

IDEAS

1. Technological Literacy: Beyond Mathematics, Science, and Technology (MST) Integration

by Thomas T. Liao

Technological literacy refers to the understanding of modern technology—its capabilities and limitations, underlying concepts, and societal impacts. Technological literacy spans the range from how specific devices or machines work to the understanding of the more complex systems for satisfying human needs and wants. Furthermore, technological literacy includes not only the application of scientific and mathematical principles underlying the devices and systems, but also consideration of the human, environmental, and societal impacts.

When designing curricula to help students to achieve technological literacy, the knowledge base can be categorized into five content areas:

- Technological systems and engineering concepts.
- Application of science concepts.
- Applied mathematics: Quantitative methods.
- How individuals interact with technology.
- How technological systems interact with our societal systems.

ASPECTS OF TECHNOLOGICAL LITERACY

Since technology education includes the study of how technology works and is designed and how it interacts with other societal systems, only an interdisciplinary approach to its study is appropriate. In my view, students need to study how five major content areas interact in today's technology-based society. First, they need to learn how mathematics, science, and technology (MST) concepts are connected. To enhance relevance, MST studies also need to include the personal and societal impacts of MST systems.

The connections among the five major aspects are shown in Figure 1. The approach in SUNY at Stony Brook's Department of Technology and Society is to start with the study of specific technological systems and related concepts.

Others are introduced as needed. However, the focus of a course can start with any of the other "circles of knowledge."

UNDERSTANDING TECHNOLOGICAL SYSTEMS AND CONCEPTS

All technologies have evolved to help people better satisfy human needs and wants. Societies have developed techniques for using tools, materials, energy, information, and human resources for satisfying these needs and wants. A system's model can be used to clarify the operation and behavior of technological systems. Technological systems are designed and developed with engineering concepts and apply concepts from other disciplines. Technological systems result from engineering design

and development. Engineers use mathematical and scientific concepts in their work. Thus, understanding of the behavior of technological systems requires study of how scientific and mathematical concepts are applied. But other concepts underlying modern technological systems are unique to engineering. For example, the control of systems via feedback is the basic concept of automation. Other concepts relate to ergonomics (human factors engineering) and aspects of decision making (criteria, constraints, modeling, and optimization).

APPLIED MATHEMATICS AND SCIENCE

The application of mathematics and science concepts and techniques to the analysis of socio-technological prob-

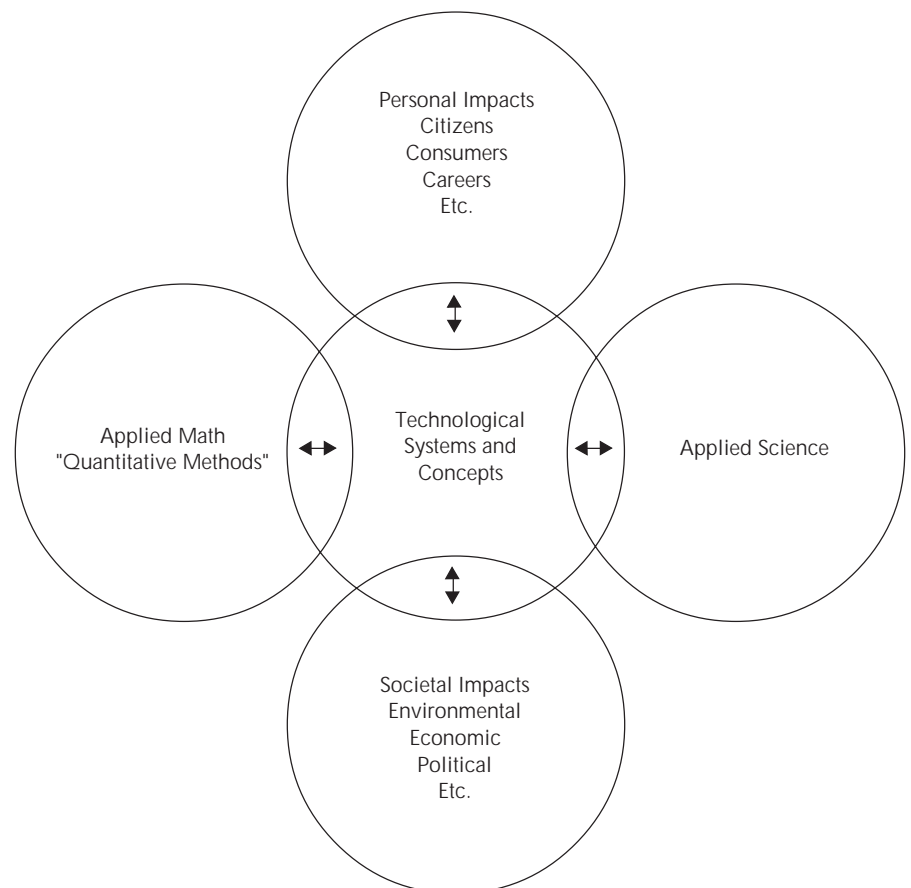


Figure 1. Interaction among five major aspects of technological literacy.

lems and issues makes the study of abstract concepts more concrete and meaningful. Many science educators, such as Shamos (1998), feel that it is the best way to help liberal arts students make sense of these subjects.

From a pedagogical perspective, studying disciplinary concepts via applications adds relevance to the learning experience. Students who are often "turned-off" to regular mathematics and science courses find technology-based courses to be more interesting and meaningful.

In order to study technology-based problems in a more precise and rational manner, both quantitative and scientific methods of analysis must be used. For example, the study of alternative energy sources requires that students learn how to measure amounts of energy and what happens when energy is converted. Risk analysis requires that students understand probabilistic models and how they are used.

TECHNOLOGY AND THE INDIVIDUAL

As individuals, we interact with technology as human users and citizens of a democratic society. As users of technology, we must learn to choose the most appropriate technology to satisfy our needs in the home as well as in the work environment. As more and more contemporary issues relate to the societal impact of technology, we need to learn how to use relevant information to make informed decisions. Those of us who create new technology, besides understanding technical concepts, must also be knowledgeable of human and societal impacts.

This aspect of technological literacy, for most of us, deals with learning the concepts and techniques of making the most cost-effective use of the technology. Decisions about selection, use, and maintenance of consumer products require an understanding of both the basic information about the product and the process of decision making.

Technology must be designed with the human user in mind. The match between the technology and the human user (ergonomics, or human factors engineering) is crucial to the optimization of health, safety, and comfort

levels.

Besides making decisions about consumer-related technologies, individuals must also participate in local and national decisions about the choice of complex systems for satisfying our needs for shelter, food, energy, and security.

SOCIETAL IMPACT OF TECHNOLOGY

Another aspect of technological literacy is the ability to understand the limitations and capabilities of current and emerging technologies. Some people erroneously believe that technology can solve all our problems; others, equally naive, blame technology for most of our ills. These two extremes can be avoided if people learn what technology can do, what it can't do, and how to deal with it. A new web site, "Technorealism" (www.technorealism.org), provides an approach to defining this technological middle ground.

Other aspects of this, the social science, component of technological literacy include understanding the historical role of technology in human development, the relationship between socio-technological decisions and human values, the trade-offs in the use of alternative technological systems, the changes occurring in high technology areas (such as computers and genetic engineering applications), and the role of technology assessment as a method for studying the environmental, societal, political, economic, and other consequences of developing and using futuristic technologies.

TOWARD NEW TECHNOLOGY EDUCATION STANDARDS

At the kick-off meeting of the National Commission for the Technology for All Americans project, held January 19–22, 1995, everyone agreed that one of the unique features of technology studies is that it is an *integrative discipline*. Technology studies require an interdisciplinary approach. Recognizing this important aspect of technology studies, the New York State Education Department formed an interdisciplinary committee in 1991 to create a new set of MST learning standards. In March of 1996, the MST learning standards docu-

ment was published (New York State Education Department, 1996).

Three of the seven major learning standards explicitly call for MST integration. The first standard recommends integration of the study of mathematical analysis, scientific inquiry, and engineering design. One way of achieving this standard is the study of technological systems (how they are designed and how they work). For this approach, relevant mathematics analysis and scientific inquiry are introduced as needed to learn how systems are designed and how they operate. The sixth standard focuses on unifying concepts that connect the three disciplines. Finally, the seventh standard recommends student engagement in interdisciplinary studies and technology and society problem-solving activities. The specific language of these three MST learning standards are as follows:

Standard 1: Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.

Standard 6: Students will understand the relationship and common themes that connect mathematics, science, and technology and apply the themes to these and other areas of learning.

Standard 7: Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions. (New York State Education Department, 1996, p. 1)

Currently, drafts of new national Standards for Technology Education are being reviewed. Designers of the new standards have recognized the importance of going beyond MST integration. One of the three universals of technology education is *contexts* and is explained in the following manner: "Technology exists in the context of particular human activities that have been categorized in the Standards as informational, physical, biological, and chemical" (International Technology Education Association, 1998).

The Standards for Technology Education draft document provides a framework for the study of technological knowledge and process in the context

of real-world systems and problems. Genuine technological literacy can only

be developed by providing students with opportunities to learn MST con-

cepts in the context of real systems and problems that have meaning for them.

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2. Is the Integrated Curriculum the Answer?

by Tom Loveland

The need for curriculum change is briefly reviewed. Some pilot integrated curriculum efforts, with emphasis on an effort in Florida, are described, and challenges and recommendations related to these are offered.

CHANGE

Secondary school statistics over the last 80 years have revealed some startling trends. High school entrance rates have gone from 50% in 1950 to 95% in 1980 and high school graduation rates have gone from 10% in 1900 to 73% in 1980 (Department of Curriculum, Instruction, and Assessment, 1996). Standards and methods of instruction remained relatively static during these years. Specialized instructors lectured to whole classes and assigned work out of textbooks. While this method of subject-centered curriculum and teacher-centered instruction is familiar to most Americans, students today are markedly different and require new ways of being reached.

Changing school demographics are well documented. There are increasing numbers of students living in single-parent households. Many of these families are living in poverty. Many students have non-English-speaking parents. In the 1940s, nonscholastic classroom problems included talking, chewing gum, making noise, and running in the halls. In the 1990s, the problems are drug abuse, rape, assault, and suicide.

Demographics are just one reason for schools to change. Other compelling reasons include legislative mandates, work requirements of new workers, competition from charter schools, and refinements in learning theory. Goal 3 of Florida's Blueprint 2000 states that

"students successfully compete at the highest levels nationally and internationally, and are prepared to make well-reasoned, thoughtful, and healthy life-long decisions" (Bureau of Curriculum, Instruction, and Assessment, 1995, p. 30). The Secretary's Commission on Achieving Necessary Skills report of 1991 identified the following five competencies and three foundation skills that graduating high school students will need to succeed in the workplace:

- Competencies:*
1. Resources: identifies, organizes, plans, and allocates resources.
 2. Interpersonal: works with others.
 3. Information: acquires and uses information.
 4. Systems: understands complex interrelationships.
 5. Technology: works with a variety of technologies.

Foundations:

1. Basic skills: reads, writes, performs arithmetic and mathematical operations, listens, and speaks.
2. Thinking skills: thinks creatively, makes decisions, solves problems, visualizes, knows how to learn, and reasons.
3. Personal qualities: displays responsibility, self-esteem, sociability, self-management, integrity, and honesty.

In 1996 the Florida legislature passed several laws that allowed for public funding of charter and private schools. Some charter schools will be linked

with businesses, providing technology and expertise that standard public schools will find difficult to match. The final compelling reason for a change in curriculum and instruction techniques comes from studies in learning principles. Gardner's theory of multiple intelligences breaks learners into seven categories including verbal/linguistic, logical/mathematical, visual/spatial, and others. Not all learning styles can be affected by an autocratic teacher/lecturer with rigid curriculum barriers (Gardner, 1995).

The usual secondary school curriculum is delivered in distinct 50-minute blocks of specific content areas. Teachers are certified as specialists in their content areas, and students are expected to study the content areas separate from their other classes. The problem with this delivery system is that it bears little resemblance to the real world. People link and use all of their skills as they move about the day solving problems. With the explosion of information, increasing legislative mandates, fragmented schedules, and a lack of applied knowledge in the school curriculum, an interdisciplinary approach to a curriculum offers a feasible solution.

INTERDISCIPLINARY CURRICULUM—ADVANTAGES AND OBSTACLES

An interdisciplinary curriculum is "a knowledge view and curriculum ap-

proach that consciously applies methodology and language from more than one discipline to examine a central theme, issue, problem, topic, or experience" (Jacobs, 1989, p. 8). A group of teachers representing all or many content areas from a team develop thematic units of study that can be linked to all of the content areas. Students join the learning community. Their studies during the year are linked from class to class by integrated thinking and learning skills, content, themes, or units of study and methodology. "Thus the 'multidisciplinary' approach transcends all boundaries of traditional disciplines and is highly interactive, actively combining social and intellectual domains" (Relan & Kimpston, 1991, p. 4).

Support for this new curriculum comes from administrators in the form of increased funding, in-service training, and school schedules that provide common planning time. Informed parents and local industry will support curricula that lead to higher qualified graduates. The biggest supporters will be the students themselves. Their classwork will be more stimulating and have more application, meaning, and relevance (Jacobs, 1989).

The advantages of an interdisciplinary education have been extolled in the popular and educational literature: There will be better student attitudes toward school. Students will assimilate lifelong learning skills, become more creative, flexible, active learners, and critical thinkers. Students will feel part of a team because they are with the same group of teachers throughout their high school years. Integrated education will help students to organize their learning, a difficult thing to do with the explosion of knowledge and information in the world. This way of learning lends coherence to abundant facts by showing how they interrelate. The advantage most visible to students is that student class schedules have first priority.

The benefits don't stop with the students. Teachers reap huge rewards from teaching this way. Teachers feel part of a team and less isolated from colleagues. Teaching is more relevant and stimulating. Teachers enjoy the support of their administrations. Curriculum supervisors like interdisciplinary teaching because the learning reflects the real world and

knowledge gained in one content area transfers to other areas. Student achievement scores should rise.

There are numerous obstacles and considerable resistance to the integrated curriculum. These include the cost of new materials, misguided curriculum materials that are not thoroughly developed and evaluated, multiple themes that lack coherence and connections, inflexible high school student schedules, difficulty in setting common teacher planning time, and state certification requirements that do not allow teachers certified in one content area to teach other content areas. In addition, it is costly to write performance-based assessments that cross multiple disciplines. Did a student do well on his or her language arts portion of the SAT because of an integrated curriculum, reading at home, low teacher-to-student ratio, or some other factor? There are social issues as well. Highly autonomous teachers may be reluctant to team teach. There could be subject area territoriality—an inability to be open to other content areas. The use of different terminology and language in content areas is a hindrance to communication.

Resistance can and does come from other parties: students who are not accustomed to seeing academic and vocational teachers working together, skeptical parents, half-hearted administrators, and out-of-the-loop teachers.

SOME CURRICULUM EFFECTS

The Ringe School of Technical Arts (RSTA) in Cambridge, Massachusetts, switched to an interdisciplinary approach in 1989. RSTA is a school within a school that integrates a strong academic program with its vocational program. In 1993 and 1994, test data from the students in the program showed improvement in student performance (Vo, 1996b). RSTA 10th-grade reading scores increased by 10.6 points and math by 3.5 points over the previous year on the California Achievement Test. Eighty-five percent of internship completers went on to college versus 71% of the students in the adjoining comprehensive program. Daily attendance increased from 80 to 91%, and the number of students on the honor roll quadrupled.

Another program, Academy 2000,

at Baltimore's Frederick Douglas High School showed increased attendance figures (Vo, 1996a). The 1995-1996 attendance in the academy was 82% versus 68% in the high school. The national Schools of Excellence program showed that 68% of these schools were using interdisciplinary units while only 29% of those schools in a random group did (George, Stevenson, Thomason, & Beane, 1992).

Most interdisciplinary teaching evidence is anecdotal instead of empirical. A typical example is a report on the Cardigan Unit, a 10-week integrated curriculum for eighth graders focusing on the environment. Teacher assessment of the program indicated it was "a vital, interesting, motivating educational experience for children in which a lot of learning took place" (Carper, 1991, p. 40). No formal assessment was cited comparing this program to traditional programs. This program was started in 1971 and still uses traditional assessment tools. In 1990 a redesign of their Progress Report form was done for the purpose of reform.

In Los Angeles, California, a five-year-old program called Teaching Excellence for Minority Student Achievement (TEAM) focused on delivering science and math through interdisciplinary instruction. Adenika-Morrow (1995) reported achievement test scores leaping by 10 to 20 percentile points. TEAM tested students who had baseline achievement levels of 5%. These students were taught on a one-to-one ratio with the teachers virtually guaranteeing remarkable test improvement. Los Angeles dropped the program in 1993 due to the high costs.

There is a lack of research concerning interdisciplinary learning from all perspectives: learning theory, brain research, achievement tests scores, and sociology. According to Relan and Kimpston (1991), "practically no long-term evaluations or studies systematically investigating the effects of any kind of integration exist" (p. 6). As more learning communities and academies are created in high schools, research will undoubtedly become more common. Use of control groups and careful development of interdisciplinary variables should help to prove or disprove the claims.

THE EFFORT IN FLORIDA

Pasco County is field testing the concept of the interdisciplinary curriculum for the Florida Department of Education. The elementary schools began a program in 1990 called Houses that placed students within teams of teachers. The students stayed with their team teachers throughout their elementary school years. The teachers developed themes to link their curriculum and classes together. Within this structure, different types of student groupings were possible: grade level, reading ability, or student interest.

In 1993-1994 the middle schools introduced their pilot program called Streams. Two years later the high schools inaugurated Learning Communities. Learning communities are developed around career clusters. In Pasco County, the four career clusters are technology, business, criminal justice, and health. Each high school initiated its choice based on local industry needs. At Ridgewood High School in New Port Richey, the two learning communities are called The Academy of Science and Technology and The Academy of Business Education.

After the learning communities were formed, the teachers worked to develop an integrated curriculum. This curriculum was based on many considerations: school demographics, definition of the career cluster, available resources (people, materials, and community), an advisory group, targeted performance outcomes, and theory (working with multilevel students, instructional strategies, new assessment methods, and leadership skills). This information was necessary for the building of the annual plan. After the annual plan was written, the quarterly and weekly content area schedules were developed. At this point the links between content areas became apparent.

The Science and Technology Academy chose the theme Connection and Congruency for the second quarter of the 1996-1997 school year. The scheduling was flexible and centered on units lasting four to six weeks. The science class studied chemical makeup, molecules, and carbon-based atoms and completed a science project. The language arts class did an abstract for science, problem hypothesis, logical fallacies, descriptive writing, and analogies.

In social studies, the students studied centers of civilization, environment, government, religious beliefs, and communication's cause and effect. Math included geo-parallelism, triangles, evaluations of formulas, solving equations, distance-rate-time, and systems of equations. Projects were linked between courses. Students were taught overlapping knowledge in order to strengthen the learning process. The entire learning community took three field trips that quarter: to the Dali Museum, Museum of Science and Industry, and a Holocaust memorial.

The Academy of Business Technology is developing their first year and quarter plans for the coming fall semester. The career clusters for business include accounting, communications, computers, management, public relations, marketing, retail, sales, and finance. Teachers in this community will include academic, business education, and technology education. Plans are in development to include links with local Pasco businesses through classroom speakers, mentorships, internships, diversified cooperative training, and on-the-job training.

LEARNING COMMUNITY SURVEY

In January of 1997, a survey was developed to determine the view of current learning community teachers in Pasco County. This survey was sent to the 37 high school classroom teachers identified by the high schools. Twenty-five completed surveys were returned, a 68% response. All but one teacher indicated to which learning community they belonged. They were not asked to identify themselves or their school. This was done so the teachers could express their feelings without jeopardizing their careers. Six of the teachers wrote detailed comments on the back of the surveys. Generally, the teachers expressed strong support for the following:

- More integrated curriculum materials from the district next year.
- More planning time for next year.
- Block scheduling would be helpful to our learning community.
- I feel our learning community will be even better next year.
- Vocational classes were integrated with our learning community.
- Joint planning time was made available to learning community members.

- More learning communities at my school next year.

On the other hand, teacher ratings were low for such statements as "My learning community students seem more mature and focused," "My curricula was integrated fully with all learning community members," "The training from the district was valuable," "I have less behavior problems with my learning community students," and "My learning community experience has been enjoyable." Almost twice as many teachers agreed as disagreed.

Pasco learning community teachers were generally positive about their first semester of the integrated curriculum. They reflected that next year will improve and that they will encourage other teachers to join learning communities.

MEETING THE CHALLENGES

More educators are likely to be introduced to the interdisciplinary curriculum in the near future. It is an educational trend that has many advocates. School systems can make the transition if they develop their program for the end users: the students. Support from the community and district and school administrators is crucial for success. Parents, local businesses, and community leaders should be consulted through their representation on school and district advisory boards. The business leaders should provide information about what they expect from the schools: smooth school-to-work transitions, and exemplary student work and communication skills.

The districts can support an interdisciplinary curriculum in many ways. The most important is to provide in-service training built around development and sharing of applied projects and lesson plans. Teachers in Pasco County, for example, list this as their number one priority. Districts can support an integrated curriculum by communicating with school administrators, school boards, and teacher teams. Funding for materials, studies, and professional development are necessary.

Administrators should examine the research on block scheduling. A careful examination of the benefits of block scheduling will aid them in their discussions with reluctant academic teachers. The benefits include support from vocational and elective teachers, increased

available credit hours for students, and increased team-teaching options.

To avoid hodgepodge programs, educators should be careful about how they set up their units. A systematic analysis of goals, available materials, teacher knowledge, and student outcomes should be used as the foundation of an integrated curriculum. Teachers can help their teams by making more efficient use of their common

planning time.

As the teachers become more experienced and creative in developing their integrated curriculum, the achievement levels of the students should rise. As more empirical research is completed, the link between an integrated curriculum and achievement will be apparent. The interdisciplinary curriculum is a new teaching delivery method. Instead of disjointed activities throughout the

school year, the curriculum makes the activities link schools and careers. These school-to-work competencies should be the driving force of American high schools. The interdisciplinary curriculum is not a perfect system. Many decisions entail tradeoffs, but it does seem to provide a way for students to develop the higher order thinking and learning skills they will need to survive in the 21st century.

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3. Environmentally Sound and Competitive Processes in the Graphic Communications Industry

by Ute Sartorius

At a time when global competition is fierce, the graphic communications and printing industry is undergoing significant changes as a result of new environmental regulations. Awareness of the precarious ecological situation of our planet has imposed exigencies to reduce waste and contaminants derived from paper making and printing. However, new technology continuously responds to these restrictions by offering environmentally friendly solutions geared towards a reduction in the use of hazardous materials and

waste production.

Every year, the United States consumes more than 67 million tons of paper products (Ortbal, Lange, & Carroll, 1996). According to Weiss (1996), 50 to 70% of all printed material is never used, and this figure is only slightly alleviated by recycling. In fact, paper represents about 40% of all solid waste in the United States (Ortbal et al., 1996). In addition, the printing industry has a considerable effect on the environment through the use of hazardous material. Undoubtedly, the graphics

industry is seen as a principal culprit in the current environmental conditions.

However, in recent years, a combination of governmental regulations and an increased social awareness has created a demand for environmentally friendly alternatives, such as recycled paper and soy-based inks. Graphic designers and graphic artists share the responsibility to question the environmental impact of a product at all possible stages of its production, from concept development through printing and production. The process thus entails

assessing usefulness, reusability, recyclability, and overall design. In order to assure an environmentally friendly production, Ortbal et al. (1996) have suggested the following actions:

1. Using fewer materials to reduce waste right at the source.
2. Specifying reused materials and making the final product reusable.
3. Specifying recycled materials and making the final product recyclable.
4. Reducing the amount of energy required for production.
5. Reducing the pollution and/or toxic waste originated by production.

ELECTRONIC PRE-PRESS

In terms of pre-press production, new graphics technology constantly evolves towards a more environmentally friendly production system. Electronic output to film, for example, has simplified pre-press work, reducing time and unnecessary use of material. Current computer graphics applications such as PageMaker, Quark Xpress, Freehand, Illustrator, and Photoshop allow for optimal screen performance, accurate color specification and separation, imposition, trapping, and screening. Combining these applications with high resolution output makes it possible to go directly from the screen to high contrast lith film, bringing more control and flexibility to the designer's desktop. Moreover, the all-digital computer-to-plate (CTP) work flow eliminates the use of film, avoiding pollution through silver nitrates, chemical developers, fixers, isopropyl alcohol, and gum arabics. Although most CTP platemakers use thermal plates processed with environmentally safe aqueous chemistry, developer-free plates using "dry toner transfer" technology are now available from manufacturers such as TechNova Imaging Systems. The implementation of CTP technology has experienced a considerable growth during the past three years, advancing from 40 installed platemakers in 1994 to approximately 600 in 1997, as estimated by Vantage Strategic Marketing, a firm in the United Kingdom that monitors the industry (Dennis, 1996). Not only is the production process of DTP technology faster and less expensive than the traditional method involving compositing, masking, and stripping of multiple generations of film, but it also yields higher

image quality. In terms of environmental impact, elimination of chemical processes as well as minimization of production materials and use of energy are highly desirable steps towards a more environmentally responsible graphic arts production process. Other emerging environmentally sensitive procedures include the usage of recycled paper, the adoption of alternative inks, and the choice of printing and finishing processes.

RECYCLED PAPER

According to the American Forest and Paper Association (AFPA), paper recovery in the United States has been on the rise for several years (Streuteville, 1996). Nevertheless, the use of virgin fiber is still preferred, arguably because of its price advantage (Kraner, 1996). Qualitatively, recycled paper standards equal virgin pulp and, with modern deinking technology, even post-consumer waste produces white, fleck-free writing and printing papers with extremely high performance levels ("Recycling Paper," 1993). In December 1994, the Clinton administration issued an executive order calling for a minimum content standard of 20% post-consumer waste for most office papers used by the federal government. The order stipulates that this standard be increased to 30% beginning on December 31, 1998 (Evans, 1997). Currently, manufacturers such as Mohawk, Cross Pointe, Monadnock, and Crane offer competitive paper grades composed entirely of post-consumer waste. In addition, tree-free paper can be made from kenaf (a hibiscus plant of African origin), hemp, fabric, banana fiber, and algae (Evans, 1997; Imhoff, 1994, 1997).

ALTERNATIVE INKS

Due to the emission of volatile organic compounds (VOCs) released from conventional inks in which pigments are suspended in petroleum, environmentally friendly soy-based and vegetable-based inks are becoming increasingly popular. These inks, comparable in quality and price to conventional inks, break down more readily in the landfill as well as in the deinking and repulping processes (Evans, 1997). According to Abramowitz (1996), the consumption of soy-based printing inks has been increasing at an annual average of

more than 300%. In fact, the majority of newspapers in the United States use soy-based ink for its better mileage, faster start-up, and good print image. Vegetable inks, on the other hand, which can be made from corn, walnut, and coconut oils, are a viable alternative to conventional inks because of their improved lithographic performance and enhanced color reproduction (Rooney, 1993).

PRINTING AND FINISHING PROCESSES

In printing processes, flexography is generally considered environmentally friendly for its water-based inks. However, water-based inks can create problems for paper recovery in pulp mills that use flotation deinking systems designed to separate oil and water. Waterless or dry printing—also called dryography—is another widely accepted option (Evans, 1997; Ortbal et al., 1996). Waterless printing eliminates fountain solution, replacing solid vibrator rollers with hollow rollers containing a cooling solution that assures even color quality on the press by controlling the ink's temperature. Some advantages of waterless plates are high resolution attained by allowing more dots per inch and better control of dot integrity (Ortbal et al., 1996). Embossing, which creates an impression of an image by molding paper around a die, is one of the most environmentally sound processes, because it does not employ chemicals or inks (Evans, 1997). Thermography and foil stamping, on the other hand, are not recommendable because their use of resins render paper virtually unrecyclable. In terms of varnishes, press-applied formulations are easier to remove from paper in the deinking process than aqueous varnish, and ultraviolet-cured varnish—the glossiest and most durable finish of all varnishes—produces the most severe environmental impact, making paper absolutely undeinkable.

FUTURE PERSPECTIVES

On a completely revolutionary level, scientists are working on a technologically advanced alternative that may completely eliminate the use of paper. Joe Jacobson, at the Massachusetts Institute of Technology, is developing an electronic display as thin and versatile

as paper but infinitely reusable (Platt, 1997). Jacobson is considering the production of a "prime sheet of paper with millions of tiny, two-toned particles" (Platt, 1997, p. 165). The so-called "paper" is coated with a grid made up of thousands of lines of flexible, transparent, conductive ink. Text and images come into focus by applying controlled electronic charges. However, Jacobson does not expect the paper-thin electronic display to replace conventional paper within the next 20 years.

In Europe, a prototype for a new ink that will not harm the environment is being tested (Imhoff, 1996). The ink is polymerically encapsulated and held in place with a bonding agent that comes off the paper at 130 degrees Fahrenheit. According to Imhoff (1996), the dye never touches the paper, and when an

item is no longer needed, the ink goes back into a solution to be shipped back to the printer so it can be reused. Moreover, paper treated with this ink will be 12 to 13 times more recyclable because there is no breaking up of the fiber by chemical bleaching.

In many fields of the graphics industry, emerging technologies offer new solutions that safeguard the environment. Universities and schools, where tomorrow's printers and graphic communicators are being educated, have the compelling task of fostering an environmentally conscious attitude among their students in order to ensure responsible graphic production decisions for the future. Vice President Al Gore highlighted the need for environmental education saying: "The most dangerous threat to our global environment may

not be the strategic threats themselves but rather our perception of them, for most people do not yet accept the fact that this crisis is extremely grave" (Ortbal et al., 1996, p. XVIII). The educational aspect should not be limited to creating awareness about possible pollution through printing processes, use of hazardous materials, and the impact of paper production and consumption on existing ecosystems. More importantly, environmental education includes making ecologically sound and economically viable options available and known to students and professionals. In the graphics industry, environmental awareness combined with state-of-the-art technological know-how is no longer a matter of choice; it is rather a strategic necessity to stay competitive in an increasingly global market.

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4. A Customer Feedback Information System

by Ke Wang, Ping Liu, and Mahyar Izadi

In the competitive global economy, every organization needs to continuously improve the quality of its products and services to meet the needs of ever more sophisticated customers. Prompt response to customer feedback is a critical step toward achieving world class quality. Today, consumers demand high quality and reliability in goods and services at a fair price. The quality of products and services can no

longer be taken for granted. Even industries that once enjoyed a monopoly over domestic products now face competition from foreign products. More than ever industrial companies realize that quality is vital to their survival, and industrial technology faculty and graduates can play a significant role in quality improvement and customer satisfaction.

All activities for quality improvement must be performed with custom-

ers in the principal position. Both manufacturing and customer service divisions should focus on fulfilling the needs and expectations of customers. Processes including design, manufacturing, and service begin with customer needs and expectations and end with what the customer sees and believes concerning the quality of the product. Managers must continuously understand customers' needs and provide

products and services that meet those needs (Shores, 1992).

To understand the statement that quality is meeting or exceeding customer expectations (Evans & Lindsay, 1993), we must understand the meaning of customer. Many employees think of a customer as the ultimate purchaser of a product or service. For instance, the person who buys an automobile, the guest who registers in a hotel, and the patient in a hospital are external customers. In education, employers of graduates, taxpayers (in state-supported institutions), and graduate schools may be considered external customers (Izadi, Kashef, & Stadt, 1996). Clearly, meeting the expectations of external customers is the ultimate goal of any enterprise. Also, failure to meet the needs and expectations of internal customers can result in a poor quality product. For example, a poor design for a computerized hotel reservation system makes it difficult for the reservation clerk to do his or her job, and consequently affects the customer who stays in the hotel. Likewise, every employee in a manufacturing company has internal customers—the individual or department which performs the next operation. In education, parents, alumni, and students are internal customers (Izadi et al., 1996).

Organizations must invest time, effort, and money to learn what their customers want and expect. According to Orme, Parsons, and McBride (1992), there are three major reasons to establish a customer feedback information system (CFIS). First, an organization should eliminate the duplication of research efforts and time, thereby reducing costs. Second, an organization should ensure that information about customers, products, and services is properly collected and interpreted throughout the organization. Third, an organization should provide decision makers access to better and more reliable quality information. In their research, Orme et al. discussed concepts regarding how to establish and manage a customer database and how to collect, archive, and access customer information. They believed that organizations that have begun a quality improvement program would understand the advantages of setting up a CFIS,

which makes the quality transformation easier by improving the efficiency of project teams and by providing managers access to more information to make important decisions. In all business activities including manufacturing and service, organizations that manage information more efficiently than their competitors can meet their customers' expectations better. As they consistently satisfy all of their customers' expectations, these organizations will be better prepared to survive and prosper in future competition (Orme et al., 1992).

A CUSTOMER FEEDBACK SYSTEM

We set out to design an original conceptual CFIS. It included the elements of system concepts and design approach, data analysis, decision making, user interface design, and program implementation. Customer feedback was managed with a centralized database. The analysis results were used to make recommendations regarding corrective actions for various departments in an organization.

Description of the System

An effective closed-loop CFIS is an essential part of the quality information system in an organization so that customers' feedback receives prompt responses. To do this, customer satisfaction and expectations must be continuously monitored and measured (Ward, 1994a, 1994b). A typical closed-loop CFIS is illustrated in Figure 1. In this

system, customer feedback is continuously collected and processed in the information system. After processing and analyzing, recommendations are promptly forwarded to various departments within an organization, including research and development, design, manufacturing, vendor relations, sales, and services.

For our purposes, the structure of customer, product, and vendor tables (explained in the Database section) was defined and constructed. This system was developed under Microsoft Windows Version 3.0 (1985) or higher operating environment and Microsoft Visual FoxPro Version 3.0 (1995). In addition, the CFIS was established to effectively measure the quality of products and services. The major technique includes a database management system, which records all relevant information on customers, products, and vendors, and structured program design. The system can analyze customer feedback, continually assess their needs and expectations, and recommend corrective actions to various departments in an organization.

A typical structure of a CFIS is illustrated in Figure 2. The system consists of five modules, including data collection, data operation, evaluation and analysis, decision making, and reporting. Customers' data are collected through various channels such as customer surveys, registrations, correspondence, communications, and returned

Figure 1. A closed-loop customer feedback system.

goods. Data input can be accomplished using keyboard, bar-code scanner, automatic reader, or other input devices. Data management operations include appending, browsing, deleting, indexing, searching, sorting, and updating. These operations can make data easily retrievable. Customers' data can be evaluated by various statistical tools such as control chart, bar diagram, Pareto chart, and so on. Data reporting sends corrective action recommendations to various departments, for example, research and development, design, manufacturing, sales, shipping, and customer service.

The Database

In the CFIS database, three two-dimensional basic tables were defined and constructed: customer table, product table, and vendor/manufacturing table. The three tables are independent in structure, but they can be related to each other. By keyword, common field, or relational expression, new tables can be derived from the basic tables.

In the CFIS, a product table is a bridging table. It includes common fields such as product code and vendor/manufacturing code for linking customer and vendor/manufacturing tables. In a product table, using product code as the keyword, customers' purchasing and returning activities can be searched and summarized. Similarly, using vendor/manufacturing code as a keyword, related information about vendor/manufacturing can be accessed.

With the three basic tables, other tables can be easily created as shown in Figure 3. Using keywords or common fields, new tables such as quality rating score table, quality feedback table, and customer/vendor contact table can be derived.

Elements in Design

The following steps are involved in the system design: planning and programming environment, design of a user-friendly interface between database and users, mechanisms for control, report design, customer satisfaction summary, and realization of object linking and embedding.

Planning and programming environment. Two major factors must be considered at this step. The first is to design

Figure 2. Structure of customer feedback information system.

Figure 3. The relation between three basic tables and derived tables.

the data flow related to data structure. Due to the entry of thousands of records about customers, products, and vendors in the CFIS, storage of the same data in multiple records or tables will be redundant and lead to waste of computer resources, especially the storage space. In addition, it also causes complicated problems for data management such as poor data integrity and extra computer processing time to retrieve these redundant records. To avoid this problem, only three basic tables were created. These tables contained the primary data required by the system and keywords as a linkage between tables. A derived table can be created through keywords such as customer code, product code, vendor code, and relational or logical expression.

Programming environment is another factor that should be considered in designing a database management system. Currently, there are many database management systems (DBMS) available. In this research, FoxPro, a relational database system, was used as the DBMS of the CFIS. FoxPro is an ideal tool for developing applications for cataloging, tracking, and processing information. Like most other database management systems, FoxPro allows

the system to work with various types of data, such as numbers and character strings. Data can be stored in tables, arrays, variables, and files. FoxPro provides a rich set of query language commands and functions that can be programmed to perform data querying and processing. The advantage of the query language is that it has flexibility for application development and it is easy to use. Moreover, FoxPro has a built-in charting software, Microsoft Graph. Microsoft Graph can insert charts directly into an application's report or document.

Design of a user-friendly interface. Ideally, an application should provide an easy-to-use interface for users to make requests with valid and accurate data (Kroenke & Dolan, 1988). Availability of a user-friendly interface significantly reduces the users' burden. With the interface, users no longer need to master the environment of FoxPro and query language commands. When menus including submenus are designed in Windows format, users can easily establish a relational or logical expression to complete their desired operations by clicking the mouse on pop-up menus, push buttons, radio buttons, or spinners.

Mechanisms for control. Once the database has been accessed, processing the database must be controlled. Such controls are primarily intended to reduce the inadvertent errors. Menus and pop-up windows are two forms of mechanisms for processing control. Figure 4 shows a two-level menu structure used by the CFIS. In the main menu, a user is given the operational options of DATABASE, RECORD, ANALYSIS, REPORT, and EXIT. All optional items are represented in icons. The structure of the menu and the allowed options provide one important means of processing control. Another mechanism for processing control is the pop-up window. A pop-up window can be placed in the screen, with full or decreased size. In a submenu, if a processing option is chosen, an associated pop-up window is defined and displayed. After the desired operations are completed, users can exit the window. Since pop-up windows can be nested, they make the system levels transparent.

Report design. Printed tables, summaries, graphs, and charts represent the major outputs from the CFIS. The readability of any report, which presents the results of analysis and decisions to be carried out, is very important in the

Figure 4. Menu structure.

system design. Figure 5 shows various report formats, including tables, summaries, and graphs. Graphic functions present data using pie, bar, or line charts.

Customer satisfaction summary (CSS). In the analysis process, CSS was used to show the satisfaction degree of products that customers purchased or returned. In the CSS report, product name, code, rating scales, and customer satisfaction index (CSI) are included. In rating scale columns, a 5-point Likert scale was used (Bragar, 1992).

Realization of object linking and embedding. In the CFIS, the task of graphic processing is submitted to Microsoft Graph. Thus, how to realize object linking and embedding (OLE) or to combine text with graph to produce quality analysis reports was one of the tasks in the system. OLE is a set of features supported by Microsoft Windows operating system that allows users to embed or link data from one Windows application into another application. OLE objects can be stored and displayed in fields of general type in a database table. Once an object is stored in a general field, the object can

be displayed or edited into tables, screens, or reports. In the system, if the GRAPH button is clicked in the ANALYSIS pop-up window, the system will work under the Microsoft Graph environment. In the Microsoft Graph environment, different graphs such as pie charts, bar charts, or line charts can be chosen to display on the screen or printed report. The charts of analysis can be stored in the general field of the relevant database file by clicking the SAVE AS button.

RESULTS: PROGRAM DESCRIPTIONS

System Requirements

Hardware and software requirements. The CFIS requires an IBM 80386SX or higher hardware system. It requires a mouse, a printer, and a 6-megabyte RAM if virtual memory is set to none or a 4-megabyte RAM if virtual memory is set to temporary or permanent. It is recommended that a VGA or higher resolution monitor be used. The hard disk should have at least a 100-megabyte storage space. The system requires Microsoft Windows version 3.0 (1985) or higher including Windows 95 in 386 enhanced mode.

System Functions Descriptions

CFIS was written using FoxPro commands and functions to realize the interface between DBMS and users. The program is divided into main program, subprogram, and procedures in structure according to their different functions. The main program is divided into three sections. A flowchart of the CFIS main program is shown in Figure 6. The first section is initialization, which sets up the CFIS environment, initializes global variables, and defines arrays. In this section, SET SYSMENU SAVE was programmed to save the FoxPro environment when users exit from the CFIS environment and the FoxPro window can be restored. The main menu definition section defines, establishes, and displays the main menu and waits for the user's choice. The third section controls the flow of the program according to the user's choice. DO CASE conditional statement was used to execute a set of commands based on a logical condition. It controls the flow and invokes associated procedures. In the system, there are four major procedures to complete database maintenance, records operations, data analysis, and reports output. They are implemented by DATABASE, RECORD, ANALYSIS, and REPORT subprograms.

Subprograms. The DATABASE subprogram consists of a series of procedures to complete operations such as OPEN, CLOSE, BROWSE, PACK, or SORT. These operations are used to manipulate tables in the database.

The RECORD subprogram includes APPEND, CHANGE, DELETE, GOTO, LOCATE, UNDELETE, and REPLACE procedures to perform operations such as adding, changing, selecting, deleting, and positioning records.

The ANALYSIS subprogram consists of customer purchase and return analysis (CPRA), product information analysis (PIA), sale and cost analysis (SCA), product and vendor summary (PVS), and customer satisfaction summary (CSS) procedures.

The function of the REPORT procedure is to generate various reports and print the data reports in tables in a desired format. In the system, 14 format files with FAX extensions were defined. Information such as text, pictures, fields,

Figure 5. Methods of reporting data.

lines, or rectangles about the reports is stored in these format files. Users can create other report formats according to their needs.

USING THE SYSTEM

In using the CFIS we learned the following:

1. The CFIS is an effective tool to collect, access, summarize, and respond to customers' feedback for continuously improving quality of products and services of an organization.
2. The closed-loop feedback system is emphasized to constantly improve quality by promptly responding to customers' needs and expectations.
3. The CFIS includes the functions of data input, storage, database maintaining, processing, analysis, and reporting.
4. The CFIS uses FoxPro and the Windows environment for data management. Microsoft Graph is incorporated to produce graphs for report output.
5. A limited number of data tables are needed to maintain data integrity and reduce redundancy. Users can create their own tables and report formats for analysis and summary reports according to their needs.

Figure 6. Flowchart of CFIS main program.

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