leaned toward "sustainable" and focused on ecological stability and distributive justice. Others leaned toward "development" and focused on growth. The concept of sustainable development allowed for weak interpretations such as the latter, which suggested that the "substitution of equivalent human-made capital for depleted natural capital" was good economics (Wackernagel & Rees, p. 37). This weak interpretation means that a forest could be depleted as long as its equivalent in income-earning potential comes from factories or other means. Here, "developed" countries appear highly sustainable while the poorest nations in Africa are the most unsustainable. In this version of sustainability, high material standards can be maintained at the expense of natural capital. With a weak framing, the United Nation's Brundtland Commission recommended "more rapid economic growth in both industrial and developing countries" (WCED, 1987, p. 89). This might have made sense if growth was *not* seen as an increase of size in material accretion but rather as an enrichment of quality of life. The World Bank (1992, p. 8) has been reinforcing this weak interpretation of sustainability as "sustainable development." World Bank policy suggests that countries can exchange accumulations of human capital for depletions of natural capital. "What matters," in World Bank policy, "is that the overall productivity of the accumulated capital…more than compensates for any loss from depletion of natural capital." Natural capital can be depleted as long as aggregate capital (humans, machines, etc.) is not reduced. The consumption of nature, in the United Nations and World Bank policies, is healthy if it produces a net growth of capital (Norgaard, 1994, pp. 17-20; Sachs, 1996, pp. 22-24).

Strong interpretations suggest that sustainability means that we live within the given productive capacity of nature or live within a range of "limitations imposed by the ability of the biosphere to absorb the effects of human activities" (Madge, 1997, p. 51). This means that there be absolute limits established for the consumption of nature and the scale of economies. In this perspective, the ecological health of the planet translates into a biophysical and psychosocial wealth for humans. The challenge of a strong interpretation of sustainability is in accounting for the natural capital requirements of economic activities. Since Schumacher's time of "cost-benefit analysis," a number of helpful models for economic accountability have been developed. For example, the Genuine Progress Index (GPI) has been developed as an alternative to the Gross National Product (GNP) and Gross Domestic Product (GDP) indicators in vogue in political economy since the 1920s. The GNP and GDP are inaccurate and misleading measures of prosperity and well-being in that they do not account for the ecological and social costs of economies. Developed by Americans Cobb, Halstead and Rowe, the GPI accounts for the unpriced value of natural and social capital in addition to values of conventionally measured economic production (GPI Atlantic, 2000).

Another model, which demonstrates both the simplicity and complexity of accountability and sustainability, deserves particular attention. The "ecological footprint" was developed by Wackernagel & Rees (p. 3) to account for resource flows or streams into and out of communities and economies. The ecological footprint “accounts for the flows of energy and matter to and from any defined economy and converts these into the corresponding land/water area required from nature to support these flows.” Wackernagel & Rees argue that we account for our resource consumption and waste assimilation requirements in terms of land area, or footprint. The footprint represents the “appropriated carrying capacity” of terrestrial ecosystems necessary to support a given person, society, country, or product (p. 11). This appropriated area necessary to support the habits of affluent countries has gradually increased throughout this century. The current ecological footprint of a typical North American is “three times his/her fair share of the Earth’s bounty. Indeed, if everyone on Earth lived like the average Canadian or American, we would need at least three such planets to live sustainably” (p. 13). A planet where everyone imposes an over-sized footprint is not sustainable. The ecological footprint puts economics into local and global perspectives and is effective in accounting for the sum of demands on nature from given lifestyles.

Establishing a clear, visible account of economic processes is central to the practice of accountability and sustainability through AT. Indeed, accountability in AT means that all “costs”— ecological, cultural, social— and not merely conventional economic costs are configured into design decisions. Like Schumacher, Wackernagel & Rees speak to “ecological” *and* “socioeconomic” sustainability. Socioeconomic sustainability means that we come to terms with social inequity and material disparity. As Wackernagel & Rees (p. 134) state the problem, “how can we reconcile the disparity between the rich and the poor at the limits of ecological stability in a socially just and politically acceptable manner?”

Appropriate Forms of Capital, Property, and Work

In the last two chapters of *Small is Beautiful*, Schumacher described ideas for gradual transformation to a decentralization and nationalization of large-scale, private business. “Private enterprise,” wrote Schumacher, or the “private ownership of the means of production, distribution, and exchange” is driven by greed and the profit motive (1973, p. 247). But he differentiated between small-scale enterprise of the working proprietor and large-scale ownership of passive owners living “parasitically on the work of others.” Small-scale enterprises aimed to assist in creative work, were personal, and had enormous social utility. While large-scale enterprises, according to Schmacher, were unjust in that large pools of labor and public infrastructure were exploited for profit. Relations in these large enterprises were impersonal. He recommended that gradually, the conversion of private to public shares of large-scale enterprises be increased to fifty per cent, and profits be split evenly between private owners and the public. Details in capital investment made his new pattern of socialization or nationalization a clear, albeit contentious, alternative to conventional economics. Nonetheless, Schumacher and most other AT practitioners placed efforts and hopes in small-scale enterprises and political arrangements for economic justice.

In AT, the question of whether small-scale technological redesign or communal reform ought to come first is a ‘chicken or egg?’ question. The challenge has been to work toward changes in economic and communal arrangements as complementary and interdependent. Neither one is a precondition for the other— both are necessary. But it is the latter that had been neglected in AT practices to the detriment of long-term, socioeconomic sustainability. AT came to represent alternative technologies rather than these, a reallocation of resources, <u>and</u> communal reform. In North America, the options tended to be communes, libertarian style self-reliant, single homesteads, or coping within conventional, large economic systems. The “intentional village” option, so crucial to AT, was rarely considered.

Intentional communities or villages are defined as a relatively small group of people (i.e., 30-500) unified by a common ethic and commitments to biological preservation and land conservation, mutual enrichment, and economic interdependence through support structures such as local currency and trade, public services, and shared capital (Mollison, 1990, pp. 519-557). This idea is based, for example, on models of aboriginal, African, East Indian villages as well as old cities like Florence and Vienna. Intentional villages can be located within any number of areas including cities or suburbs, isolated regions, or adjoined to existing villages. An ethic for appropriate resource use and voluntary simplicity typically includes commitments to:

1. reduce needs to earn by developing food, energy, and shelter;
2. earn and trade within the village as much as possible;
3. produce a surplus from services for outreach potential;
4. provide as many of non-material needs to villagers as possible (e.g., child care, education, entertainment, recreation, work);
5. cooperate and participate in various enterprises;
6. provide access to tools.

Commitments to energy, land, and water conservation tend to be strong with bases on AT practices which are consistent with Schumacher’s principles. Property trusts, created and governed by villagers investing varied amounts of money, are used to manage and purchase land for ethical reasons (e.g., protection, reclamation, rehabilitation, sustainable energy maintenance). Investors are given opportunities to design recreational areas, do site work, hold leases, or provide supplies for various duties. This is one way in which money and services are kept within the village system. While a locally created currency supports an internal system of exchange, income generated through outside services is useful for replacing degenerative (e.g., tools, vehicles) with generative assets, investing in procreative (e.g., trees, wildlife), informational (e.g., books, seeds), or conservative (e.g., dams, insulation, strategic forests) assets. Money is also useful for exchanges outside the village to secure (buy or rent) assets and goods which cannot be accessed within the village. Ethical investment involving money, time, and work is used for assisting in conservation and reduction of waste; building energy conserving buildings; founding ventures; growing organic food; producing clean transport and energy systems; and producing durable, useful products. Ethical investments within intentional villages support “good work.”

Good work lends productive form to peoples’ livelihoods (emotional, intellectual, physical) and appeals to their desires to engage their capacities in the world in a rewarding and positive way (Gillingham, 1979, p. 204). Playing various roles in production, service, and recreation depends on a supportive structure of family, friends, and co-workers. Confinement to one form of labor, whether by choice, force, or necessity is to be the exception rather than the rule. Good work— paid and unpaid— involves caring for the Earth and for other people. To be sure, good work is about functioning at local and global levels.

Summary

The centralization and globalization of capital have pushed the scale and volume of economic pressure on the Earth well beyond sustainable limits. With liberalized trade agreements translating into “anything goes” policies toward vast, free-enterprise markets in the 1990s, we have witnessed yet another decade where economic options in “developing” and “developed” countries have been narrowed. The southern hemisphere has become a dumping ground for surplus material and military goods along with dangerous agro-chemicals made illegal in northern countries like Canada and the USA. Street-level markets are flooded with “out of fashion” consumer items while biocides such as Chlordane DDT are liberally used on fields and cultivation facilities in countries such as Ecuador. Large-scale, capital driven textile and shoe manufacturers have made the exploitation of children and women common practice in sweatshops in Central and South America and southeast Asia.

Consumption of products and services increased in profoundly unsustainable amounts in the last half of the twentieth century, quadrupling since 1950. Reflecting huge inequities, it is common knowledge that 20% of the world’s richest populations are using 80% of the world’s resources (Sachs, 1996, pp. 16-17). For example, while at least three-quarters of all Americans and Canadians live a life of comfort, one-quarter of the world’s population do not have basic necessities such as food, shelter and clean water. In commodities and services, industrial countries out-consume developing countries by a factor of sixteen to one. American consumers outpace their industrialized counterparts by equally staggering amounts of consumption and the generation of waste (Wackernagel & Rees, 1996; Westra & Werhane, 1998). Along with consuming 120 pounds per day in resources, each American throws four pounds of garbage away each day. The USA consumes as much oil for leisure activities (i.e, pleasure boats, jet skis) as India consumes for its entire economy. Globalization is meaning that northern or western cultures are overproducing and over consuming at the rest of the world’s and the future’s expense, and the resources necessary to maintain current levels of consumption and production are rapidly depleting. All in the name of economic development and growth, globalization in its realities makes possibilities such as AT extremely important.

As argued here, AT is personal and social, which is to say that it is a politics of personal choices and relations. In most areas of the world today, rejecting the values of capitalist economics and its concomitant globalization is not economic autonomy or freedom. People in nearly all countries today are forced to act within a pervasive system of capitalism, but a compromise of the types of principles in AT is neither imminent nor necessary. Inasmuch as AT is about choosing among technologies and lifestyles, it is a facet of the larger debate over the nature of economics, capitalism, communitarianism, socialism, and other paths. And appropriate technology education speaks directly to the debate on education, indoctrination, and human justice. Currently, education about economic matters is typically no more than indoctrination in the ways of capitalism for a vast majority of students in countries such as Canada and the USA. As Nelson (1983, p. 3) concluded:

> There is a hazy boundary between education and indoctrination, and in few areas is that boundary more hazy than in education about economic matters. Economics provides a primary rationale for identifying, explaining, and legitimizing power, and education provides a primary agency for producing believers. We come to understand the societal determination of what constitutes value, what accounts for production, distribution and consumption of goods and services, and the direct relationship of wealth to power, in educational settings: family, peers, media, and schools. That understanding serves to legitimate a particular interpretation of what economics is, how it should work, and who should be in charge of explaining it. Contrary beliefs are given little credibility.

In some states (e.g., Florida) in the USA, there are statutes prohibiting, in public schools, criticisms of free enterprise and capitalism, or prohibiting a celebration of socialistic views. In design and technology education, especially in the USA, pro-capitalist and pro-corporate sentiments are predominant and rarely, if ever, balanced (O'Riley, 1996; Petrina, in press).

Teaching AT in design and technology education necessarily requires that economic matters be addressed without bowing to the compulsions and dictates of capitalism. For those who argue that design and technology education offer ideal settings for interdisciplinary work, AT provides a wealth of diverse topics including economics. And a core lesson that AT prompts us to learn is that economics, like ecology, is rooted in the Greek *oikonomos*, or knowledge of the household— not only individual houses but the household of Gaia. Perhaps AT will be a catalyst for us to get the house of design and technology education in order lest we continue to contribute unnecessarily and unwittingly to the disorder of our big house— the Earth.

Activities for Global Economic Awareness and Activism

Activity #1. **Global Economic Awareness**
OBJECTIVE: To illustrate to students the imbalances of the current world order.

PROCESS:
A. Present students with Scenario I from the Findlay-Kettering Committee on International Awareness Fact Sheet.

B. Present students with Scenario II from the Real Global Village.

C. Divide students into groups to demonstrate global distributions of wealth and purchasing power.

Scenario I: Imagine that we could compress the world's present population of over six billion persons into one town of 100 people, with all of the existing human ratios remaining the same, there would be:

- 6 American citizens
- These 6 Americans– a mere 6% of the town's population– would receive 59% of the town's income.
- This would be the direct result of their controlling over half of the town's available material resources.
- The 6 Americans would have an average life expectancy of 70 years.
- The other 94 would have an average life expectancy of less than 40 years.
- The lowest income group among the Americans, even though it included a number of people who were hungry much of the time, would be better off by far than the average of the other townspeople.

Scenario II: In this village of precisely 100 people, with all of the existing human ratios remaining the same, there would be:

57 Asians

21 Europeans
14 from the Western Hemisphere, both North and South
8 Africans

52 would be female
48 would be male

70 would be non-white
30 would be white

70 would be non-Christian
30 would be Christian

89 would be heterosexual
11 would be homosexual

6 people would possess 59% of the entire world's wealth and all 6 would be from the United States

80 would live in substandard housing
70 would be unable to read
50 would suffer from malnutrition
1 would be near death, 1 would be near birth
1 (yes, only 1) would have a college education
1 would own a computer

Review Questions:

a. Could such a town, in which the 94 non-Americans were quite aware of both the fact and means of the Americans' advantages, survive?

b. Could the 6 Americans continue to extract the majority of raw materials essential to their own standard of living from the property of the other 94 townspeople?

c. While the 6 Americans were using over half the resources to maintain their own comfort, could they at the same time convince the other 94 to limit their population growth by saying that resources of the town were limited?

d. Would some of the 6 Americans have to become soldiers and would some of their material and human resources have to be devoted to military efforts in order to keep the rest of the town at its present disadvantage?

e. What roles might technology play in this village?

f. Should all of us try to learn more about the have-not nations of this world and become more aware of their importance to our well being?

A. Distribution of Wealth

Divide the class into groups to demonstrate the distribution of wealth of the world with the use of peanuts.

This example is based on groups of forty students. Use proportions adjusted to class size.

Region	Number of Students (Based on share of world population)	Number of Peanuts* (Based on GNP)
Asia	24 (60%)	7 (17.5%)
Africa	4 (10%)	1 (2.5%)
USA and Canada	2 (5%)	13 (32.5%)
Latin America	3 (7.5%)	2 (5%)
Western Europe	3 (7.5%)	10 (25%)
Eastern Europe and Russia	4 (10%)	7 (17.5%)

*About 85% of the world's economic activity (GDP) is controlled by the richest fifth of all people in the world. The total economic activity of the top 200 corporations is nearly twice the amount of the poorest four-fifths, or 4.5 billion people. While incomes have increased over the past forty years, the relative positions of people in dollar-rich versus dollar-poor countries remains the same. Currently, over 50% of the world has an income of $300.00 or less per capita per year.

Ask the students how they feel about the distribution of "wealth."

a. Is it just?
b. Should it be changed?
c. If so, how might you change it?
d. Have you ever experienced a similar situation where something was distributed so unevenly? What did you do?
e. What roles does technology play in distributions of wealth?

B. Purchasing Power

Now with the class divided, demonstrate the global purchasing power of these regions of the world, using peanuts again. This example is also based on a class size of forty students so adjust accordingly.

Region	Number of Students (Based on share of world population)	Purchasing Power (Based on "real" GNP)
Asia	24 (60%)	11 (27%)
Africa	4 (10%)	1 (2%)
USA and Canada	2 (5%)	13 (33%)
Latin America	3 (7.5%)	3 (7%)
Western Europe	3 (7.5%)	9 (22%)
Eastern Europe and Russia	4 (10%)	4 (10%)

Ask the students how they now feel about their global purchasing power (Ask the previous questions, and add):
f. What can be done with "surplus" goods and services (peanuts)?
g. What ought to be done?
h. What roles might technology play in this scenario?
i. What if more than food (peanuts) are needed or desired?

Activity #2: **Appropriating and Globalizing Technology— Labels, Labor and Shoes**

Context
Shoes have for some time, been an important part of the total fashion outfit for teens and older adults. “Ath-leisure” fashion has been a hot trend over the past three decades, Companies such as Nike are prospering within this larger revolution against formality in dress codes. Coolness and rebellion are connected to hats, shirts, or shoes with Freshjive, Nike, Quicksilver and other labels. Wearing a brand label is now the fashion norm in countries like Canada and the USA. The average person remains unaware of the practices of global companies and the harsh conditions under which laborers produce branded clothes or shoes.

Problem
Design and construct an “appropriate” pair of shoes (cross trainers).

Design Constraints
- The shoes can be any size and must be cross trainers.
- One pair of cross trainers must be constructed.
- There is no constraint on cost of <u>new</u> materials, but: a) you must account for all money spent, and b) you must provide details for the resource stream of the materials you purchase.
- Must use recycled soles.
- Uppers must be assembled from pieces.
- Must <u>not</u> involve offensive labels.
- Must <u>not</u> include dangerous materials.
- Must be a design that is original (but can be modeled after big name brands).
- Must be accompanied by a “Labor Behind the Label” report.

Design Considerations
- Pay close attention to form of materials, economy, ecology, simplicity, and unity.
- Ductility and durability are important considerations for materials.
- Consider the parts that can be made by machine and parts that will be assembled by hand.
- Ecology and economics are more important than style.
- The designs of DC, Etnies, Nike, and Vans are good examples, but do <u>not</u> design an identical duplicate of these.
- For design of shoes and Labor Behind the Label report, use information on advertising, labor, and production practices of Nike (see web sites on Nike practices and child labor: Labor Links:

http://www.ufcw.ca/pubs/clabour/links.htm, UNICEF: http://www.unicef.org, Clean Clothes: http://www.cleanclothes.org/, Campaign for Labor Rights: http://www.summersault.com/~agj/clr/, Corporate Watch: http://www.corpwatch.org)

Construction Sequence

- Collect information on shoe designs.
- Sketch your designs and choose appropriate forms, materials and patterns.
- May use 2D computer aided design (CAD) techniques to lay out patterns.
- May use 3D CAD to work out details of color and form.
- Locate recycled materials or new materials.
- Cut materials to forms on patterns.
- Use glue to temporarily hold pieces together for assembly.
- Final assembly.

Management Issues

- End of Day 2 or 3: Approval of design sketches.
- End of Day 4 or 5: Approval of forms, materials and patterns.
- End of Day 10: Submit “Labor Behind the Label” report.
- End of Day 16: Submit finished shoes.

Related Studies

- Accounting
- Home economics
- Materials science
- Social Studies

Review Questions:

1. (To be answered in Labor Behind the Label report)
2. If you were going to produce 10,000 pairs of your shoes, how will your company plan deal with labor and technology?
3. How will you manage profits to sustain your business? Provide a spread sheet to explain the "costs" of producing your shoes.

4. Should you try to get the lowest wages, cheapest working conditions and lowest standards of employment you can or are there other considerations?
5. What will you do about wages? Lowest possible or minimum, "fair" standard? Explain.
6. What about working conditions such as hours per day, length of work week, benefits, etc.?
7. Will you employ appropriate technology or try to automate as much as possible?
8. What about worker safety?
9. What about taxes?
10. What will be the minimum working age?
11. What about unions?

Honest Self (Group) Evaluation

1. We stayed within the design constraints and deadlines	______ out of 5 marks
2. Our shoes are unique in their design	______ out of 5 marks
3. Our shoes have design features that are improvements over existing designs	______ out of 5 marks
4. The materials used are local and recycled	______ out of 5 marks
5. Our use of materials was economic and efficient	______ out of 5 marks
6. Our shoes can be reproduced by people working for fair wages under health conditions (Labor Behind the Label report)	______ out of 5 marks
7. Our report explains how the design and production of Our shoes is an improvement over practices of big name brands	______ out of 5 marks
Total	______ out of 35

Assessment

Group's Self Assessment	________ Total/ 35
Design Principles	
Features and Form	________ out of 10
Originality	________ out of 10
Economics and Ecology	________ out of 10
Craft and Quality	________ out of 10
Labor Behind the Label report	________ out of 15
Deadlines, Safety and Participation	________ out of 10

Total	________ out of 100

Curriculum Resources for Global Economics (for Teachers)

Child Labour: Costly at Any Price
Co Development Canada
205 2929 Commercial Drive
Vancouver BC V5N 4C8
Phone: 604-708-1495
Fax: 604-708-1497
Email: codev@web.net

Child Labor: ILO Kids
US International Labor Organization
http://us.ilo.org/ilokids/

Global Sweatshop Curriculum Packet
Campaign for Labor Rights
1247 "E" Street, SE
Washington DC, 20003
Phone: 541-344-5410
Email: clr@igc.apc.org
http://www.summersault.com/~agj/clr/

Learning Materials for Your Classroom:
Development Education Program
Getting Down To Data
World Bank
http://www.worldbank.org/html/schools/

Next Steps in Global Education
The American Forum for Global Education
120 Wall Street, Suite 2600
New York, NY 10005
Phone: 1-800-813-5056
Fax: (212) 624-1412
http://www.globaled.org/order.html

The Paper Trail: Connecting Economic and Natural S
Sustainability Education Center,
The American Forum for Global Education
120 Wall Street, Suite 2600,
New York, NY 10005
Tel: 212-624-1300
Fax: 212-624-1412
Email: globed120@aol.com
http://www.globaled.org/sustain/sustain.html

United Food and Commercial Worker Union
Child Labor Links
http://www.ufcw.ca/pubs/clabour/links.htm

Wear Fair Action Kit
Labour Behind the Label Coalition
606 Shaw Street
Toronto, ON M6G 3L6
Phone: 416-532-8584
Fax: 416-532-7688
Email: perg@web.net
http://www.web.net/~msn/5cats.htm

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Chapter 3

Ramifications of Failure to Use Appropriate Technology

Charles H. McLaughlin, Jr.
Rhode Island College
Providence, Rhode Island

This chapter will review the impacts of failing to use appropriate technologies, resulting in challenging problems related to land use and fisheries exploitation. Appropriate technology (AT) should be a participatory experience for all project members. The applications of appropriate technology must invite innovative and diffuse solutions to problems if it is to succeed in complex working environments. These answers usually lie within the members of the local community.

The idea of AT is often married to the notion that it is a Third World agenda or a second best solution. Arguably, attitudes toward AT may prevent the incorporation of technologies--those which are not high tech--into the lives of the people who could benefit from their development and use. Additionally, attitudes held by a nation’s leaders may prevent the implementation of appropriate technology projects. Unfortunately, AT often carries a connotation that it is a poor substitute for high tech or more sophisticated technologies. The modern industrial mega-complex has become the measure of wealth and prosperity in most countries. The standards set by industrialized nations are typically well beyond the capabilities of most developing countries. Developing nations can not follow the same path to economic and industrial growth as the more developed nations have done in the past. They must create their own models of sustainability which by-pass environmental degradation and systems inefficiency.

Most of the developing countries and the newly industrialized countries have resource based economies. This means that the economic survival of each of these nations depends upon their stocks of environmental capital: soils, fossil fuels, forest, fisheries, livestock, minerals, etc. Developing nations’ economic solvency depends on maintaining those stocks and even increasing them. However, over the last several decades, developing nations have lost control their own natural resources and must rely on the resources of other nations to maintain their standard of living and development. If industrialized countries should move to more sustainable patterns of consumption and production, then the economies of developing nations may be adversely impacted because the commodities on which these economies depend will no longer be needed to the extent of their previous consumption levels. It is a tangled web! Strong (1993) noted that both capital and technology could be the principal engines toward sustainability, but another overlooked resource must be considered. He wrote,

> ... both of these essential economic fuels are in short supply in developing countries, so it is imperative for them to use their scarce capital and technology in ways that take advantage of their main resource, which is people. (p.6)

Ideally, the industrialized world could share its technical resources, and improved sustainable technologies with developing countries. The nations of the earth must become aware of their responsibility to one another. Certainly, the prosperity of countries is interrelated and depends upon the earth's ability to provide food and resources for all people. Therefore, it is in the best interest of all nations to undertake measures to improve the economic conditions and food security of developing nations. Growth in developing nations could be based on development processes which protect rather than undermine environmental resources and provide a way out of poverty. Such initiatives would require broad integrative approaches to be successful for both the industrialized and the developing countries. Toledo (1997) suggests, ". . . a new strategy of sustainable development at the community level can be converted into appropriate options for rural modernization based on the evolution--not substitution--of peasant practices and the adequate management of material resources" (p.248). However, self-reliance gained by sustainable development must be achieved in a way that communities take control of the processes that local people encounter during daily life.

Appropriate technology benefits society because it fosters self-reliance and responsibility. Use of appropriate technology brings with it a sense of control. Communities which become involved in appropriate technology projects can decide if the introduction of new technologies will benefit each member and will match local conditions. Appropriate technology provides education, skills, jobs, goods, and services for a wider societal cross section than high technology. Hazeltine and Bull (1999) noted, "If technology only slightly different from that existing is introduced, for instance, an improved farming method, even those not directly involved with the new method can learn about it. More people would therefore benefit from the improvement" (p.6). Appropriate technology is less disruptive to the populace than the introduction of new high technology, because it is normally based on existing technology people are familiar with. At the national level, AT may provide the very impetus necessary to bring some measure of industrialization to Third World nations, without the ubiquitous high-technology and monetary handouts from more affluent nations. In its broadest sense, AT provides an alternate route to economic development.

Successful AT projects have at their core an orientation toward initiative and self-reliance, popular participation, local leadership, and decentralization of authority (Bush, 1994; UNESCO, 1981). A primary consideration of successful development interventions is that the users, “beneficiaries,” should decide what technologies are appropriate and more likely to meet their needs. At the time E.F. Shumacker wrote *Small is Beautiful* (1973), he identified Intermediate Technology as a panacea for unemployment. Twenty-seven years later, much has changed, including the view of AT and its wider applications in developmental thinking (Scott, 1996). While technology was the impetus for change, more recently AT organizations have shifted their emphasis to developing the technological capabilities of those people they assist.

Few movements have played as important a role in the emergence of technological innovation in developing nations as appropriate technology. The AT movement has also contributed to, “ . . . new ideas and values, it helped create a new social demand for different types of technology, and this demand in turn is beginning to have a major impact on the technological system” (Jéquier, 1983, p.4). So with all its apparent benefits, what are the impacts from failing to use appropriate technology?

This chapter will explore the problems associated with the failure to develop and use appropriate technology to create desired outcomes of economic, social, and resource stability. Examples from both developing and industrialized nations will be utilized to demonstrate the delicate balance between technological self-sufficiency and the uncertainty of modernized development.

Participation: The Key to Implementing Appropriate Technology

The history of development assistance (e.g., United States Aid for International Development - USAID) is littered with the machines and technologies of good intention. In many development assistance cases, the selection of technological equipment for the international community was made by external agents with minimal knowledge of the local culture or environment. A prevailing philosophy within AT programs recommends participation and choice by the end-users, the local community members. A variety of AT devices should be made available for the end-users, so the most suitable one will be chosen and used in the community. Acceptance of appropriate technologies fails when development strategies are often foisted onto a community rather than introduced in a side-by-side, collaborative relationship.

Appropriate technology must match the end-user in both scale and complexity. Hazeltine and Bull (1999) related the story of an African community that was the beneficiary of ten modern combines that would be used to harvest grain. The aid project did not provide training of mechanics or the spare parts necessary to maintain these farm production machines. The combines rest, rusting, at the edge of the fields as the farmers use traditional methods to harvest their crop. Simply put, “What we have here is failure to communicate.” The external organization “knew better” than the community what the local needs were. This is a trap that many well intentioned organizations find themselves creating.

During another intervention by an external aid organization, wood stoves were designed with the sole intent of providing energy efficient cooking facilities. The end users attached greater priority on cooking time, smoke emissions, and space heating. The main reason for the stoves' failure to attract users was that no one within the assistant agency took into consideration the needs and priorities of the people who would actual use the stoves.

Grace and Arnoux (1998), proponents of approaches meeting local needs and global sustainability, advocated the use of locally produced biomass fuels. Communities would replace fossil fuels with renewable biomass resources. “Most discussions of improved stove programs are invariably premised on an assumption that users are destined to progress up the *‘energy ladder’* from biomass fuels to *‘modern fuels’* such as, kerosene, LPG gas, and finally electricity” (Grace and Arnoux, p.265). Success for programs such as these are tied directly to the knowledge of local women as the providers of fuels for household activities. Grace and Arnoux suggested women become part of the process, including production of the biomass fuels. Such a program places women in a position to control many aspects of a required resource. The other option is to use non-sustainable, polluting fossil fuels that are expensive or to burn fuel wood exposing women to high levels of CO^2, and the burdensome chore of searching for and collecting fuelwood.

The benefits of local participation in design and construction of AT devices are numerous. However, a community's failure to use AT is often related to the degree of participation by the local people. Without participation, most projects are doomed to failure. Worse, technical choices can be made by politicians, managers, and other administrators who may not know or understand the subtle issues within the culture that are essential for design, implementation, and utilization. While these individuals may have the best interests of the people in mind, they may not fully understand the complexity of implementing simple AT projects. Here again is the problem where leaders forgo practical projects in favor of those which have an appearance of complexity. History has demonstrated, projects imposed by external authorities do not fare well because the goals often do not match the needs of the community. It is also difficult to inspire loyalty by the end-users for a project when the responsibility for decisions has been given to one or several people who are outside of the local community population. The issue of external decision making becomes even more problematic when imported foreign products and machinery are necessary to implement a project of any scale.

Several developing nations have mounted efforts to create affordable power supplies for their citizens. With the expected tripling of CO^2 levels by 2025, it seems reasonable that such enterprises would be supported by more industrialized nations. This has not been the case. Many of the locally planned power systems in countries like Peru, Sri Lanka, China, and Nepal have been suspended in favor of large scale power systems (Holland, 1993). The investment in and use of foreign materials, resources, and machines requires these countries to commit important monetary resources toward the purchase of equipment, skills, and fuel from outside their borders. Such project do little to improve the lives of the majority, since few rural communities have the infrastructure or hope to connect to the energy grid. Large foreign projects often impede development because they siphon off money, jobs, and other opportunities for the very people the project is supposed to help.

Developing countries need to foster their own technological and scientific capabilities, or they may find themselves in a weaker economic position and may actually impede their own development. It is for this reason that participation, especially by end users, must become the paramount process for AT to succeed. All stake holders must recognize the importance of the “people’s technology”. The input of local farmers, artisans, and potential users is central to the success of AT. Should their contributions be ignored, failure becomes certain.

Land Use and AT

Agriculture systems throughout the world vary in size from the one-plot subsistence farms to the industrial, multi-acre farm. Their individual sizes can not distract from the fact that their purpose is to provide food. There is a problem, though, which is as old as agriculture itself; that is, that food demand will increase as the population on Earth grows, and there will be an unprecedented need for more varieties of food in the near future. In previous eras, the loss of crop land could be easily rectified. Adjacent lands were cleared of vegetation or nearby forests were cut down. However, many industrialized countries no longer have the luxury of expanding their farming enterprises. Most, if not all, of the arable land is in use. In many developing nations, marginal and semi-arid tracts of land are available, but the tenuous nature of climate and rain make cultivation a risky proposition.

In developing countries, 1.4 billion people rely on subsistence farming (Nebel & Wright, 1998). A typical subsistence farm includes a small parcel of land for growing food, and maintains a few farm animals--chicken, goats, and perhaps a few head of cattle. Subsistence farming is extremely labor intensive and is often hindered because it is practiced on marginal land; the only kind these farmers can afford. The practices defy sustainability as woodlands and forest are cleared exposing soils to the elements. Erosion generally follows if ground cover is not replaced.

In the United States, large planting fields of the same crop, called monocultures, require heavy mechanization, large tracts of land, and large sums of money. Machines and fossil fuels replace human muscle power and beasts of burden. Unlike other types of farming, only one crop is grown making equipment changes during harvesting unnecessary. Modern farmers avoid planting plots of land with crops of different varieties because it reduces the efficiency of farming.

There are serious drawbacks to monoculture farming. For instance, if every country were to farm as intensely as in the United States, it is estimated that the known oil reserves would become depleted in 12 years (Bush, 1997). Not only is fossil fuel required to run farm equipment, but is essential for manufacturing pesticides and fertilizer. These chemicals do the work that humans would to cultivate the crop. The are a very costly alternative to pest prevention and nutrient replenishment. The backlash to this type of farming can be seen in consumers' demand for produce which has been treated with little or no chemicals.

A popular farming method in developing nations with low density populations and poor soil is slash-and-burn agriculture. Small sections of forest are cut and burned to release their nutrients into the soil. Typically, the small plots support a variety of plants, not just one species of crop. Beans and shade plants share the plot because of the beneficial aspects they possess. The mixing of species also prevents the loss of the whole endeavor from pest infestation. The characteristics of some plants allow them to repel nuisance insects from the plot. It is an ingenious form of agriculture, but is not effective over large areas. Crops may be cultivated for several years, until the soil nutrients are spent. Once this occurs, the process of slashing-and-burning is repeated, if land is available.

Agricultural development in the marginal and semi-arid lands of many developing nations requires efficient technology transfer systems for the benefit of all levels of farming. Research efforts must support innovations which enhance a nation’s resources, rather than overtly exploit them. The applications of research needs to involve managers and end-users during survey trials. The introduction of all new technology must be facilitated through specialized workshops. Too often end-users are left to their own device to determine proper and safe use of equipment. Farm machinery must be made adaptable to a variety of conditions, and ideally should be developed by the users. This dispels the notion that, “Most third world or developing countries, thought that they could be consumers of technologies while the developed world would generate technologies for them” (Agboola and Tijani-Eniola, 1991, p.54). Serious efforts must be made to assure appropriate agricultural technologies reach the largest number of people possible. This stimulates diffusion to quarters of the farming population not reached by community programs and may stimulate innovation beyond the locale that implemented the project.

The use modern farming practices, rather than appropriate technology, in developing nations began in the 1960s. The results have been mixed. The *Green Revolution* hoped to improve crop production and agricultural practices in developing countries. These assistance programs brought “temperate zone technology” which worked well in the industrialized nations. The consequences for developing nations were crop failure due to tropical temperatures and climate, dispersion of pesticides and fertilizers during monsoon events, and the inability of crops to withstand pestilence. During drought, some farmers had to eat the seeds they intended to plant in order to survive (Boyle, 1994). And, as a result of planting and developing “foreign” seeds, many of the local varieties were lost. In many cases, assistance agencies promoted the use of non-native seeds without consulting communities about their crop preference (Boyle, 1994).

Attempts to plant monoculture crops have had a tremendous impact on rural communities. Banking on one crop brought with it a multitude of problems. For instance, when aggressive pest infestation took place, the entire crop was lost. Specific traits within the plant species were lost as communities resorted to planting simple rotations of a crop. The demand for fertilizer, often very expensive in developing nations, prohibited growth in crop lands because essential nutrients were removed from the soil. Many early planted crops relied on the plant residue from the previous cultivation. In semi-arid zones, residue is often grazed on by livestock or burned accidentally. Even more commonplace is the over-application of soil-active herbicides. These chemicals are meant to destroy weeds which inhibit plant growth; if applied improperly, they will destroy the crop itself. In most cases the land ultimately succumbs to erosion.

Better animal husbandry practices, in conjunction with agricultural development have a critical place in the survival of humans in marginal areas. Cunningham and Saigo (1999) noted a study by the U.S. National Academy of Sciences which concluded, “the semi-arid lands of the African Sahel can support only 20-28kg (44 to 62 lbs) of cattle per hectare but can produce nearly three times as much meat from wild ungulates (hooved mammals) in the same area” (p. 308). The competition to support both animal and crop land also minimizes productivity. Grazing animals often select the most palatable grasses, leaving barren niches for opportunistic weeds or other undesirable plants to fill. Erosion fields are created as these same animals pulverize the soils. Either one of these accidental disruptions to the soil will degrade the capacity to cultivate, but combined, they create soil erosion problems which occur very quickly threatening the farmers’ hard-won niche.

Social problems related to farmers classifications are common in developing nations. Farm classifications based on land holdings are as follows: marginal, poor, medium, and rich (Abedin, A.& Chowdhury, M., 1985). Technologies brought into the community have been accepted or rejected as a result of classification. There are many incidences of the acceptance of a technology which benefits a few community members because of class rank. To avoid this scenario, it is paramount that the farmers, who are at the epicenter of agricultural activities, provide their input and opinions as equals during selection of materials, technologies, and agricultural practices. The entire community needs to participate when new techniques require training. Every resource should be made available to every farmer for new and improved seeds, as well as, the pesticides and fertilizer needed to insure good productivity which creates security in the community (Bush, 1997). Certainly, the intent is to place these advantages into the hands of as many farmers as possible, not just the richest members of the agricultural community.

The impact of land degradation has caused entire agrarian communities to move into less desirable areas. These migrations cause economic and cultural disruptions. Particularly insidious is the loss of traditional homeland to erosion, desertification, and deforestation. These losses could be avoided with the use of proper resource management techniques and appropriate technology. Often, the actions of the people near resources such as a forest cause disruptions out of need to survive rather than for economic reasons. Serageldin (1993) eloquently stated:

> To outsiders, it appears to be as illogical to cut a tree that produces needed food, fibers, or medicines as it is to consume the seeds for next year's crop--illogical, that is, unless survival today is dependent on selecting that option. In most cases, the peasant farmer who cut and burn forest do it out of urgent need--not out of malice, profit, or ignorance (p.8-9).

In Nigeria, for example, the forests contribute to the overall well-being of those who live near them. The forests act as an environmental buffer and regulate local and regional climate somewhat. Forests provide huge amounts of goods and other benefits. Unfortunately, some areas are being used to extinction. Deforestation has become a major threat to global environments because huge tracts of forest are removed for short-term purposes. As African populations increase, the forests are turned to for space and materials. ". . . clearing forests to support agriculture and to meet the needs of a rapidly expanding population is the main reason for deforestation" (Serageldin, p.8). Once cleared of its cover, the area may be inhabited by people in search of their own tracts of land on which they farm. The exploitation of forests for logging promotes two problems. First, the trees are harvested for export, then farmers take over the clearings to create subsistence farms. These new forest farmers, by far and away, have the greatest impact, "creating an environmental problem attributed to the intense demands on sparsely vegetated lands" (Okafor 1988, p.153). The infertile soils loose their nutrients making the land useless for cultivation. After this occurs, the farmer must seek out another plot; and the cycle begins again. A problem which has continued to plague forest managers in the tropics is the accidental or intentional introduction of non-native species of plants. These opportunistic species have few competitors in the forest clearings and other marginal lands. Without natural enemies, they may over-grow and prevent native plant species from flourishing. Egunjobi (1993) estimated that Nigeria alone destroys about 600,000 hectares of forest each year; only 25,000 hectares are replenished.

Another troubling impact of deforestation places a burden on domestic life. Nebel and Wright (1998) reported that 3 billion people, 60% of the world's population rely on firewood to complete domestic chores. The exploitation of forests has made the work of collecting firewood, a job usually performed by women, even more burdensome. As the forests are cut back, the trip to and from home gets longer and more arduous. In the tropics, government forest departments have attempted to exclude local populations from forest areas. This has often created intense conflicts placing local residents, who collect fuelwood and fodder, in direct opposition with the government's wishes to protect the forests for timber sales (Shepard & Stewart, 1998).

With deforestation comes another land use problem. Although its onset is usually associated with climate change and over-use of soil, desertification can begin with the loss of forests. The mechanics of desertification can be confounding. The persistent occurrence of drought in areas of marginal land subjects inhabitants to psychological and socio-economic stresses and the soils to utter uselessness. The process of desertification, when natural and human intervention create changes which disrupt vegetative growth, impacts stability and development, and reduces an region's carrying capacity.

The reduction of land to an infertile state, desertification is a consequence of losing the organic components of soil. The resulting soil is sandy, does not return water, and is liable to blow or wash away (Bush, 1997). The desertification of areas is the Sub-Sahara Africa are the result of both intervention by human activity and natural events. The Sahel is a band of dry grasslands which stretch across Sub-Sahara Africa. Close to 50 million subsistence farmers and their families live in the area. The region has been plagued with a series of droughts since 1967. While there has been enough water in the form of rain, to support the grasslands, there has been little to support agricultural practices. Soils in this region are the most sensitive to change and rarely produce crops with frequency. With few available technologies, the people of the Sahel live a nomadic existence. Still, some groups attempt subsistence farming or become pastoralists. The expanding population in the Sahel has caused unsound agricultural practices and over-grazing to become commonplace. Ashby (1994) reported, "The drought of 1983 caused record crop and livestock losses and triggered significant migration of cultivators and pastoralists across state and international boundaries" (p.30). The refugees were in search of water and food. The influx of people into regions already inhabited created great stress on the environment. There was a tremendous migration to urban areas which challenged the capacities of all services. Simply put, the drought disaster had become a crucible for human suffering, the likes of which had never been seen. Famine and armed conflict soon followed as the resources of one country were usurped by citizens from another. The political instability created threats to economic and agricultural development in the region.

A final example of the impacts from failing to use appropriate technology can be found during a unique project. The World Bank actually paid Latin Americans to clear cut tropical forests. The purpose of this endeavor was to assist beef production for export. The project created low yield cattle estates, which were quite large. Despite the size, cattle ranching requires less labor than other types of agriculture. The World Bank program created a new class of cattle barons. The local inhabitants did not benefit from this project, but were forced onto marginal or less desirable lands. Budowski (1984) remarked,

> With better land management techniques, the same land could produce ten, perhaps fifty, times as much food. Instead of being a source of beef for export, it could sustain local families. However, this may not favor the interests of the landowner, and under the prevailing political system, it is almost impossible to change land use patterns. The landowners have a perfect right to use the land as they do under the present constitution. But something is wrong with a system that allows a person not to make the most of his land on a sustained yield basis when there are scores of hungry people in the same region (pp.61-62).

The end result of such projects is displacement of the poor, and perpetuating the cycle of poverty. Projects like that of the World Bank must strengthen local inhabitants' resolve to use the forest to improve their lives. The use of the forest might have succeeded if the project had been based on ecological and economic concerns of the region's inhabitants.

Troubled Waters: The Decline of Fisheries

In March of 1954, the British christened the ship that was to change the course of fishing on oceans around the world. The launch of the HMS Fairtry brought about the first distant water factory ship with a self-contained, quick-freezing unit and fish processing machinery. Once the efficiency with which this ship scoured the ocean became known, many oceangoing nations got in line to build replicas.

> "They're fishing in ocean liners!" is the way astounded Canadian and American fishermen who saw these vessels invariably described their arrival. The description is accurate, with only a trace of pardonable exaggeration. Seen from afar, the new ships look very much like passenger liners. And they were big--bigger in length and much bigger in tonnage than any and all fishing vessels that preceded them (Warner, 1984, vii).

While human activity threatens the oceans and the near-shore, the most serious threat to marine life is fishing. By all accounts the major fishing areas in the oceans have reached peak production and are in decline due to over-fishing (McGinn, 1999). The intensity of some fishing efforts can remove up to 90 percent of fish populations in a given year. This dramatically reduces the success of recruitment classes (Safina, 1995). All over the world, fish are taken at a rate faster than populations can reproduce.

The problem of over-fishing is a worldwide problem, not restricted to either industrialized or developing nations. The operation of marine fisheries at present levels can not be sustained, endangering economies and life styles. The best catches were routinely made on fish spawning grounds. For that reason, fishing trips by the great fleets of Spain, Portugal, America, Canada, United Kingdom, and Germany were scheduled to coincide with the large congregation of spawning fish. The results of the catches were quite dramatic.

The virtual commercial extinction of Northwest Atlantic groundfish--notably cod fish--was considered impossible. Yet, as early as 1970, catches of cod fish had dropped noticeably from previous levels. However, government subsidy programs were established to assist fishermen[1]. These subsidies were used to purchase high-technology gear, such as navigation electronics, sonar, and improved nets. The killing got even more efficient. O'Riordan (1994) compared these events to, "having witnessed the Industrial Revolution in global fisheries" (p.15). As a result of the decline, many fishermen sold their equipment or simply did not put out to sea. Still, with fewer boats, catch levels remained respectable. This was accomplished because of technological advancements in fishing equipment. Harris lamented, "We just became too technically competent. We became able to kill too easily. We became able to kill everything" (cited in M. Harris, 1999, p.333).

Efficiency doomed the modern fishing fleets. Ignoring international fishing quotas also helped. The use of cutting edge electronics, ships with spotter planes, drift nets, sonar, and longlines (80 mile long lines of baited hooks) have conspired to destroy fishing stocks. Huge trawl nets have been introduced which, when open, can engulf the equivalent of ten or more jumbo jets (Harris, 1998; Safina, 1995). Coastal nations alarmed by the decline of fish stocks established 200 mile economic zones to protect their remaining biomass. Traditional fishing grounds held since the 16th century were no longer available for foreign exploitation. However, for fish stocks like the groundfish of the Northwest Atlantic, it may be too late to recover. Even with reduced pressure on the fish, they are not returning to the inshore nurseries or even in their mid-water habitats on the great fishing banks of the Atlantic.

Stradling stocks, fish that move in and out of the protected 200 mile limits, are often the source of international confrontation. Coastal nations view these fish as their protected resource and should not be harvested by other nations. A rather dramatic situation occurs when fish migrate to and from protected zones of neighboring countries. For example, in 1997, commercial fishermen from British Columbia blockaded a U.S. ferry in protest of excessive fishing by the Americans. At the heart of this incident was the rule of law governing the catch of the dwindling Sockeye Salmon. However, the disappearance of fish coincides with the loss of their habitats from construction of dams and hydro electric projects, poor forest and watershed management, and urbanization of pristine areas. Protecting home waters has degenerated into one country’s navy firing upon another country’s fishing vessel. There is a lot at stake to preserve the fisheries around the globe.

Many coastal developing nations have benefited from the global strife related to fishing. They have learned the lessons of the global community; to develop fishing resources requires management. Over the last twenty years, a number of regional fisheries development organizations have emerged. These organizations were charged with providing assistance to individual fishermen, their communities, and to a greater extent developing countries. The goal was to prevent over exploitation of valuable sources of protein. However, many developing nations must export large portions of their catch to the industrialized nations who sponsored the upgrade of home fishing fleets. Under the guise of creating foreign exchange, there has been a dramatic transfer of much needed protein from poor countries to their rich benefactors.

Fisheries in developing nations’ coastal zones have been a consistent employer. There are 21 million individuals worldwide who identify themselves as fishermen (McGinn, 1998). Worldwide, over 200 million people derive their income from fishing interests. While fisheries contribute a small portion to the economic standing of communities, it does provide stable employment and food security. McGinn (1998) related the following: “More than half the fish eaten today came from inshore and coastal areas that are dominated by more than 19 million small- and medium-scale fishers who are officially counted in FAO statistics.” How is it that fisheries can sustain this many people? The answer is, scale of the effort. Most subsistence fishermen use hook and line gear to land their fish. This technique produces better quality fish than trapping or netting fish. This simple technique also reduces the amount of by-catch that industrial type fishing is noted for. Artisan fishermen use canoes, sailing boats, and most recently motor powered craft. The majority of fishermen in the world are artisan fishermen. What they lack in technology, they make up in sheer strength of numbers. They harvest up to 90 percent of the daily catch, most of which is directly consumed by the communities they live in. Almost all of the fishing takes place near shore.

However, looming not far offshore, large mechanized fleets have secured the rights to fish in waters of many cash strapped coastal nations. Not surprisingly, these fleets represent the countries who fished out the world's premier fishing grounds. Should events repeat themselves in Southern waters, the tragedy would be two-fold: the loss of irreplaceable protein and the decimation of valuable fish stocks.

Lately, traditional fishermen have been afforded the opportunity to participate in development which will increase their catch and improve catch quality. Coastal nations' governments recognize that artisan fishermen have intimate knowledge of the resource, the areas where fish spawn, and other migratory habits. With this in mind, measures to ensure protection of fishing areas have been established. Small scale fishermen have assisted in the determination of limits on commercial fishing interests, licenses, catch and by-catch quotas, and vessel size limitations. Recognizing the low impact of artisan fishing, they are rewarded with protection measures and extended seasons, while the mechanized fleets await seasonal quotas.

Technology Education and Appropriate Technology

The infusion of AT into technology education makes good curricular and pedagogical sense. Appropriate technology provides students with opportunities to engage in solving problems with a real human dimension. However, the discussion of solutions to problems which relate to real world problems can not take place when the solutions are firmly rooted in the traditions of industrialization which ignore the customs and culture of others. Without AT infusion, students may not develop values and broaden their perspectives of the world beyond their school and community. Participation in activities which support AT development demonstrate to students the importance of culture of other people and people groups, unlike the many rote activities used in contemporary technology education. Appropriate technology activities give students the opportunity to study other cultures and the contexts for their technology. There are few occasions for this to occur in the "New Basic". Certainly, AT exploration gives technology education a more meaningful and global perspective, which it currently lacks. A feature of AT is that it illuminates the widening gap between rich and poor countries as well as the gaps within their own nation. While industrialization and global competition are viewed as the driving forces of the technological elite, many developing nations have the untapped potential to meet or exceed the standards set by wealthier nations.

Technology education's students should be made aware of how technological problem solving involves many aspects that go beyond technical procedures and equipment. Students need to learn that technology must fit within the context of culture for it to be successful. Students should learn that all problems need not have their answers embedded in high technology; a simple solution might be the best solution. For instance, development problems requiring the use of appropriate technology might require a simple solution. By avoiding AT development, and heading for high technology, students miss the chance to learn about technological development, evolution of a device, and the influences of technological change. Creating a simple innovation may be as complex and challenging as producing a high technology device which has little chance of diffusion within a community. AT problems, long ignored by the confederation of technology educators, allow students to engage in poignant exercises which provide the means to satisfy basic human needs, not the luxuries that accompany mass consumerism. Where in the technology education curriculum reside the concerns for the problems of poverty, social change, the betterment of the human condition, economic development, employment, self-reliance, and self sufficiency? Providing students with ways to study these important facets of AT affords them perspectives unlike those framed by life in an industrialized country. Technology education can be improved by using AT to build upon the cultural constraints which have shaped the many traditional communities in developing nations and modern societies, too. Such experiences create new world views and improvements in the application of knowledge.

Appropriate technology permits the use of the world community as a resource and training ground. The unique global experiences are radically different from the process oriented technology education laboratory. The community is transformed into a learning laboratory with real people, real opportunities, and real resources. Underlying the use of the community is the development of students who become actively engaged in their education, who are no longer challenged by artificial constraints of the technology education classroom, and who respect the diversity of other people. This becomes possible when lessons include “people’s technology.”

The use of AT has inherent risks. To study AT and the people who benefit from it requires novel approaches not yet accepted by technology educators. Provided with proper guidance, students can develop an awareness of their abilities to solve technical problems. They can learn the requirements of scale to solve local problems. With the use of appropriate technology in the classroom, technology education can become World Class Education.

Review Questions

1. a. Competition for water is often a source of problems for dwellers of semi-arid lands, especially when rainfall is erratic. What alternative sources could be developed to provide water for both humans and their animals during dry or drought-like conditions?

   b. Your community’s water supply has become polluted. The situation requires each home to develop a plan to supply its own water for one week. Create a plan to provide your home with water for one week.

2. Nomads and pastoralists move about to ensure that they and their animals have enough food to eat. During their migrations, seeds from species other than those that inhabit the soil are introduced. What impact will this have on the region?

3. Monoculture farming is practiced on large tracts of land. Could this form of agriculture take place in your community? What kind of crops are grown?

4. Locate historic evidence of groundfishing in the Northwest Atlantic. How long was the fishing sustainable? What were the technologies which led to its ultimate extinction?

5. How would you define inappropriate technologies? What factors make them inappropriate?

End Note:

1. The term fisherman is used throughout. The term “fisher” is used by academics for gender--neutral purposes. The word “fisher” is widely disapproved of by those who work and live in the fishing community. See Greenlaw, L. (1999). The Hungry Ocean: A Swordfish Captain’s Journey, p.51. Also see, Harris, M. (1999). Lament for an Ocean, p.367, for discussion regarding this term.

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Chapter 4

Moral and Ethical Issues Related to Appropriate Technology

Roger B. Hill & Garner Dewey
The University of Georgia
Athens, Georgia

The issue of moral and ethical behavior is a topic of considerable discussion as the dawn of a new century begins. Perhaps due to the failure of society to successfully master the desirable characteristics espoused by civilized peoples throughout history, people frequently express concern about declining integrity and decaying ethical standards. In this, as in so many areas of societal concern, educators are increasingly expected to address the moral and ethical development of their students.

Numerous educational initiatives, reports, and goal statements have endorsed moral and ethical development as an outcome of school activities (Beach, 1991; Lankard, 1990; Noddings, 1991; Secretary's Commission on Achieving Necessary Skills, 1992). Often this is in the form of a general goal statement, as is the case for vocational education and technology education. In other instances, a more specific initiative to address this area is included in either programs of study or extracurricular activities. For example, a Milwaukee high school has implemented a Career Pathways program for all students to that includes a required work ethic component (Hill & Womble, 1997). All students participate in a unit of instruction that emphasizes the importance of initiative, interpersonal skills and being dependable. Components included in this program also stress development of integrity, responsibility, and consideration of others.

The recently developed national standards for technology education (International Technology Education Association, 2000) address moral and ethical behavior in grades as early as K-2 under standard number 13, to assess the impact of products and systems. The content standards in this section call for students to "assess how a product or system will affect individuals, society, and the environment" (p. 133) so that they can recognize the potential for good as well as bad impacts on families, classes, school, neighborhoods, cities, countries, and the world. Whether discussing the disposal for waste products generated by technological processes or determining how best to provide access to information technologies such as the Internet, moral and ethical issues are involved. One of the difficulties in addressing this portion of the standards is the scarcity of instructional strategies for addressing moral and ethical issues. In some instances, technology education curriculum has focused on understanding technical systems, materials, and processes and has not adequately addressed social and cultural impacts of technology.

Appropriate technology is particularly suited to development of problem solving and thinking skills for moral and ethical decision making. Studies in this subject area include issues such as conflicting belief systems, consideration of individual needs, and the importance of compromise (Lickona, 1991; McClellan, 1992; Veugelers, 2000). Appropriate technology often involves exploration of varied people groups, political systems, and cultural settings. As a result, moral and ethical issues often surface in relevant ways that create natural opportunities for discussion and consideration.

The potential for controversy when introducing moral or ethical content into the middle school or high school classroom is an important issue that must be considered thoughtfully. As indicated by the criticism and protest about the introduction of character education in schools, some individuals do not think that issues related to morals and ethics should be a part of the school curriculum or disagree with the instructional strategies being used for it (Molnar, 1990). Their arguments include statements about separation of church and state and suggestions that these issues are more appropriately addressed in the context of family, church, synagogue, or mosque. However, upon further investigation these kinds of moral and ethical content can and should be addressed in schools because they consist of topics that persons of all religious backgrounds can agree on. Issues of trustworthiness, respect, responsibility, fairness, caring, and citizenship are characteristics that are compatible with all major religions and do not violate church/state separation unless they are presented in a biased format. For those who do not subscribe to any organized religion, a strong logical case can be made for a "moral law" that is inherent to human beings and apparently an integral part of their design (Lewis, 1952). In fact, the rule of law found in all civilized societies reflects these fundamental principles of behavior.

Identifying the moral and ethical issues that are appropriate for school programs to include can be approached from at least three differing perspectives. One is to simply choose a list of topics that seem to represent commonly agreed upon concepts. The problem with this approach is that it usually involves efforts of one individual teacher or a small group of people within a school setting and is subject to criticism with respect to how choices were made. If manners, for example, are chosen as an area to be covered, the question then becomes whose manners. Some people subscribe to say "yes sir" and "yes mam" while others consider this to be rude or disrespectful. If students are taught to behave in certain ways with respect to manners, criticism arises if the choices of manners fail to coincide with those of parents and others in a community.

Another approach to be considered in selecting the moral and ethical issues is the published work of organizations such as Character Counts. Based on a 1992 survey that showed significant problems with cheating, lying, stealing, and substance abuse, Character Counts was developed to help guide character development efforts (http://www.charactercounts.org/backgrnd.htm). A consensus was reached by a group of educators, ethicists, and nonprofit leaders who met in Aspen, Colorado during that year to develop a list of ethical values that could be taught at home, in the classroom, and at work without offending political, racial, religious, gender, or socioeconomic sensibilities. This list included trustworthiness, respect, responsibility, justice & fairness, caring and civic virtue & citizenship.

A third strategy available for choosing what moral and ethical issues schools should address is that of a research-based approach. Hill (1995) used a sample of 1,151 working adults to examine work ethic attributes and identified three constructs that characterize work ethic. These were interpersonal skills, initiative, and being dependable. While these constructs do not encompass the range of moral and ethical issues addressed by Character Counts, they are representative of a third approach for identifying moral and ethical issues to be considered – that of an objective, research-based approach. In this instance, data from a relatively large sample was used to establish what issues are important in the workplace.

The latter two approaches described above, as compared with the first, provide a more defensible basis for selecting moral and ethical issues to be considered in a school setting. Regardless of how topics are selected, appropriate technology as an area of study provides the ideal context for addressing the issues. Without a relevant and practical context for instruction, addressing moral and ethical issues in the school setting will likely be perceived by students as "preaching" and results will be minimal.

Moral and Ethical Issues Related to AT

The field of appropriate technology includes several prominent areas of concern that provide an excellent context for considering moral and ethical issues. Three of these are environmental pollution, labor issues, and nonrenewable energy resources. In each of these areas, appropriate technology offers critique and potential solutions. The perspective provided, in conjunction with technology education studies of systems related to manufacturing, transportation, construction, and energy and power, can provide opportunity for students to develop a balanced outlook on issues they make decisions about.

Environmental Pollution

One of the concerns implementation of appropriate technology addresses is the application of modern technologies in developing nations. When these technologies are introduced without consideration of other factors, serious side effects often result. One example is urban air pollution in most large cities in developing nations. In cities such as Beijing, Delhi, Jakarta, and Mexico City air pollutant levels sometimes exceed World Health Organization (WHO) standards by a factor of three or more (World Resources Institute[a], 1999). Estimates by the WHO indicate that as many as 1.4 billion people worldwide, primarily located in urban areas, breathe air that exceeds the WHO air guidelines (World Resources Institute[a], 1999).

Air pollution creates significant health problems for some urban residents in developing countries. A recent study in Jakarta estimated that on a yearly basis 1,400 fewer deaths, 49,000 fewer emergency room visits, and 600,000 fewer asthma attacks would take place if particulate levels were reduced to WHO levels (World Resources Institute[a], 1999). In Latin America an estimated 65 million days of illness each year for 81 million city residents can be traced to high air pollution problems (World Resources Institute[a], 1999). This represents approximately one fourth of all city residents in the region.

A problem even more serious in developing countries than pollution of the atmosphere is indoor air pollution. In many regions “modern technology” in the form of housing has been introduced, but traditional solid fuels continue to be used for cooking and heating. This mix of old and new has resulted in high rates of indoor air pollution for an estimated 3.5 billion persons (World Resources Institute[a], 1999). With approximately 2.8 million deaths per year resulting from breathing of indoor air that exceeds WHO particulate standards, indoor air pollution contributes to about 6 percent of all deaths each year in developing countries (World Resources Institute[a], 1999).

Based on studies in the Pacific, South Asia, China, Africa, and Latin America, exposure to indoor air pollution from dirty fuels contributes to four main categories of serious illnesses: acute respiratory infection (ARI) in children, chronic obstructive lung diseases (asthma and chronic bronchitis), lung cancer, and birth complications including stillbirths (World Resources Institute[a], 1999). ARI appears to be the most serious of these problems. Children with exposure to smoke from cookstoves in dwelling places are from 2.5 to 5 times more likely to develop ARI and require hospitalization (World Resources Institute[a], 1999).

The crux of this problem can be traced to weatherproofing techniques used in housing without consideration of other factors present in the environment. In industrialized nations, numerous technologies such as electricity, clean-burning fuels, appliances, heating and cooling systems, and housing have developed side by side. When one segment of these technologies are introduced into the environment of a developing nation without consideration of other related issues, situations such as that of the problems with indoor air pollution can arise.

The moral and ethical issue that should be addressed during a lesson on home weatherproofing techniques is whether it is appropriate for a company or organization to market products in developing nations without regard to other relevant factors in that environment. For example, a company that produces modular housing or other forms of modern building products that are of high quality and provide strong, weathertight structures expands its markets into the international arena. It might not take into account the appliances or other technologies that are typically used by the new customers in another country. If that resulted in significant health risks to customers due to their continued use of other incompatible technologies, is there a moral or ethical problem the building products company has a responsibility to consider?

Labor Issues

The introduction of technological processes in the form of manufacturing operations in numerous parts of the world has resulted in serious labor concerns. In particular, the use of child labor has increasingly drawn attention in recent years. Other issues involve failure to provide adequate care for workers with respect to safety, appropriate remuneration, and working conditions.

With regard to child labor, modern communication and transportation systems have supported the widespread development of multinational corporations. These firms have pushed to locate various segments of their enterprises in regions of the world that provide the lowest costs and greatest overall profits in producing their products. In some instances this has allowing children or other underemployed segments of an indigenous population to be employed in work that is physically possible, often due to modern manufacturing technologies, but ultimately harmful from the standpoint of individual human needs. A 1997 report on The State of the World's Children (UNICEF) showed that in developing nations approximately 23% of primary school age children did not attend school as compared to 1% in developed nations. In most instances these children are a part of the labor force, either performing domestic or agricultural work or producing manufactured products of some type.

With respect to agricultural work that involves migrant and seasonal farm workers, even more serious circumstances are often present. It is estimated that 250,000 children migrate as farm workers each year, and 90,000 children are moved across an international border (Migration World Magazine, 1998). Those that migrate across a border are often traveling to a developed nation, such as the United States, where modern technology has allowed agricultural operations to become tremendously efficient, but where some crops still require the human touch for harvesting or other delicate operations. Aside from problems associated with missed educational opportunities and similar issues, research has shown that as many as 48 percent of these children have been exposed to fields still wet with pesticides (Migration World Magazine, 1998). With their lower body weight and higher metabolism, this exposure is especially hazardous to children.

Another example of a labor issue that raises moral and ethical issues that might be addressed within the context of a study of appropriate technology is the advent of “maquiladoras” along the Mexican border. These are foreign-owned assembly plants that manufacture products for export to United States markets. In a survey by the Comite de Apoyo Fronterizo Obrero Regional (Nation's Health, 1998), 53 percent of mauqiladora workers reported that they had not received any material safety data sheets for chemicals they were exposed to at work, 40 percent had not received safety training, 38 percent reported noise levels so loud they had to shout to be heard, and 26 percent operated machinery without shields over pinch points and moving parts.

The actual investment of multinational corporations in “maquiladoras” or industries in other developing nations represents approximately one-fourth of their total international investments (Wilson, 1997), but the magnitude of these operations is nevertheless significant. Much of the work performed in these plants consists of assembly work for apparel, electronics, and automotive parts, and operations are often labor intensive. While the movement of various manufacturing operations to locations where costs can be reduced and profits increased is good for business, caution is needed to be sure that basic human rights and worker health and safety are preserved.

Study of appropriate technology provides excellent opportunities to address moral and ethical issues related to labor. When manufacturing technologies are introduced in developing nations, economic benefits can be produced, but they must be balanced with appropriate regard for human rights and dignity. The extent to which a company is responsible for these issues, especially when competition is stiff and economic issues are pressing, is an important topic in the development technologically literate world citizens. When economic benefits are primarily focused on few individuals while the majority are relegated to unsafe work environments with minimal wages, moral and ethical issues are involved.

Nonrenewable Energy Resources

The introduction of new technologies in developing nations is contributing to significant increases in demand for commercial energy. Developing nations are expected to increase their share of world energy use by 40 percent by 2010 (World Resources Institute[b], 1999). The primary source of this new energy consumption will be fossil fuel – oil, natural gas, and coal. Even though these fuels produce fewer pollutants per unit of energy than other fuels typically used in developing countries, increased air pollution is anticipated as a result of expanded energy consumption.

Of greater concern are issues surrounding reliance on nonrenewable fuels. Estimates are for oil production to peak sometime between 2007 and 2019 (MacKenzie, 1996). As peak production approaches, oil prices will increase and will continue to do so as demand continues to grow. One likely outcome will be increased strain on the economies of developing nations who are dependent on fossil fuels for construction of basic infrastructure and least able to afford price increases. The result could well be disappointments or failures by developing nations to achieve the same technological prosperity modeled by industrialized nations.

Growing dependence on nonrenewable energy resources will likely contribute to continued dominance by industrialized nations within the realm of global economics. Unless some type of global political turmoil upsets the balance of power, the rich will likely get richer and the poor will get poorer. The construction of roads, bridges, dams, airports, seaports, transportation systems, schools, and government buildings require technologies that are heavily dependent on fuels such as diesel and gasoline. Once these types of structures are in place, maintenance requires similar technologies, but not to the extent that is required during initial construction. For that reason, developing nations without these features are apt to be much more needy of scarce petroleum resources while at the same time least able to thrive economically without them. Most industrialized nations developed these basic structures during years when petroleum costs were relatively low.

Appropriate technology enters the picture asking the difficult questions about alternative fuels, long-term planning, and encouraging a course of action that can be sustained in a competitive global environment. Perhaps rather than purchasing construction equipment that is lowest in initial cost and operates on diesel, expenditures would be made on equipment capable of operating on methanol or other alternative energy sources. Whether this particular illustration is practical or not, the approach should be one of thinking through the long-term consequences and using the best knowledge available to make decisions.

The moral and ethical issues involved should balance the interests of big business against the long-term good of people groups in developing nations. Sound education and advice with a view toward technological growth that is sustainable at the local level should underpin key decisions. In some instances, a somewhat altruistic approach would be needed on the part of those who might facilitate this process and this type of assistance would not necessarily come from people watching the bottom line of existing businesses. This assistance would more likely come from technologically literate citizens in industrialized nations seeking to both support developing nations as well as to preserve dwindling nonrenewable resources.

A somewhat more extreme position regarding use of nonrenewable resources such as petroleum for fuel is that burning of this material is not appropriate. The long and complex chemical molecules provided by petroleum are irreplaceable in the production of plastic and polymers. These materials are increasingly essential to modern life and without them, many benefits to both industrialized and developing nations would be deprived. For this reason, a rational case could be made that appropriate technology precludes the use of petroleum products for fuels when renewable resources could be used. This is a long-term perspective and one that would not be popular, but one that future citizens of the world might wish had been considered further.

Technology Education and Appropriate Technology

A key outcome of technology education as an educational discipline is the development of technologically literate citizens. As we have moved into a truly global economy, this perspective should be one of global citizens rather than citizens of a particular nation or territory. No longer is an isolationist outlook appropriate – certainly in a moral and ethical sense – when so many decisions in both business as well as in government influence peoples' lives around the globe. Students who will become future corporate leaders, consumers, and voters need to be aware of the balanced perspective available through a study of appropriate technology.

Society at the dawn of the 21st century is enamored with technology. Just as printed books were once considered the purveyor of truth, computers tend to be considered the source of truth in the present age. Whether in computing the magnitude of a consumer debt or calculating the risk involved in administering a new pharmaceutical, computers and information technology are central to decision-making and commercial activity.

Appropriate technology, without approaching the issue from a luddite perspective, provides opportunities for students to experience problem-solving opportunities and decision-making practices in situations where the latest microchip might not be the correct answer. In some instances, appropriate technology calls for applications of simple yet elegant solutions that were first developed long before the first printed circuit board or even the harnessing of electricity. Whether using a simple solar collector to heat water for bathing or applying strip-till techniques to the planting of crops, appropriate technology solutions are often devoid of the common assumptions underlying mainstream technologies.

By addressing the learning opportunities provided through appropriate technology instruction, students are taught to look beyond the obvious answers and to consider options that are innovative and creative. The thought processes involved are extremely valuable, but difficult to enhance within a context where correct answers are clearly available and often listed for odd numbered problems in the back of a textbook. Problems provided through appropriate technology are often ill-structured, have multiple possible solutions, and require considerable integration of math, science, and technology to solve.

With respect to moral and ethical issues, appropriate technology presents opportunities for students to include consideration of peoples' needs in a holistic manner and encourages consideration of long-term, sustainable benefits rather than temporary satisfaction or relief. With mainstream technologies, moral and ethical issues often fail to be considered – not because they are not relevant, but because society appears to have already resolved them. Within the context of accepted practice, it is difficult to have students seriously question practices that are assumed to be acceptable. Evidence of this is available in failed efforts at convincing people to carpool or use mass transportation even though there are ethical issues involved related to the conservation of resources and reduction of pollution.

Appropriate technology provides basic opportunities for technology education to educate students not only about the impact of technology on society, but also to consider issues such as civic responsibility care and concern for others, and personal and societal values. Students can be challenged to think about issues ranging from personal lifestyle to corporate responsibility. The end result is a better-informed citizenry and a more responsible worker, regardless of one's chosen occupation.

Review Questions

1. In some ways developing nations have a greater need for fossil fuels such as gasoline and diesel than do industrialized countries. Why is this the case and what are the moral and ethical ramifications of this issue?
2. If morals and ethics are to be addressed in schools, what standards should be used to determine "right" and "wrong?"
3. When multinational corporations locate factories in developing nations, the wages paid to local workers are often high as compared to other wages available locally but much lower than wages paid in industrialized nations for comparable work. Is this right or wrong? Why?
4. Provide a rationale for students in the United States to study air pollution problems in China. Give a minimum of three reasons for study of problems like this in other parts of the world.
5. Describe a reasonable approach for introducing new technologies into the marketplace of a developing nation. Use the five-step problem solving approach as an outline in preparing your comments (1-define the problem, 2-explore possible solutions, 3-select a solution using a systematic process, 4-implement the solution, 5-assess and revise the solution).
6. Develop a list of behaviors that that should be practiced by someone who truly supports sustainable technology and conservation of resources (turning lights off, avoiding unnecessary automobile trips,

etc.). Use this list to formulate a "Sustainable Technology Ethics Test" and pilot test it with students in a technology education class.

7. Past experiences have shown that the price of gasoline in the United States is a sensitive issue. When prices rise and stay high over an extended period of time, consumption is reduced. It is also clear that the rate of consumption of petroleum in the United States is much higher per capita than in most parts of the world. What arguments can be presented in support of adding taxes that raise the price of gasoline and using the funds generated to support development of alternative fuels? What arguments can be presented against this idea?

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Chapter 5

Design Criteria for Developing Appropriate Technology

Marie Hoepfl
Appalachian State University
Boone, North Carolina

Waste, especially when wasted, is a sure sign of bad design.
J. Baldwin

This chapter will explore the role of design in creating technological solutions that are in keeping with the goals and tenets of appropriate technology. While the characteristics and definition of appropriate technology are explored throughout this book, this chapter will focus on how these ideals are interpreted and implemented in practice through the following goals:

- Development of the relationship between appropriate technology and the emerging field of ecological design;
- Review of the underlying principles of ecological design, their application in a variety of contexts, and criteria for determining the appropriateness of design solutions; and
- Recommendation of ecological design criteria, within the context of appropriate technology, can be applied in technology education classrooms.

Design is the process through which human needs and wants are translated into physical form. The process involves a series of decisions about the specific characteristics of the designed object, system, or space. The appropriate technology movement that emerged in the late 1960s provided a framework for designing technological solutions that could be readily understood, operated and maintained by members of the community they served, while using minimal material resources and energy inputs. The concept of appropriate technology has evolved over the past three decades into an emphasis on *sustainability* of both natural and cultural resources for future generations. Design for sustainable living requires a commitment to new ways of addressing human needs and a re-examination of human wants, along with a deeper understanding of the natural world and its physical limits. The emerging field of ecological design provides a foundation upon which innovative technologies for the 21st Century can be built.

The Role of Design and the Designer

Design can be defined as “the intentional shaping of matter, energy, and process to meet a perceived need or desire” (Van der Ryn and Cowan, 1996, p. 8). Our technologies and the process of design are inextricably linked, for the creation of all human-built artifacts, environments and systems is the result of purposeful activity on the part of a designer, whether he or she is an architect, a farmer, a housewife, or a child. Design, whether we choose to call it that or not, is all around us.

The process of design is the critical link between what is valued in a culture and what the built world is like. As we survey the modern landscape, we may observe a number of technologies that are a detriment to humankind and the environment. In many ways, this problem exists because designers at all levels have become trapped in outmoded and wasteful, yet standardized, ways of doing things. What results is “dumb design,” according to Van der Ryn and Cowan (1996), or designs that fail to take into account human and environmental health and well-being. The human and environmental crises that result can thus be considered the consequences of a deeply imbedded, yet flawed, culture of design. “ We keep adding one technology to another like extension cords to a single outlet -- but we rarely stop to ask what we want those technologies to accomplish, other than speed, production, and profit” (Wann, 1995, p. 116).

On a global level, overconsumption on the part of industrialized nations has depleted their natural resource capital, and now threatens the resource base of many lesser-developed nations. Disparity between the wealthier consumers and the world’s poor is marked: the richest one fifth have 85 percent of the world’s income. Over 800 million people are chronically undernourished, contrasting with the problem of widespread obesity in the United States. Poverty can be just as incompatible with sustainable development as overconsumption is, since those in poverty strive first to meet basic needs and achieve a form of economic security (Carley & Spapens, 1998). Thus, environmental protection is a luxury they cannot afford. The overriding challenge for the coming decades is how to help people in developing nations reap some of the benefits of a market economy -- better nutrition, higher standards of material comfort -- without passing the costs of such development off on to the environment and to future generations.

Technological Choices

Designers work within a variety of constraints, and trade-offs are always involved. There are, first, the broad goals defined by the society or by the business plan: increases in productivity; greater market share; higher employment rates; more attractive communities; and so on. These set the stage for what kinds of decisions are made. Next come the more specific goals determined by the constraints of the system, such as material availability; human resources; energy inputs; and environmental conditions. Finally, designers must satisfy the technical constraints: how big should it be; what mechanisms will be employed; how will the materials be processed? The answers to these particular questions will depend on the larger goals and their relative importance. The goals of market economies dictate the trade-offs that will be accepted. If siting a pulp mill on a scenic riverway will lead to good jobs and economic development for the community, then the community will accept the trade-off of degraded water quality in the river. People may object, but the overriding concern that governs decision-making is toward the health of the market economy.

There is evidence that such trade-offs are no longer palatable, however. Surveys conducted in the United States in 1996 found that the majority of those polled reject trade-offs between different social needs, and believe that economic development, environmental protection, and the well-being of people can all be accommodated (DeSimone & Popoff, 1997). What results, then, is the goal of *optimizing* these apparently competing demands.

To illustrate this, we can examine a conventional view held by some economists regarding the economics of environmental protection. The *theory of optimal pollution* states that the costs of achieving environmental protection rise in an ever-increasing curve. According to this theory, "optimal" pollution is achieved when the cost of reducing pollution exactly matches the costs that would be incurred by not reducing pollution. The flaw in this view lies with the fact that it calculates costs in terms of cleaning up emissions "at the end of the pipe." It does not consider the economics of preventive action, which involves re-arranging the way we accomplish tasks, rather than reacting to problems after they occur. By implementing preventive measures within a system, much greater levels of environmental protection can be achieved at lower costs (Jackson, 1996). Designers can apply the concept of optimization to any set of desired goals.

Appropriate Design

"*Appropriateness* … must always be judged by a particular set of *values* and under particular *conditions.* One must always ask: Appropriate for what? Appropriate where? We can take seriously the insights of the appropriate technology movement, without making any list of specific characteristics absolute or universal" (Barbour, 1993, p. 247).

In the most basic sense, the goals of appropriate technology represent those fundamental human and social values that we would hope for all people. They include adequate food, good health, meaningful work, personal fulfillment, distributive justice, participatory freedom, and economic well-being. Increasingly, we see the need for coupling human values with environmental values such as resource sustainability, environmental protection, and respect for all forms of life (Barbour, 1993). Taken together, these form the underlying theme that guides appropriate technology design decisions.

The concept of appropriate technology, which emerged from the work of E.F. Schumacher in the 1950s and 1960s (Hazeltine and Bull, 1999), has thus evolved along with global economic changes, population growth, and a rising concern for the environment. It might be said that *sustainability* is the 1990s incarnation of appropriate technology. From their counterculture roots, the tenets of the appropriate technology movement are now emerging within a variety of more mainstream design trends, such as urban ecology, industrial ecology, sustainable development, and ecological design. An examination of these various trends will lead to a deeper understanding of appropriate design and the criteria that guide it.

Designing for People and the Environment: Ecological Design

John and Nancy Jack Todd describe ecological design as "design for human settlements that incorporates principles inherent in the natural world in order to sustain human population over a long span of time" (1984, p. 1). This approach is based on the belief that "if we are to continue to shelter and feed the people of the world in the coming centuries, we will have to design in a different way than we do now" (p. 12). That different approach must incorporate information about the potential consequences of technology for human life, society and the environment into the decision-making process (Vanderburg, 1999).

Ecological design is based on several precepts, including the following (adapted from Todd & Todd, 1984):

- *The living world is a model for all design*. The Gaia hypothesis posed by Margulis and Lovelock provides one way of looking at ecological design. In this view, the earth is seen as a system that maintains homeostatic conditions, “actively seeking to keep the environment optimal for life” (Todd & Todd, 1984, p. 20). For the designer, the recognition that all designs must operate within a highly complex, living system provides the basis from which design activity proceeds. Additionally, some of our greatest breakthroughs and creative solutions can arise by incorporating natural processes (e.g. decay, magnetism, photosynthesis, etc.) into our designs (Papanek, 1971; Van der Ryn & Cowan, 1996; Wann, 1996).

- *Design should follow, not oppose, the laws of nature.* All organisms are composed of cells that interact and cooperate with other cells. At the same time, the larger organism is interdependent with other life forms. This recognition of interdependence should inform all technological design as well. The natural process of succession in biological communities can also be incorporated into the designed world. In nature, succession leads to an increasing diversity of organisms within an ecosystem, creating a more stable and efficient system (Todd & Todd, 1984).
- *Design must be equitable.* Access to, and the distribution of, resources should not lead to great disparity between the “haves and have-nots.” This concept is also known as *distributive justice.*
- *Design must reflect bioregionality and regional culture.* A bioregion is an area that can be seen as topographically and climatically distinct from surrounding regions. The pueblos of the southwestern United States are an excellent example of bioregional shelter design (Todd & Todd, 1984). Standardized approaches to design cannot be expected to work in all cultures and all bioregions (Van der Ryn & Cowan, 1996).
- *Projects should be based on renewable energy resources.* Our dependency on non-renewable sources of energy “is one of the prime symptoms of the lack of resiliency that characterizes developed countries at present” (Todd & Todd, 1984, p. 58). One source of renewable energy that could be based on bioregional sources is the conversion of waste biomass. Examples are cotton gin trash in the areas of the South where cotton in grown; walnut and other nut shells in California; and logging waste in timber regions. The establishment of one of the world’s largest windfarms in the sparsely populated mountain passes of California is another example of a bioregionally appropriate energy resource.

- *Designers must explicitly consider the environmental impacts of their designs* (Van der Ryn & Cowan, 1996). Through new understandings in ecology, biology, cybernetics, and technology, humans are beginning to devise ways to restore the fabric of the natural world that has systematically been torn apart through human activity over the centuries. An example of this is the work being done by William McDonough, a Virginia-based architect and professor who has designed energy-efficient buildings for the likes of Wal-Mart, Herman Miller Furniture, and The Gap. These buildings use sustainably harvested woods, low toxicity finishes, and incorporate features like storm water runoff filters and an emphasis on interior air quality. Recently, McDonough and partners designed a biodegradable upholstery fabric made without the use of toxic chemicals. For McDonough, "'any emission [is] a signal of inefficiency'" (Litvan, 1996, p. 14).

The following can be considered a sort of checklist of foundational design criteria for appropriate technologies. They are:

- Small scale
- Affordable
- Energy efficient, using solar power resources where possible
- Environmentally sound
- Controlled and repairable by members of the local community
- Conducive to the good health of humans and habitat (Hazeltine & Bull, 1999; Wann, 1996).

The sections that follow offer examples to illustrate these criteria in more depth.

Urban ecology

There is growing interest in the design of communities that enhance the quality of life for residents by encouraging economic and cultural diversity and by encouraging increased use of public transport, walking and cycling (Berghall & Konvitz, 1997; Wann, 1996; Van der Ryn & Calthorpe, 1986). Curitiba, a Brazilian city of over 2 million people, provides a remarkable example of an urban area that works on a variety of levels. During the 1960s and 1970s urban planners made some key decisions regarding the nature of development that would take place in that rapidly growing city. Flooding, once a problem, was alleviated by prohibiting building in strategic low-lying areas, turning many riverbanks into parks, and creating lakes to hold floodwaters. The city reduced the need for high-cost flood mitigation technologies, and at the same time realized a 100-fold increase in the amount of green space per capita. Curitiba's public bus transportation system is considered one of "the most influential elements in accounting for the shape of the city" (Rabinovitch & Leitman, 1996, p. 48). By making bus transport faster, safer, cheaper, and more accessible, Curitiba achieved impressive results: three-fourths of all commuters take the bus; fuel consumption overall is 25 percent lower than in other Brazilian cities; and low-income residents spend only about 10 percent of their income on transportation. At the same time, the choice of buses over a subway system addressed some key criteria of appropriateness: the cost per kilometer of service was 300 percent lower, and bus operation and maintenance could be handled by local technicians. Pedestrian and bike paths that are integrated with a road network designed to reduce congestion, even in densely populated areas, complement the public transport system (Rabinovitch & Leitman, 1996; Zelov & Cousineau, 1997).

Industrial Ecology

Current practices in industry are increasingly seen to be too costly on a variety of levels in relation to the economic wealth they bring. The focus of industrial ecology is on rethinking these current, destructive practices. Industrial ecology is based on the implicit belief that industrial activity can be made sustainable in the long term by introducing new practices. Tibbs (1992) describes an industrial park in Denmark, in which an electrical plant, an oil refinery, a drywall manufacturer and others have coordinated efforts and material flows to the point where the "waste" from one becomes a key input to another. This reconceptualization of "wastes as products" is a model of industrial ecology that can be implemented widely (p. 9).

Another promising industrial practice is design for disassembly, which Fortune magazine calls "the hottest new production trend in the world" (Bylinsky, 1995, p. 103). Design for disassembly (DFD) means designing products that can be easily refurbished, reused, or safely disposed of at the end of their useful life. Several major industries are currently addressing the goals of DFD. For example, BMW recycles 80 percent (by weight) of its automobiles, with a goal of 95 percent. Hewlett-Packard and other manufacturers have significantly reduced the number of parts and the time required to disassemble obsolete computers, and to reuse the parts, including microchips. In Germany, "take-back" laws that make manufacturers responsible for what happens to product packaging resulted in a 600 million ton reduction in solid waste during the first two years after enactment. Companies like Colgate, responding to this legislation, created toothpaste tubes that stand on their heads, eliminating the need for a box. The second phase of Germany's take-back legislation requires manufacturers to recycle used products. Other European countries and Japan are likely to follow suit.

Cultural Implications: Industrialized versus Developing Nations

The appropriate technology (AT) movement that arose in industrialized nations shares many of the goals of appropriate technology in developing countries. However, "the issues in the North [are] the problems of overdevelopment, not underdevelopment; personal fulfillment, not unmet basic needs; and meaningful work, not the creation of jobs" (Barbour, 1993, p. 246). In spite of increased awareness about some of these issues, the problem of distributive justice remains a primary concern to those interested in the principles of the AT movement.

Lardner (1999) describes the latest wave of consumer spending in the United States, where the Department of Commerce estimates that more than 8 million households have average incomes of over $100,000. Evidence of the "urge to splurge" is ample: 20 million households have big-screen televisions; 4,000 + square-foot "McMansions" have proliferated across the nation; sport-utility vehicles have become the number-one selling class of vehicles in the country. Americans are "caught in an arms-race-like cycle in which a series of decisions, logical in themselves, add up to collective madness" (p. 52). Obviously, our consumption of resources has long since passed the realm of addressing needs and is fully and unabashedly in the realm of supplying frivolous and non-essential wants. Furthermore, we are as a society trapped in a paradigm of practice in which the scope of our consumption patterns is often obscured. The following "clothesline paradox," attributed to architect Steve Bauer, illustrates this problem:

> We drill for oil in Alaska, send it through pipelines, refine it, and ship it to an oil-fired electrical utility. The oil is burned, producing steam to push turbines that generate electricity. The electricity is sent out to the grid, traveling hundreds of miles with transmission losses along the way, and thence to your clothes dryer. Here the electrical energy is converted to the mechanical energy of the revolving drum and the thermal energy of the heating coil in your dryer, allowing your clothes to dry. On the other hand, you could have just hung your clothes out to dry on a clothesline! (van der Ryn & Cowan, 1996, p. 73).

Cultural blocks can prevent us from looking at things in new ways. Van der Ryn (1978) describes the history of human waste treatment over the centuries, and contrasts the approaches prevalent in industrialized nations like the United States with lesser developed countries like China. "Advanced" waste treatment systems use several gallons of fresh water, mix the water with the human waste, send it to a centralized facility where specialized machines then attempt to separate the waste and water, treat the water with chemicals, then (in many cases) send the chemically-treated brew back into the water supply. At the same time, the rich nutrients contained in the excreta are wasted, while farmers make use of expensive, artificial fertilizers that also do their part to pollute our water supplies. What is considered good practice in this country, presumably because, once flushed, the waste is "out of sight, out of mind," appears completely irrational when viewed through a different lens. By contrast, lesser-developed nations like China continue to make use of composted human waste as a source of natural fertilizer, without using large amounts of fresh water in the process.

Developing countries have the apparent goal of achieving, through industrialization, the level of material prosperity enjoyed in the West. This process is only intensified by developments in global communication capabilities. In spite of grave concerns on the part of industrialized nations that widespread industrialization and consumption at Western levels would be environmentally disastrous, "simple equity argues that it is also morally unavoidable." The challenge, then, is to help newly industrializing nations achieve prosperity with "intrinsically less environmentally demanding industrial patterns from the outset" (Tibbs, 1992, p. 14).

An established, measurable trend that has emerged in industrialized countries is that material and energy "intensity" in industrial products has declined, a trend Tibbs (1992) calls "dematerialization." This trend shows that economic growth can be decoupled from growth in material use. The process of dematerialization could be accelerated and integrated into an emerging industrial ecology in developing nations. At the same time, a commitment to the goals and principles of appropriate technology dictates a re-examination of consumption patterns in overdeveloped countries like the United States.

In the process of trying to help newly industrializing countries, designers and policy makers in the West must acknowledge that solutions that work well in their nations may be totally inappropriate elsewhere:

> In the mid-1950s, designers visiting the third world would sweep into a native region like white missionaries, forcing their wisdom on the natives. It took them years to realize that these people need half-horsepower tractors more than large combines…. Their hopes lie so close to sheer survival, their needs are so different from ours, that it is difficult to build bridges of understanding"”(Papanek, 1983, p.153).

Wicklein (1998) discusses seven criteria for appropriate technology in developing countries. These include being affordable and being able to function without extensive supporting facilities, but also address less obvious cultural factors such as the need for an “image of modernity” so that the technology appeals to the dignity of those who will use it. Another culture-bound criterion is the degree to which a new technology fits the collective versus individual priorities of the community, which can vary from place to place (p. 372).

<u>Applying Appropriate Technology Design Criteria in the Technology Education Classroom</u>

Design has long been a part of the industrial arts/technology education curriculum, and in recent years it has gained a renewed emphasis in many programs, largely due to the influence of the British Design Technology curriculum, and to the greater focus on constructivist learning. Certainly a strong rationale exists for including the process of design as a prominent feature of technology education. Educators must take care, however, not to employ methods and ways of thinking representative of the industrial age coming to a close. For example, writing prophetically three decades ago, Papanek (1971) noted that schools fall short in the area of locating and identifying problems. “Students in most learning situations are asked to solve projects. This means that a ‘special case’ situation is presented to the student, and the student is expected to regurgitate a ‘special case’ answer to the teacher” (p. 298). This approach engages students in design problems in the absence of a larger sociocultural context to give them greater import.

The technical efficiency model characteristic of 20th Century industry permeates technology education activities almost universally. Consider the CO2 car, the boat hull design, the assembly line, the bridge design projects: nearly all include a calculation of efficiency as a culminating evaluation of success. While admirable in its intent, this sort of exercise reduces design to the simplistic and somewhat myopic formula of maximizing efficiency. The more powerful challenge would be to optimize several desirable characteristics, such as resource and energy use; life span and life cycle costs; environmental impacts; and human health.

Selected Appropriate Design Tools for the Classroom

One tool that Papanek (1971) has used with his students, to help them keep track of the interrelated parameters one must consider in integrated design, is to construct a large, graphic flow chart in the classroom. The flow chart shows all the issues and ideas the teams generate for a particular situation, as well as the interrelationships between those parameters. Each flow chart remains a work in progress, as new ideas and linkages constantly emerge.

This is similar to the more formal tool known as a *life cycle analysis*. A life cycle analysis helps us trace the impacts of a design over its history. Both the design and purchase of a product provide an inherent, if indirect, support for all steps in its life cycle, placing a burden of responsibility to discover the effects of its creation and use. A life cycle analysis can turn up some surprising information about how raw materials were extracted; the human and environmental impacts of the various stages of processing those materials; the long-term effects of use of the product; and what happens to the product when its useful life is done (DeSimone & Popoff, 1997; Jackson, 1996; Van der Ryn & Cowan, 1996). This can be a systematic, powerful tool for helping students understand the far-reaching implications of what they design and/or use. That information can then be used to improve the products of design. A simple chart for documenting this type of "cradle to grave" examination is shown in Figure 1.

Place Figure 1 About Here

Another tool that designers can use is *technology assessment*. Technology assessment, like life-cycle analysis, tries to anticipate consequences of design or policy decisions beforehand, rather than waiting for them to happen. The unique power of technology assessment is that it attempts to identify the diverse groups who may be affected by a technology, and the variety of ways they might be impacted. It looks at the adverse social, political, environmental and economic impacts on the various stakeholders. In addition, technology assessment examines the differential effects of alternative policies or solutions, providing decision-makers with data to answer the question "If we do this, then what might occur?"

(Barbour, 1993). When this tool is applied to the design process, it helps identify alternative solutions earlier in the development process, when less is at stake. Perhaps more than any other tool, technology assessment can help designers address the broad principles of appropriate technology and sustainability.

Using components of Total Quality Management, such as Statistical Process Control (SPC), we can examine cause and effect by pursuing the root causes of problems. SPC involves monitoring the manufacturing process on an ongoing basis, and then addressing any production errors at their source, rather than fixing flawed products after the fact. Students can examine a negative outcome and ask the question "Why?" until they have traced the problem back to a potentially changeable source (Wann, 1996). Take, for example, the problem of tree death in the forests of Appalachia. Why did tree death occur? Because of acid rain. Why is the rain acidic? Because of the combined effects of industrial air pollutants in the air stream. Why are industrial emissions in the air stream? Because of large smokestacks designed to move exhaust away from its source. Etc., etc. "Analysis of how environmental damage happens reveals targets of opportunity for a new generation of designers. For example, if 40 percent of US energy is used in the construction and operation of buildings … [then] it's clear we need more efficient houses" (Wann, 1995, p. 116).

Papanek (1971), in helping his students understand that design solutions can come from nature, gave his students the challenge of examining a maple seed for two weeks, at the end of which they were asked to find a practical design application that used its general form and dynamic motion in flight (though not necessarily its size). Solutions ranged from a nighttime rescue flare, to a device for stocking fish in remote locations, to toys, to a means of extinguishing forest fires in remote areas (p. 177). William McDonough and his partners use a similar approach. In the design of buildings they ask the question "'how can we design a building like a tree, [which is] a fecund structure that purifies water and makes oxygen and food?'" In the design of a community center in Indiana, the team asked, '"What if a town were like a forest?" (Rosenblatt, 1999, p. 45).

Selected Examples of Appropriate Design

Design principles are usually easiest to describe through illustrative examples rather than simple definitions. Appropriateness, being both abstract and very much context-bound, is one of those principles. For this reason, several examples of designs that address the foundational criteria listed earlier in this chapter are provided.

Papanek and a student designed a hand-cranked refrigeration device for Third World citizens that could protect perishable food at about 40 degrees. The unit was inexpensively produced, ran on renewable energy, and was easy to operate and maintain (1971, p. 153). They gave their design to UNESCO, rather than trying to patent it or to make a profit on the idea themselves. In this example, we see the principles of ease of understanding, availability to the poor, and being conducive to the health of humans and habitat.

Van der Ryn & Cowan (1996) describe the work of Mel Chin, an artist working in the St. Paul area, who has experimented with the use of plants such as sweet corn, bladder campion, and other species known as “hyperaccumulators” because they are capable of taking up heavy metals in contaminated water and storing them. When dried and burned, these plants can then be “mined” for their heavy metals. Chin and his colleagues have had great success, through successive plantings of hyperaccumulators, in cleaning up contaminated landfill sites, and the recovered metals are sold to offset the cost of cleanup. In this example, we see the principles of being nontoxic (and actually contributing to a reduced toxicity in the environment), conducive to good health, and using natural processes as a model for design solutions.

Soybean-based inks, now used in over 75 percent of American newspapers, replace petroleum-based inks. The ink meets the needs of both press operators, who require that inks have certain physical characteristics, and newspaper managers, who look at cost, compatibility with existing systems, color, and other factors (Wann, 1996). Here, the principles of being nontoxic, more readily recyclable, conducive to good health, bioregionality, and use of naturally renewable materials are evident. Soybean-based inks would be an excellent example to apply the assessment/analysis tools described in the last section. A comparison of the effects of soy-based versus petroleum-based inks could readily show students how far-reaching the consequences of material selection decisions can be.

Design Challenges for the 21st Century

For the teacher who is committed to updating his or her program, and to developing in students a technological literacy that is consonant with 21st Century demands, incorporating an emphasis on appropriate technology for sustainable living seems crucial. Exciting challenges await both teachers and students beyond the well-used traditional design activities like bridge design. The list below, created from a variety of sources, provides the beginning of a list of significant design challenges that might be addressed instead:

- Exercising equipment for children and others with physical impairments
- Walking and other types of physical aids for the elderly

- Truly safe safety devices (goggles, hearing protection, shoes, etc.)
- Farm implements
- Agricultural techniques for organic farming, food storage, irrigation
- Anaerobic digesters for household use that will convert organic wastes to methane
- Communication tools for people without electricity
- Teaching and training devices for the handicapped
- Medical, surgery and hospital equipment
- Experimental research tools
- Systems for sustaining life under marginal conditions
- Re-use and different-use packaging
- Appliances that use decreased amounts of electricity and/or water
- Your ideas here

Summary

We have the inherent capability and inferentially the responsibility of making humanity comprehensively and sustainably successful.

~ Buckminster Fuller

In this chapter, we have examined the important role the designer plays in the development of technologies to meet human needs and desires. All of us are designers at one time or another. Individually and collectively, we make decisions about the physical form our design solutions will take, and must take responsibility for the impacts of those decisions. As the 21st Century begins, we are faced with a growing understanding of the problems, both local and global, caused by inappropriate design decisions.

The appropriate technology movement begun in the 1950s was one of the first efforts to critically examine technological choices on a global level (as opposed to more localized movements such as Luddism in 19th Century England). More recently, the principles of appropriate technology have evolved and been absorbed into the concept known as sustainability, which seeks levels of technological development that allow for the health of humans, cultures, and the environment over time. The emerging field known as ecological design addresses these broad goals, and provides very specific examples of how sustainability might be achieved.

As technological design continues to play a prominent role in the technology education curriculum, educators must become more knowledgeable about the precepts of appropriate design, and begin to incorporate them into the design challenges posed for our students. Technological literacy in the new millennium will not be complete without a deeper understanding of the human and environmental challenges we face, and the power of technology to meet them in a responsible way.

Review Questions and Topics

1. Identify and discuss at least six broad design criteria that appropriate designs attempt to address.
2. Standardization, according to Van der Ryn and Cowan, has led to “dumb designs” that fail to take into account human and environmental well-being. Give several examples of how standardization has led to positive outcomes, and several examples of how it has led to negative outcomes.
3. What can tools such as life cycle analysis and technology assessment do for the designer? Why should such tools be used?
4. Describe the concept of sustainability. How can ecological design contribute to sustainability?
5. What practices are becoming more commonplace in modern industries as they move away from the wasteful practices that have traditionally been used?
6. Do you feel the design approach described in this chapter is appropriate for the technology education classroom? Why or why not? How would you seek to implement this approach in your own classroom?

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Figure 1. Chart for documenting the analysis of a product's life cycle. (Adapted from Mackenzie, 1991, p. 36)

Environmental or Social Issue	**Product Life Cycle Stages**				
	Supply	**Production**	**Distribution**	**Use**	**Disposal**
Soil Contamination					
Water Pollution					
Air Pollution					
Waste of Material Resources					
Energy Consumption					
Noise Pollution					
Loss of Habitat					
Social/Cultural Changes					

Chapter 6

Cultural and Gender Issues In Appropriate Technology

Edward C. Pytlik & Ernest Frank III
West Virginia University
Morgantown, West Virginia

Anthony Akubue
St. Cloud State University
St. Cloud, Minnesota

The investigation into Appropriate Technology (AT) in the U. S. began with the realization by development experts and policy makers that technology transfers from the more industrialized countries were not improving conditions within the nations receiving the technology. The expectation that direct transfers of large-scale capital intensive technologies from highly developed countries (HDCs) to poorer lesser developed countries (LDCs) would initiate immediate economic and industrial expansion was negated by the many ancillary problems that such transfers induced. This transfer of technological systems from HDCs to LDCs failed to appreciate that development is primarily a social process and not a technological one. Jéquier (1976) noted that:

> Imports of foreign ideas, values and technologies have a major part to play [in development], but few societies in history have developed exclusively on the basis of such imports. One of the major tasks facing the developing countries is to create, nurture and … rehabilitate their internal capacity to invent and innovate. (p. 16)

Since its inception by E. F. Schumacher, AT has been redefined to the point where there now are almost as many definitions for it as there are for the term technology itself. The definition used in this text: *Appropriate Technology seeks to aid and support the human ability to understand, operate, and maintain technological systems to the benefit of humans while having the least negative societal and environmental impact on communities and the planet,* adds to this collection. For this chapter, its broadness is an asset, because cultural and gender issues are very often ignored when other, less inclusive definitions are used. This definition allows for the inclusion of discussions on the different levels of appropriateness and the differing types of needs required by the various societal levels and genders.

Cultural Differences & Needs

For most cultures, development is viewed in terms of growth in aggregate economic values, brought about through advanced technology-led industrialization. This approach to development has yielded phenomenal gains in global and national economies over the years in the U. S. and most other industrialized nations. For example, in only three decades LDCs have experienced the equivalent growth that took advanced economies a century or more to attain. However, the achievement of this unprecedented global prosperity has occurred simultaneously with the worsening conditions of global poverty, unemployment, and inequality. Worse still, the achievements in global technological and socioeconomic development have not been gender equal. The proceeds from developmental progress tend to accrue disproportionately to males. Studies by the United Nations Development Program (1995) indicated that
70% of the approximately 1.3 million people living in poverty in the LDCs were women. In its 1995 Human Development Report, the UNDP observed: "For too long, it was assumed that development was a process that lifts all ... that it was gender neutral in its impact. Experience teaches otherwise" (p. 1). Economic growth without redistribution does little or nothing to assist the poor.

The following sections compare and contrast cultural and gender needs as they apply to the development and/or transfer of appropriate and sustainable technologies in LDCs and HDCs. Each section focuses on a development sector essential for overall growth and progress in society.

Environmental Issues

LDCs

The predominant motivation behind much of the AT movement in LDCs has been economic in nature. Environmental issues within the AT movement in HDCs have been decidedly marginalized. This difference in perspective has been sharply felt, particularly by those in the AT movement who are trying to achieve an acceptable level of national development. Accusations have been made by critics that the introduction of environmental issues into the AT movement is a veiled mechanism for class-based diversions by the wealthy nations, away from the true problems of development.

Yet, environmental concerns have always been represented by the AT movement, even within the LDCs. For example, deforestation, soil erosion, river pollution, and solid waste treatment/recycling are all problematic in LDCs. The potential for fusing environmental concerns with economic development objectives may be seen in the increasing interest in waste recycling. However, the focus is only of a secondary nature. It is difficult to expect the poor to express any profound interest in environmental issues while enduring mass starvation and death through disease. Thus, while theoretically compatible with environmental concerns and acknowledging the relatedness of environmental issues to economic sustainability, the AT movement in the LDCs has generally emerged apart from the environmental movement.

<u>HDCs</u>

In contrast to the situation in LDCs, environmentalism has supplied a great impetus to the AT movement in HDCs. The recognition of the need for environmentally compatible technologies is largely the result of HDCs extensive use of environmentally destructive technologies. AT is seen as that which does not violate the ecological system beyond the point of viability. Agricultural technologies and practices that lead to deforestation and erosion are not appropriate because they are not sustainable practices. Appropriate technologies are only those that are environmentally compatible. Willoughby (1990) recommended that:

> waste products be re-used and recycled as much as possible; that maximum use be made of locally available resources, with technology being tailored to match those resources; that local and distant environmental impact be minimized where possible, with technology-practice taking full account of ecological principles and local ecosystems; that renewable resource supplies be used wherever possible; and that a transition to low-pollution, renewable-resource economy be pursued diligently. (p. 301)

<u>Energy</u>

<u>LDCs</u>

Schumacher stated that "energy is for the mechanical world what consciousness is for the human world. If energy fails, everything fails" (1973, p. 112). The economic prospects of the LDCs are directly related to the availability of energy. The dilemma is how to increase the energy use of the poor without causing undue pressures on global consumption and without creating too much dependence by the poor on essential resources over which they have little control and capacity to afford. Comprehensive energy planning is therefore a high priority for LDC’s.

Current development strategies run from the more traditional import-substituting industrialization to more radical alternatives that place severe limits on industrialization and propose near exclusive reliance on "soft" energy technologies at the household or village level. Such alternative strategies involve substantially less per capita energy consumption and are generally less well received among policy makers in LDCs.

There is, however, clear evidence that renewable energy technologies are available which conform to the AT rationale. Interest has been generated for using systems that digest organic waste for the production of both methane gas and fertilizer. Biogas digesters have proven effective and have been extensively adopted in many rural areas. In addition, such technologies as solar, wind, geothermal energy, and hydropower also are beginning to be used in LDCs.

HDCs

Interest in energy in the HDCs rose sharply as a result of the energy crisis in 1973. The crisis created shortages of gasoline and fuel oil, resulting in hours-long waits for fuel, gas stations running out of gasoline, and a sharp rise in fuel costs. These events reinforced the awareness of a need for energy diversification. Rapid investment into research on energy technologies was directed toward averting a repetition of the events of 1973. It focused on what the AT movement was advocating for LDCs and attempted to transfer some of the research and perspective to the HDCs. The primary nexus between energy and AT in HDCs was the notion espoused by Amory Lovins (1975) of soft and hard energy systems. Lovins rejected the notion that the options for energy supply and demand were technologically determined and not open to human choice. He defended on both ethical and economic grounds the view that urban-industrialized societies need to transition from the dominant hard energy strategy to an alternative soft energy strategy. He believed that the hard energy strategy was maintained only by distortions in the market, such as massive government subsidies, and by inadequate dissemination of knowledge about soft energy alternatives.

Shelter

LDCs

LDCs approach shelter from the pragmatic perspective of human needs and available resources. Indigenous cultures abound with examples of shelter systems uniquely adapted to particular locales and the availability and use of local building materials. Local use of construction materials historically have varied from the ice and snow in traditional arctic igloos, to mud brick construction in semi-arid plains, to pole and thatch structures in jungles. These traditional materials and shelter systems are natural and renewable. As traditional lifestyles are displaced and people move toward industrial development, the problem becomes one of incorporating elements of the new technologies without abandoning the effective and culture-laden elements of the old.

An AT example for implementing this perspective is the Grameen Bank Housing Project in Bangladesh (Steele, 1997). Begun in 1976 by Dr. Mohammed Yunus, the project provides loans and a building package for the rural poor. The structure is comprised of prefabricated reinforced concrete columns at each corner of a rectangular slab. Concrete is used because of endemic termite problems and replaces traditional wood columns. Corrugated metal is used for the roof for the same reason. The intermediate structural members and partitions are of bamboo or jute. Flooring is of rammed earth. The package includes a prefabricated sanitary latrine.

A more urban example of the LDCs perspective on appropriate shelter technologies is the urban housing project in Sana'a, Yemen, designed by the Jordanian architect Rasem Badran, (Steele, 1997). Badran used an approach that was sensitive to socio-cultural, environmental, and technical factors in the design of tower houses oriented to sun and natural ventilation, using locally acquired stone and brick. The design was purposefully taken from the housing system of the earlier nomadic agricultural society in the region.

HDCs

In the HDCs, increasing concern for the ecosystem has produced an interest in what has been termed Green, Ecological, Biological, Sustainable, or Gaia Architecture. These terms refer to designing shelter systems in concert with natural systems in an environmentally responsible manner. Sustainability, described as meeting the needs of the present without compromising the ability of future generations to meet their own needs (McDonough, 1992), provides the principle AT concept.

Many of the advances in the AT movement in HDCs relate to the issue of shelter design and energy conservation. The oil crisis and the resultant tax credits for energy efficiency resulted in an expansive research effort into shelter and energy conservation technologies. Projects launched by government agencies, universities, private organizations, and individuals continue to provide proof of the efficiency and viability of these technologies.

At the beginning of the third millennium, as the world becomes smaller and the interrelationships between nations more delicate, it is increasingly important to find ways to be appropriately sheltered in an environmentally efficient, energy-responsive, manner that does not compromise the ability of our children and their children to do the same.

Industry/Manufacturing

LDCs

Industrial or manufacturing technology transferred to LDCs, is very often modern technology and capital intensive. That this type of technology transfer has been, in many cases, extremely unsuccessful, seems to have eluded "development experts" for some 50 years. One example of this lack of success was described by Sow (1999) in the Courier. The article evaluated the textile industry in 7 West African countries belonging to the West African Economic and Monetary Union (WEAMU), where European industrialists began setting up spinning, weaving, and dying units in 1950. A summary of the units evaluated included such comments as: poor material, energy and machine output problems; equipment in bad shape; very high energy costs; irregular production; operates at 10% of capacity; (p. 84). In the conclusion the author asks the question, "Is it illogical to envisage, rather than large, single-product companies, smaller concerns that seek to satisfy the needs of the local markets?" (p. 85).

Another example of technology transfer failure is the export processing zones (EPZs), special areas in LDCs where unfinished products are shipped for assembly or completion of manufacture and then re-exported, duty free. Located mostly in Asia and Latin America, these free trade zones evolved in the 1960's to help stem the flow of illegal immigrants into the U. S. and to help bring LDCs into the modern industrial world. One description of an EPZ stated: "Hot, unventilated, and overcrowded workplaces, abuse, sexual harassment, unpaid overtime, and dismissal for pregnancy: these are just a few of the labor issues faced by the more than 335,000 factory workers – most of them female – in Central America's five free trade zones" (LaCroix, 1998, P. 24). Clearly, these sites, where normal working hours may run 80 to 90 hours a week for a salary of approximately $75 a month, do not qualify as AT sites.

In order to find examples of AT in LDCs it is often necessary to look to the indigenous manufacturing industries. These small-scale industries are often designed to solve in-country problems. One of many examples can be found in Tanzania, where two budding, small-scale industries are aiding in the solution to a major environmental problem, deforestation. One company has developed a local charcoal briquette that is smokeless, produces no soot, and is more dense, more porous, and breaks less easily than traditional charcoal. A competing company, a sugar producing company, has developed a secondary industry, manufacturing briquettes from bagasse, the residual cane by-product from the manufacture of sugar. These products are being touted for use in a clay stove designed by the government. (Kigotho, 1999).

The success of this project exemplifies how AT can be developed collaboratively. The partial solution to a national problem was realized through the combined activities of local entrepreneurs and government-affiliated scientific researchers. Many local industrial developments are beginning to evolve in the LDCs. Local entrepreneurship, coupled with indigenous research operations, are beginning to create technologies that are truly appropriate – to the locale, the environment, the economy, and most important of all, to the people themselves.

HDCs

The vast majority of industrial enterprises within the HDCs manufacturing sector are not employing AT. In general, they are not efficient in their use of non-renewable resources nor are they labor intensive. They are rarely friendly to the environment, and as corporate consolidation, expansion, and growth are their major goals, they often are not concerned with local issues. As such they do not fall into the category of AT. On the other hand, these highly technologically developed and capital-intensive enterprises have been responsible for unprecedented economic growth since the end of WW II and have produced prosperity (at least for some) unparalleled in the history of humankind. It is this industrial replication that economic development programs, often sponsored and supported by HDC multi-national corporations, are trying to duplicate in the LDCs. And therein lies the dilemma.

It is evident that there are insufficient amounts of non-renewable resources available for the rest of the world to duplicate the industrial enterprises found in the HDCs. Even if there were, the resultant environmental degradation would soon render this planet useless to many of the existing forms of life. Alternatives must be found that will bring to the inhabitants of the LDCs at least some of the economic fruits enjoyed by the majority in the HDCs.

The use of passive solar energy, photo-voltaic cells, wind energy, hydropower and pedal power have not yet found their niche in mainstream modern manufacturing centers, as they have in energy production and in the agricultural and transportation sectors. But research in their future utilization in manufacturing is being conducted at research centers and universities in many HDCs throughout the industrialized world. It can only be hoped that significant breakthroughs will be made in the near future.

Agriculture

LDCs

As with the industrial enterprises, the LDCs again were on the receiving end of the transfer of modern practices. Collectively entitled the Green Revolution and begun in the 1950's, a variety of programs were designed to bring modernization to the LDCs agricultural systems. Supported by agencies such as USAID, UNDP, and the Ford and Rockefeller Foundations, these programs are touted as being highly successful. Millions of people throughout the world reportedly have been brought from the brink of disaster into a modern self-sufficient world. India for example, once known for its starving millions, is now said to be growing sufficient food to supply its total population.

But other data do not bear out the breadth of the purported successes. A study done for the National Science Foundation in 1997 (Pytlik, Vasudevan, Bayles, & Spitznogle) revealed that, despite the spending of more than $6 billion over a 10 year period (1985-1995) just on science and technology related agricultural projects, half of the 103 LDCs surveyed were producing less food. These figures were calculated for both the actual amount of food produced and a food-per-capita basis. One country was producing 43% less food and two others each were producing 36% less food.

The discrepancy in the reported success of agricultural-based technology transfers could be because the agribusiness-type of transfers often aid the already wealthy. It is they who can afford the expensive chemical fertilizers and pesticides, modern farming equipment, imported hybrid seed, irrigation systems, and are able to purchase the large tracts of land necessary for this technology to be successful. Evaluations of these lands would produce positive results. But these results have also produced the same type of environmental degradation as described below in the HDCs.

Obviously, these results are not examples of appropriate or sustainable agricultural technology. But not all modern technology is necessarily inappropriate or destructive. Sometimes appropriate agricultural technology can be found through melding the traditional techniques with modern technology. In the Kenyan highlands for example, where the potential for agriculture is among the highest on the African continent, crops produced by nearly 10 million subsistence farmers are often small, sickly, and diseased. Maize farmers produce an average of a single ton per hectare, in an area that should produce 10 times that much. The problem lies in the soil. It contains an insignificant amount of phosphorus, and the traditional method of fertilizing, composting, produces only tiny amounts of phosphorus. Chemical fertilizers would solve the problem, but few can afford this modern alternative.

Scientists from the Kenya Forestry Research Institute were asked to find a solution to the problem using a local, inexpensive technology. They found that "the leaves of the *tithonia* shrub can be used to double or triple maize yields when used either alone or in combination with phosphorus fertilizer. Fresh *tithonia* leaves contain high amounts of several nutrients required by the crop, including phosphorus" (Legault, 1998, p. 7). Introduced into Kenya in the 1920's as a boundary marker, the *tithonia* shrub became a truly appropriate fertilizer, thanks to modern scientific technology and research.

HDCs

The U. S. has the world's most sophisticated and efficient agricultural production system. The mix of modern technological developments, economic enterprise, and corporate industry have created an agribusiness that feeds, not only U. S. citizens, but substantially adds to the food consumed by many of the 6 billion people throughout the world. This highly efficient system provides, for U. S. citizens, an average of 3500 calories per person, and does so while employing less that 3% of the population in growing this food. But the costs are high, some say too high, even for the substantial benefits produced.

Included in these costs is the virtual demise of the small family farm, which was noted for its use of sustainable AT. The traditional small family farm was a multi-crop enterprise. Vegetables, fruits, berries, and fodder for a variety of animals were grown for both market and home consumption. The additional cash crop provided money to purchase “outside” necessities. Natural fertilizers were commonly used and weeds were tilled under rather than chemically destroyed. Chemicals were used sparingly and only when no other alternative was available. Work was long and hard, but the rewards were many. Few jobs provide the satisfaction the small family farmer felt at the end of the day.

Unfortunately, every year, more family farms are being consumed by large corporate operations. The conversion to a system of mono-cropping of both plants and animals is now almost universal. Residual chemicals from the overuse of pesticides and artificial fertilizers are fouling land and waterways at an unprecedented rate. This modern type of agriculture leads to the yearly loss of nearly 5 billion tons of prime U. S. topsoil, an average of 10 pounds of soil lost for every pound of grain produced. In addition, there is a high dependence on biotechnology and the use of hybrid seeds, and consequently, an increase in the loss of natural seed strains. Finally, feedlots concentrate large numbers of animals such as hogs and chickens into torturously confining cages. When their effluent leaches into surrounding waterways it can cause disease in fish and animals, as well as humans, who come in contact with this contaminated environment.

Transportation

LDCs

At the beginning of the 21st century, the major transportation concerns in LDCs are appropriately focused on particulate pollution in cities from poorly maintained vehicles, inadequate and frequently ignored pollution regulations, gridlock caused by inadequate traffic control systems, animal powered vehicles sharing streets with motorized vehicles, and vehicle safety.

The one exception is Brazil. Begun as a way to reduce dependence on imported oil and as a way to utilize excess sugar cane production, Brazil has had an ethanol program, some say the world’s most successful alternate fuel program, since 1979. The program now includes virtually all of Brazil’s autos. Most are fueled with 22% ethanol blends, but more that 4 million of Brazil’s vehicles operate on 95% ethanol. Even though the reasons for the initiation of the program have diminished and it still must be federally subsidized to make the fuel economically acceptable, the program has continued unabated because of its success in reducing air pollution and mitigating global warming.

HDCs

The transportation sector is one area where appropriate and sustainable development theory have been put to use in the U. S. Americans have had an unprecedented love affair with the automobile ever since Henry Ford developed the inexpensive Model T in 1908. Sixty years later, faced with unacceptable urban pollution caused, at least in part, by an overabundance of automobiles using highly inefficient, gasoline powered, internal combustion engines, Federal and State governments began legislating numerous restrictions to rectify the problem. These regulations have resulted in the automobile industry and gasoline producers developing new innovative, appropriate, and less polluting ways for urban dwellers to transport themselves. Research on alternative fueled vehicles has been undertaken by most of America's major automobile manufacturers and in other HDCs as well.

Some alternative fueled research continues to focus on fossil fuel, while other projects focus on vehicles powered by direct solar gain or battery power. Regarding the fossil fuel research, the use of compressed natural gas (CNG), liquefied natural gas (LNG), liquefied petroleum gas (LPG), ethanol, and methanol are being tested in automobiles, trucks, and busses throughout the U. S. But only 4% of the 50,000 transit buses in our cities are alternative fuel vehicles, operating on fuel other than gasoline or diesel.

In 1999, the Ford Motor Company offered 9 vehicles that either ran on straight CNG, had bi-fuel systems of CNG and gasoline or LPG and gasoline, or ran on an ethanol and gasoline mix. Dodge had available vans fueled by CNG or an ethanol and gasoline mix. Chevrolet and GMC had vehicles that were fueled with a bi-fuel system of CNG and gasoline, and Honda had available a straight CNG vehicle. Many more companies were involved in electric vehicle research, with Chevrolet, GMC, Solectra, Honda, Chrysler, Nissan, Toyota, and Ford all having electric vehicles available in 1999. These vehicles were powered by either lead-acid, nickel metal hydride (NiMH), or nickel cadmium (NiCd) batteries. Still in the prototype stage, these vehicles were available only through leasing agreements with the manufacturers.

These examples of research into alternate fueled vehicles in the U. S. exemplify the type of research being conducted in many of the HDCs. It is expensive for the automobile manufacturers, and, through federal and state subsidies, expensive to the individual. But for the level of technology that the HDCs are at, and the needs they have, this type of technological development is appropriate.

The sector examples discussed above clearly indicate that AT has a totally different meaning in the LDCs than it does in the HDCs. Where a country is located on the development continuum determines which technology is appropriate for its constituents and which is not. Clearly then, general lists of “appropriate” or “inappropriate” technologies are themselves inappropriate.

Gender Factors Related to AT for Third World Development

A common assumption in technological and socioeconomic development planning is that development is gender neutral. This partly explains why many target groups for projects are given genderless names such as "small farmers" or "the rural poor" (Ostergaard, 1992). While the use of such terms leaves the impression that these groups are men, the reality is that many of them are groups of women. Contrary to conventional thinking, technological and socioeconomic development does not have the same impact on males and females. Women make up more than two-thirds of the 1.3 billion people living in poverty today in the LDC’s. It is not uncommon for the impact of a development project to increase earnings or labor-saving techniques for the males while also increasing the unremunerated workload for the females.

Since women have less access to technology and other resources in rural areas of LDCs, they often carry out multiple and time-consuming tasks with skills and tools that have hardly changed for generations. It is not uncommon for rural LDC women to perform traditional subsistence activities such as farming, food production and processing, weaving and sewing, soap-making, petty trading, craft-making, cooking, shop-keeping, fetching fuel wood and water, household chores, and child and elderly care. (Akubue, 1995). Without access to technology, education, technical training, land, credit, and basic needs, the development of women's motor, cognitive, technical and interpersonal skills are adversely effected. Consequently these women assume subordinate roles to men because their traditional tools and skills are not compatible with those necessary to conduct modern mechanized agriculture and industrial production.

To resolve this tool and skill disparity will require that more women become involved in the decision making, planning, and designing of technology-based development projects, and that the introduced technologies be appropriate to their capabilities. AT can improve women's productivity and save them time for other activities only if they become part of the decision-making body and/or have a means of communicating their needs to decision makers. In reality, women are rarely involved or consulted when development projects and programs that directly effect their lives are planned or designed. Development of technologies for women's use without their input often result in unsuccessful development efforts.

Sometimes an AT may not apply universally. Some technologies may be appropriate only in one region but not in another. As Bourque and Warren (1987) pointed out, "what may appear appropriate to engineers and development workers may not be at all appropriate to the people expected to use the new techniques" (p. 179). The case of solar cookers in India and Kenya seemed like an excellent example of AT considering the decimation of forests because of fuel wood needs. Children often spend hours away from school in search of wood for family cooking. As logical as the solar cooker appeared, it was not embraced enthusiastically by the rural women. Since the solar cooker must always be facing directly into the sun, it must be constantly adjusted to track the sun's changing position. Furthermore, solar cookers designed to make use of a small pot are inadequate when the needs of large families are considered. Finally, in many LDCs, the main meal of the day is prepared in the evening when the women return from the fields (Carr, 1985). Obviously the solar cooker will not work after sunset.

Women will not change their traditional lifestyle to accommodate a new technological device. Besides, AT is an approach that is supposed to adjust technology to people's circumstances, instead of forcing people to adapt to it. Unless action is taken to involve women in all aspects of decision making in technological and socioeconomic development so that it becomes truly appropriate for them, their plight will continue to go unheeded and their access to resources will continue to be limited.

Summary

To summarize, throughout the lesser-developed world, both gender and culture often have been neglected when AT-based development programs, designed to improve indigenous quality of life, have been implemented. Too often, the prescribed technology is inappropriate for the society. It may be too sophisticated for the local educational level, too expensive, maintenance personnel and/or parts may not be available, or it may be designed for men but women are the ones responsible for the activity in that culture.

It is difficult for those of us with highly developed technological skills to comprehend how drastically these proposed programs change the lives of the recipients. Try to imagine an alien group from a distant planet suddenly appearing in your community. They look human but dress differently. They talk in an undecipherable language, but are attempting to learn English. Their objective is to show you how unsophisticated your way of life is. Life would be so much more rewarding, they explain, if you didn't have to spend from 12 to 22 years becoming educated. All you need is to have a small device implanted into your brain, at no cost. Then when you want to know about a particular technology, you simply program your personnel digital processor (carried conveniently in a belt pouch) and instantly, you would "know" the information.

How many of you would rush to accept this previously unknown, untried technology? Would not most of you prefer the old fashioned, slow, but tried and true technology of schooling? Suppose a few tried it and for some it was successful, but many others wound up with less knowledge that before because of "unforeseen circumstances". Suppose those few that did accept the implant, even though it was successful, were ridiculed and ostracized by their friends and neighbors? Suppose two years later the aliens came back and said "Oops, we thought we had the answer to your education problem, but there was a glitch in the implant program. But we have fixed the glitch, and now the system works even better." How many of you would now sign up to try this new technology?

Science fiction? Perhaps, but it typifies the scenarios and decisions that persons in LDC's are asked to make daily about new "appropriate" technologies. The question of course is, appropriate to whom? On what basis do they make the decision about accepting the new seed, fertilizer, manufacturing, or building technique? It is equivalent in every way to your having to make a decision about the brain implant. You both are being asked literally to put your life in the hands of an unknown technology. If successful, your life will be far better. But if not, then what?

Which choice would you make? Why?

Review Questions

1. What criteria determine whether or not a country is seen as an LDC or an HDC?
2. Discuss why in some areas of a given country (LDC or HDC) a particular technology is seen as appropriate, while in another area it may be deemed inappropriate.

3. The authors chose 6 societal sectors to exemplify how AT differs in LDC's and HDC's. What other sectors could they have chosen? Why?
4. What factors have allowed poverty, unemployment, and inequality to continue in some areas while the world economy in general has achieved unprecedented prosperity?
5. What can be done to ensure that a newly introduced AT is acceptable to women?
6. Why is it necessary to include women or seek their input in planning technology and the design and implementation of development programs?

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Chapter 7

School-Based Issues and Appropriate Technology

Peter Wright
California University of Pennsylvania
California, Pennsylvania

This chapter provides an understanding of why appropriate technology content and themes should be a part of every technology education classroom. The foundational concepts of appropriate technology are also described and applied to specific areas of technology education activities and content through the use of various appropriate technology themes and related methods. A discussion of how appropriate technology content can be incorporated at various age and grade levels is also included.

Three major goals make up the focus for this chapter, they are:

- Discussion of four objectives of technology education which can be best achieved with appropriate technology content;
- Discussion related to adapting appropriate technology activities to elementary, middle school, high school, and post-secondary students enrolled in technology education programs; and
- Presentation of the following appropriate-technology-related content and methodology strands and examples of their application in the technology education classroom. The strands include: basic human needs; technology assessment and impacts analysis; global content; technology transfer; involvement and research in local communities; and problem-based education.

Appropriate Technology and Technology Education Curriculum

A major emphasis in technology education is on the design process. Standard eight (8) of the Standards for technological literacy (2000, pp. 90-112) document addresses the content of design in the technological process. A significant component of technological design process is to identify human wants and needs. After these wants and needs are identified, the "designer must determine how to satisfy or solve them" (p. 90). In addition to identification of human wants and needs, the text noted that time, money, and resources are also major constraints of design and that efficiency is a major goal.

While this model is intellectually valid, it suffers from a serious limitation of vision because there is no mention of social or environmental contexts. The implication is that any device can and should be designed if someone feels they need or want it. In reality, the assessment and consideration of the impacts of technological systems should come before they are created, and this assessment should comprise an integral part of the design process.

The consideration of impacts, materials sources, sustainability, and waste streams is an integral part of any system of appropriate technology. In addition, it is critical for communities to assess new technological systems which will be adopted by, or placed in, their communities in advance of their implementation. Who in the community will be able to conduct these efforts if not students who have been through a strong technology education program with appropriate technology content as part of their general education?

Goals of appropriate technology content in the technology education curriculum include increasing the students' ability to:

- analyze systems in a broader perspective;
- become more aware of international dimensions;
- value technological systems and processes; and
- think critically.

Each of these goals represents an aspect of current technology education which is under-represented in the curriculum as it is actually taught today in most settings.

Analyze Systems in Broader Perspective

The use of appropriate technology content in the technology education classroom enables students to view technological systems in a broader perspective. In the analysis and assessment of particular technological systems, the students should become much more aware of many interrelated aspects of the system being studied.

In a manufacturing process students need to know how products are manufactured efficiently and how to physically manufacture items. In additon, during the study of a particular manufacturing process in their community, facts students should become aware of include:

- the source of materials being used,
- the ownership and control of the machines and processes used,
- and the nature of any waste and/or toxins released during the process and its precursor processes.

Become More Aware of International Dimensions

In an age when a small portion of the world's population consumes a large share of world resources, it is important to consider global factors when making technological choices. The radioactive fallout from the Chernobyl nuclear accident was detected around the globe. When people in developing countries cannot obtain fuel for cooking, they often strip the trees for miles around their communities, thereby leading to deforestation and probable increases in both flooding and droughts. As fish trawlers have become more efficient and wide ranging, international tensions have increased over territorial waters and coastal fishers have often found their livelihood vanishing (Brown et al, 1999).

Knowledge of lives, resources, and problems in other countries related to rapidly evolving technological systems is critical for tomorrow's citizens. Appropriate technology content can increase awareness of global issues and interactions. This area is also commonly neglected in current practice.

Value Technological Systems and Processes

As students grow into adults and accept a full role in society, their ability to value technological systems becomes increasingly important. Whether deciding which type of housing to purchase or voting on the Stars Wars missile defense system, citizens need valuing skills. Students should be able to apply their values in a conscious way to their technological choices. This valuing and assessing process should occur before any specific design process, rather than be included as an afterthought, or left out entirely, as is currently the norm.

However, incorporating *valuing* in technology education courses does not mean teaching specific values. Appropriate technology is a conceptual framework for valuing technological choices, but it is not the only such system - or even the best one. Other valuing frameworks which should be taught in connection with technology include maximizing return on capital and maximizing personal comfort and convenience.

Think Critically

Informed voters in a democracy need to be able to ask questions and critically evaluate the strength and veracity of the answers received. In an age where political "spin", propaganda, and highly sophisticated advertising are endemic, it is imperative for students to be able to think critically. Appropriate technology content will facilitate the ability of students to evaluate societal choices using a coherent framework.

Technology Assessment is the process of systematically analyzing the impacts of a given technological system using criteria developed by the people doing the analysis. An Environmental Impact Statement (EIS) for a new highway is an example of Technology Assessment, but so is a community analyzing the worth of inviting or rejecting a new toxic waste incinerator using criteria such as economic, environmental and social impacts.

Any proposed technological change can be evaluated against other societal choices in a systematic manner using Technology Assessment tools. It can be assessed in regards to how it helps or hinders communities from meeting their basic human needs for shelter, food, health care, clean air and water, productive jobs, and so on. This focus will help students later to ask questions and think critically before speaking out or voting on societal choices, particularly as they relate to technology.

Appropriate Technology Content by Educational Level

As with all technology curriculum, appropriate technology content must be varied according to the age, interests, and abilities of the students. What follows is a general overview of the major themes of appropriate technology content which might be stressed at different educational levels.

Appropriate Technology at the Elementary Level

Elementary students need to understand that all technological systems, both new and old, have impacts which are both positive and negative. In other words, not all technology is good for the lives of all people. They can then discuss technological changes which they like and those which might have hurt some people. Obviously this conversation should be structured on a basic level with such innovations as guns, computers, cars, etc. discussed.

For elementary level activities, any type of design and build activity is appropriate (provided it is safe). Having students wrestle with design problems and real materials is such an improvement over the neglect that technology usually receives in the elementary curriculum that it should be encouraged. Obviously, an activity related to food or shelter is usually more relevant than a consumption-based activity. Any mention of global issues related to resource use and misuse, climate change, and food issues are also welcomed if they can be explained at the student's level.

Appropriate Technology at the Middle School Level

At the middle school level teachers can implement activities designed to connect students with their communities and technological systems and choices. Students can study the community's water, waste, and food supply systems, for example and conduct related activities. In this way, the critical thinking focus can be continued.

Design and build projects are important for the always-active middle school students. As much as possible, these can be broadened by considering the source of materials used, the purposes and impacts of the artifacts being created, and the ultimate effects of the waste and products being created.

Appropriate Technology at the High School Level

As students progress through high school, both global concerns and the valuing of technology can play larger roles in the curriculum. In addition, classroom activities and problems can become somewhat more elaborate. International issues, such as the decline in world fish harvest, or the world food distribution and supply problems can be investigated and then serve as the basis of classroom activities (in this case, such as hydroponics and aquaculture). Simple problems can form the basis of classroom activities, such as challenging students to devise a way to boil 8 ounces of water using only solar power.

On a local level, students can test local air and water sources for pollutants and try to determine their sources. In addition, students can take a local technology-related issue (such as a proposed heavy industry or new sewage system) and conduct their own analysis of the potential benefits and costs of its implementation. A debate permitting both sides to be heard can help stress the message that all opinions are important, but that they must be supported by facts if they are to be successful.

Appropriate Technology at the Post-Secondary Level

At the post-secondary level, the possibilities are unlimited. Using a problem-based education model, students can be placed with an open-ended real-world problem and left to conduct research and then propose and test solutions. All of the activities described above can be conducted on a more elaborate and student-directed level. In addition, the global connections and content can become more elaborate as students research skills and background knowledge should be relatively extensive.

A solar car project can be quite useful, but time should also be devoted to the science of solar energy and the issues related to fossil fuels and the amount of each fuel being consumed annually compared to known reserves. Elaborate tests of energy efficiency can be conducted on construction and insulation systems. The total life cycle cost of an automobile can be calculated including fuel and maintenance. Alternatives to mass consumption and standard technological solutions can be investigated, designed, constructed and demonstrated.

Using Appropriate Technology Themes in Technology Education

The following seven themes reflect concepts and provide perspectives on incorporating them into technology education curricula and activities. Following this, a sample activity pattern will be suggested in more detail. The ideas provided are intended to stimulate teachers to develop specific activities and curricular content which will fit their communities and their students abilities and interests.

Basic Human Needs - Appropriate Technology Concept

One of the key aspects of appropriate technology is its emphasis on using technological systems to effectively meet basic human needs. In other words, a community should first consider how its basic needs are being met and how much cost and control are being given up to meet them. Consideration of secondary wants and desires is secondary to meeting the community's basic needs in an economical and non-destructive way which leaves them with maximum self-sufficiency and technological choices.

Most lists of basic human needs include: Food, Water, Clothing, Shelter, and Medical Systems. Burkey's definition stated:

> "Basic needs are those things that an individual must have in order to survive as a human being. Essentially these are clean (unpolluted) air and water, adequate and balanced food, physical and emotional security, physical and mental rest, and culturally and climatically appropriate clothing and shelter."

Burkey, 1993, p. 3

Basic Human Needs - Application to Technology Education Classroom

While basic human needs is not itself technology content, it provides a very useful framework for generating and valuing technology curriculum ideas. In general, an activity related to meeting people's basic human needs is more relevant than one based on pure consumption-based or style-based products.

While shelter systems are addressed in the Construction area (although usually in an extremely limited manner), the areas of food, clothing, water and medical technologies are often totally neglected. An area of critical importance to human survival, food storage and transport, is hardly ever mentioned in technology programs even though these issues are essential in developing technological literacy.

Questions which could be used to challenge technology students include:

- What is the best way to store tomatoes and transport them in quantity?
- Is it cheaper to grow vegetables in Michigan under greenhouses in the winter or to transport them from Northern Mexico?
- What other impacts do the above choices involve?
- If you wanted to grow hydroponic vegetables in your area, what techniques and equipment would be used?

Obviously, a lab activity which involves designing and building an indoor food production system would provide a strong background to enable students to wrestle with such questions.

Technology Assessment and Impacts Analysis - Appropriate Technology Concept

One approach to retaining the positive benefits of advancing technology while mitigating the negative ones has been through Technology Assessment. Technology Assessment involves studying a particular technological project or process to evaluate its impacts--both positive and negative.

A technology assessment model for use in community-scale development projects could help people to assess how well the proposed technological system meets the criteria for an appropriate technology. Therefore, a community-based technology assessment model should be oriented to helping the local people assess the degree to which they can control and maintain the proposed technical system to meet their needs.

Technology assessment represents an organized attempt to evaluate the many primary and secondary impacts of the introduction of technological systems into areas where they have not been before. Careful assessment of the intended and unintended results of the use of a new technology can provide a framework for decision-making about the advisability of implementing the technology. In fact, Environmental Impact Statements (EIS) are a form of technology assessment that is required in the United States before large projects can be constructed. These statements have been instrumental in preventing and modifying the construction of projects that were deemed to have more negative than positive impacts.

For practical purposes, the impacts studied are often broken into categories. The most common include economic, environmental, political, social, and technological. Any technological system which is being newly implemented in an area, or is a new discovery altogether, can be assessed in some fashion to predict or evaluate its impacts. There is a distinction between attempting to assess a technology before its implementation and assessing it after it is in place.

The pre-implementation assessment can help influence the decision process as in Environmental Impact Statements, but secondary impacts are often very difficult to predict. Assessing entire technological systems after implementation is also difficult, but there is more evidence to go on. Entire books have been written about the impacts of such inventions as television and the atomic bomb.

Technology Assessment and Impacts Analysis - Application to Technology Education Classroom

Students can learn about the process of conducting Technology Assessments using the rubric presented in Figure 1. The actual work done can be as simple or elaborate as the teacher wants it to be. More advanced students can obtain an actual Environmental Impact Statement (EIS) for a large project (preferably in their geographic area) and critique it.

Place Figure 1 About Here

While any innovation can be evaluated for its primary and secondary impacts, there are some topics which lend themselves to community-based Technology Assessment in the classroom. These include:

- proposed manufacturing industries using new or heavy technologies;
- various waste disposal plans, including incinerators;
- proposed energy generating systems, such as coal and nuclear power plants;
- and large public projects, such as proposed highways and airports.

Any of the above can be used as the basis for a classroom exercise, even if they are not currently being proposed in your area.

It must be made clear to students that the results of a Technology Assessment are dependent on the values and assumptions used and that they are never totally "objective". This lesson will, hopefully, enable them to develop their own critical thinking and technology valuing skills so that they will, as a minimum, be able to ask insightful questions later in life before voting on technological choices facing their communities.

Global Content (for the International Technology Education Association) - Appropriate Technology Concept

The importance of studying global content is critical in the technology education field. Resource issues, most communication and transportation systems, and military technology threats are all global in nature and we cannot ignore them. As transportation and communication systems evolve, it is not possible to claim anywhere is "at the ends of the earth" anymore. The truism that we are all connected is evident with each product we buy and in more and more of the people we meet. It is obvious that education must include far more content related to other parts of the globe and to problems of the earth as a whole, such as over-fishing, global warming, and declining cropland acreage.

However, the goal of increased global content has long been under-pursued and selectively pursued. For every mention of the techniques used to produce housing in developing countries or the problems of food storage and transportation in such countries, there are a hundred discussions of the Japanese bullet trains. Most people in the world have gone hungry at least once due to problems with food storage and transportation, but less than a fraction of 1% has ever seen a bullet train - so which topic should be stressed the most in technology education?

Barriers to effective global content include the lack of global content taught to technology teachers during their own education, both at the secondary and post-secondary levels. In addition, for whatever reason, the lives of the majority of the world's people, who are peasant farmers, seem irrelevant to many technology students and teachers. At the risk of sounding judgmental, it must be stated that these are not acceptable excuses anymore for ignoring the lives, technologies, and impacts experienced by the majority of the world's people.

Global Content - Application to Technology Education Classroom

After learning about the massive problems of food loss due to improper storage and/or lack of transportation, students can, for example, be presented with the problem of how to store bananas for three months so that people can eat and transport them. It should not take too long for them to realize that drying is an excellent preservation method. However, most people in developing countries cannot afford fuel or electricity to power a standard food dryer. However, sunlight is almost always available.

Hopefully, students will then become motivated to develop and test several (one for each small group) solar food dryer designs. This project can be as elaborate or simple as the teacher deems warranted. Similarly, most middle school students will respond to the challenge of boiling water with the sun. Most can complete this successfully within several days.

Another activity which involves community members is to invite people from (or who have lived extensively in) foreign countries to speak to the class about the technological systems used to meet basic needs in their countries, technology-related problems, and the impacts of technological change.

Technology Transfer - Appropriate Technology Concept

Technology transfer is a field of study which is concerned with all transfer of technological systems from one setting to another, both intended and unintended. However, the stealing of corporate or military secrets is not the focus of this particular discussion. Technology transfer, as it is used here, refers to the factors involved in intentionally transferring a technology to another environment and having accomplish a set of goals which the local people deem desirable.

In this case, technology transfer to developing countries is connected to development work. Many development projects are designed to transfer some new, and supposedly improved, technology to people who do not currently have access to it. It is a testament to the difficulties of such efforts that many well-funded technology transfer projects have been miserable failures. Reasons for such failures include such common factors as lack of infrastructure and lack of training. A more important reason for failures is that it turns out the new technology, which the outside agents felt was such an improvement, is not appropriate in some ways to the lives of the targeted communities.

In the book, People First (1993), Burkey argued for a development process based on Self-reliant Participatory Development. In his model, people planning to do development work, called change agents, must work with the local people to investigate their lives and help them determine for themselves what is most needed. The change agent should then help the people organize and fund cooperatives to provide themselves with capital and a unified purpose. Only after all of this has been completed can the outside change agent consider bringing new technologies and resources into the community. Contrast this with the typical development project where rich outsiders (international consultants) show up in a village bearing money and machines after seeking little or no input from the community which is supposedly being aided.

One of the major beliefs of self-reliant participatory development is that you cannot make people self-reliant. You can encourage them, assist them, and provide them with information, but they must be willing to develop themselves and work together in order to make their communities more self-reliant. The beauty of Burkey's approach, and the reason it is explained herein is that this philosophy applies to all community improvement and development, not just in poorer countries. For a community to truly advance and develop, even in an affluent part of the United States, the people must develop and work together to face their problems and opportunities.

Technology Transfer - Application to Technology Education Classroom

Students can often do projects, and build objects which benefit their communities. However, building something and donating it or having the teacher conduct all of the external communication severely limits the educational experience for students and it limits the input of the people or groups being helped. Students should be involved in discussing what playground equipment the local daycare center needs but cannot afford. If possible, they should be involved in designing what they plan to build and then meeting with the daycare staff to "market" and revise their plan. These are extremely valuable technology experiences and they force students to deal with the "real world" in their design process.

Similarly, projects involving people with disabilities or the elderly are often possible. Designing and building a particular device for someone who needs it, teaches students numerous real world skills and helps transfer their technical knowledge into a product of use to their communities. Technology transfer activities tie in with a number of the other themes in this section. In fact, decisions related to transferring (or not transferring) technological systems from one place to another are at the heart of appropriate technology content.

Involvement and Research in Local Communities - Appropriate Technology Concept

The concept of appropriate technology involves the belief that, since the technologies we use shape our lives, we must choose technological systems to meet our basic human needs which are sustainable and amenable to local human control. Local control is a key concept of Appropriate technology and it follows that communities must work together to make decisions related to local technological choices.

In practice, efforts at implementing Appropriate technology programs have involved attempts to develop locally-controlled systems to help meet basic needs for food, shelter, clothing, employment, etc., in a manner that does not destroy the local social or ecological environments. As with any utopian ideal, the implementation of these ideas has yielded growing successes, romantic failures, and much debate.

Technology education activities with appropriate technology content can be immeasurably strengthened by utilizing the knowledge, opinions, and resources of the communities in which they are located. Community involvement makes the issues of technological impacts real, as students can see for themselves that certain technological systems and choices will benefit certain groups and individuals while spreading costs elsewhere. As with all technology content, it is vitally important when studying the community that the teacher maintain a neutral stance on the issues being investigated, even while encouraging students to make their own judgments of value and feasibility.

Involvement and Research in Local Communities - Application to Technology Education Classroom

One way to become involved with a community is to conduct a Community Resource Inventory to determine what assets the community has which could be recombined in different ways to provide new opportunities. See Figure 2 for one way of organizing such an inventory.

Place Figure 2 About Here

After an inventory has been completed (this can be done as a one hour class activity in small groups or extended up to several weeks with extensive research), the next step is to brainstorm ideas for new enterprises and technological ideas. The author completed this with a group of Indiana college students and one group chose to investigate the feasibility of using a farmers' coop to develop, produce, and market Hoosier cornflakes, thereby profiting from the difference between the high price of breakfast cereals and the relatively low price which farmers get for their corn.

Enterprise ideas can be subjected to the seven resources test in that all technologies need: capital ($), tools and machines, materials, knowledge, time, energy, and people in order to succeed. Further investigation of the impacts of the enterprises can reveal their potential effects and, also, the need for people with the proper knowledge to make the technological systems function. This can help students to consider careers in technology and to recognize the importance of vocational education in a community.

Problem-Based Education in AT - Appropriate Technology Concept

Problem-based education (PBE) is an instructional system that can be used to teach both problem-solving skills and technology content by placing students in the active role of problem solvers confronted with a real world problem. Problems used in PBE are presented before students are provided the specific instruction which would fully enable them solve that particular problem. Students must take the unusual step of figuring out what they need to know to attack the problem and, often, determining where to find it.

Because problems are "real-world" they are usually complex and cover multiple objectives. Students learn facts, concepts and procedures in the context of trying to solve a problem. Using this method, students learn material in context and are often more highly motivated to learn than during a routine lecture. In addition, they can develop skills in teamwork (most problems are used with groups of students); information location and retrieval; and in integrating subject matter from a variety of disciplines. While this may sound, and can be, quite complex, PBE has been used with all ages and levels of students. Teachers must structure and limit problems more carefully with younger students.

PBE is different from, and more extensive than, the "Problem-solving" in typical classroom activities or contests. In fact the two main drawbacks of problem-based education are the difficulty in writing problems that both work well and teach the desired content, and the transition teachers and students must make in adapting to this method for the first time. However, PBE offers unique benefits as discussed above which mesh well with technology education goals and appropriate technology content. In fact, many of the classroom ideas presented above are stated in a problem-based format.

Problem-Based Education in AT - Integrating the Above Themes in the Classroom

Ideally it would be possible to have upper-level students wrestle with an open-ended problem such as, "How can certain African villagers replace their stick and mud huts with something better which they can afford?". This could involve researching why earth and sticks are used (on-site, known technology, and free), what the main problems with this technology are (rain and snakes), and what might be better and still use free materials (rammed earth or Cinva-ram earth compressed blocks).

The laboratory portion of such an activity could include researching and then making a rammed earth wall section or making some compressed earth blocks with a lever press (such as the Cinva Ram) and then testing them for strength against non-compressed blocks. It is also possible to make and test adobe (non-compressed) earth blocks and vary the percentages of sand, clay and organic material (experts recommend more sand than clay, and no organic material).

Lower level students would certainly enjoy, and benefit from, making blocks of sand and clay with different proportions of water, sand, and clay and destructively testing them. This can be done on a small and simple scale. Just remember to leave sufficient drying time.

The literature of appropriate technology and the web links cited below can yield many creative and valuable ideas for classroom content. Each would have the advantage of being clearly relevant and of teaching technological literacy in the broadest possible sense. The type of analysis and production students will be able to accomplish will include, but go far beyond, simply designing to meet a need or want.

Summary

The world is wide open for appropriate technology content in technology education programs and its use is long overdue. The appropriate technology paradigm is one of the many ways that technology can be viewed, designed, implemented, and assessed. Students are taught far too little about how their basic human needs are met and where their waste products go. Similarly, they are taught far too little about parallel technological systems in the rest of the world.

The extent of valuable appropriate technology activities related to technology education is almost unlimited. The use of appropriate technology themes can help teachers and students realize the impacts of their own lives and of their own classroom activities. In other words, aren't values such as conspicuous consumption, waste, and speed being promoted by spending an entire semester making a CO2 powered race car? Can't there be some balance in the purpose and context of activities? Aren't there more relevant and educationally powerful activities available, such as those suggested and described above?

Appropriate-technology-based integrations of problem-based learning, global content, and applied practical research into ways local communities can meet their basic human needs can form an important part of almost any technology education program. Such innovative, yet relevant, approaches can greatly increase the effectiveness of technology education in teaching problem-solving, research, critical thinking, valuing of technological systems, and a broader view of impacts.

Review Questions

12. All technology education activities send many messages to students based on their purpose and context. Is there a balance in your classes between consumption and leisure-based activities and those which are related to meeting a local community's basic human needs in appropriate ways (productive)?

13. Does your curriculum reflect the effect technology has had on world resources. Have you discusses with your students the connection between technological systems and the fact that world fish harvests peaked several years ago or the shortages of fresh water in many areas of the world (Worldwatch, 1999)?

14. Most importantly, how can your curriculum be more involved in the way basic human needs are being met in your community? All students in transportation courses should know where and how their water gets to their taps and the waste is removed and treated.

4. Are your students prepared as citizens of a democracy to help determine through technology assessment which technological systems their community wishes to adopt and which it wishes to reject - and why?

References

Brown L.R., Flavin, C., & French, H. (1999). State of the world - 1999. A Worldwatch Institute Report on Progress towards a Sustainable Society. New York: W.W. Norton.

Burkey, S. (1993). People first: A guide to self-reliant, participatory rural development. Atlantic Highlands, NJ: Zed Books.

International Technology Education Association (ITEA). (2000). Standards for technological literacy: Content for the study of technology. Reston, VA: ITEA.

Annotated Useful Web Links

http://www.jademountain.com/booksVideos/atbooksKids.html
Activity kits for children, mostly middle school level

http://www.jademountain.com/bookspi.html
Books on alternatives in construction, transportation, energy, etc.

High school and above level. Each book could lead to multiple educational activities.

http://www.auroville-india.org/csr/reatintr.htm
Relates the activities and accomplishments of the Auroville Community and its Building Center in India. Direct reporting from a serious community in a rapidly changing country.

http://www.drexel.edu/minisite/undergrad/pages/academic/pages/majors/pages/app_tech.html
Drexel University promotes its Appropriate technology major in this page with a discussion of career opportunities in the Appropriate technology field.

http://www.personal.u-net.com/~nchadd/approp.htm
The Science, Technology, and Society overview of Appropriate technology with a number of further links including those to Sustainable Development sites

http://sorrel.humboldt.edu/~ccat/index.html
The campus center for Appropriate technology at Humboldt State University with information about their projects and particular technological systems which they consider appropriate.

http://www.earthship.org/menu/index.html
The home site of earthships, self-contained self-sufficient houses built mostly of discarded tires and earth. Construction and alternative sanitation and energy systems are covered.

http://www.ITDP.org/
The Institute for Transportation and Development Policy promotes transportation policies in developing countries which increase the mobility of all individuals. They are often pro-bicycle and supply interesting information.

Figure 1 - Sample Technology Assessment Rubric

Technological System being assessed ___________________________

Focus of judgments ___(usually community name)____________

Person or group conducting assessment ______________________

Impact Category	Positive Impacts	Negative Impacts
Economic		
Environmental		
Social		
Political		
Technological		
Overall Summary		

Figure 2 - Community Resource Inventory

Physical resources -

land (owned locally vs. not), soil fertility, tools and machines, water, climate, views, timber, minimal resources, air quality, schools, buildings, roads, cars, vehicles, farm animals, houses, etc.

Financial resources -

income, money, retirement funds, tax stream, retirement income streams, etc.

Human and information resources -
citizens, knowledge in citizens heads, citizen's abilities, libraries, internet connections, communication systems, community organizations, teachers and trainers, trades-people, managers, etc.

Chapter 8

Multidisciplinary Curriculum and Appropriate Technology

Vincent W. Childress
North Carolina Agricultural & Technical State University
Greensboro, North Carolina

This chapter briefly provides an illustration of the multidisciplinary nature of appropriate technology (AT) and a rationale for the multidisciplinary study of AT in technology education. Hopefully it leads the technology education teacher to the realization that a multidisciplinary approach to the study of AT will be relevant and challenging for students. The last section provides an example of how to use curriculum integration to provide instruction in AT.

There is little evidence that the study of AT in technology education and other subject areas is wide-spread or very popular as an educational topic or social issue. When discussing the status of multidisciplinary approaches to the explicit study of AT there is even less evidence. However, it is the *multidisciplinary* study of AT that is the most fundamental consideration that the teacher will make in preparing to teach AT and in providing instruction for technology students.

The Multidisciplinary Nature of Appropriate Technology

Originally, AT as conceived by Schumacher and others, was primarily concerned with improving the plight of people in the third world. It was Schumacher's response to failed applications of industrialized, *large-scale* technology as solutions to third world problems. During the 1970's, the scope and meaning of AT was relatively more narrow than it is popularly conceived of and applied today. The idea that technology can be controlled and maintained by everyday people in everyday communities to solve significant problems has wide appeal. This realization has empowered the helpless to seek solutions to very complex problems in very simple ways.

The appeal of AT is reflected by the wide range of fields that embrace it and apply it. Energy conversion, agriculture, and water systems are frequently cited examples, but others range from sustainable manufacturing to women's health. The breadth of knowledge required to fully understand such localized, small-scale technology needs to be focused, yet general. AT is best accomplished from a broad range of knowledge that transcends the technical and addresses the sociological and anthropological factors of the users. This broad range of knowledge and application helps characterize AT as a field that is multidisciplinary in nature. The reasons are as numerous as its applications and as numerous as the factors that interact among the cultures involved, the needs of the people involved, and the technologies applied to solve their problems.

Previous chapters have spoken about the successes or failures of localized AT applications as being dependent upon the designers' understanding of the related culture, economy, and environment. There are many failed attempts to address the needs of people through the implementation of large-scale technology, and AT has provided some successful alternatives. Kranzberg (1986), a historian of technology, points out that technology can be viewed as a system that interacts with other systems, technological or not. One cannot change one system without affecting the other. Kranzberg also suggests that while technology is an important public issue, other issues and influences take precedence. Technology is usually characterized by the context or circumstances of its implementation. Kranzberg maintains that it is these interactions of technology, with other fields of study, that bear on the success or failure of technology transfer.

In hindsight or in preparation to solve problems, sociologists are often able to show what cultural beliefs or habits cause technological solutions to fail or succeed. Anthropologists are able to identify cycles of cultural behavior that influence local lifestyles that are deeply rooted in the history of the people affected. Historians are able to identify past political events that affect the current and future circumstances of the local people. Theologians and missionaries are able to identify spiritual beliefs that affect the acceptance and use of a technology. Environmentalists are involved to determine what interaction the AT will have with the surrounding areas. Economists are involved to assess the interaction of the technology and the economy. Engineers might be consulting partners in the effort to assist in the design, construction, implementation and maintenance of the technology. Physicians and social workers are involved in AT that influences the health and welfare of the people in need as well as, lawyers, politicians, and government officials also play an important role in the success or failure of AT through policy and law (see Figure 1). The idea that so many fields of study, and the practitioners and intellectuals that represent them, are actively involved in the AT movement around the world certainly demonstrates the multidisciplinary nature of AT.

Insert figure 1 about here.

Technology Education and the Multidisciplinary Study of Appropriate Technology

Individuals around the world and across cultures often feel dominated by what they see as the forces of technology, and they often feel powerless to control them. Without considering the full context of the interaction of technology and society, it appears to the casual observer that technology has a life of its own (Pannabecker, 1991). Yet, it is more appropriate to understand the full context of technology because it is empowering.

The Multidisciplinary Nature of the Technology Education Curriculum

In the social studies classroom, the student is a historian, sociologist, economist, politician, and anthropologist. In the science laboratory, the student is a scientist, experimenter, and observer of physical and biological phenomena. In the mathematics classroom, the student is a logical thinker and observer of patterns in the universe. In language and composition class, the student is an intuitive communicator. In art, music, and drama classes, the student is a creator of aesthetics and expression. And, in the technology education laboratory, the student is an engineer, a technologist, a technician and has the potential to be all of the above. Certainly the school can provide a multidisciplinary learning perspective for students if educators choose to present education in this manner. Because of the broad nature of technology in the lives of humans, technology education can be a great integrator of the curriculum (Maley, 1959).

Consider the breadth of the technology education curriculum. Everyone on earth from the poorest person to the richest person is influenced in some way by systems like manufacturing, biotechnology, construction, communication, transportation, energy, medical technology, agricultural technology and many other areas related to technology in general like engineering and design. What disciplines and school subject areas do not overlap in some way with the content domain of technology education? Given the support of other school subject areas, technology education has the potential to provide meaningful educational experiences.

The Importance of Context

Resnick (1987) cautioned that the student’s ability to transfer concepts from one learning situation to another should not be assumed. She theorizes that key concepts and skills should be explicitly taught so students are aware of their opportunities to transfer learning across the curriculum and in different contexts. Context is an important factor in learning (Resnick, 1987). Its importance demonstrates the social significance of content (Dewey,1931), and it seems to matter in understanding and characterizing the nature of technology as

presented by Kranzberg (1986). The breadth of the technology education curriculum and its opportunity for multiple modes of learning make it a great platform for the study of AT. AT is different in every local situation, and these various appropriate applications of intermediate technology can cross the scope of the technology education curriculum.

Context also plays an important role in the relevancy of education to the student. Providing problems in AT that span cultures is an opportunity to include the interests and values of all students’ ethnic, racial, cultural and social backgrounds in instruction. Technology issues related to gender are also included through the context of a problem. And, issues-based instruction also provides students with the opportunity to develop a better understanding of the roles and influence of social institutions in the student’s life (Apple, 1990).

Curriculum Integration

Context-based instruction is inherently problem-based. Robust and meaningful problems are multidisciplinary, and ideally require interdisciplinary instruction (Maley, 1992). If one’s objective is to provide students with a holistic understanding of AT, then he or she should not depend on the rest of the school curriculum to naturally augment the student’s understanding. Just as real-life applications of AT involve people from various disciplines and professions in a deliberate way, so too should the technology education teacher deliberately plan and coordinate multidisciplinary approaches to the study of AT. While the significance of the multidisciplinary nature of AT will not be understood by students relative to the breadth of the school curriculum simply through osmosis, the technology education teacher may plan AT instruction in relation to other subjects in the school curriculum. This further argues the case for curriculum integration. Curriculum integration’s most significant advantage is relevancy. The tired phrase familiar to most teachers, “Why do we have to learn this?” is a vivid reminder of how many students perceive the relevancy of their educational experience. Instructional context provided by the technology education curriculum, within the AT domain, answers the relevancy question.

The teacher may be able to integrate content from other disciplines into the technology education class as the only teacher involved. The advantage is that he or she will not be constrained to wait for the time of the year when the social studies teacher is teaching about the relevant issue of study. In addition, teachers do not have to share students in common in order for the social studies concepts to transfer to the technology education laboratory. The teachers do not have to share common planning time in order correlate the concepts that each is teaching. But, the

degree to which a holistic perspective is accurately presented will be less than had the technology education teacher teamed up with the social studies teacher (LaPorte & Sanders, 1993).

It seems reasonable that students have input to the selection of social problems that they believe can be solved through the introduction of AT and that matter to them and their community. Yet, as a pragmatic exception to an ideal situation, the students should choose from within a large social context, for example *housing*. It will do little service to students if they choose to study a topic not covered by the social studies teacher and the technology education teacher. At the same time, the teacher must make sure that instruction covers certain fundamental technology content and the *Standards for Technological Literacy*. However, all of the essential technological process content does not have to be covered in one unit. These are simply practical considerations in planning to teach AT through curriculum integration. By integrating a societal-concerns approach to AT within the curriculum, educators can address many of the *Standards for Technological Literacy*, because the contexts provided by such an approach are replete with opportunities for design, problem solving, and for the study of the relationship of technology to other fields.

Housing and Human Dignity Example

Perhaps the best way to get started planning an integrated unit in AT or any other topic is to develop a web. Webbing provides a diagram that connects concepts that are related to each discipline or subject area involved (see figure 2). The example used may have wide appeal to readers of all backgrounds. The most noteworthy thing about the Housing and Dignity web is that there could be an overwhelming number of connections among the subject areas represented. The teachers involved should not attempt to help students learn every relationship that they can think of. To a certain extent, the connections utilized by students will be planned, and to a certain extent some connections will be determined by students' critical analysis of the AT problem at hand.

Insert figure 2 about here.

---

*Planning the sequence of related instruction***.**

To the extent possible, teachers will want to determine the order in which students will need to learn the AT related content. There will certainly be prerequisite concepts and others that are less critical to the sequence. Figure 3 shows a possible sequence of interdisciplinary instruction related to the Housing & Dignity AT problem.

Insert figure 3 about here.

The possible sequence of instruction is not meant to imply that teaching and discussing the social issues related to the AT problem is the responsibility of the social studies teacher. However, the social studies teacher is a primary influence for students' *awareness* and *basic understanding* of the fundamental related social studies content. Truly all three of the teachers involved in this example will want to take full advantage of the context provided by the AT problem.

The teachers' instructional approaches should acknowledge the content and context related to the problem students are attempting to solve. As much as possible, students should set the AT evaluation criteria based on their knowledge of AT, the affected community and its related sociological phenomena, and their understanding of important technological processes. Students work in cooperative groups that may set out to solve various parts of the overall problem, and the teachers allow students the freedom to experiment, debate, and implement solutions. Students are afforded access to knowledge that will enable them to better understand the nature of the AT problem and how to solve it such as learning statistical methods in science as needed. Finally, while multiple solutions may prove *appropriate*, students are assessed on both process and product. Students can help the technology education teacher write a design brief that introduces the problem and helps to establish a path toward solving the problem (see figure 4).

Insert figure 4 about here.

Groups of students can investigate the community that will benefit from the AT approach to housing. They could put themselves in the roles of residents and various partners cooperating in the housing problem. Students might

collaborate on architectural plans based on AT design criteria and data they gathered from the community. They could build a scale model of a housing unit including partition walls and room layouts which can demonstrate ergonomic design, handicap accessibility, and the use of remote, in-house medical technology. Students would develop maps and scale models of housing developments that depict local plans for land use and zoning. Students might feel it is necessary to develop solar panels or alternative materials for insulation and test their working models scientifically (see LaPorte & Sanders, 1996). And they can evaluate themselves based on the appropriateness of the design process which they followed, the solutions they developed, and the predictions they made about the success of the solutions. Students should help the technology education teacher develop an assessment rubric like the one in figure 5. The teacher will provide a copy for each student so he or she will know what is expected from the assignment.

Insert figure 5 about here.

Standards for Technological Literacy

Depending on how it is taught, the Housing and Dignity AT problem could address or partially address many *Standards for Technological Literacy* and their benchmarks (Technology for All Americans

Project, 2000). For example, design, engineering design, troubleshooting, and construction technologies are processes directly related to the problem at hand. However, choosing to teach the AT problem from a multidisciplinary approach will lend itself to specifically addressing Standard Three and some of its benchmarks are listed below.

> Standard 3
>
> Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study. (p. 44)
>
> Benchmark C
>
> Various relationships exist between technology and other fields of study.
>
> Benchmark D
>
> Technological systems often interact with one another.
>
> Benchmark E
>
> A product, system, or environment developed for one setting may be applied to another setting [with adaptations].
>
> Benchmark F
>
> Knowledge gained from other fields of study has a direct effect on the development of technological products and systems. (pp. 48-50)
>
> Benchmark H
>
> Technological innovation often results when ideas, knowledge, or skills, are shared within a technology, among technologies, or across other fields. (Technology for All Americans Project, 2000, p. 52)

However, the technology education teacher must deliberately focus attention on the connections among the disciplines. Students may not necessarily be aware of the relationships on which they are capitalizing. Deliberately teaching these connections in the process of solving a multidisciplinary problem will help students see the power of integrated knowledge and its role in the responsible application of technology.

Models for Curriculum Integration in Technology Education

There are several good resources that provide models for curriculum integration. Jacobs (1991a, 1991b) provides a variety of approaches to the integration of subject areas for any teacher. There are also good models of curriculum integration developed specifically for the technology education teacher. See table 1 below. These curriculum integration resources provide in-depth guidance to the technology teacher on how to conduct the specific activities provided within the publications. The activities do not necessarily address appropriate technology, but some can be adapted to the interdisciplinary study of AT.

Insert table 1 about here.

Summary

Appropriate technology is multidisciplinary in nature. Participants in the AT movement and partners in AT projects represent a wide range of disciplines, professions, and fields of expertise. There are many social contexts to the application of AT, and because of the recognized criteria for AT implementation, it provides a very humanistic approach to the solution of problems. The small-scale of AT truly characterizes technology as “thoughtful doing.”

The range of relevant AT applications is as broad as the technology education curriculum. The study of AT in technology education is enhanced if approached from a multidisciplinary perspective and should be problem based. As a result, students are well informed and have some awareness of the broad range of circumstances that influence applications of AT. Students are provided with a range of freedom to decide what content is applicable to their needs in solving the AT problem. Cooperative student groups can develop and implement as much as possible authentic AT solutions and do real technology. And the fact that the problem is set in a real-life context provides relevance to all students at some time in the process no matter what their backgrounds. Teachers can easily implement AT into technology instruction. However, some extra planning can greatly enhance the learning of students through curriculum integration with related school subjects. It is certainly an approach worth trying.

So, can technology education take what is right about AT and incorporate it responsibly into the curriculum? Some within the field have suggested that we should teach AT as an area of study (Karian, 1996; Chaplin, 1980). The reader is encouraged to consider AT as an important area of study for technology education and general education. One should consider AT as a means to helping students gain a more complete understanding of technology interacting with other dimensions of human society and the environment in a larger context and as a means of teaching students throughout the school building about kindness and responsibility in a technological world.

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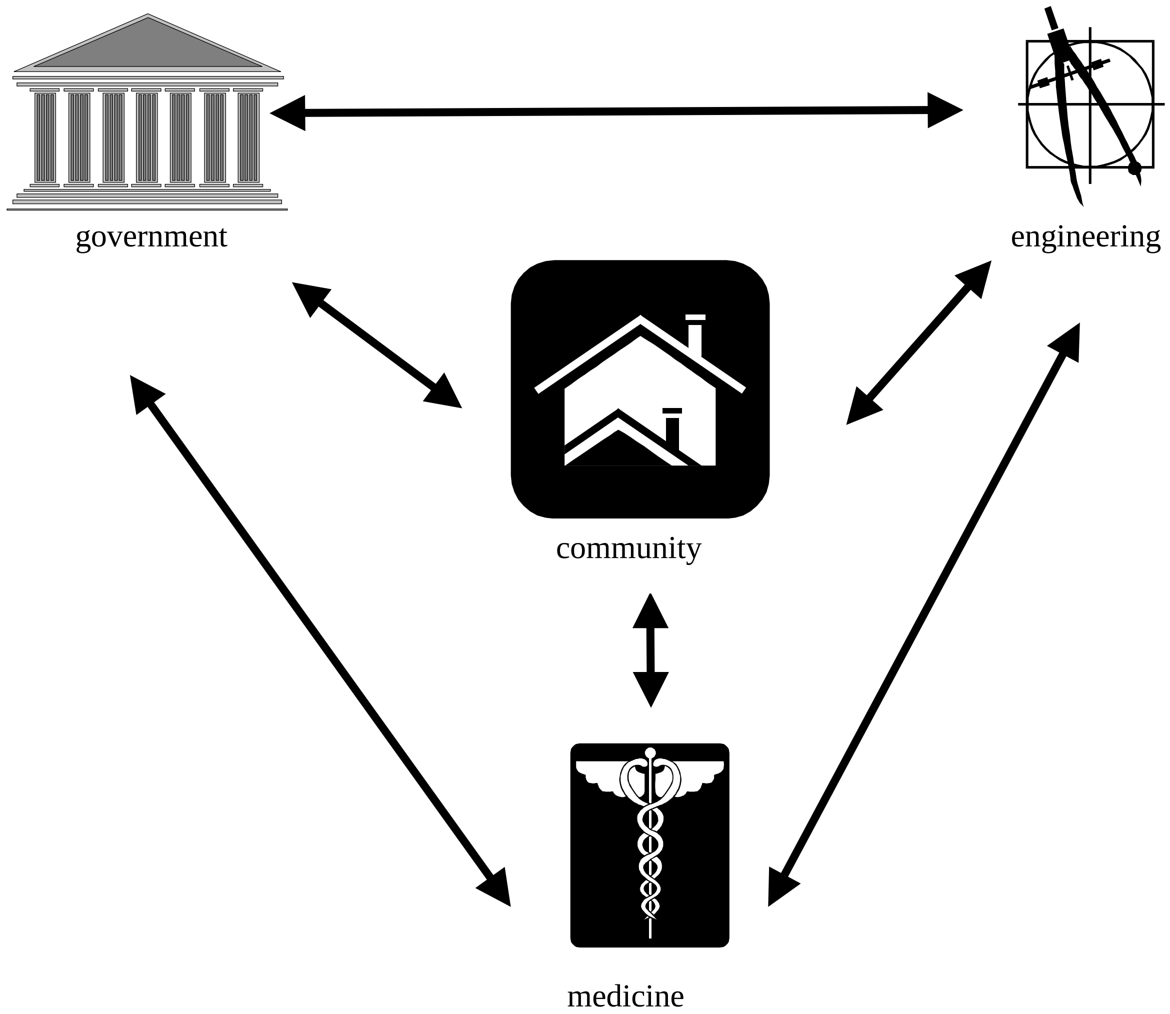


Figure 1: Human interaction in AT. Every person involved should consider each others roles and include the community throughout the process.

Figure 2. Webbing shows teachers where concepts are shared among the disciplines involved in AT curriculum integration.

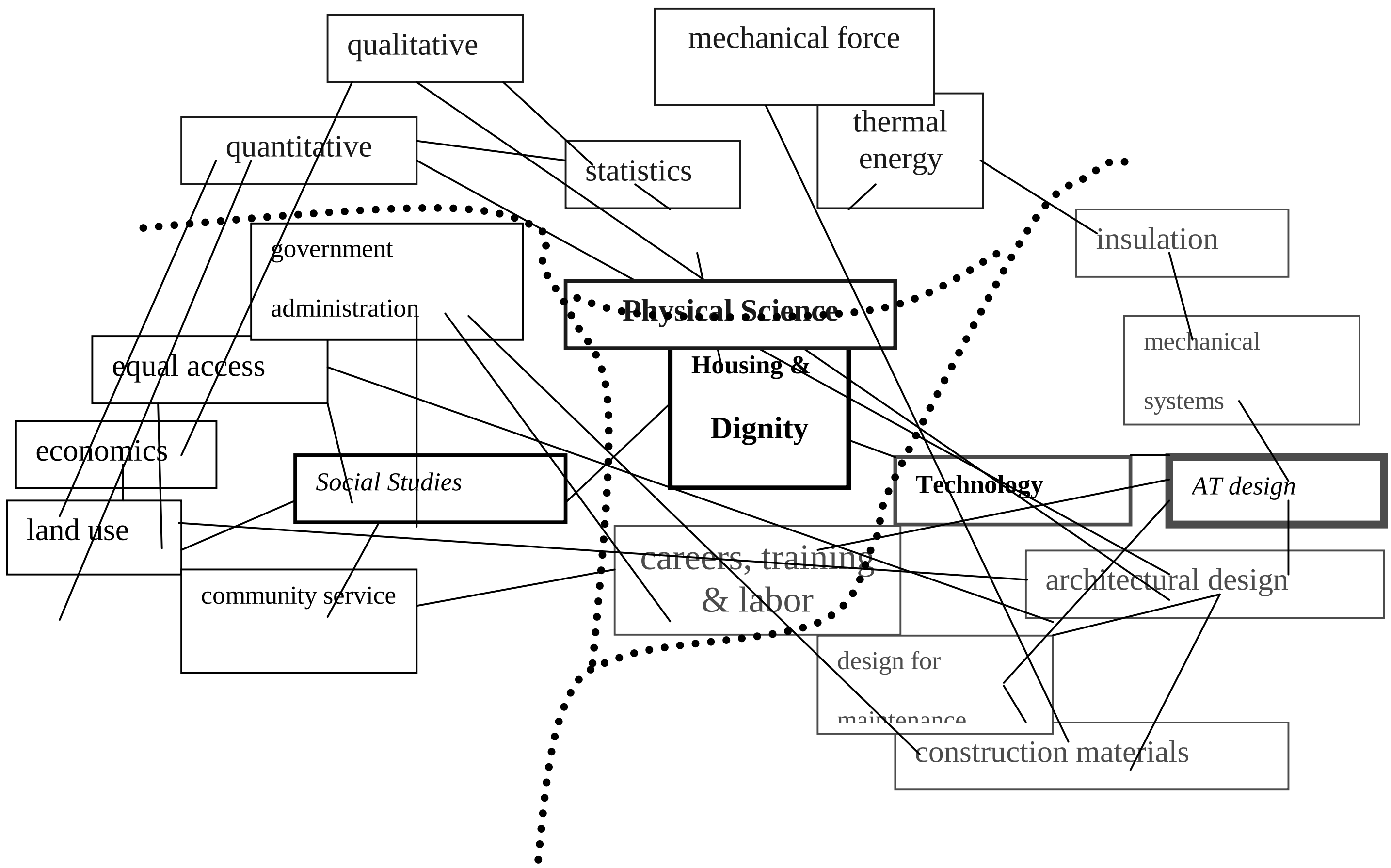


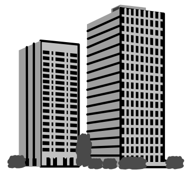
Figure 3: Possible anticipated sequence of instruction for the integrated AT problem.

	Technology	Social Studies	Physical Science
1.	AT design	Economics	
2.	Technology & other disciplines		
3.	Students select issue	Poverty and access	
4.	Product life cycle		Statistics
5.	*Architectural design*	*Equal Access*	Controlling experiments
6.	*Structures*	*Land use*	*Mechanical force*
7.	*Mechanical systems*		*Thermal energy*
8.	Aesthetic design	Cultural influences	
9.	*Housing management & maintenance*	*Cooperative mgnt. vs government mgnt.*	
10.	Testing solutions	Panel discussion on cultural/social success of solutions	Gather & analyze data
11.	Redesign solutions based on results		

Figure 4: Sample design brief used to introduce the housing problem.

Housing and Dignity: Design Brief

Background
Many people cannot afford to buy or even rent their own homes. Often in the past the government has provided housing for low-income families, but the living arrangements and conditions in such government housing has not been very suitable to the needs of the residents.



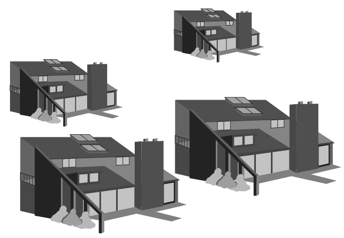
Context
You are an architect and researcher for a construction company. Your company has become interested in serving the community and has joined a housing organization that wants to apply appropriate technology to the problem of developing and managing affordable, sustainable housing that is suited to the cultural needs of the people involved.

Problem Statement
One particular group of citizens in the community has had few alternatives when it comes to housing. So far this group has been living in government managed high rise buildings. The buildings are not easy to maintain, there is no input from the residents on how to manage the buildings, and the design of the housing has caused the group's sense of community to deteriorate.

Challenge
Apply appropriate technology design criteria, science, social science, and technology to the design of a housing development that will provide alternative housing for the group mentioned above.

Requirements
The housing should:

- Be designed for 100 families and for each family to occupy its own residence,
- Be relatively easy to maintain, sustain, and manage by the residents,
- Use land and energy wisely,
- Use designs developed with close community involvement and input,
- Provide inexpensive access to health care,
- Provide for the cultural needs of the group, and
- Be designed using sound architectural and construction methods.



Objectives
As a group, using notes from class, research, and group design work, show that you can meet the following objectives by compiling all evidence in your portfolio.

1. Understand the relationship of technology to other fields of study.
2. Apply appropriate technology design criteria.
3. Discuss social issues related to housing.
4. Understand architectural design and construction technology.

Assessment of the Student
You will be graded using the assessment rubric, which will be provided to you. It will show you exactly what is expected of you. However, you can expect that your grade will mainly be based on how well you apply what you learn in technology, social studies, and physical science classes, through research, and during critiques in your group's meetings. You should try your best to show all of this learning in your portfolio.

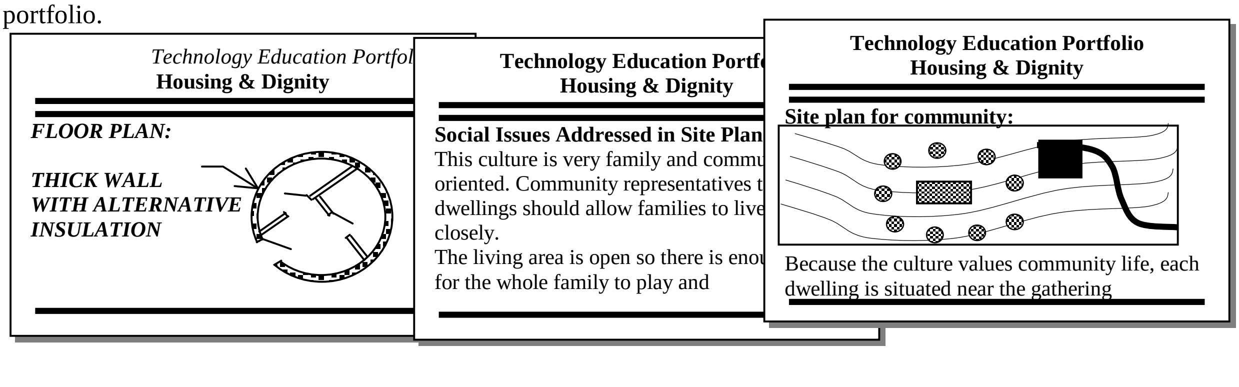


Figure 5: Housing & Dignity Student Assessment

Based on evidence in the portfolio and through teacher observations, students should try to get a checkmark in every square below in order to score as high a grade as possible.

Objectives	**1 point**	**+**	**2 points**	**+**	**3 points**	**6 points for each objective**
Understand the relationships among technology, social science, and physical science	Research notes indicate the student knows about social and science concepts related to the problem..	+	Student identified local examples of the concepts learned in social studies, science, and technology that relate to the problem.	+	Student was able to apply interdisciplinary knowledge to the design, implementation, and testing of the solution to the AT problem.	
Apply AT design criteria to the solution of the problem.	Student knows the AT design criteria.	+	Student can show how the criteria guided the design of the AT solution to the problem.	+	Student incorporated the AT design criteria in the evaluation of the AT solution.	
Identify social issues related to housing design.	Student identified social issues related to housing.	+	Student identified social issues directly related to the specific housing problem.	+	Student was able to address a social issue via the AT solution.	
Design working drawings that communicate part of the solution.	Group's plan was technically correct.	+	Group's plan communicated the AT solutions to the problem.	+	Group's plan was redesigned based on testing/evaluation results.	
Develop models that depict the group's plan.	Models were technically accurate and scaled proportionally.	+	Group's models depict the AT solutions to the problem.	+	Group's models were redesigned based on testing/evaluation results.	
Work as a member of the team.	Student was in charge of a job the group had to get done.	+	Student also helped with other jobs the group had to get done.	+	Student completed all assigned jobs required by group.	
					Total Points:	
Comments:						

Table 1. Curriculum Resources that Provide Good Models for Curriculum Integration.

Integrated Mathematics, Science, and Technology Project.

Secondary teacher resource binders and student texts

Glencoe/McGraw-Hill.

Technology, Science, Mathematics Integration Project.
Technology, Science, Mathematics Connection Activities
A binder of activities for the middle school.

Glencoe/McGraw-Hill.

Mission 21 Project
Mission 21: Launching Technology Across the Curriculum
A binder of activities and booklets for the elementary school.

Glencoe/McGraw-Hill.

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Chapter 9

Problem Solving in Appropriate Technology

Michael Daugherty
Illinois State University
Normal, Illinois

Is modern technology the key to successful development? Will technology “deliver” on its promise to bring prosperity to the entire world? Can technology be “transferred” from one cultural setting to another in ways that are more beneficial than destructive? These questions lie at the heart of all studies in appropriate technology. Technology is often portrayed as a “two-edged-sword, simultaneously the bearer and destroyer of values. Although it usually originates in “developed” societies, modern technology circulates around the world rapidly using a variety of transfer channels. In the space of a century, the relationship between technology and society has undergone radical change. Even though the products of technology have changed dramatically in the last one hundred years, the methods used to disseminate the products of technology have remained much the same since the British Colonial period. The manner in which technology has been distributed has led to a great deal of criticism. Leaders in technology have been criticized for sending the latest technological products to all corners of the globe without a great deal of concern for the role that this technology might play or the impacts that it might have on cultures, values, or society at large.

Public schools in the United States are little different. Technology education programs (and teachers) across this nation have traditionally presented technological and industrial breakthroughs as the solutions to all of life’s problems and rarely consider the ramifications or impacts of technological proliferation. Recently, technology educators have begun to address the social, cultural, and value-laden issues associated with technological advancement. Most recently, technology education has been defined as a K-12 curriculum designed to help individuals understand the impacts of technology on society (ITEA, 2000). One of the goals of technology education is to promote technological literacy in a broad and encompassing nature (International Technology Education Association, 1993; Technology Education Advisory Council (TEAC), 1988; Technology For All Americans (TFAA) 2000). Waetjen (1985) suggested that to achieve this goal of technological literacy, technology education courses must not only prepare students to understand, use and control technology, but to also to determine when and where it is most appropriately used. The most recent national project in the field, the Technology for All Americans

Project, emphasized the importance of technological literacy and a healthy study of the impacts of technology as primary goals for the profession:

> Technological literacy is the ability to use, manage, assess, and understand technology. A technologically literate person understands, in increasingly sophisticated ways that evolve over time, what technology is, how it is created, and how it shapes society, and in turn is shaped by society. (ITEA, 2000, p. 9)

If technological literacy is to be the primary goal of the technology education discipline, and students completing programs are to be inculcated with the ability to use, manage, and understand technology, then all completing students must be provided with a level of understanding about the nature of "appropriate technology" as a part of their basic education. Sound decisions demand an understanding of the impacts, relationships, and costs of technological activities (ITEA, 2000).

Regardless of the instructional content delivered in technology education classes or the approach utilized, it is clear that students have an innate desire to use contemporary technology like cellular telephones, lap top computers, and virtual reality to make their lives more pleasant. Given this fact, technology education teachers have a responsibility to expose these students to the impacts, alternatives, and side-affects of the use and proliferation of technology. Johnson (1985) suggested that technology education should provide an avenue for teaching students about the nature of a technological society and the benefits and burdens the technological society creates.

Problem Solving in Appropriate Technology

Once considered to be the moral force of civilization and the highest expression of human dignity, science and technology have come to be regarded more and more as a tool by society in general (Calvora, 199?). Louis Pastuer was once quoted as having said, "at the stage we have reached in what is termed modern civilization, the cultivation of science in its highest expression is perhaps even more necessary for the moral well-being of a nation than its material prosperity." (L. Pasteur, Quelques reflexions sur la science en France, Paris, 1871, p.6.)

However, the paradigm in technology education is changing. Technology teachers are moving from the age of teaching traditional industrial processes to the contemporary age of teaching problem solving and technological application. This shift in instructional approach may be the result of a long-term and concerted effort by leaders in the profession to shift instructional attention in technology education from the "product" of technology to the "process" of technology. Many authorities (Gloecker, 1990;

Illinois State Board of Education, 1992; Thode, 1989; and Wicklein, Hammer, Balistreri, DeVore, Scherr, Boudreau and Wright, 1991) have long emphasized the need for technology teachers to use instructional approaches that enable students to become critical thinkers and problem solvers, able to make the difficult decisions that are often associated with technological applications.

In contrast to traditional educational experiences, in which the curriculum is driven by key concepts, studies in appropriate technology are organized around societal issues that are used to uncover key concepts (Raizen, Sellwood, Todd, and Vickers, 1995). To establish an appropriate technology curriculum within technology education, teachers must form connections between their classrooms and the outside world by focusing on issues relevant to the students. By taking up such contemporary issues and relating them to technology, students examine technology as more than the latest device at the electronics store, and are encouraged to apply their knowledge of technology to personal and social issues. Holbrook (1992) (in Raizen) suggested that the ultimate goal of studies in appropriate technology is to change student attitudes and develop decision makers who ask questions about the world around them (i.e. Is it a problem? How did it become a problem? What are alternative approaches to solving this problem? What are the potential effects of applying the alternatives to individuals and/or societies?)

Raizen, et.al. (1995) suggested that activities must be based on problem solving and investigation, with students asking questions and searching for solutions. Yager and Roy (1993) (in Raizen) suggested that students in these courses are expected to see technology and science as a way of dealing with problems rather than as a body of knowledge to learn. By expanding the technical knowledge base to include social, cultural, environmental, and other impacts, students' increase their technological literacy level and become better suited to deal with technology-related problems that will occur during their lifetime. While appropriate technology content may be delivered in technology education courses using a variety of tools, techniques, and approaches, a problem-based approach may be the most realistic approach. Some common themes that can be delivered using a problem solving format include:

1. Technology and its impact on values, norms, and ethics;
2. Technology's effect on the family, religion, education, industry, etc.;
3. Technology and decision-making. For example, should we use nuclear power if we cannot adequately manage the waste byproduct?

The Relationship Between Problems, Solutions, and Future Problems

As technology education instructors strive to incorporate studies in appropriate technology into the curriculum, care should be taken to remember this ultimate goal of all projects—the improvement of life and living conditions. In the drive to satisfy human needs and wants, people have developed and improved ways to communicate, travel, build structures, make products, cure diseases, and provide food. This development has created a world dependant on technological products and machines, roadways, buildings, data and global communications (TFAA, 1996). By definition technology is interested in getting things done, consequently, it breeds impatience in society as well as in the classroom. It also breeds impatience with regard to the speed at which we solve technological problems. Aristotle warned long ago that "the amount of property which is needed for a good life is not unlimited. He qualified Socrates' dictum that "a man should have so much property as will enable him to live temperately, which is only a way of saying 'to live well'. In relation to technology, Aristotle may have been suggesting that humans dependence and desire for technology should be measured against the appropriateness of that technology.

Technology in the developed world has grown and escalated at an astonishing rate during the later half of the 20th Century. During that same period of time, the citizens from these regions have adapted to and accepted most of these technological advancements with open arms. However, advocates of technological development and expansion seem to assume that advanced technologies are transferable to wholly different circumstances in other regions of the world and that they are appropriate in all situations (Cashman, 1987). Meanwhile, many leaders in developing countries avidly seek technological development and await such benefits as improved material living standards and new wealth through greater production and productivity.

To some extent, the cultures of the world have always interacted and shared technologies. The most efficient methods of agriculture, industry, and organization have been copied, adapted, and spread far and wide. The plow, paper, gunpowder, and the steam engine are just some of the developments—which spread from culture to culture until they became the common property for most of the human race. In more recent times, the underlying scientific knowledge behind modern technology has also spread around the world (Sowell, 1998).

Technology affects society, traditions, and culture on a number of levels. When new technologies are introduced into a population, they can be a major resource for creating new wealth and opportunities for the citizens. These technologies may also serve to make life in the community safer, easier, and healthier. However, when new technologies are introduced into a cohesive community, they can also serve as an instrument allowing its owners to exercise social control in various forms; they can affect the modes of decision-making; and create new and artificial class distinctions that did not previously exist (Goulet, 1977).

The often stated purpose of appropriate technology is to provide individuals and groups from all societies and cultures with devices and techniques that assist them in making the most of their existence. The difficult matter with carrying out this directive is to provide these devices and techniques without altering, damaging, or cleansing a culture or tradition from the face of the Earth.

As technology teachers seek to include appropriate technology problem solving activities, students should be made to carefully analyze the impact that technology may have on cultures, social norms and values. The overriding difficultly arises from the fact that the average technology teacher has limited background and knowledge in appropriate technology. The only realistic method of overcoming this shortcoming, is through continuing research and resource procurement. James Burke's "Connections" series (book and video formats) could serve as a starting point and valuable resource. In his books, Burke draws connections between the development of technological devices and the impacts these devices had on societies and cultures.

Solving Appropriate Technology Problems

Although technology can brings new freedom from old constraints imposed by nature, tradition, or ancient social patterns, technology can also introduce new problems into the life of the people who use the technology. Appropriate technology is not a matter of rejecting a particular technology, but rather a matter of selecting the best answer to the question. Long-term, sustainable solutions to technological problems are more likely to occur if local skills are used, thereby using the knowledge and experience which already exists, and which can be passed on through the community, and from generation to generation. The use of local resources also cuts down overall costs. The solution should be consistent with the culture(s) of the local community. The use of high technology to solve a problem often involves the use of expensive components, which usually need to be imported. This normally requires specialist training, requiring additional costs and time. The need for a supply of spare parts, often expensive, also decreases the likelihood of a sustainable solution to the problem, by increasing the cost of the overall project. In any one solution not all the benefits mentioned are possible, or occur with equal weighting. Yet the involvement of the local community, use of local resources and local skills is at the heart of successful application of appropriate technology.

As technology teachers attempt to interject appropriate technology problem solving activities into the classroom experience, care should be taken to understand the nature and constraints of these technological problems. Appropriate technology problems involve students in the selection of technological solutions that best meet the needs of the end user. As technology education instructors develop or students attempt to solve appropriate technology problem solving activities, they should consider the following list of tools and techniques, which form a framework that can be used in the development of student activities. Appropriate technology problems usually include solutions that:

1. Result in low capital costs;
2. Use local materials when possible;
3. Create jobs, employing local skills and labor;
4. Are small enough (in scale) to be affordable by the impacted citizens;
5. Can be understood, controlled, and maintained by the impacted citizens without a high level of Western-style education;
6. Can be produced with local materials and skills;
7. Require the cooperative skills of all citizens involved (in most of the world, important decisions are made by groups rather than by individuals);
8. Involve renewable resources, such as wind power, solar energy, water power, methane gas, animal power, and pedal power;
9. Use understandable technology to the people who are using it;
10. Are flexible so they can continue to be used or adapted to fit changing circumstances; and,
11. Do not involve patents, royalties, consulting fees, import duties, or shipping charges (Congdon, 19??).

Our task as technology educators is to prepare students who can find the technological solutions that solve the problem while causing the lowest residual effect on the local culture, traditions, and values.

Teaching Problem Solving in Appropriate Technology

Content in technology education is delivered in a variety of manners: lecture, demonstration, case studies, laboratory prototyping, problem solving, etc. The problem solving method of instruction is particularly helpful in delivering content of a technological nature. Problem solving is a method where the instructor develops a problem and asks the students to solve that problem under given constraints. The problem solving method is usually conducted in a group setting and involves basic, complex, and higher level thinking skills. Problem solving activities are often used to introduce critical thinking and teamwork strategies that can lead to greater learning skills in all academic areas. The primary mental strategies exercised through the implementation of a problem solving activity include brainstorming, mental mapping, consensus reaching, psychomotor activity, and individual or group assessment. This method of instruction actively involves both convergent and divergent thinkers, as well as right and left brained individuals.

Teaching students to solve problems within an appropriate technology framework has been proven to be a very successful approach for improving student’s awareness of how humankind interacts with technology. Carefully crafted problems can expose students to the positive and negative impacts of technology and how this technology affects individuals and societies differently. In our society, technology is used every day at home, in public and private work places and for leisure by every age group. Therefore, it is critically important that all members of our society understand and question the impacts of that technology on our society and others.

The Appropriate Technology Problem Solving Process

The problem solving approach can be used to deliver any number of technical concepts, is exciting for the instructor as well as the student, and has many possibilities for creative teaching. However, technological problem solving is also one of the most often misused teaching techniques in the profession. Lewis, Petrina, & Hill (1998) suggest that the recent emphasis on design problem solving in technology education lacks theoretical grounding. Lewis et.al. suggest that classroom studies indicate that students find the prescribed design problem solving methods cumbersome to use, and if held accountable, merely retrofit methods to meet the results of their actual experience. The difficulty is that the term “problem-solving” (and the behavior and thinking associated with it) is complex and refers to different things in various contexts. Technological problems are distinct from other types of problems (e.g., social, environmental, interpersonal, economic, international, mathematical, puzzles, etc.). For example, a family with an alcoholic son or daughter has a problem, but it is not technological (MacPherson, 1998).

Understanding a particular technology and solving problems related to the use and placement of that technology requires a comprehensive set of *skills* that are technological in nature. Unfortunately, most technology education curriculum developers limit technological problem solving to design problem solving. Design problems usually require students to develop a product or device that solves a particular technological problem. While these design problems are important, they are not inclusive, and leave out a great number of the technological problems that are encountered by individuals. The framework that will be used to *classify* technological problems for this chapter include trouble-shooting, design, technical-procedural, and invention. Each of these technological problem solving dimensions require a unique set of skills. The technological problem solving dimensions are as follows:

- *Trouble-shooting*: Trouble-shooting is a classification of technological problem solving where problems tend to be well defined and activity is directed at finding a single solution to a problem (e.g., locating a fault in an electronic circuit, finding the leak in an irrigation channel, etc.). Trouble-shooting problems typically require specific technical knowledge and they require the student to have a background with the technology in question. Without a technological background in the given technology, students will find it extremely difficult to solve problems that require trouble-shooting skills, much like the individual with a stalled automobile would not have the technological capability to fix the car without some automotive background.
- *Design*: Design is another classification of technological problem solving. Unlike trouble-shooting, design problems frequently are less well defined and often can be solved in a number of different ways within a set of constraints. Also in contrast to trouble-shooting, design solutions often reflect the unique knowledge and experience the designer brings to the situation. Design problems almost always include the solution to the problem in the problem statement (e.g. design a vehicle that will travel the greatest distance using only the materials supplied).

- *Technical/Procedural*: Technical/procedural problems are those associated with following or developing sets of procedures or instructions. Typical examples include the difficulties associated with attempting to follow written assembly instructions for a technological device or apparatus. Technical/Procedural problem solving involves seeking relationships and working out new solutions. Sometimes problems are solved largely by trial and error, however, a number of technological problems are best solved using a step-by-step chronology of procedures. This step-by-step chronology of events may be the result of following a set of technical directions, reading a schematic, or using a systems approach. Like trouble shooting, technical/procedural problem solving requires background experiences and knowledge of technical sequence.
- *Invention*: Invention problems are utilized when new processes or devices are developed to address human wants and needs. This classification of problems tends to require considerable creativity, an ability to visualize and model, and an ability to think "outside of the box." Technological invention problems are similar to design problems in that they require the student to create a device that will solve a problem. They differ from design problems in that the solution is not given in advance. For example, a design problem might require a student to build a floatation device that will allow them to cross the river using only the materials available. However, an invention problem never states the solution to the problem in advance (a floatation device). Given this same example, an invention problem would simply present the student with the problem (e.g. you are unable to cross the river and you must find a way) and ask them to invent a device/technique that would solve the problem.

A common error made in teaching technological problem solving is to attempt to reduce the process to a simple, generic set of steps (one size fits all). This usually takes the form of clarifying the problem, proposing solutions, selecting a solution, trying the solution, and evaluating the solution. Lewis et.al. (1998) implied that this model may have had political utility in redirecting attention from traditional practice in industrial arts, but the method is constraining and does not fit all technological problem solving scenarios. The framework outlined above is less refined, more global, and takes into account that there are different kinds of problems and that different *classifications* of problems require different approaches, skills and knowledge to solve.

Short- and Long-term Problems

In addition to sorting problem-based instruction by dimension (invention, design, technical/procedural, trouble-shooting), problems should also be sorted by the degree of difficulty. By varying the degree of complexity and the time that students must exhaust to complete a problem solving activity, instructors may be able to use problems for differing purposes. For example, a *short-term* problem may be used to introduce or summarize a major concept and a *long-term* problem may be used to assess student understanding of a major concept (or a series of concepts) related to the appropriate use of technology. *Short-term* problems are usually limited to five minutes of response time while *long-term* problems may require a semester to complete. One of the benefits of *short-term* problems is that they can be completed in one class period. *Short-term* problems may also be used to summarize a unit of instruction or may be used as a question on an examination. An example of the short-term problem might look like the following: After being presented with a picture of a natural resource found in a developing nation (e.g. palm leaves), describe or sketch three products that could be produced from the natural resource that would improve the lives of people in that nation.

Long-term problems require several class periods to complete and usually require more complex solutions or the development of a device or system to be constructed. An example of the *long-term* problem might resemble the following: Working in teams of three and using only the materials supplied by your instructor (materials that would be available in the native country), design a pedal-power machine capable of pumping water 4 feet up a 20 degree incline. The water must flow at a rate of at least 30 liters per hour. This long-term problem would require the students to draw from a number of resources and learning experiences.

Initiating The Problem-Based Curriculum

Creating the Appropriate Learning Atmosphere

The environment in which technology education is delivered has a significant impact on the learning that does or does not occur. Technology teachers can think of the classroom as a stage and the curriculum as the play—a good production requires both. Quality learning experiences depend upon classrooms with appropriate resources, materials, and tools as well as a sound curriculum. Some suggestions for creating an environment that is conducive for studies in appropriate technology problem solving include:

1. Establish a technology resource center in the laboratory which includes technological, industrial, engineering, and design journals as well as government resources, resource texts, research and development materials, a list of references in the local library or local university library and Internet sites;
2. Obtain media materials free or almost free from industries such as General Motors, General Electric, John Deere, Caterpillar, NASA, EPA, United Technologies or institutions like the United Nations, the United States Peace Corps, Catholic Charities and other international organizations. These materials can be used to introduce the topic or to spur ideas;
3. Require students to develop activities, projects, or products which show the impacts of a particular technology (i.e. students develop a television commercial and after playing the commercial, study the impact it has on the viewer);
4. Conduct field trips to local businesses and industries that ship equipment and materials to Third World nations;
5. Conduct field trips to non-traditional industries and sites like the local landfill, sewage treatment plant, a recycling center, or an EPA hazard site and then conduct a lively discussion in the classroom;
6. Use reports and written or oral presentations to allow the student to conduct research on the effects of a particular technology and then take a position on the effects of that technology.

Generating Appropriate Technology Discussion in the Classroom

Technological discussion in the classroom is a combination of the inquiry and discovery methods. Discovery learning is defined as the learning that takes place when students are not presented with subject matter in its final form, but rather are required to organize it themselves. A major goal of this method is to stimulate independent, resourceful thinking and to generate critical thought and analysis. This creates an open atmosphere in which students feel free to contribute and to analyze the various ideas presented. Students are encouraged to think when this method is used even though the ideas they arrive upon are sometimes bizarre. To examine appropriate technology concepts using the discussion technique, provide information by means of lecture, reading, Internet, film, or some other technique and then pose a problem to the class. After presenting the students with the problem, ask them a series of probing questions that will cause them to examine critically the problem and their solution to the problem. The key questions must be planned in advance to avoid straying from the subject matter at hand. A typical example of the discussion method used in a technology education classroom might include a discussion related to the advantages and disadvantages of a particular technology (i.e. nuclear power), or the social/cultural impacts of a particular technology (i.e. birth control pills). Evaluating students when using the discussion method of presentation can be accomplished by utilizing the essay examination format to determine whether students are able to draw conclusions and inferences from the discussion or by having students develop a position paper outlining their personal position and defending that position against opposing points of view.

Developing The Curriculum

The first and perhaps most important step in developing a problem-based appropriate technology curriculum involves creating a target upon which the subsequent efforts in curriculum development will focus (McCade, 1995). McCade states that: "…it is essential that teachers understand and believe in both the mission and the content base they will employ with students." (p. 44) Developing this mission and content base would logically begin with the identification of the basic skills, thinking skills, and personal qualities that all students should achieve within the program and end with the development of program goals, objectives, and outcomes.

While any curriculum development process must logically begin with the development of program goals, objectives, and outcomes, developing a problem-based appropriate technology curriculum will require an examination of the relationship between those criteria and strategies for introducing appropriate technology concepts into the daily lessons. Unfortunately, when studying technology in the United States, technology teachers tend to over-emphasize the positive impacts of technology and de-emphasize the limitations of technology. Schumacher (1973) suggests that one of the side effects of technology is the idolatry of giantism—bigger and better technology is always the answer. He further suggests that this is particularly true in matters of transport and communications (Schumacher). In an effort to balance the delivery of technological concepts, it is therefore necessary that technology teachers to identify avenues for inserting problem-based appropriate technology activities and techniques into the overall curriculum framework. This author does not recommend inserting an appropriate technology unit into the curriculum, but rather infusing the entire program with appropriate technology activities that balance the curriculum.

There are generally four major problem areas that permeate almost all appropriate technology problems. These four problem areas can be used to develop curriculum materials/activities and would fit into almost any technology education curriculum model. The problem areas include:

1. Construction/Housing: Developing alternative types of cement, alternative mortar materials and ingredients, low-cost roofing materials from native materials, alternative materials for ceilings and partitions from native materials, low-cost door and window frames;
2. Water: Developing low-cost water supply and purification systems for small rural communities, techniques for constructing low-cost small-scale water storage systems, small-scale sewerage treatment plants;
3. Power: Conducting research on improvements to present methods of using fuel, developing non-polluting methods of utilizing local coal supplies as a substitute for wood in rural areas, low-cost solar energy systems for developing countries (e.g. for water heating and pumping), uses for wind power (e.g. for water pumping), alternative uses for methane gas (e.g. for water pumping and heating); and,
4. Agriculture and manufacturing industries: Developing small-scale manufacturing systems that utilize native materials and natural resources, grain storage systems for rural communities, alternative and small-scale manufacturing systems for agricultural implements, systems for the production of ornamental stone, small-scale and alternative techniques for foundry processes; and, systems for the recovery of waste engine oil (Singer).

The list above and other similar lists, can serve as a catalyst for selecting content and ultimately developing curriculum materials and activities for the technology education classroom. The materials and resources from technological, industrial, engineering, and design journals as well as government resources, resource texts, research and development materials, and selected Internet sites may also provide assistance in the identification of appropriate content.

Guidelines for Developing Problem Solving Activities

While the concepts delivered, the problem solving dimension, and the degree of difficulty will vary according to the goals of the activity, the general guidelines below can be used to guide in the development of all problem solving activities. Although, these general guidelines include strategies for developing as well as implementing appropriate technology problem solving activities, this information will be vital during the curriculum development process. As the technology education instructor begins the problem solving activity development process, they should consider each of the following:

1. Team Selection: Generally, problem solving involves students in teamwork situations. While teamwork is an invaluable skill in the work place and should be a major part of the educational experience, it is presented here for a different reason. In most developing nations where appropriate technology is most important, decisions are made by the group and for the good of the group and individuality is a very foreign concept. Therefore, for the sake of reality, it is essential that problem solving activities related to appropriate include a full dose of team work.
2. Problem Clarification: When writing appropriate technology problem solving activities, instructors should include statements that encourage group members to work toward clarifying the problem, both in written and oral formats. By requiring teams to clarify problems prior to attempting to solve them, many potential “wrong turns” may be avoided.
3. Strategies: The problem solving framework (outlined previously in this chapter) provides strategies for solving appropriate technology problems by type (invention, design, technical/procedural, trouble shooting). These strategies require the student to brainstorm, plan, sketch, and analyze the potential solution prior to beginning to create the solution and can serve as a “roadmap” for students.
4. Establish Rules: Instructors should set basic ground rules and timetables before allowing the students to begin the activity. By establishing these rules, instructors may avoid teaming problems and questions later.
5. Teach Problem Solving Techniques: It is commonly assumed that students know how to work in teams and know how to solve technical problems. In many cases, this could not be further from the truth. The typical high school student has been assessed for the bulk of his/her education experience on an individual basis and is often ignorant of the skills needed to perform as a team member. By setting aside class time at the beginning of the school year/term to teach general problem solving and brainstorming techniques, teaming strategies, instructors will more adequately prepare students to flourish in this environment.
6. Teach Analysis Skills: Technology education students need to develop analysis skills. These skills provide individual students with the abilities to critically assess the products of their efforts. Problem

solving analysis usually involves the student in the selection of an appropriate solution, the implementation or construction of that solution, pilot-testing the results of the implemented solution, and the evaluation of the whether the solution adequately solved the problem.

7. Mirror Reality: Develop problems that are as “real” as possible. Search the Internet, examine copies of National Geographic and other journals that include an international flavor.
8. Tools and Materials: Require students to adapt local cultures and economic conditions into the solution. Students should also be required to incorporate the tools and processes used by the local population into the solution. Emphasize the use of technologies created from locally available materials and energy resources, when possible.
9. Customs. Cultures, and Values: Students should be required to examine local customs, cultures, and values. Solutions to given problems should be structured to take local cultures, values, and customs into consideration. The solution should also be affordable by the local population and should avoid or prevent cultural domination by a developed nation.
10. International Marketplace: Require solutions that are not only be appropriate at the local level but also be formed in such a way that they take regional, national, and international conditions into consideration. For example, the Bagen Radio (a wind-up radio) was developed to help poor villagers in Africa who could not afford to purchase batteries. Later, the radio found a huge market in the developed world.

Ideally, appropriate technology problem solving activities will incorporate those technologies to which the small farmers, artisans and other small producers in the region impacted by the problem will have easy access to with their limited cash resources. This is not to suggest that modern technological knowledge and capacity can not be a part of problem solving solutions, but only that a selective approach to the adaptation and adoption of known methods is needed. Deciding which technologies will be easily assimilated and which ones will not is a debate that cannot be easily solved, however it will provide interesting debate among students.

Identifying Potential Problem

Where can the technology education teacher find appropriate technology problem solving problems for their classrooms? Problems may be located in numerous sites, but most will require some creativity and insight on the part of the instructor. A major consequence of technological change is a difference in levels of technological ability and understanding. Since technological issues and problems have more than one viable solution, decision-making should reflect the values of the people and help them reach their goals when appropriate (TFAA, 1996). The philosophy of appropriate technology reaffirms what most of the world's villagers know inherently – that culture, social systems, politics, religion, economics and ecology are all threads in the same fabric of life; and that technology exists only as a tool, a loom upon which all the other threads are woven (Clavaud, 1982). The first role of the curriculum developer is to respect and understand the intricacy and interdependence of the factors that define life in many developing nations. Only then is it appropriate to assist and encourage people to utilize their talents, apply their creativity, and recognize options for change.

The first decision to be made when identifying appropriate technology problems is the choice of technology for a given project or range of activities. Singer (1979) suggests that choice involves a range of alternatives and the major determinants may be listed as follows:

1. What technologies currently exist within the culture, society, or region?
2. Do the native people involved have the ability to adapt existing technology to their own special or changing conditions?
3. Does the country in question have the capacity to create national or indigenous technology suitable for and specifically geared to their objectives?
4. Are there sufficient funds within the country in question to support the implemented solution?

Assessment And Reflection

Many people embrace technological change, believing that through technology their lives will be made easier. Each technological advance builds on prior developments and leads to additional potential problems, and more complexity. The accelerated rate of technological change, inspires and thrills some people, but confuses and even alienates others. If solutions to appropriate technology problems are to have long-term positive impacts, they must include a component of reflection and assessment. Reflection calls on the providers (problem solvers) to critically analyze the implemented solution. In the technology education classroom, this reflection might take the form of answers questions that require introspection. For example, problem solvers might be required to answer questions like:

1. What impact will my chosen solution have on the culture, life, and circumstances of the local citizens?
2. Are there potential long-term side-effects of implementing this technological solution?
3. What are the most negative/most positive side-effects from this implementation that I can imagine?
4. Would this technological solution be appropriate if implemented in another similar location?
5. Will the technology used to solve the problem be accepted by all? If not why?
6. Does the chosen solution include potential input from the impacted citizens?
7. Does the chosen solution have a strong potential for sustainability?

By answering these questions upon reaching a tentative solution to a technological problem, students are forced to use forecasting skills and to be reflective. Often, upon answering these questions, students will return to the problem and make adjustments to the tentative solution reached earlier. The result is a more robust solution to the initial problem.

While assessing the results of appropriate technology problem solving in a technology education classroom is somewhat artificial, it is an essential component of the learning experience. Often this assessment may include little more than testing technological devices, products, or systems created as a part of the proposed solution and then comparing the results of that assessment against a set of previously developed criteria. Some suggested assessment techniques include the following:

1. Comparing the results of prototype/system tests with the results of other problem solving teams;
2. Comparing the results of prototype/system tests with the results of students from other schools;
3. Comparing the results of the problem solving activity with a previously developed rubric;
4. Using independent consultants (other teachers/students) to analyze the results of the activity; and,
5. Using intra-team assessment techniques.

Sample Problem: Pedal Power

Problem Introduction

The bicycle may be one of the most important technological developments of modern society. It represents the breakthrough in modern technology. It took about 5,000 years of technological development to move from the wheel to the bicycle, and the bicycle itself took another 50 years to evolve. Gottlieb

Daimler and Karl Benz produced their first automobiles in 1885 based on bicycle technology. Humans on a bicycle rank first in efficiency among traveling animals and machines in terms of energy consumed in moving a certain distance as a function of body weight. The rate of energy consumption for a bicyclist (about .20 calorie per gram per mile) is approximately a fifth of that for an unaided walking man (about .90 calorie per gram per mile). Although the bicycle is clearly a very efficient means of transportation, it also has a lot of stationary uses. The Chinese have developed a simple chain pump from bicycles. In Uganda one can find a number of pedal-powered machines in use (a two-man corn grinder, a portable winch, an energy cycle, a butter churn). It is fairly safe to assume that many machines with electric motors could be converted to pedal drive.

Your Task

In many developing nations, concrete is mixed by hand at the building site (usually, on the floor). This is a very labor intensive and inaccurate process. Design a model of a low cost, pedal-powered concrete mixing device that could be constructed of native materials in most any developing nation.

Problem Parameters

Students should work in teams (as assigned by your instructor) to solve this problem. Successful team solutions must be created within the design parameters listed below. Your team must:

1. Select a country or region in which the solution will implemented;
2. Use the Internet and others sources to identify materials, equipment, resources, and human resources that might be available in the selected country/region;
3. Use only recycled or freely obtained materials;
4. Develop a device that will mix at least 50 pounds of mortar or concrete per use (you may use sand during pilot-tests);
5. Develop an operations and maintenance manual that ensures citizens in the selected country will be able to use and repair the device using locally available materials and skills;
6. Develop a presentation that outlines each of the following:
    a. Historical abstract detailing the country selected for implementation;
    b. Merits of the pedal-powered cement mixer;
    c. Potential side-effects of implementing this technology;

d. The operations and maintenance manual.

Problem Assessment

Student should use appropriate problem solving strategies to solve the given problem. Upon completion of the team presentations, solutions will be evaluated according to the following criteria:

1. Device (40 points): Did the selected team solution adequately solve the problem?
2. Parameters (20 points): Did the team remain within the stated design parameters?
3. Problem Solving Strategies (20 points): Did the team use appropriate problem solving strategies to solve the given problem?
4. Presentation (20 points): Did the team provide a presentation that met all stated requirements?

Sample Problem: Playing The Game

Problem Introduction

Throughout history, people have created and developed devices that make everyday tasks easier to perform, safer, and faster. Often, people assume that the great inventors of history had capabilities that the common person could not possibly understand. This perception is simply not true. Most people who have been recognized as great inventors were simply trying to develop devices that would make everyday chores easier to perform. For example, the typewriter was developed in an effort to take the monotony out of writing letters by hand. Unquestionably, there are numerous other examples of devices created simply to make life easier. As a student, you face problems, challenges, and monotonous chores each day. There is a distinct possibility that some of those chores could be made easier through the creation of a product/device.

Your Task

Simple board games are used as a form of education and entertainment by almost every society and culture on earth. This is particularly true in regions where access to modern electronics (i.e. television, computers, etc.) is limited. One goal of the appropriate technology movement is to assist native populations in the effort to raise much needed resources by marketing arts and crafts that they current use. Recently, a traditional African board game called “Mancala” was introduced quite successfully to the U.S. market. The potential for helping native cultures raise funds by assisting them in the marketing of traditional games is great.

Your task is to conduct Internet (and other) research to identify a traditional game used in an underdeveloped nation or region, develop a prototype, and finally to develop a marketing plan that can be used to raise funds for the nation or region in question. Care should be taken to avoid imposing yourself or your marketing plan on the values, beliefs, and cultures of native populations.

Problem Parameters

As you solve this problem, it is imperative that you meet each of the parameters listed below:

1. The game prototype and marketing plan must be based on a traditional game used in an underdeveloped nation or region. For example, you could develop a prototype that is based on a traditional game played in Ethiopia (nation) or a prototype based on a traditional game played on the Navaho reservation (region) in New Mexico.
2. The game should not resemble any games currently on the market. Remember, the ultimate objective is to develop a marketing plan that can be used to raise funds for an underdeveloped nation or region.
3. The prototype version of your board game should include:
    a. A prototype of the game with appropriate graphic logos and illustrations;
    b. A complete set of rules and instructions affixed to the game;
    c. Instructions for assembly and disassembly;
    d. A logo and/or name that will attract attention in the store and assist in the marketing effort;
    e. A package that can be used for displaying the game in stores;
    f. Safety guidelines (printed on the package) for parents outlining age appropriateness and safe use;
    g. A durable design that will stand up to the rigors of hard use.
4. The marketing plan should include:
    a. A written description of the nation, region, or culture from which the game originated;
    b. An estimate of the costs associated with producing the game;
    c. A list of materials necessary for producing the game;

   d. A written description outlining suggested procedures for using profits from game sales to assist the inhabitants of the nation or region;
   e. A list of board game manufacturers that could be contacted to initiate this development effort.

5. The completed prototype and marketing plan should be submitted in a professional manner. For example, the marketing plan should include color photographs and illustrations, and should be bound using a portfolio format.

Investigation Procedures

Complete the following steps as you identify and refine ideas for your product:

1. Conduct extensive research using your school library, the Internet, magazines and journals. You may be able to gather a number of resource materials from sources like the United Nations.
2. Locate/obtain all necessary materials for the construction of the game;
3. Discuss and brainstorm ideas for the design of the game;
4. Develop ten possible designs for your game taking care to include the parameters listed above;
5. Sketch your design ideas. The design sketches do not have to be perfect, but will help generate ideas;
6. Select the best idea or combine several ideas to create the final design idea;
7. Develop a drawing of the final board game idea using drafting materials or computer aided drafting;
8. Develop drawings of the package and logo/name that will be used for the final version of the board game.

Developing Your Product

Complete the following steps to create a 3-D prototype of your product:

1. Using the drawings you developed during the investigation phase of this activity, begin cutting, laying out, painting and assembling the board game;
2. While one member of your team is completing this first step, other members of your team could begin developing and word processing the directions for the board game or working on the marketing plan;
3. Simultaneously, other members of your team could begin developing the packaging and name and logo materials that will be used on the board game and package;

4. When the board game, name and logo, directions, and package are complete, your team should complete the following assembly activities:
   a. Affix the directions to the board game;
   b. Prepare the package by attaching the board game name and logo as well as parental guidelines and any assembly instructions;
   c. Complete the assembly by packaging the board game within the previously designed package.

Presenting Your Idea

As with any new product, you will probably be asked to present your game a number of times. Prepare a presentation for your new board game. Your presentation should include a description of the nation or region from which the game originated, a description of the game, the purposes of the game (and maybe a demonstration of how the game is played), and most importantly, an overview of the marketing plan. Remember, the objective of the presentation is to encourage others to accept your ideas and buy your game rather than other games that may be on the market. When you are finished preparing the presentation, notify your instructor that you are prepared for the presentation.

Problem Assessment

Problem solving teams must meet each of the “parameters” listed in the noted section above and will be evaluated according the criteria listed below:

1. Game Prototype (40 points): Did the selected team solution adequately solve the problem?
2. Marketing Plan (20 points): Did the team provide an adequate marketing plan that met all of the criteria listed in the problem?
3. Presentation (20 points): Did the team illustrate adequate research and preparation in the delivery of the presentation?
4. Summary Questions (20 points): Did the team provide adequate responses to each of the questions outlined below?
   a. In your opinion, what aspect of your new board game will be the most appealing?
   b. What items where included on the packaging and the game itself simply for the purpose of attracting attention to your board game?

c. If you had the opportunity to start this activity over, how would you approach this problem differently than you did this time?
d. If this board game were to be produced and marketed, what impact might this have on the nation or region from which the game originated?
e. If this game were to be marketed, how could you assure citizens of the nation or region involved that it would not adversely impact their culture?
f. If you had an unlimited budget, what changes would you make in the product?
g. Compare the board game developed by your team with the board games developed by other teams in your class. If you where a typical consumer in a store, would you purchase some of the other board games or the one developed by your team? Why?

Summary

Man was once a cave dweller. In the Ice Age this provided a form of accommodation which ensured the survival of the species. Even today it is hard to improve upon the four main advantages of a good dry cave: moderate ambient temperatures, low maintenance costs, hygienic conditions, security. Caves are, however, in very short supply and are badly situated in mountainous areas away from flat agricultural land. As the earth’s temperature rose and the ice receded, man was able to move out of caves in the hills and change from a hunting/gathering economy to farming. Shelter was still needed, especially during the winter and at night, and people became enormously resourceful in building dwellings out of naturally occurring materials (Congdon, 1977).

The dominant modern belief is that the soundest foundation of peace would be universal prosperity. One may look in vain for historical evidence that the rich have regularly been more peaceful than the poor, but then it can be argued that they have never felt secure against the poor; that their aggressiveness stemmed from fear; and that the situation would be quite different if everybody were rich (Schumacher, 1973). Through technology, people will not solve all of the problems in the future. They will, in fact, create some. But if the people develop and use technology in the context of the country’s goals and values, they will continue to offer each other even more ways to work, enjoy leisure, communicate, and order their lives (ITEA, 2000).

Members of the technology education profession must strive to develop and transmit an understanding of the true nature of technology. Graduating technology education students must be prepared to comprehend and respect the power of technology to solve problems as well as its power to create entirely new problems. If graduating students are inculcated with a basic knowledge of the power technology has to alter the environment, change native cultures and values, impact the ecology and economies, we will have gone far toward preparing a group of citizens more adequately prepared to deal with the future.

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Chapter 10

Appropriate Technology Case Studies: Lessons Learned

Charles Linnell, Ed.D
Clemson University
Clemson, South Carolina

and

Dennis Scanlin, Ed.D
Appalachian State University
Boone, North Carolina

Since the early 1970's groups and individuals have been searching for appropriate solutions to the problems created by the earth's growing population and have been trying to accelerate the adoption of them. Many solutions have been found and many educational and development projects have been initiated, implemented, evaluated and described in the literature. This chapter will identify, describe and analyze several significant projects. The following collection of appropriate technology (AT) case studies, AT curriculum efforts and energy education curricula, will, hopefully, provide comparative information for technology educators and others to make informed decisions concerning the value, uses and relevance of AT. Appropriate technology is an often-misunderstood field of study. People have different interpretations of technology and its appropriate applications. Who decides which technology is appropriate or not? Who determines its appropriate uses? As E. F. Schumacher (1973) writes appropriate technology is "technology with a human face" meaning it is technologies that will not harm the environment and will improve the basic quality of life for less fortunate people. The following cases studies and AT curricula all have one trait in common: they strive to present technology "with a human face".

Appropriate Technology Case Studies

Merriam-Webster's Collegiate Dictionary (1999) defines a case study as a method of education research that makes use of a group of case studies to reach general conclusions and principles. Examining appropriate technology case studies that were implemented in different countries and educational environments will give researchers and practitioners comparative background for practical application and curriculum design. The appropriate technology case studies that are in this chapter will address AT in development situations, and how AT can be introduced into technology and other education curricula.

Marketing appropriate technologies is not an easy task. People are resistant to change and appropriate technologies are often perceived as inferior technologies. Case studies documenting efforts to transfer appropriate technologies and/or introduce them into technology education programs can provide valuable insights into what works and what does not; both in terms of the technical and economic characteristics of technology and the social, psychological and pedagogical aspects of the technology adoption/education process.

Green Building Case Study

Appropriate Construction Technology or Sustainable/Green Building, as it has more recently been described, has been an important part of the AT and Sustainable Development movements. Energy efficient construction and appliances, natural heating and cooling, alternative materials and techniques, resource efficiency, water and waste issues and indoor air quality have all received significant attention and provide outstanding opportunities for Technology Education activities. "The primary goal of "sustainable building design" is to lesson the harm poorly designed buildings cause by using the best of ancient building approaches in logical combination with the best of new technological advances. Its ultimate goal is to make possible offices, homes, entire subdivisions that are net producers of energy, food, clean water & air, beauty, and healthy human & biological communities" (Barnett & Browning, 1995, p.2). By contrast, most buildings today contribute in many ways to the degradation of the earth's environment. They consume energy and materials and excrete wastes. They contribute to deforestation, air and water pollution, global warming, stratospheric ozone depletion and health problems for people living and working in buildings. The average American household now produces each year about 3,500 pounds of garbage; 450,000 gallons of wastewater and 25,000 pounds of carbon dioxide (Barnett & Browning, 1995). Buildings use 1/3 of our total energy, two thirds of our electricity, and consume one–fourth of all wood harvested (Hawkin, Lovins & Lovins, 1999). Forty percent of all material and energy used worldwide is used to construct and operate buildings each year. But the appropriate technologies exist to produce much better buildings; buildings that are beautiful and generally use 50 – 80% less energy (Cole & Skerrett, 1995) and water (Barnett & Browning, 1995) and produce corresponding less pollution than a conventional building. The following case study will identify the characteristics of many of the most exemplary buildings.

Adam Joseph Lewis Center for Environmental Studies at Oberlin College

While many green residential-scale buildings have been designed and constructed, the full range of appropriate technologies and green design approaches is probably most clearly seen in a growing number of larger building projects. A significant number of large green commercial and institutional building projects have been constructed throughout the world during the 1980's and 1990's. Some of these include projects for the Body Shop, Compaq Computer, the National Audubon Society, Natural Resources Defense Council, Sony, Herman Miller, Wal-Mart's Eco-Mart. Also, more projects include the School of Natural Resources and Environment at the University of Michigan, the Barney-Green Renovation Project at Deniston University, and a residence hall at Wisconsin's Northland College to name but a few (Barnett & Browning, 1995). One of the most exemplary model projects constructed as of this writing is the Adam Joseph Lewis Center for Environmental Studies at Oberlin College. This building was completed in early 2000. The project was mindful of material selection, energy efficiency, water use and wastewater recycling. It was designed and constructed to be not only a building where teaching takes place, but a place that teaches. William McDonough, who won the first Presidential Award for Sustainable Development in 1996, was the project architect.

The project was initiated by David Orr, the chair of the Environmental Studies Program at Oberlin. He organized a class of students in 1992 to develop a plan for an environmental studies center. The students, Orr and numerous architects and green building experts spent two semesters exploring green building possibilities for an Environmental Studies Center building. The class work resulted in a list of desired features (Orr, 1999) which included:

- No wastewater discharge
- The ability to generate more electricity from a PV system than the building would require
- Avoid all materials known to contain carcinogens, mutagens, or endocrine disrupters
- Use energy and materials with great efficiency
- Use only products and materials grown or manufactured sustainably
- Promote competence with environmental technologies
- Landscape to promote biological diversity
- Promote analytical skill in assessing full costs over the lifetime of the building

- Promote ecological competence and mindfulness of place

The wish list was submitted in 1995 to a new president and was endorsed by her. Two graduates from the class of 1993 were hired to coordinate the design of the project and to engage students, faculty, and the wider community in the design process. They also hired an architect to help conduct design charrettes, or group planning sessions, to further develop and refine the goals for the project. A design charrette is a short, intensive, team oriented, multidisciplinary roundtable to define the best solution to some problem. Many recent exemplary green institutional and commercial construction projects have used this process. Over 250 participants eventually took part in 13 design charrettes. The design process included students, faculty, town residents, university officials and green building experts.

During this time a design team was also assembled that contained leading figures in the field of ecological engineering. It included Amory Lovins and Bill Browning of the Rocky Mountain Institute, NASA scientists, John Todd and others, in addition to the McDonough firm. The team approach was new to Oberlin, but it was felt to be critical for the successful integration of the building systems and technologies. In addition to the new design process, the selection of materials, relationship to manufacturers, and the method of estimating the cost of the project were done differently. Energy and lighting computer analyses were done for the building and demonstrated that the goals could be met at a reasonable cost, as is most often the case.

The beautiful building is a stunning success. It uses only 21% of the energy used by an average newly constructed academic building. The roof of the building was designed for photovoltaics and will generate more electrical power than it needs to operate; and the north side of the building is protected by an earthern berm and tree grove. The building is elongated on an east west axis and has large south facing windows with overhanging eaves and shading trusses that shade the summer sun while allowing winter heat gain. The building was designed to provide all the interior with natural daylight to minimize the need for electric lights. And the electric lights used were very energy efficient. One of the most unique features is a “living machine” designed by John Todd, which purifies all waste water produced in the building naturally in an indoor marsh like environment that is a public part if the building. Diverse communities of bacteria, algae, microorganisms, plants, trees, snails, and fish interact as whole ecologies in tanks to purify the waste water and the purified water provides all non-potable or gray water uses in the building. The roof and walls are well insulated and the windows used are the most energy efficient available. To ensure the best indoor air quality possible the building used low-VOC materials, paints, and adhesives provides 100% natural ventilation to all spaces. Operable windows are in all occupied spaces. Complete HVAC testing and balancing was performed and a maintenance protocol was developed to establish acceptable cleaning products and practices. The durability and required maintenance of materials selected was carefully scrutinized before selection and all wood used was supplied by certified sustainably-managed forests. The building has a special raised floor for ventilation air, and electrical, data and communication wiring and carpeting which are leased to the College by the manufacturer. The college gains the services of the floor and carpet without the liabilities of ownership. This beautiful building will continue to inspire the students and faculty at Oberlin for many years to come and many others around the world. It was a wonderful learning experience for all those involved and will continue to powerfully demonstrate that our problems are solvable and better buildings are possible.

Indian Bio-gas Program Case Study

Bio-gas is primarily methane with traces of other gases. It is a clean burning fuel that can be used for cooking stoves. Efficient, low-cost gas cooking stoves eliminate the need to constantly collect firewood. The raw materials, agricultural waste and animal manure, are very inexpensive or free in India and other developing countries. The generation process, which takes place in a biogas generator (also called methane digesters), employs bacteria that work under anaerobic conditions, that is without oxygen - oxygen kills bacteria (Hazeltine and Bull, 1999 p. 136). The bio-gas generator can be constructed of inexpensive or recycled materials. However, methane digesters are not in common use in the third world. Perhaps the collection of manure from fields is too difficult (Hazeltine and Bull, 1999 p. 153).

The technical and economic aspects of rural bio-gas systems in India are examined in this study; however, the main focus seems to be with diffusion. The technology to convert agriculture and animal waste into usable energy, primarily cooking fuel, is presently at the stage where it is economically feasible to operate on an individual level (Lightman,1987). Again, the problem stems from “the organizational philosophy that serves as a basis for this and many other rural technology diffusion efforts in developing countries” (p. 348).

Foreign Technology and Indigenous Technological Capability in Brazil Case Study

This case study focuses on the experience of Brazil, a country that has drawn extensively on foreign technology for its economic development, to illustrate the positive relationship between the importation of technology and the development of Indigenous Technological Capability, (ITC) (Dahlman, 1984). Dahlman (1984) found that the secondary support systems necessary for success of the introduced technology, education, training, and specific technical expertise, were sometimes lacking. However, Dahlman suggested if the foreign investor pursues an "aggressive technological strategy" the end results will be beneficial to the local, or indigenous, population. The creation of jobs, the provision of training and education are all end results of imported technology. With this training comes, hopefully, the creation of Indigenous Technological Capability. So far, in Brazil, two manufacturing industries have benefited from foreign investment, the automobile and the aircraft industry (p. 322).

In some examples of "aggressive technological strategies", the population in Brazil has not benefited. The clearing of the rain forest, the high infant mortality rate and the intense crowding and poverty of the large urban areas are reminders of a level of development still to come (Linnell, 1996).

AT and Bicycles Case Studies

In many developing countries efforts are being made to improve transportation access for large populations. An energy efficient and environmentally conscientious appropriate technology is the bicycle. Onn (1984) stated that the bicycle is the simplest technique of personal transport, other than walking, and therefore a basic need in many developing countries (p. 54). In Malaysia a number of manufacturers, funded by the World Bank, are using appropriate technology to make the basic components of the bicycle. These firms make the low-technology items, such as body frames, forks, mudguards, handlebars and chain covers. The manufacturing characteristic that makes the bicycle production appropriate is the substitution of labor in the machining activities. In the cutting/filing/threading operation for body frame manufacture, the tube length is manually adjusted instead of being done by machine.

The basic need that the bicycle satisfies is mobility, the ability to travel from the place of residence to the place of work and the ability to move about for social purposes. People in much of Africa, Asia, and Latin America depend heavily on bikes and load-carrying three-wheelers to commute to work, reach remote rural communities, and haul produce to markets. In many cities in Asia, pedal power, including rickshaws, accounts for 20-60 percent of people's transportation needs (Lowe, 1994, p. 86). The "Oxtrike" developed at Oxford University is currently being tested in various countries (Hazeltine and Bull, 1999 p. 94). The "Oxtrike" is an improvement on the cycle rickshaw, in that the frame is not made from thin tubing like regular bicycles, rather, it is constructed from standard steel sheets that has been folded and welded. This makes for a sturdy, multi-faceted form of transportation that can be manufactured locally, and used to carry people and goods.

Honduras Solar Education Project Case Study

In 1992, two faculty members from Appalachian State University (ASU) and 15 students traveled to Honduras to undertake a project demonstrating solar technologies. The goals of the project were to:

- Demonstrate practical uses of solar energy
- Teach as many Hondurans as possible how to design and build solar ovens, dryers and Photovoltaic (PV) systems
- Learn more about the people, problems and opportunities for sustainable development in Honduras

The project was a collaborative effort involving ASU's Appropriate Technology (AT) and Sustainable Development (SD) programs, and the Institute for Socio-Economic Research (IISE) in Tegucigalpa, Honduras. Meetings took place in Honduras the year before the project began to explore possible ideas for collaborative activities. Representatives from the ASU and IISE met with a variety of grass roots development organizations to discuss possible projects. There was a consensus among the groups that renewable energy technology would be a good focus for the activities. Solar ovens, solar food dryers and photovoltaic technologies were selected as attractive examples of renewable energy utilization for Honduras.

Ramon Velasquez, the director of IISE, was particularly interested and offered IISE's training facility just outside of Tegucigalpa, the capital of Honduras. He identified participants and gathered tools and materials needed for the project. . The Director of ASU's SD program took charge of making all the travel plans, recruiting students and preparing students for life in Honduras. The Coordinator of ASU's AT program coordinated the design, prototype construction and testing of the technologies; developed instructional materials; raised funds for the tools and equipment; and led the initial “train the trainer” workshops. Several graduate assistants from ASU assisted with this component of the project.

The project was conceived as a “train the trainer” program, which would help ASU’s Appropriate Technology (AT) and Sustainable Development (SD) programs, to multiply our efforts. Mr. Velasquez surveyed Honduran organizations from all regions of the country to identify persons who might be interested in learning more about solar technologies. The project sought to use the strengths of local leaders who were respected in their communities and were likely to be able to organize educational events in their communities and share information with others.

The project staff found considerable interest in these technologies and eventually established representatives with 17 different organizations. These representatives came from all regions of the country and represented educational institutions, coffee and arts cooperatives, health programs, programs for women, literacy programs and others. Representatives from these organizations traveled to the IISE training facility outside of Tegucigalpa in the beginning of July of 1992 and the ASU contingent conducted the workshops at this location. Project staff and Honduran representatives participated in a six day “hands on” workshop focusing on solar ovens, solar food dryers and photovoltaic system design and construction. The total group of about 30 individuals was divided into six groups, with Hondurans and ASU students working together in each group.

Each of the three technologies was introduced with a classroom presentation and then

Each of the six groups constructed a system. The systems were designed so they could be constructed with simple locally available hand tools and for the most part with locally available materials. The staff from ASU did provide a tool kit with a few power tools, and PV modules donated by Kyocera and Carrizo, Teflon glazing donated by DuPont Corporation, reflective Mylar donated by 3M and some dark aluminum screening purchased in the US for the food dryers absorber. All the remaining tools and materials were purchased locally in Honduras.

By the end of the six-day workshop project participants had constructed six solar cookers, six solar dryers, and six PV systems. More importantly 30 people were trained and ready to teach others about solar energy. Tools, materials, PV components, solar ovens, dryers, and instructional manuals were divided among the teams who then traveled throughout Honduras, mainly to rural areas, to put on additional educational programs. ASU students accompanied Hondurans back to their communities where they assisted with the solar education efforts and experienced life in Honduras.

During the remaining weeks of the project, the Honduran trainers along with their ASU companions organized and conducted numerous workshops and demonstrations. Systems were designed and constructed and instructional manuals distributed in eight different geographical locations. Eight, single module PV systems were installed in community buildings and used primarily for lighting; 18 additional solar ovens were constructed; and the dryers constructed at the initial workshop were delivered to those who could put them to use. The project workshops impacted over 700 Hondurans with a message of hope and a vision of a sustainable energy future and a better life.

After the project was completed and the ASU staff had returned to the United States 10 of the participating Honduran organizations met to form a National Solar Alternative Network to further promote the use of solar energy in Honduras and to develop a solar loan fund to help finance future projects. The tools, instructional materials and trained community leaders left behind ensured that this work would continue. Although no formal follow-up study was performed, some problems were identified. Some ovens were not being used, primarily because firewood was easy and inexpensive to secure for cooking. And the solar ovens required a different approach to cooking and could not be used to cook some traditional foods. Additionally some of the PV systems were not functioning. Another PV project recently completed (Kroon & Guda, 2000) avoided problems by closely monitoring the systems after installation to answer questions people had, to continue educating the owners about the technology and to take care of any problems that arose. The owners were asked to keep a record of hourly appliance and light usage and the records were collected each week.

Solar Cooker International (SCI) and Kenyan Case Study

Half the world still cooks with wood and close to 1/3 of humanity is facing fuel wood shortages for cooking (Blum, 1997). Burning fuels for cooking also pollutes the air and deforests the land. Solar Ovens have been designed, constructed and successfully used as early as early as the 18th century. Two basic types of solar ovens have emerged: parabolic reflective cookers and box ovens.

The Solar Cooker International Organization (SCI) was formed in 1987 to promote the use of solar cookers for cooking and water pasteurization worldwide. Since that time they have become the central hub in the solar cooking network. They facilitate communication among over 500 independent organizations throughout the world promoting solar cooking. They have developed solar cooker plans, kits, complete units, and instructional materials in many languages and conduct many workshops all around the world. Until recently most of their work has focused on single reflector solar box ovens made of cardboard, but recently they have developed a simpler and less expensive cooker called the cookit. It is a simple device made from cardboard and tin foil, which wraps around a dark covered pot of food that is placed inside a sealed plastic oven cooking bag. In 1995 SCI began a project in Kenyan refugee camps. The funding for the project came from an anonymous donation. The location of the refugee camp was close to the equator, hot and sunny, and mostly deforested. The people were very poor and given only one stick of wood per person every two weeks for cooking. Many were spending a large percentage of their time gathering additional fire wood or having to give away part of their food for additional wood or pay as much as 75% of their income to purchase the wood.

Despite the bleak situation faced by the refugees, there was some skepticism about solar cookers initially, but as of January 1997 more than 5,000 families have attended workshops on solar cooking and received a solar cooker. Women were the target audience for the project. Workshops were put on by project staff and refugee leaders in January of 1995 to educate Kenyan refugees on the uses and applications of solar ovens. With the new *CooKit* design there was not a need to spend much time constructing the ovens so more time was spent discussing proper cooking techniques and demonstrating how the ovens cooked. The second workshop was put on for refugees who had been designated by their leaders as good candidates. At first the refugees thought the idea was humorous and were reluctant to participate, however the SCI workers offered free food, a free oven and cooking pot as incentives. By the following week the cookers were being used routinely by the women refugees for baking bread, and cooking carrot and potato soup and pasta. Six more workshops were then put on for various ethnic groups staying in the refugee camps. The SCI leaders decided that instead of a traditional diffusion model where the initial work would start with leaders who would then influence others, the participants in each workshop should be women who live near each other so they could assist and encourage one another. After these initial workshops which were taught by SCI staff, the most capable and enthusiastic of the workshop participants were asked to become paid trainers. A coordinator and 2 monitors were also hired to oversee the project. There were a total of 24 trainers training about 85 families each week at the height of the project. Each trainer was responsible for identifying a group to train, conducting the training; making home visits and leading a group follow up meeting with all the participants. During each home visit a survey was completed describing the women's experiences and difficulties. Payment was received when completed paper work was turned in. One of the monitors made a second follow-up visit to each household. A cardboard manufacturer in Nairobi was hired to laminate aluminum foil onto one side of cardboard and spray a waterproofing wax on the other side and cut the cardboard to the proper shape. When SCI left Kenya they had set up all the logistics and the project continued.

Appropriate Technology and Energy Curriculum Projects

An excellent appropriate technology curriculum designed for fifth and sixth grade students was developed and published by the National Center for Appropriate Technology (NCAT) in Butte, Montana; *Connections: A Curriculum in Appropriate Technology for Fifth and Sixth Graders* (Melcher, Ed. 1980). The curriculum is well written and has many activities that can be correlated with other subjects. It gives the background and characteristics of AT then introduces students to hands-on, cooperative activities that urges them to construct models, compare and question the impacts and appropriateness of different technologies. Some of the topics that are covered are; conservation, transportation, a look at waste, recycling, renewable resources, making solar models, "the food we eat", and "growing your own". Although this curriculum was published in 1980, it is still very relevant and innovative for implementation in the classroom and the technology education environment.

Mr. Charles Kachmar, (2000) a technology education teacher at South Gwinnett High School in Snellville, Georgia, has developed a unique appropriate technology fifteen-day module for students. The students are introduced to the characteristics of appropriate technology. After reviewing the AT characteristics they select a third world country with a specific development problem and design an AT solution. Once the country and problem are identified the students brainstorm AT design solutions, begin the design process, including detailed drawings and demographic information, then construct their model AT solution. The AT design activities have been successful in providing the students practical knowledge and AT application strategies. The students present their appropriate technology solutions in a school exposition for parents, teachers and their fellow students.

The AT solutions that the students designed follow a format which included; a Project Title, the Problem to be Solved, Materials, and How it Works. The AT model was constructed using low-cost, recycled, or reused materials that were assembled and tested. After the tests the students describe how the AT solution works to solve the identified problem. Three of the AT solutions to problems that the students have produced were;

- Operation Clean Water (O.W.C.), problem solved – impure drinking water. The students collected water in a tower of 55 gallon drums. The water then flows down into a second drum and over a filter to remove solid impurities. The water is boiled in the next drum and, finally, is collected, tested, and stored in the third.
- The Combine, problem solved – eliminates unnecessary labor. The students designed a model of a combine that would replace the repeated bending over that sugar cane workers are required to do, with a machine that could be pulled by a horse or mule.
- The Portable Planter, problem solved – provides a practical use for old tires for growing vegetables. The students placed a sheet of plastic into a old tire, filled it with earth and planted and harvested vegetables.

At the end of the appropriate technology design activity, Mr. Kachmar said that the technology education students had a sense of ownership and empowerment in their groups' AT design and problem solving solutions. Students who previously had difficulty focusing in class became enthused by the possibility of actually solving real-world problems using technology appropriately.

Another important curriculum area that discusses using technology appropriately is energy conservation. The oil embargo of 1973-74 precipitated a rush to include conservation activities in school curricula. Many states began initiating energy conservation curricula. Many of these activities were designed by the National Energy Foundation. The National Energy Foundation is a nonprofit educational organization devoted to the development of instructional materials and teacher and student educational programs dealing with energy. Some of these energy curriculum projects/efforts and locations where they were implemented were:

California – *Energy Action in Schools: Animated Bibliography* (1988)

This curriculum is a sample of energy education materials for grades 7 – 12. The activities associated with this curriculum are a collection of interdisciplinary materials and supplemental materials developed by teachers. There is a section on practical energy projects for industrial arts, grades 10 – 12. A set of seven "hands on" instructional plans for the construction of energy products were developed by the Alternative Energy Collective in Berkeley. The projects are a window greenbox, solar oven, weatherization, concentrating breadbox solar water heater, passive solar water heater.

Colorado – *Quick Energy and Beyond: Ideas for the 90's* (1991)

This collection of middle level and junior high school quick energy activities was created and field tested by Colorado teachers. The activities are divided in in this manner: Chargers – designed to begin the student's thinking about energy, its sources and its future. Sparks – require little or no preparation and materials. These are simple, paper and pencil, creative, problem solving activities. Conductors – requires some preparation, materials and teacher direction. The Conductors sections contain activities such as; Energy is a Gas: Can You Build a Machine to Inflate a Balloon?, and Solar Energy is Great But What Do You Do at Night? (How can solar energy be stored?).

Community Services Administration – *Energy Education Guidebook* (1980)

The guidebook is divided into three major sections. Section I provides an overview of the types of energy education activities as well as providing a model for starting a local energy education curriculum plan. Section II contains and overview of energy audit procedures for school facilities as well as descriptions of 18 educational (AT) activities. Section III contains a list of projects, an annotated bibliography, and a list of training and technical assistance resources.

Georgia - *Teach with Energy!* (1992)

These are fundamental energy, electricity and science lessons for grades 4 – 6. *Teach with Energy!* is a teacher-friendly collection of energy conservation and energy education activities. The collection of activities is based on seven broad energy categories: energy sources, uses and applications of energy, energy forms and conversion, environmental and economic impacts, limits of energy resources and supply, energy future, and energy conservation and management.

Quick Energy for Elementary Teachers (1989)

The activities and activity ideas in this approach were designed to reinforce energy concepts when only short periods of time were available.

Teach with Energy! (1994)

This is a useful energy, electricity, and science resource guide for teachers of grades K – 3. It has thirty-one interdisciplinary energy lessons. These lessons can be easily incorporated into the agenda for mathematics, social studies, or science instruction.

All About Energy: A Beginner's handbook for Georgia Students (1988)

This is a very simple, but informative, well-illustrated energy conservation resource. Discussions of ways to save natural resources are introduced.

U.S. Department of Energy – *Energy Education Resources: Kindergarten Through 12th Grade*. (1997)

This collection of resources is published by the National Energy Information Center (NEIC), a service of the Energy Information Administration (EIA), to provide students, educators, and others, with a list of free or low-cost energy-related educational materials. Each entry includes the address, telephone number, and description of the organization and the energy related materials available. Many entries also include Internet (Web) and electronic mail (e-mail) addresses. Copies of this publication are available at no charge.

The Energy We Use: Grade 1(1980)

These resources are interdisciplinary student/teacher materials in energy, the environment, and the economy. The collection contains a set of nine lessons. In the mid 70's and early 80's, these activities would inform first graders of the relationship of energy and themselves.

Community Workers and the Energy They Use: Grade 2 (1979)

This publication combined social studies and science education to help children understand how different jobs in the field of energy can affect their community.

The Energy Future Today: Grades 7,8,9 Social Studies (1980)

The major goal of this collection of activities is to help seventh, eighth, and ninth graders gain a greater understanding of the complexities and implications of the major energy decisions that must be made. Quality of life depends of how these decisions are made. Some of the topics discussed were the use of fossil fuels, conservation and short and long term development of alternative energy resources

Summary

All of the case studies provided here demonstrate the possibility of more environmentally benign technological systems. They are paradigms of sustainability. Appropriate Technology is not the optimum choice in every situation. However, people are learning to recognize both the technology factors and the social, economic, and political factors that make it a good choice (Hazeltine and Bull, 1999 p. 352). If students are aware that the AT philosophy and implementation strategies are not perfect, but have much potential, there will be opportunities to introduce creative problem-solving and student empowerment. An important goal for technology education teachers should be to prepare students to use technological literacy in an appropriate manner.

Lessons Learned:

- Appropriate technology has potential for adding a global and altruistic perspective to the Technology Education curriculum. Students can become empowered AT problem solvers, researching and designing appropriate solutions to real-world problems.
- Schools can make education more relevant, they can provide students with real world models of more responsible, more environmentally benign, ways of living. The Oberlin green building case study, the Honduras Solar project case study and the public school program described, all demonstrate ways AT can be introduced into the school curriculum in exciting ways.
- Often successful AT projects require new and often more time consuming approaches to planning, design and cost estimating. They are often interdisciplinary efforts. The success of the green building project at Oberlin in part is the result of getting so many people involved at the beginning of the project. The design charrettes, and interdisciplinary team approach had synergistic impacts on the project and resulted in an outstanding building.
- Another lesson learned is that change is possible, although often difficult. We can develop better technological systems and facilitate their adoption. The new technologies require perseverance if they are to be successful integrated into a culture or institution. The Oberlin green building, the Honduras case study, the Oxtrike project, and the Kenyan solar cooker project all successfully introduced new appropriate technologies, however, they all required significant planning and follow-up work to achieve their success.

- Planning for maintenance and continuing education is critical. The designers of Oberlins' green building developed a maintenance schedule and procedure guidelines to make sure that indoor air-quality problems would not be caused by inappropriate cleaners. The Kenyan solar oven project and the Honduras project used a "train the trainer" model to develop a multiplier effect and enlarge the sphere of exposure. The biogas and Brazil projects described were less successful because an effective diffusion plan was never developed or implemented.

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Chapter 11

Future Directions for Appropriate Technology in the Technology Education Curriculum

Anthony F. Gilberti
Indiana State University

We live in an interesting and fascinating time, and our society is being transformed at an ever-increasing rate due to the application of technology. The tools used today are uniquely more powerful than those of earlier eras, and they bring with them a sense of finality as they replace many older methods of previously dealing with technical problems. Rifkin (2000) notes that modern technology has led to a new culture of hypercapitalism and describes this new era as the 'age of access.' Rifkin may indeed be correct in his hypothesis. People around the globe have more access to products, goods, and services than at any time in previous history, and this trend is increasing at an even faster pace. Rifkin illustrates this new world order:

The first thing to understand about a network-based global economy is that it both drives and is driven by a dramatic acceleration in technological innovation. Because production processes, equipment, and goods and services all become obsolete faster in an electronically mediated environment, long-term ownership becomes less palatable, while short-term access becomes a more frequent option. Sped-up innovation and product turnover dictate the terms of the new network economy. The process is demanding and relentless (p. 20).

Efficiency and Social Progress

As one thinks of the problem and possibilities of this new world order, it is clear that the use of technology has taken on an increasingly important role in human endeavors. In fact, two terms often come to mind when thinking about technology. These two terms are efficiency and social progress. Societies that are based on technological endeavors (as opposed to agriculturally based or industrial based societies) appear to place an emphasis on efficiency. Thus, these societies place a greater amount of resources on technological processes or systems that increase the speed or reduce the resources needed to perform activities related to work.

Likewise, social progress is often viewed as a reflection of the products, goods, and services that a nation produces. While this view is dependent upon technological endeavors, and it is not a reflection of true social progress (i.e., living in harmony with nature, a reduction of social conflict, or betterment of the human experience), it has become a defining characteristic of modern society. The tools, machines, and technological systems at our disposal help to create our society and offer a means to enrich our lives. Yet, one could question the value of efficiency and social progress in light of the problems of environmental decline, loss of species, and the destructive effects of economic activities. The major question that should confront us is: Do we have a social vision with regard to technology? Other pertinent questions related to a social vision, progress, and efficiency might include: Does technology provide a balance in our lives? Do all the new time saving technology devices help benefit our quality of life? Do they reduce stress, and do they provide us with more time to better the human experience without an adverse consequence to our biosphere?

Ecocide

Boyer (1984) in the text America's Future: Transition to the 21st Century used the term *ecocide* to refer to the killing of ecological systems. For Boyer, ecocide was a by-product of obsolete economies that resulted from a failure to plan economic and technological activity within the carrying capacity of the biosphere. When ecocide occurred, economic or technological objectives had a higher priority than the preservation of the biological environment. Boyer's contention in the text was that efficiency and social progress were misaligned. The technological economy of the future needed to be based on a survival-based peace economy that permit people to do socially useful work without the negative consequences on the environment or society.

Boyer may be correct if one considers the many consequences that technology has brought to civilization. Today there is an increasing disparity between the have and have-nots in society. For example, about 40 percent of the world population has never made a phone call, and 65 percent do not have access to electricity. In largely rural societies, grain production per person is an indicator of not only food availability but also economic progress. Grain production by this measure has been decreasing steadily since 1990. If world population continues to grow, this trend is likely to continue, raising the possibility that the number of people in the world who are undernourished will increase from the current 828 million. Further, the result of wide scale implementation of technology has resulted in rising global temperatures, falling water tables, collapsing fisheries, shrinking forests, and the loss of plant and animal species (Brown, Renner, & Halweil, 1999). Clearly, this is not the social vision of technology that we desire. Yet, if we are to change our vision, we will need to take some fundamental steps with regard to education. This process will need to begin with a careful examination of our curriculum efforts for technology education.

The focus on this chapter is on the technology education curriculum for the future. The topic is difficult since it is very easy to become caught up in conjecture and become nothing more than a fortuneteller. Yet, the future is important to ponder for it often leads one to consider what is of value, what is possible, and methods for achieving one's vision. To this end, this author looks to the future with optimism for meeting the needs of society, students, and the discipline of technology education.

Role of Education

Before addressing the topic of a curriculum for the future of technology education, it is necessary to note the role of education in society. In a democratic society the focus of education has centered on the concept of general education and the liberal arts. The word 'liberal' is derived from the Latin 'liber' which means free. The meaning of the phrase 'liberal arts' is the arts of freedom or the arts of the free person. Mason (1972) documented that the ideal of the liberal arts in Greek society was to have a free person practice the arts of freedom. These arts of freedom included: thinking clearly and logically, speaking effectively, reading analytically, having knowledge of the world and human nature, and knowing the ways in which society and the universe operated. In this idea of developing a free person, the purpose of education was not to prepare a person for some economic vocation. Instead, education should prepare people for a moral life; to develop their intelligence to make choices that affected their nation, their family, and themselves.

Social Responsibility

It can be concluded that one of the basic purpose of school is to prepare students for their future social responsibilities. In many schools the technology education curriculum has been designed primarily to prepare students for an understanding of how technology is used to meet human needs and wants (Colelli, 1989). Further, technology education has been organized to help prepare an individual to understand their place in the nation's industrial, and economic modes of activity. Realistically, however, the curriculum area of technology education has been dominated in the past with a study of materials, tools, and skill development related to industrial processes and systems. Thus the curriculum has historically contributed to a lesser degree to encouraging the general public to understand the nature of technological development and providing a background of understanding the social context from which technology operates.

The latter objectives are intended to promote social responsibility among members of technology-related professions and among the population. Whether the newly identified technology education standards will lead to social responsibility has yet to be researched and qualified. Yet, the new directions being fostered by the Standards for Technological Literacy: Content for the Study of Technology and the endeavors by the Technology for All Americans Project are encouraging (International Technology Education Association, 2000).

Questions related to the discipline of technology education and particularly to the Technology for All American Project include: Do the identified objectives include the full range of technology-related social responsibilities of the average student? Are the objectives too narrow is scope? Can the objectives be met by the curricula approaches common to the discipline? Will the meeting of the identified objectives lead to social responsibility in the daily lives of students, or are they merely being presented as theoretical ideals?

The above questions are important if the purpose of a curriculum rationale is to provide a logical conceptual framework and identify methods for directing the assessment of our current educational practices. These questions are also important for developing a future direction for reform.

Focus on the Future Technology Education Curriculum

What then should be the focus on a quality technology education curriculum? If technology education is to meet the needs of society and provide students with a background for understanding the social context from which technology operates, then it is of paramount importance to concentrate on those technology and politically related skills that would promote social responsibility. As Appelbaum (1982) noted:

The possibilities for expert technical wisdom are severely circumscribed by the very nature of such knowledge. Therefore, our belief in the possibility of finding expert-dictated technical solutions to our problems is a mystification, and one with highly political consequences. The second argument is that if we are to have a hope of regaining some measure of control over our lives, we must revise our theory of knowledge, rethink the differences between technical knowledge and political choices, and—in a word—repoliticize our lives (p. 36).

It should be clear from the above that social responsibility must include far more than knowledge of government or the use of tools, materials, and systems of technology. Students must become skilled as responsible decision makers. Technology is not just a casual concern to educators, parents, or governmental officials. The use of technology has consequences for every man, woman, or child. As one examines the pervasive nature of technology, it can be concluded that technology often determines the nature of work, patterns of work, the organization and delivery of commerce, modes of entertainment and leisure, social class values, and the use or extinction of resources.

The strength of a democracy is bound in the intelligent participation of citizens in the concerns of society at all levels. Since many of the public policy issues involve technology, it is reasonable to expect that students would obtain an understanding of technological development and its relationship between humans and their environment (Israel, 1992). It is further important that the technology education curricula of the future focus on providing the young citizen with an opportunity to understand and analyze the problems related to technology. These would include the problems of bioengineering, developing natural resources, minimizing pollution, protecting the environment, and the interactions of institutions in the management and development of a technological infrastructure.

Second, citizens need to understand how technology is used in conjunction with science to find new knowledge. Clearly, technology is the result of historically long and diverse activities of human beings. Technology is the outcome of splendid innovation, invention, and development. The importance of the *social nature of scientific or technological activity* is not to only view science or technology as a potential for materialistic gain, but they should be viewed as methods for thinking and verifying conclusions—a means to distinguish between the true and false. The development of social responsibility in this point would help students to interact with science in more useful ways of thinking about problems. Thus, students would better understand the nature of proof and the role that technological evidence plays in deciding public concerns. This knowledge would help students to examine facts and distinguish between truth and conjecture. Such knowledge would further help students to realize the limitations of science and technology in solving the problems of society (cf. Block, 1986).

Third, it is necessary to note that the problems facing society involve not only scientific and technological issues but also questions involving choices and values. The future curriculum of technology education must provide students with the opportunity and skills to investigate the consequences of implemented or proposed technologies. By examining the consequences of technology and the interrelationships that exist between society, culture, and the environment, students will have the opportunity to apply decision-making and value clarification skills to the problems under study.

Consider the following perspective with regard to the clarification of values and the need to select a technology that is least harmful to the environment. Each day, every one of us meets situation that call for thought, forming opinions, developing a decision, and taking the appropriate action. While some of these experiences are familiar, others are novel and have extreme importance. In the selection of technology, everything we do, every decision we make, and every action taken is based consciously or unconsciously on beliefs, attitudes, and values.

Clearly, people of today are confronted by many more choices regarding the development, adoption, or rejection of technology. They are surrounded by a bewildering array of alternatives. The use of modern communication technologies have made them less provincial and more sophisticated, but the complexity of these times has made the act of selecting appropriate technology more difficult.

The teaching of value-clarification skills should not be confused with the aim of instilling a particular set of values. Rather the goal of teaching values-clarification is to help students apply the processes of making informed decision and methods for considering alternative modes of thinking and acting. An accomplishment of these activities will help students to become aware of beliefs and behaviors, to weigh pros and cons, and understand the consequences of various alternatives (Simon, Howe, & Kirschenbaum, 1972).

Waetjen (1994) reinforced the above perspective by writing that school personnel had a responsibility to provide students with an in-depth knowledge of technology. Waetjen wrote that this responsibility should: "provide young people with an education that prepares them for empowerment in a technological society. The opportunity is to prepare citizens who understand technology so well that they can participate in decision making about technological matters" (p. 58).

Fourth, our curriculum of the future should provide an authentic view of technology. The study of technology must model life. It cannot be learned solely from books, lectures, or even laboratory experiences. The most compelling source of knowledge can be found outside the school and in the actual community where students live, work, and play. The contemporary technology of the community needs to be brought into a closer interaction with the learning environment of the school (Dewey, 1900). Because the problems of technological development are current and personal, students are appreciative of their relevance when combined with planned and purposeful technology studies. The curriculum of the future in technology education must capitalize on this motivational element.

This idea of providing an authentic view of technology should be presented to students as a dimension of the *social application of technology*. As an important aspect of the nature of technology, technological knowledge is applied in cultural traditions (i.e., commerce, work, recreation, etc.) and in the social and personal life of citizens of all countries. Thus, the study of technology could be learned by:

1. Having an orientation towards a problem
2. Being concerned with realistic situations and problems
3. Elaborating on the alternatives that exist for situations and the skill to selecting between the competing alternatives
4. Utilizing purposeful activities as an integral component of learning
5. Using the school, local community, and natural environment as a context for learning.
6. Involving value clarification skills
7. Increasing the ability of students to contribute to improving their own technological or environmental situations

If one examines the above list for learning about technology from its social application, a rich body of curricula endeavors comes to mind. These might include the development of units of study around the content areas of:

The Interactions of Technology and Society

Consumption and Conservation of Resources

Technological Development and the Environmental

Predicament

The Role of Technology in Ecological Destruction

Using Technological Fixes to Solve Social Problems

Assessing and Managing Technology

Ethics and Technology

Appropriate Technology

Energy Production and Conservation

Fifth, the current instruction in technology education presents a *social ideology* that too often emphasizes the positive commercial and economic applications of specific technical means. This view is of value and has served the needs of student regarding career awareness. However, its dominance in technology education has limited the instruction of valuable content. This position can be illustrated by examining a definition of technology. Wright, Israel, and Lauda (1993) wrote that technology is: “a body of knowledge and action. It is used by people, to apply resources in developing, producing, using, and assessing products, structures and systems. It extends the human potential for controlling and modifying the natural and human-made (modified) environment” (p. 2).

The previous definition is positive in its perspective, and it implies that certain activities could lead to socio-economic betterment. A case can be made that the definition further implies that technology leads to progress and to the improvement of the quality of life. While many would agree with these implications, others (e.g., Cebotarev, 1989; Taylor, 1986) would note that the definition represents the human-centered, egocentric, or anthropocentric paradigm that often results in a lack of respect for nature, diversity of species, resources, and the serious effort to promote technologies that lead to a sustainable future. As Cebotarev (1989) noted:

> While some technological invention may truly benefit the majorities in a country, others serve the economic interests of a few and increase the disparity between the rich and the poor. Development research has documented innumerable cases of such technological misfit. . . . Thus, the diffusion of modern technology, although at time conductive to increases in productivity, health, and standards of living, also tends to endanger the ecology and disrupts the cultural fabric of developing societies. In many cases, the acritical application of our technology negates the very process which it attempts to promote by limiting a nation’s control over her destiny and future (p. 53).

The future curriculum area of technology education has an unprecedented opportunity to critically examine the relationship of technology to environmentally sound development. The examination would further prepare students for social responsibility by preparing students with the skills necessary to implement the concepts of sustainable development. To do so, the future curriculum of technology education must begin to address the concepts of environmental survival, environmental protection, sustainability of resources, progress and efficiency, social equity and justice, technology assessment, risk assessment, long term integrated planning, and cultural enlightenment and accessibility (Wiseman, Vanderkop, & Nef, 1991).

Summary

The ultimate success of implementing future technology education curricula that promotes social responsibility depends in no small measure upon a reconceptualization of the entire program of schooling in all disciplines. The success is also dependent on the commitment of technology educators to design a curriculum that benefits all students and stresses democratic duty and personal development.

The technology education curriculum of the future must provide a holistic philosophy for education with content being derived from the sciences and technology. Further, the curriculum needs to be approached from ecological concepts of sustainability with an emphasis on the combination of relationships between science, technology, society, and the environment. These relationships offer opportunities to further examine human concerns including: aesthetics, ethics, values and the problems confronting society.

The teaching of the above concepts can be fostered by utilizing the best lecture based and laboratory experiences common to technology educators including the use of case studies; interdisciplinary approaches; modeling, gaming, and simulation; the project method; research and experimentation; role-playing; science, technology, society approaches; team teaching; and the use of independent study. This curriculum focus for the future reflects the position that technology education should serve the common good of society by promoting social responsibility. Further, it is vision of technology education in which students are prepared to actively participate in solving many of the technological problems that confront society.

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