Promoting Excellence in Preparation and Excellence in Practice

Volume XXVIII, 2002
No. 2 Summer/Fall

The Journal of Technology Studies

A refereed publication of Epsilon Pi Tau the international honorary for professions in technology.

Table of Contents

Volume XXVIII, Number 2, Summer/Fall 2002

As soon as the editorial process is completed, each article is posted online. As articles are added, the order and sequence in the Table of Contents and within the body of the journal may be changed to reflect and communicate the editor's concept and intentions for the issue and for this print version.

Making Technology a Major School Curriculum

Now is the time for all the professions in technology to mobilize. A unified effort will achieve a status for the technology curriculum equal, in every way, to that of other traditional curriculum areas in K–12 schools. Although such a campaign may be in the vanguard to change other aspects of the nation's K–12 curriculum, the focus here is technology.

Some may argue that seeking to change curricula at this time is a vain exercise. Persons of influence are not likely to listen or respond because of the nation's economic circumstances and attendant pressures on states and localities. The foreboding international situation and the War on Terrorism could also be invoked as possible deterrents to change.

Leaders in the technology professions ought not be put off. Rather, they need to find strength and determination in the fact that such circumstances define a National Necessity that demands wider recognition of technology subjects that may augur a comprehensive revision of the entire school curriculum.

Technically Speaking: Why All Americans Need to Know More About Technology (Pearson & Young, 2002) is the prime motivator of this commentary. This auspicious document concerns the delivery of technology curricula in K–12 and the higher schooling levels. Perhaps unintentionally, it sets the stage for the undertaking advocated here.

The National Academy of Engineering (NAE), the National Research Council (NRC), and the National Science Foundation (NSF) stand behind the publication. This makes it a declaration to be taken seriously, a product to be used wisely and effectively, and it gives substance to this appeal. The document has high praise for the work of two organization: the International Technology Education Association (ITEA) and the National Association for Science, Technology and Society (NASTS).[1] The curriculum effort of the American Association for the Advancement of Science (AAAS) that addresses technological literacy is also recognized.

It is fair to say that the document's positive views of ITEA members' work that resulted in conceptualizations, standard, and assessment processes and other references to ITEA is deserved recognition that it is the legitimate leadership group for the technology curriculum area at the K–12 level.

While the document does not use the term *National Necessity*, it does make a compelling case that technology studies deserve a high national priority. It covers the ubiquitous role of technology in our society. It refers to the need to prepare for a technological future, which, even today, requires that the nation's citizenry will (must) be technologically literate in order to participate in normal life functions and for the U.S. to continue its world-leading scientific and technological role.

More can be inferred from *Technically Speaking*. For example, the U.S. is faced with increasingly critical shortages of high school graduates with interest in pursuing advanced studies to prepare for careers in science, technology, and engineering. Reliance on foreign students to fill the voids thus created may not be a sound national policy over the long run. Therefore, there are significant expectations that properly developed and taught science and technology curricula at the K–12 and community college levels will produce a technologically literate citizenry and a larger pool of students who will pursue the advanced studies and careers so critical to the American future.

The Case to Adopt Technology and Then Revolutionize the Curriculum

To develop technologically literate persons, appropriate learning experiences need to be more widely and very quickly incorporated in the schools. But, according to *Technically Speaking*, no single curriculum area can achieve this goal. Therefore, it recommends that existing curricula in science, social science, and other subjects also deliver technology subject matter.

Such a recommendation smacks more of expedience and politics of the possible rather than one that aims to properly restructure and redirect the curriculum. It is a patchwork solution to a major problem, and because it fails to lodge the responsibility with technology educators who have the most experience and capabilities, it diminishes their authority and the contributions they can make.

The plaudits and appreciations expressed toward technology educators, particularly those that suggest they could and should lead the curriculum effort, are subverted by the aforementioned proposal for other subjects to assume a role in teaching technology. It places limits on technology educators to deliver their effectively conceived content and experiences to produce technologically literate students.

Another reason behind such a slight may be that most students meet high school graduation and college entrance requirements without studying technology. So, the expedient way to get around that and quickly reach the largest number of students is to attach technology content to subjects that are required for graduation.

This sort of thinking highlights symptomatic weaknesses and discrepancies that exist throughout the curriculum. For example, does it really make sense to add technology content to subject areas that claim to already be challenged to teach their rapidly increasing knowledge base? Might not the resource

[1] Epsilon Pi Tau is the official honorary for ITEA and NASTS.

requirements to get that done be as great as what it would take to get technology subjects recognized as a graduation requirement?

All this about technology marks a need for curriculum revitalization beyond the subject of technology. Comprehensive reform requires keen attention and response to cognitive science findings, applications of computer and information technology, workplace and workforce changes and needs, leaps in the knowledge generation base of most disciplines, associated emergence of new fields of inquiry and knowledge or disciplines, and the dramatic changes in our society. Because technology educators have consistently given appropriate attention to such matters and will do so when they undertake to achieve greater visibility for technology in the curriculum, a model for wider reform may evolve.

In an open atmosphere of change that responds to National Necessity, the subject area of technology would receive respectful attention. Technology professionals should work to produce that open environment by building on the accomplishments of ITEA leaders noted above. In fact, it is ITEA leaders who have the breadth of experience to lead such an undertaking.

A Consortium to Support the Change

Over the years these pages have offered arguments, enticements, rationales, and appeals concerning the need for and advantages of unified and cooperative efforts among the professions in technology in the U. S. This is a nationally important issue around which a consortium of professional organizations can be formed.

ITEA has a record of success with government and private sector agencies and has developed links with the science and engineering and technology and workforce education professional communities. The organizations in these fields will quickly recognize the human resource issues as enumerated in *Technically Speaking* that apply to their interests. ITEA leaders know how to obtain commitments from them.

The stakes are large. The goal is worthy. And the challenge to turn centuries of schooling tradition around is great. But the nation may be ready to listen and accept, particularly if prominent professional organizations, government agencies, business entities, and educators of all disciplines stand in support.

Making the Case

As with the matter of forming a consortium, ITEA leaders have been adept at making a case. It makes sense that they will take advantage of the status conferred on them by the powerful sponsors of *Technically Speaking* and the engineering and science professions they represent.

ITEA leaders are aware of the need to overcome the prejudices of those who have had traditional academic school experiences. They can effectively explain the role, contributions, and significance of technology as a school subject to certain members of the consortium itself and then to those citizens, politicians, and educational leaders they are trying to persuade.

The arguments and rationalization of *Technically Speaking* will certainly be helpful. And to those could be added the history of a field that has evolved out of a tradition of innovation in content and methods that have responded rapidly to societal change and student needs. It is no shame to point to instructional methods that have been responsive to the activity inclinations of youth and that the ideas of content applications involving active problem solving and teamwork have been adapted and employed by other disciplines, even in professional education venues such as medical education.

ITEA also has links with educators in other lands enabling them to use first-hand information to communicate about other industrial nations where technology curricula in one form or another are receiving serious consideration to be, or are already, required courses in the nation's schools.

Add these to the important issues of National Necessity as related to the future of the science, engineering and technology workforce and maintaining U.S. leadership in those areas leads to a summarizing and effect concept to clinch the argument: ***The central purpose of schooling is still to produce literate citizens. For the 21st century the purpose will be achieved when an effective technology component is included in the curriculum.***

What a powerful message to carry and argue! And as it becomes obvious that the campaign will succeed, there will be a change in the statement in *Technically Speaking* that elicited criticism in this piece. Currently, it says:

Short of widespread adoption of dedicated courses in technology—an unlikely scenario in the committee's view—inclusion of technology subject matter in other academic areas is one of the surest ways of increasing the visibility of technology in U.S. schools. (p.104)

This is what it will be changed to:

> The surest way of increasing the visibility of technology in U.S. schools is to encourage the acceptance of offerings from the technology curriculum as major courses that satisfy graduation requirements and for widespread adoption of such a curriculum in schools which currently do not have it.

Full success of the campaign will be realized when that begins to happen. **JS**

Reference

Pearson, G., & Young, A.T. (Eds.). (2002). *Technically speaking: Why all Americans need to know more about technology.* Washington, DC: National Academy Press. Retrieved from http://www.nae.edu/techlit

"Technically Speaking—Why All Americans Need to Know More About Technology" was published this year by the National Research Council (NRC) and the National Academy of Engineering (NAE). It pays high compliments to the evolving curriculum conceptualizations produced by, among others, industrial arts and technology education leaders and science, technology, and society leaders and to their respective professional organizations, The International Technology Education Association and the National Association of Science, Technology, and Society (Epsilon Pi Tau is the official honorary for these organizations).

Their work provided a meaningful framework and strongly influenced the NRC/NAE document, which also speaks directly to all readers of this journal. It observes that members of all technology professions have a significant stake in the issues and challenges of fostering curriculum experiences that would result in all Americans knowing more about technology. And it suggests how the various professions in technology will benefit, become enriched, and be better able to serve society when all citizens are truly technologically literate.

The Special Section articles are based on presentations at the 88th Mississippi Valley Technology Teacher Education Conference, November 8–10, 2001, in Chicago. Because the editors view the history of the profession to virtually parallel human existence, the original session title "Roots of the Profession" is not used. This in no way lessens the importance or quality of what is presented here. While they may not be roots of the profession, the works reported here, with the first undertaken in the late 1940s and others continuing to the end of the last century, are truly roots of a new and compelling movement. We trust that all readers will appreciate its use.

The editors invite submissions that describe similar efforts in technology, science, technology and society, and engineering that have been undertaken in the United States and in other nations. We expect that such materials will not only create an archive, of sorts, but will exemplify meaningful conceptualizations and healthy borrowing of concepts. Above all, they will show that there are commonalities in curriculum and educational procedures along with concepts and procedures that are unique to national traditions and social customs. **JS**

Dr. Kenneth Phillips, president emeritus of Metropolitan State University of Denver, is a member of Alpha Chapter of Epsilon Pi Tau.

Sheila Lefor is an educational and organizational consultant with the Center for Technology Education at California State University, Los Angeles.

A Curriculum to Reflect Technology

It is best to review some background and professional leadership contributions behind the development and introduction of *A Curriculum to Reflect Technology* (Warner et al., 1947/1965). This review will acquaint the reader with the evolutionary process that led to the proposal of a new curriculum and the use of the word *technology* in discussions of the industrial arts profession. It was accomplished by William E. Warner, who is recognized as one of the great leaders of the industrial arts profession.

Warner received his doctoral degree from Columbia University in 1928. Columbia was *the* place to go for an advanced degree in education at that time. Its faculty included many of the American leaders and advanced thinkers in education who believed in student activities as an excellent method and important part of education. Warner worked with professors such as Frederick G. Bonser, John Dewey, Ira S. Griffith, Lois Mossman, Charles R. Richards, James E. Russell, and David Snedden. Warner was able to relate his studies to industrial arts as part of his degree requirements. He often said that he was the first person in the United States who received his advanced degree with an emphasis in industrial arts.

He also started the industrial arts PhD graduate program at Ohio State in 1925 and immediately attracted candidates for advanced degrees from throughout the country who were leaders, department chairs, and administrators in the field. As these men graduated, they formed a network that Warner depended upon to assist and participate in studies and curriculum development, to promote the profession, and to serve as his sounding board.

In 1929 Warner organized the industrial arts and industrial vocational education honorary fraternity Epsilon Pi Tau (EPT). Warner worked with his graduate students and corresponded with his network of leaders to develop the purposes of the fraternity, its constitution and by-laws, and the initiation ritual. He felt it was time for industrial arts to have an honorary fraternity to recognize outstanding upper division undergraduates as well as graduate students. He also felt that it would elevate the prestige of the profession.

From 1929 to 1932, Warner directed *The Terminological Investigation of Professional and Scientific Terms in Vocational and Practical Arts Education* (Western Arts Association, 1933). The research was done primarily by Herbert H. Hutchinson and Elroy Bolllinger as part of their graduate work under Warner's direction. This study was sponsored by the Western Arts Association whose membership included art teachers as well as practical arts teachers. The membership supported the concept of a broad approach to their discipline as part of general education for all students. The terminology study defined many terms that were often used interchangeably by educators; an example from our field includes such words as manual training, manual arts, and industrial arts. While the study established definitions, Warner was also establishing terms describing programs and their differences and establishing industrial arts as a broadly conceived and important program of general education. The terminology study made quite an impact, and educators and board members grew to better understand program differences. Warner served as president of the Western Arts Association in 1932 and was on its council until 1937.

In 1934 *A Prospectus for Industrial Arts in Ohio* by the State Committee on Coordination and Development was published. Warner, as chairman of the committee, was a prime mover in the coordination, support, and improvement of the industrial arts program in Ohio. The members of the committee included Frank C. Moore of Cleveland, Elmer W. Christy of Cincinnati, Fred C. Whitcomb of Oxford, and William E. Warner as chair. The prospectus defined a broad industrial arts concept as an important part of general education utilizing a multiple activity facility called the general shop. The prospectus was approved by the Ohio State Department of Education. The state director of education, Dr. B. O. Skinner, stated that "the Prospectus is written for the progressive teacher, supervisor, administrator, board member, parent, and interested layman, all of whom are concerned with trends in this study of the industries for educational and social ends." The prospectus paved the way for Warner to promote the concept of the general shop for junior and senior high schools. Warner and his graduate students supported and assisted school districts in the development of new facilities. For years Warner had been writing and speaking about the broadly planned program of industrial arts being provided in a facility called the general shop. As programs were being developed and facilities were being planned for Ohio schools, a new title was being used. In 1930 the new demonstration school on The Ohio State campus included a laboratory of industries. The term *laboratory of industries* was used extensively as new facilities were planned and built throughout Ohio. Warner conceived this title as better representing the broad program approach. Oberlin, Ohio, opened its new laboratory of industries in 1935; Grove City, Ohio, opened in 1933; New Albany, Ohio, opened in 1936; Gahanna, Ohio, opened in 1937; Clinton County, Ohio, developed and opened facilities for junior and senior high as well as for adult education in 1937; and Greenhills, Ohio, opened in 1938. Other laboratories of industries were also planned in Ohio, including Troy, Newark, Napoleon, and Reynoldsburg—all part of program expansion in Ohio. Visitors from many other states and some foreign countries came to see the facilities as well as learn about the program. Grove City's laboratory of industries, for example, had 4,000 visitors from 36 states during the four-year period from 1935 to 1939. Other programs had almost the same number of visitors including visitors from England and China. The development and expansion of the Ohio industrial arts program after the prospectus was adopted was very impressive and the envy of many other states.

In 1933 Warner went to Washington, DC, and had a discussion with the U.S. commissioner of education. He was urging the commissioner to support, at the national level, the broad concept of industrial arts, similar to the Ohio concept. This meeting resulted in a national conference in 1934. At this conference the U.S. Office of Education Conference Committee on Industrial Arts Education was designated. Two persons from Ohio were appointed to the committee. Warner and Elmer W. Cristy, director of industrial arts for Cincinnati, Ohio, were chosen. In 1937 the conference committee published a booklet titled *Industrial Arts: Its Interpretation in the American Schools* edited by Proffitt. This was the first federal publication developed for the industrial arts profession. The program concepts and philosophy were quite similar to the Ohio prospectus. Warner had a great deal of influence in the writing of this national document. Of course, a broad program concept as part of general education was recommended. Warner was consistent in his support of a broadly conceived program of industrial arts as an important part of general education.

Warner also led the development and organization of the American Industrial Arts Association (AIAA). Before AIAA was organized, industrial arts teachers had a choice of attending the National Education Association (NEA) national conference where the industrial arts leaders were able to organize sessions. The other choice was to attend the trades and industries sessions of the American Vocational Education Association (AVA). The leaders at the NEA meetings were presenting the concept of a broad program of industrial arts as an important part of general education. The sessions at the AVA most often dealt with the problems of the trades and industries teachers and rarely discussed industrial arts. If they discussed industrial arts at all, they described the role and objectives of industrial arts as being pre-vocational. Industrial arts was to develop basic skills and recruit students for vocational education. Contrast this approach to the industrial arts program and the nine objectives introduced and explained in detail in the Ohio prospectus. The titles of the nine objectives were (a) vocational interests, (b) exploratory experiences, (c) consumer knowledges and appreciations, (d) aesthetic/artistic expressions, (e) personal/social traits, (f) common technical knowledges and abilities, (g) guidance and counseling responsibilities, (h) manipulative functions, and (i) vocational connections and professional considerations. One can immediately conclude that there was a great deal of disagreement inherent in the differing approaches. (The profession still has problems growing out of this basic disagreement.) Warner concluded that the only way to advance a broad concept of industrial arts was to organize an association of industrial arts teachers, administrators, teacher educators, business/industry representatives, and board members.

As part of the 10th anniversary celebration of Epsilon Pi Tau, Warner invited leaders to a "national conference" at the American Association of School Administrators (AASA) conference in Cleveland, Ohio, on February 27 and 28, 1939. The first day of the conference, leaders interested in industrial arts spoke on six major topics: (a) bases of the program; (b) the prospective of teaching; (c) the curriculum spread and viewpoint; (d) the physical setting: housing, equipment, and supplies; (e) administrative policies and practices; and (f) developing the American program. After considerable discussion of the topics presented, the leaders then proposed and approved a draft of a constitution of a new organization, the AIAA. Warner was elected as the first president, and Heber A. Sotzin of San Jose, California, was elected as the vice president. The first official meeting of the AIAA was held in San Francisco at the July 1939 meeting of the NEA. In July 1940 the second meeting of the AIAA was held in Milwaukee, again as part of the NEA conference. In 1941 a meeting was held in Atlantic City as part of the AASA at which time a constitution was adopted. In 1943 AIAA became a department of the NEA, which was a significant event in gaining national recognition. Warner was a major leader in the activities of AIAA, serving as president for two years and then as chair of the liaison and advisory board as well as chair of the executive committee. He essentially was the major leader in AIAA activities and served in that capacity until he went into military service in 1943. After he returned from World War II, he again served as the leader of AIAA. In 1944, at a special meeting of the leadership, it was decided that in the future AIAA would hold independent national meetings. The first national meeting after the war was held in March 1947 in Columbus, Ohio, at The Neil House. No national meetings had been held in 1943, 1944, and 1945. It was at the 1947 meeting that *A Curriculum to Reflect Technology* was introduced.

An important part of every graduate student's experience at Ohio State was the leadership forum series. The forum series, scheduled every Wednesday evening for all graduate students, was organized as a graduate seminar where students and professional leaders could present ideas for discussion. In addition to student presentations, professional leaders were invited to speak on special topics. Often the same person would speak several times on the same topic. Warner would then ask the leader to produce a report or brochure to be published by Epsilon Pi Tau.

The forums were the place during 1946 and 1947 where the six graduate students who were writing the sections of a detailed proposal to be called *A Curriculum to Reflect Technology* had an opportunity to organize and present their drafts of their section and have it discussed by the other graduate students as well as by visiting teachers and industrial arts leaders. It was very helpful, for this process and exposure forced or encouraged the writers to carefully prepare for their presentation. It also helped to prepare for questions and counter concepts that might be part of any discussion.

Their product was to be presented at the first national conference of the AIAA after World War II. The six graduate students were Joseph E. Gary, Carlton J. Gerbracht, Harold G. Gilbert, Paul L. Kleintjes, John P. Lisack, and Kenneth Phillips. All had been in military service, were in their late 20s, and were enrolled in the graduate program in 1946.

Dr. Warner was the organizer and chairman of the convention. National publicity was given to the convention by a nationwide mailing of the March issue of *The Industrial Arts Teacher*. The announced title of the convention in this issue was "New Developments in Industrial Arts Education," but when the convention program was printed, the title was changed to "Reconstruction in Industrial Arts Education." The featured presentation at this convention was to be the new curriculum; however, when Warner opened the general session of the convention, with about everyone at the convention in attendance, he spoke about *A Curriculum to Reflect Technology*. His general introductory statements were followed by the graduate students introducing a draft outline of the five curriculum areas, plus personnel organization and management. This was the introduction of the concept of the industrial arts program being developed or evolved into the curriculum areas of communications, construction, manufacturing, power, and transportation with personnel management being an important teaching and learning strategy of each area. The graduate students assumed that a concept was being introduced that would lead to study, consideration, and discussion by the profession as they had been doing in the forum sessions as part of their graduate work. However, the reaction of many of the men in the room was one of great upset and anger. They shouted their objections and a few stomped from the room. Perhaps, some of the reaction was due to the fact that the audience at the meeting were generally older men who had worked very hard keeping the industrial arts program operating during the war. Now, after working under very difficult conditions, a group of young graduate students, who had no idea how difficult it had been to keep the program alive, were telling them that what they had been doing needed to be changed. Change is difficult under the best of conditions. It is unfortunate that the members of the profession generally reacted as they did, for even though some of the national leaders wrote supportive and thoughtful articles about *A Curriculum to Reflect Technology*, the concept was really never considered or discussed generally until about 30 years later, in the 1980s.

The outline of the major sections of *A Curriculum to Reflect Technology* is included here because many have not seen the outline that was presented at the 1947 AIAA conference.

The Management Organization

The effective development of the industrial arts/technology program requires that the time and effort of every participant be well organized just as in any complex enterprise. This is possible through the establishment of a personnel management organization within the laboratory.

This section is then organized under the following heads:

The Need for Organization

Types of Organization
1. Line
2. Functional
3. Committee
4. Multiple
5. Line and Staff

A Proposed Personnel Organization
1. Organization Chart
2. Job Specification Index
3. Cumulative Personnel Record Card
4. Activities Chart or Record

A Curriculum To Reflect Technology

I. The Communications Division

Composition & Duplication
Graphic Arts—Sound Recording
Drawing, Sketching
Drafting, Blueprinting
Letterpress
Photography
Intagliography
Planography
Duplicating
Sound Recording
Transmission & Reception
Mechanical-Electrical
Telegraphy
Telephone
Radio (CD, MOD)
Teletype
Facsimile
Television
Multi-Channel Methods
Radar
Interpretation
Visual, Sound, and Codes
Historical
Signal Flags
Lights
Sound Devices

II. The Construction Division

Homes
Highways, Including Bridges and Tunnels
Factories and Public Buildings
Airports
Waterways
Single Fabrication, Housing, Public Works, Industrial, National Defense….

III. The Power Division

Sources—Natural, Electrical, Thermal
Generation—Solar, Hydro, Biological, Combustion, Nuclear Fission, Electrical
Transmission—Hydraulic, Pneumatic, Mechanical, Electrical
Utilization—Manufacture, Construction, Transportation, Communications

IV. The Transportation Division

Land—Highways, Railroads
Air—Heavier than Air, Lighter than Air, Navigation, Meteorology, Airports, Aerodynamics, Space
Sea—History, Carrier Types, Ship Construction, Power Plants, Propulsion Units, Small Boat Building, Model Making, Terminals, Routes, Organization, Documents

V. The Manufacturing Division

Major Areas—Food, Textile, Rubber, Chemical, Cellulose Fiber, Leather, Metal, Ceramic, Miscellaneous
Areas of Study—History, Materials, Fabrication, Consumption, Applications

---

A Curriculum to Reflect Technology

Dr. Warner was never able to develop the same type of support and enthusiasm for the concept of *A Curriculum to Reflect Technology* as he had been able to generate for *A Prospectus for Industrial Arts in Ohio*. He believed that the program should be a multiple-activity program with a facility designed to develop problem-solving abilities, encourage inventiveness and basic management skills, and generally reflect the same nine objectives that were described in the Ohio prospectus. He encouraged the development of a laboratory of industries to reflect the industrial technology that was emerging so rapidly. The profession was not ready and the vision of *A Curriculum to Reflect Technology* was never fully realized. However, much of the curriculum development that followed was strongly influenced by this proposal of curriculum development. It certainly indicated a direction.

Warner's contributions to the profession were phenomenal. He died in 1971 at the age of 74.

References

Dewey, J. (1915). *School and society*. Chicago: The University Press.

Dewhurst, J. F., & Associates. (1955). *America's needs and resources: A new survey*. New York: The Twentieth Century Fund.

Good, H. G. (1943). *Education through work*. Columbus, OH: Epsilon Pi Tau.

Hornbake, R. L. (1951). *Professional progress in industrial arts education*. Columbus, OH: Epsilon Pi Tau.

Latimer, T. G. (1974). *William Everett Warner: Innovative pioneer of industrial arts*. Unpublished doctoral dissertation, North Carolina State University, Raleigh.

Ohio Department of Education. (1937). *Ohio high school standards*. Columbus, OH: Author.

Proffitt, M. (Ed.). (1937). *Industrial arts: Its interpretation in American schools*. Washington, DC: U.S. Government Printing Office.

Snedden, D., & Warner, W. E. (1927). *Reconstruction of industrial arts courses*. New York: Bureau of Publications, Teachers College, Columbia University.

State Committee on Coordination and Development. (1934). *A prospectus for industrial arts in Ohio*. Columbus, OH: The Ohio Education Association and The Ohio State Department of Education.

Warner, W. E. (1930, August-November). Establishing the general shop. *Industrial Arts and Vocational Education Magazine,* **19,** 8–11.

Warner, W. E., et al. (1947, April). *A curriculum to reflect technology*. Paper presented at the American Industrial Art Conference, Columbus, OH. Reprinted 1965 by Epsilon Pi Tau, Bowling Green State University, Bowling Green, OH.

Western Arts Association. (1933). *The terminological investigation: Professional and scientific terms in vocational and practical arts education*. Columbus, OH: Author.

Dr. Donald G. Lux, professor emeritus of technology education at The Ohio State University, is a trustee of Alpha Chapter of Epsilon Pi Tau.

IACP—An Innovative Project of the 1960s

The Industrial Arts Curriculum Project (IACP) was a massive effort to modernize the traditional industrial arts curriculum by moving it from its 19th century manual training base to a basic liberal education curriculum component rooted in contemporary industrial technology. It was seen by its developers as serving the same purpose in preparing youth for life in a world largely shaped by industrial technology, much as science classes would prepare youth for understanding and living in the natural world. Both would be required of all students as core components of the curriculum.

IACP conceptualized, produced, field tested, and revised and retested for three years two complete courses age-graded for early adolescents.

Agreements were made with field test center schools in Chicago, Illinois; Trenton-New Brunswick, New Jersey; Dade County, Florida; Austin, Texas; Long Beach, California; and Cincinnati, Ohio. To be participants, the school systems each had to provide two certified industrial arts teachers and two classes of students, both boys and girls and of varied abilities, in each of two schools. The teachers were to teach a normal full load exclusively in industrial arts.

IACP provided the schools (a) an opportunity to participate in a research and development project of national scope; (b) receive in-service education for their teachers; (c) complete instructional software and hardware both for all teachers and all students, with the latter receiving age-graded textbooks and laboratory manuals; (d) detailed teacher's guides with daily performance-based outcomes, standardized periodic and term tests, and all the necessary instructional aids and devices for activity-centered instruction; and (e) consumables also were provided. Most important, teachers had the opportunity to be partners in the ultimate design of the complete program, and, as it worked out, most became teacher educators during summers, at the program's end, at teacher education institutions, teaching other teachers the content and methods of the new programs.

Where the Ideas Came From

Both the faculties at the University of Illinois and The Ohio State University knew that if there was to be modernization of industrial arts instruction it was going to have to come from some relatively small group that had the dedication and could have the great amount of time required to provide the necessary leadership and could demonstrate that the new could in fact be better and was needed. Originally Willis Ray and Edward Towers of Ohio State and Jacob Stern and myself from the University of Illinois wrote some brief papers on the problem and what could be done about it. Ad hoc meetings to discuss these papers and to improve them eventually led to more formal meetings and proposal writing. During the proposal writing stage, Rupert Evans contributed significantly though he never was a working member of the IACP staff. He also was a working member of the National Advisory Committee that contributed significantly to the project.

In 1963 a proposal was submitted to the U.S. Department of Education for a multi-year research and development project that was to be funded out of the career education portion of the Vocational Education Act of 1963. If fully funded, it would run to millions of dollars. Of course, it was funded annually, based upon the quality and timeliness of the preceding year's work. It was fully funded, though one year the funding for the student texts was cut $25,000. When that became known to the Associated General Contractor's Chapter of Denver, Colorado, they passed the hat and came up with the balance. This is simply indicative of the support the project had from the communities involved in it. There is no end to the list of supporting individuals and groups. The Society of Manufacturing Engineers, Building and Construction Trades Department of the AFL-CIO, The Associated General Contractors of America, and many others contributed advisors for days and even weeks when requests were sent to them. The president of the International Brotherhood of Electrical Workers authorized a movie, *Genesis of a Giant,* to be produced by Disney Studios to introduce the several days devoted to electricity. Then copies were sent to every IBEW Chapter with directions to make it available to local schools. It teaches a lot about electricity in 30 minutes, from house wiring to generating station and everything in between.

The Work of the Project

The first year's work was extremely critical because it required a written rationale and structure for the subject matter of the two 1-year courses. All of the technological expertise and philosophical help we had identified had to be scheduled and organized to help us be as sure as we could be that we had a sound foundation before going any further. Concurrently, it was necessary to establish the nature and format of our instructional materials, including lab manuals and texts and teacher's guides and evaluation schema. Sample materials had to be developed and tried out to gain a sense of unit time requirements, schools and teachers had to be gathered and briefed on the grand design and their part in it, etc., ad nauseum. Work also had to be done on materials for the fall term of the next year. This then required an accelerating and expanding demand for even more materials of every description. When Labor Day came each year, we had to be certain that the truck loaded with all the materials for teachers and students would be at the loading docks all over the United States at least a week before the start of classes. While this was going on, dozens of graduate research associates had to be recruited and oriented and personnel changes had to be taken care of. Jacob Stern left the University of Illinois and was replaced by perhaps the hardest working man on the team. Dean Hauenstein became the production coordinator and the field liaison on deliveries and problems. Ed Towers left OSU, causing Willis Ray and me to each take management responsibility for the World of Manufacturing and the World of Construction, respectively. We also became codirectors and principal investigators with regard to management of the project with the OSU Research Foundation. Professor James Buffer also was added to the staff as director of program and pupil evaluation.

Much of the work of the project was done by the cooperating teachers in the field test center schools. Daily they made notes on what went well, what did not, and of what changes, if any, needed to be made in timing for the daily activities. On Saturdays the construction teachers and the manufacturing teachers met and discussed their recommendations and consolidated their daily reports into a weekly one. These were then sent to the eagerly awaiting graduate students working on revisions. Each year during the mid-year break, the teachers were brought to Columbus to a conference of the whole to see what things other schools were suggesting for changes, and when they came to the second of these conferences, they were much more avid participants, as they now had experienced that what they wanted changed mattered, and the materials were improved as a result of their feedback. These sessions grew more like family affairs, year by year, as the team spirit saturated the group. In addition, after the project ended the project staff worked with requests from the field to provide field test teachers as directors of workshops for teachers who had bought the materials and wanted help to use them effectively. This ultimately led to many of the field test teachers becoming teacher educators. Some also wrote new textbooks.

Clearly the field test center teachers were, collectively, the most significant contributors to the final products because they were the ones with their "feet to the fire" and were the real authorities regarding what the learners needed and wanted. Wouldn't it be lovely if all instructional materials could be developed in like manner?

Getting the Methods and Products to the Field

As the project was ending, distribution of the products to the field became the next concern. IACP never produced or employed the use of any "kits." Instead project goals sought to provide youth with hands-on experiences and individual problem solving with industrial design, architectural, engineering, production, and city and regional planning technologies of lifelong values in many ways, such as home maintenance skills, career interest development, hobbies, etc. Kits were anathema, and to the extent that any of the hardware products were saleable, entrepreneurs would produce and sell the items, as the marketers of the "Land Speed Record Assault Vehicles" originally designed, fabricated, and customized by individual IACP students ably demonstrated. The software was another matter. Recognizing the problem, the U.S. Department of Education came up with the idea of a limited copyright for books and other written matter, produced with public monies and in the public domain, were not attractive to publishers who would have to spend much money for pre-production work on materials that could be copied and sold by anyone. IACP invited several leading publishers to a bidding conference to test their interest in a limited copyright with 50% of the royalties going to the U.S. Department of Education and 50% to the OSU Research Foundation, for use in extending the impact of the project and development of others. The proposal was taken to the U.S. Department of Education and the first of its kind limited copyright was issued to IACP, with royalties quickly generating hundreds of thousands of dollars before the limited copyright expired.

Project Impact on the Field

It can fairly be claimed that IACP did, in fact, accelerate the modernization of industrial arts. All of the field test school systems adopted the two-year offerings in their junior high schools. Many states also adopted the courses within their junior high school standards, but perhaps the largest impact was in having teachers adopt and adapt new teaching methodologies as well as new content to move into the 21st century.

Another peripheral gain was in the nationwide establishment of new and very helpful contacts within communities and states with leaders in construction and manufacturing technologies.

There was no intent to replace industrial arts. The overall goal was to provide two 1-year courses to the junior high school that would provide comprehensive knowledge and practical skills needed for living in the technological world in much the same way as general science prepares students for life in the natural world.

From the outset the envisioned two 1-year courses were seen as part of the liberal education core for all junior high school youth, with the same type of textual and laboratory guide materials, organized instruction, and periodic testing as for other basic school subjects.

Much research has been done on the impact of the program on student learning and the junior high school program. It casts a very favorable light on the accomplishments of IACP.

The significance and impact of IACP is even more dramatic in light of more than a dozen curriculum projects of varying scope but focused on changing or updating industrial arts during the 1960s and 70s. These are reported in detail by Householder (1972). But, IACP is unique in several ways. It is the only major industrial arts curriculum effort that has been rooted in an analysis of the structure of knowledge. It is the first project to produce instructional materials and a sequence of courses correlated with a taxonometric classification of a body of knowledge. The intensive field testing and in-service teacher education which accompanied the development have been unequalled. Finally, IACP is the only program that has produced a substantial group of integrated instructional materials and made them available through a commercial publisher. In view of these attributes, IACP is considered by many to be the outstanding accomplishment of past decades in industrial arts curriculum development.

Reference

Householder, D. L. (1972). *Review and evaluation of curriculum development in industrial arts education.* Bloomington, IL: McKnight.

Dr. Donald P. Lauda, professor emeritus of occupational studies and dean emeritus of the College of Health and Human Services, California State University, is a member of Alpha Phi Chapter of Epsilon Pi Tau.

Conceptualizations of Jackson's Mills

In the early 1980s, 21 professional educators in the discipline of industrial arts education were brought together to accept the challenge of synthesizing information concerning trends within the discipline with the goal of reaching consensus on the rationale and direction for the future of industrial arts (Snyder & Hales, p. ii). The results of this effort became known as the Jackson's Mills Industrial Arts Curriculum Theory (Snyder & Hales, 1981).

This article offers a personal perspective helped by the recollections of other participants who participated in the project that took place 21 years ago. The following describes the genesis of this project, its philosophical contributions, and its impact on the discipline. Those who contributed will understand that the passage of time may have embellished their recollections and will therefore also forgive that these have been mercifully edited.

Cultural Context

I believe that curriculum development cannot succeed if those involved fail to recognize the cultural context in which it exists. In that connection, I am compelled to say that the leaders in industrial arts education failed to recognize the trends and indicators that mandated radical change within content and instructional strategies. This failure endured in the face of evidence in the general literature and industrial arts literature. This might be best illustrated by saying that the study of technology can be traced back to the 19th century with Wilson's (1855) classic lecture entitled "What Is Technology" delivered at the University of Edinburgh.

The development of technology following World War II was quite dramatic. A large number of landmark developments developed that radically altered our way of life (e.g., ENIAC, synthetics, nuclear power). The 1960s and 1970s produced a significant increase in analyses of the consequences of what Ways referred to as the "era of radical change" (p. 19). Table 1 provides a representative sample of a number of these classic references. Pytlik (1987), at West Virginia University, conducted a study funded by the CTTE that resulted in a paper entitled "Great Books in Technology." Of the 52 books identified by scholars in the profession, 28 were published in the 1960s and 1970s. I would be remiss if I were to fail to state that a significant number of other classic references appeared prior to the 1960s (i.e., Wiener, 1950; Mumford, 1954; and Ellul, 1964).

Table 1. Classic References on Technology and Change Representative Sample

Burke, J. (1978). *Connections.* Boston: Little, Brown.

DeVore, P. W. (1972). *Education in a technological society: Access to tools.* Morgantown, WV: West Virginia University.

DeVore, P. W. (n.d.). *Technology: An intellectual discipline.* Oswego, NY: Oswego Teachers College.

Ellul, J. (1964). *The technological society.* New York: Vintage Books.

Ferkiss, V. (1969). *Technological man: The myth and the reality.* New York: Braziller.

Ginzberg, E. (1964). *Technology and social change.* New York: Columbia University Press.

Harvard University. (1968). *Program on technology and society: Fourth annual report.* Cambridge, MA: Author.

Helmer, O. (1966). *Social technology.* New York: Basic Books.

Kranzberg, M. (1964). *Technology and culture: Dimensions for exploration.* Washington, DC: American Industrial Arts Association.

Morse D., & Warner, A. (1966). *Technological innovation and society.* New York: Columbia University Press.

Olson, D. W. (1973). *Technol-o-gee.* Raleigh: North Carolina State University.

Toffler, A. (1970). *Future shock.* New York: Random House.

Warner, A. W., et al. (1965). *The impact of science on technology.* New York: Columbia University Press.

West Virginia University. (1970). *Industrial arts teacher education fellowship program.* Morgantown, WV: Author.

West Virginia University. (1970). *Proceedings of the West Virginia University industrial arts development conference.* Morgantown, WV: Author.

Wilson, G., MD. (1855). *What is technology?* Edinburgh, Scotland: Sutherland & Knox.

Both lists of books focused on a common theme, that is, technology as a primary determinant of social change. Within this context, we were facing a society characterized by new and recurring themes such as:

- Post-industrial
- Knowledge-based
- Futurism
- Technological forecasting
- Global village
- Technological assessment
- Information age
- Finite resources-infinite demand

Discipline Response

The 1960s and 1970s saw the emergence of new curricular approaches within the discipline of industrial arts education. It was becoming abundantly clear that two primary foci were surfacing for curriculum development. To illustrate this, reference is made to the IACP curriculum at Ohio State University (IACP, 1968) and the American Industry project at the University of Wisconsin-Stout, both of which focused on industry as the content base. At the same time, DeVore (1966) offered his ideas on the study of technology as a discipline base while at Oswego. Olson (1963) also called for the study of technology. It should be noted that an even earlier pioneer, Warner (1947), called for the study of technology as a more defensible content base. Maley (1973) offered his approach, which called for the study of technology, industry, and the problems and benefits resulting from the industrial and technological society. The call for change came from individuals outside of our discipline. For example, in 1964 noted historian Melvin Kranzerg delivered his landmark paper to the AIAA, entitled "Technology and Culture: Dimensions for Exploration."

West Virginia University, with the leadership of Thomas Brennan and Paul DeVore, offered the first major research effort for the study of technology as a discipline base. This was accomplished in 1969–70 with a funded project that involved 10 industrial arts professionals studying for a full year. This resulted in a document entitled "Industrial Arts Teacher Education Fellowship Program" in 1970. That same year another seminal document appeared entitled "Proceedings of the West Virginia University Industrial Arts Undergraduate Program Development Conference." It was these efforts that led to the development of the first undergraduate technology education program in the United States at Eastern Illinois University in 1976 (Lauda & Wright, 1983).

Change was in the proverbial wind and sufficient enough to warrant a major study that would assess the discipline. The preface to the Jackson's Mills document placed this in perspective.

> The literature in our field over the past few years has been replete with concerns and warnings about the direction and future of industrial arts. Committees within the AIAA structure have issued reports with the same conclusions. It is, therefore, time to translate debate into action. It is time to assess the relationship of industrial arts to comprehensive education. It is time to rededicate ourselves to a common professional cause. Hence the purpose of this document is to provide a rationale and direction for the future industrial arts from which we might all find a point of view. (Synder & Hales, n.d., p. ii)

The Jackson's Mills Experience

Directors: James Snyder, Coordinator, Instructional Learning Systems, West Virginia Department of Education; James Hales, Director, Division of Technology, Fairmont State College.

Funding: West Virginia State Department of Education

Location: Jackson's Mills, WV. Jackson's Mills State 4-H Conference Center is centrally located in the heart of West Virginia. Jackson's Mills became a well established landmark in the early 1800s, having been settled by the grandparents of General Thomas J. "Stonewall" Jackson in 1801. After changing hands many times, five acres were donated to the state by the Monongahela Traction Company for a West Virginia 4-H campsite. It was placed under the care of the Extension Service of West Virginia University. The isolated location in beautiful surroundings made a natural location for the Jackson's Mills Conference.

Selection of Participants: A modified delphi technique was utilized in which the directors identified two leaders in the discipline as participants. They then asked these two to identify the next two leaders. This process was repeated until the same names began to reappear, thereby reaching consensus. Twenty-one individuals were identified with the following composition: teacher educators (16), public school personnel (3), state department personnel (1), and the AIAA director.

Participants: See Table 2

Table 2. Participants in Jackson's Mills

Joseph E. Basile, West Virginia Department of Education
Myron Bender, University of North Dakota
M. James Bensen, University of Wisconsin-Stout
Paul W. DeVore, West Virginia University
William E. Dugger, Jr., Virginia Polytechnic Institute
Frank R. Field, University of New Mexico
James E. Good, Greece Central School District
Normal Heasley, Summit Board of Education, Ohio
Daniel L. Householder, Texas A & M University
Everett N. Israel, Illinois State University
Donald P. Lauda, Eastern Illinois University
Les Litherland, president, American Industrial Arts Association (AIAA)
Gary E. Lintereur, Northern Illinois University
G. Eugene Martin, Southwest Texas State University
Charles A. Pinder, Virginia Polytechnic Institute
Willis E. Ray, Ohio State University
John M. Ritz, Old Dominion University
Alvin E. Rudisill, Eastern Michigan University
Earl E. Smith, Oregon State University
Kendall N. Starkweather, executive director, AIAA
Thomas Wright, Ball State University

Meetings: Jackson's Mills 4-H Camp (2) and Oglesby Park, Wheeling, WV (1)

Final document: Snyder, J., & Hales, J. (n.d.). *Jackson's Mills industrial arts curriculum theory.* Charleston: West Virginia Department of Education. Reprinted by AIAA (1982) and Ball State University (1986). Available in ITEA archives, Millersville State University.

Process: The charge presented by the co-convenors (Snyder and Hales) was open-ended, that is, the group was asked to assess the relationship of industrial arts to comprehensive education, seek new models if appropriate, and hopefully reach consensus, realizing that the outcome would be "work in progress." Self-introductions revealed a wide range in experience (teaching and professional association), philosophy, biases, exposure to ideas, institutions attended, current employment, etc. By design, the group had representation from teacher education, the state department of education, and the public schools, albeit the latter two had a very small representation.

The group initiated its efforts with a broad discussion of societal trends, our heritage, curricular models in the discipline, efforts in other disciplines, needs of children, etc. This served as a "warm-up" exercise and a chance for positioning among the participants. It would be naive to think that individuals came without bias, preconceived notions, or ego involvement. But these would have to be set aside as much as possible and compromises would have to be made if the group was to meet its goals. Following lengthy discussions, an outline began to take form which included:

- A base for curriculum derivation which became a discussion of society and culture, including their evolution.
- Domains of knowledge (sciences, humanities, technologies, and formal knowledge).
- Human adaptive systems (technological, sociological, ideological) that exist in our natural and human-made environment.
  The interaction between Items 2 and 3 above led to:
- A universal systems model (input-process-output) which has allowed a means to bring order to human actions. This included an analysis of the source of inputs (people, knowledge, materials, energy, capital, finance).
- Implementation (learner, program levels, learning models, state and local models).
- A definition of the discipline.

At the risk of personal bias or possible senior moments, the following observations are proffered:

At the outset, five major "hurdles" provided potential roadblocks for discussions: (a) that our own discipline might restrict our thinking, (b) that the group might be reluctant to look at interdisciplinary possibilities, (c) that the group may attempt to be/do all things for all people, (d) the obvious division in philosophy with one coming from a "study of industry base" and the other a "study of technology base," and (e) that the discussion of the sociological and ideological elements of the human adaptive systems might meet intense resistance since traditionally industrial arts educators had not focused on values, norms, institutional responses to change, and their relationships.

The group was in agreement that a primary "driver" of deliberations should evolve around the realities of society and culture. Attention to the realities of the primary references included in Table 1 was obvious.

The domains of knowledge were also accepted based on input from the literature (sociology, anthropology).

The human adaptive system discussion was lengthy because industrial arts educators who had traditionally focused on materials and processes had little or no training in handling discussions evolving sociological concepts. The end result was a high level of emphasis on the interaction between the domains of knowledge and the human adaptive systems. It seemed to me that this was the point at which the group solidified and the basis for the curricular theory was founded.

The adaptive system conversation was further enhanced with the acceptance of the universal systems model, which was advocated by some from an engineering perspective. This clearly reinforced the notion of the interaction between knowledge and systems, and perhaps, most important, offered an interesting instructional strategy for the classroom. From these discussions it was inevitable that interdisciplinary relationships surfaced and provided additional opportunities for content and instructional strategies.

The definition adopted came from Maley's work incorporating both technology (evolution, utilization, and significance) with industry (organization, personnel systems, techniques, resources, products, and their social/cultural impact). This was a significant compromise in the group and it ameliorated the two philosophical viewpoints.

Vigorous debate ensued over the fundamental technological systems with one group advocating production, transportation, and communication and the other advocating manufacturing, construction, transportation, and communication. Others that were considered were power and energy. Bio-technology was discussed tangentially but never seriously considered as one of the primary parts of the system. Ultimately, the group compromised and accepted manufacturing, construction, transportation, and communication.

The implementation section, although offering unique insights, had to be hastily crafted due to a lack of time.

Overall, the discussions were in-depth and of a highly professional nature. This is not to say that there were no moments of agitation. Different philosophical positions bring inherent dangers when presented since invariably there are those who think otherwise. Having said this, I felt that closure came with the feeling that the group had coalesced and generated a curricular "theory" that had great potential for leading to a sustained conversation to help the discipline of industrial arts retain and improve its position in the educational system.

Impact

The "proof of the pudding" comes from a demonstrated use of one's efforts. Did the Jackson's Mills Project make an impact? Did it change the discipline? Was it worth the effort of 21 professionals who contributed endless hours of their time and energy? I believe the answer is "Yes!" for every question. Much of the proof is difficult to document, and it is anecdotal evidence that is the curse of solid research. However, there is ample evidence, albeit some implied, in the literature. For example, the Jackson's Mills document has been cited in a large number of seminal documents including the Standards for Technological Literacy (2000). Table 3 includes a sample of citations.

Table 3. A Representative Sample of Citations Using Jackson's Mills Industrial Arts Curriculum Theory

- 1983 - Eastern's Technology Plan (Eastern Illinois University)
- 1988 - Industrial Teacher Education in Transition (MVITEC)
- 1990 - A Conceptual Framework for Technology Education (ITEA)
- 1990 - Communication in Technology Education (39th Yearbook, CTE)
- 1992 - Transportation in Technology Education (41st Yearbook, CTE)
- 1993 - Manufacturing in Technology Education (42nd Yearbook, CTE)
- 1993 - A Decision Maker's Guide to Technology Education (ITEA)
- 1994 - Construction in Technology Education (43rd Yearbook, CTE)
- 1995 - Foundations of Technology Education (44th Yearbook, CTE)
- 1997 - Elementary School Technology Education (46th Yearbook, CTE)
- 1999 - Advancing Professionalism in Technology Education (48th Yearbook, CTE)
- 2000 - Standards for Technological Literacy (ITEA)
- 2000 - Technology for All Americans (ITEA)

Sanders (2001) in his research on the status of technology education practice in the United States provided highly useful information. His research shows that little change has occurred in the ranking of the top 10 courses taught in 1999 and those found 40 years ago (i.e., wood technology, metal technology). However, the second top 10 included courses identified as manufacturing, communications, construction, and transportation, with biotechnology almost nonexistent. Although he did not cite the Jackson's Mills Project, the author feels that the following questions must be raised. Was it the Jackson's Mills Project that laid the groundwork for landmark subsequent efforts (i.e., "Conceptual Framework for Technology Education," from AIAA to ITEA including the changes in all councils, ITEA standards)? Might have these efforts been delayed or forestalled had Jackson's Mills been nonexistent?

The luxury of speculation is left to the original participants; however, it leaves ample room for a more detailed analysis of the literature. In addition, the Jackson's Mills Project, as well as all subsequent projects, has left ample room for debate on the definitions, organizers, strategies, etc. After all, we cannot afford to be blindsided by the realities of the inevitable changes yet to come, can we?

References

DeVore, P. (1972). *Education in a technological society: Access to tools.* Morgantown: West Virginia University.

DeVore, P. (1966). *Technology: An intellectual discipline.* Oswego, NY: Oswego State University.

Ellul, J. (1964). *The technological society.* New York: Vintage Books.

Industrial Arts Curriculum Project. (1968). *IACP rationale—A brief description.* Columbus, OH: Author.

International Technology Education Association. (2000). *Standards for technological literacy.* Reston, VA: Author.

Kranzberg, M. (1964). *Technology and culture: Dimensions for exploration.* Washington, DC: American Industrial Arts Association.

Lauda, D., & Wright, J. (1983). *Eastern's technology education plan.* Charleston: Eastern Illinois University.

Maley, D. (1973). *The Maryland plan.* New York: Benzinger, Bruce & Glencoe.

Mumford, L. (1954). *Technics and civilization.* New York: Harcourt, Brace & World.

Olson, D. (1963). *Industrial arts and technology.* Englewood Cliffs, NJ: Prentice-Hall

Pytlik, E. (1987). *Great books in technology.* Morgantown: West Virginia University.
Savage, E., & Sterry, L. (Eds.). (1990). *A conceptual framework for technology education.* Reston, VA: ITEA.
Sanders, M. E. (2001). New paradigm or old wine: Status of technology education practice in the United States. *Journal of Technology Education,* **12**(2), 35–55.
Snyder, J. & Hales, J. (n.d.). *Jackson's Mills industrial arts curriculum theory.* Charleston: West Virginia Department of Education.
Warner, W. (1947). *A curriculum to reflect technology.* Columbus, OH: Industrial Arts Center, The Ohio State University.
Wiener, N. (1950). *Human use of human beings.* Cambridge, MA: MIT Press.
Wilson, G. (1855). *What is technology?* Edinburgh, Scotland: Sutherland & Knox.

Dr. William E. Dugger, Jr., professor emeritus of technology education, Virginia Polytechnical State University, is a member of Beta Chi Chapter of Epsilon Pi Tau.

Roots of Technology Education: Standards Projects

Standards created at the national level began to influence educational policy and practice in the 1980s. Today, 49 out of the 50 states have developed and implemented some form of standards in dozens of subject areas, many of which are adaptations or direct adoptions of nationally developed standards. The roots of standards in technology education go back to the 1970s, with industrial arts education.

Most nationally developed standards are "content standards," which means they focus on basic concepts and "big ideas," deliberately leaving curricular decisions to state and local agencies. Content standards offer a vision for what is needed to enable all students to become literate in a given subject.

Technology education is rooted in standards. This article discusses the evolution of standards in our profession over the past 25 years with specific reference to:

- Standards for Industrial Arts Programs (1978–1981).
- Standards for Technology Education Programs (1985).
- International Technology Education Association's (ITEA) Technology for All Americans Project (1994–2003).
- The future.

Standards for Industrial Arts Programs (1978–1981)

In the late 1970s, the former U.S. Office of Education (USOE) and several professional associations became interested in developing and promoting quality standards for selected subject areas. In 1978, the USOE requested proposals for developing industrial arts program standards. Consequently, the Standards for Industrial Arts Programs Project at Virginia Polytechnic Institute and State University in Blacksburg, Virginia (Virginia Tech) was funded. Per the USOE, the three primary objectives of the project were:

- To **develop a database** on industrial arts programs (as defined in Title 1, Part C, Section 195 (15) of the Education Amendments of 1976) and on industrial arts student organization activities as an integral part of the industrial arts instructional program.
- To **develop a set of standards** and related handbooks for ensuring quality industrial arts programs.
- To **familiarize, publicize, and demonstrate** the standards developed for industrial arts programs.

The database was developed from October 1978 through November 1979. The results of this effort were included in the *Report of Survey Data*, which was published in 1980.

The *Standards for Industrial Arts Education Programs* (*SIAP*) developed by over 400 industrial arts teachers, state and local supervisors, teacher educators, and consultants, served as a model for schools, districts, and states that voluntarily wished to develop, adopt, or refine standards for the improvement of their industrial arts program. The standards are comparative statements that were developed around 10 major topics:

- Philosophy
- Support systems
- Instructional program
- Instructional strategies
- Student populations served
- Public relations
- Instructional staff
- Safety and health
- Administration and supervision
- Evaluation

Under these headings, 235 specific quality measures were listed. These were used to determine if an industrial arts program met, exceeded, or did not meet a standard. Once a determination was made, persons assessing a program prepared a summary profile and wrote summary comments concerning the strengths and deficiencies of the industrial arts program.

Three additional publications were produced by the Standards for Industrial Arts Programs Project as companions to the *SIAP*:

- *AIASA Guide for Industrial Arts Programs.*
- *Sex Equity Guide for Industrial Arts Programs.*
- *Special Needs Guide for Industrial Arts Programs.*

The guides offered suggestions for program improvements related to student organizations, sex equity, and students with special needs. The *SIAP* and its companion documents contained the best thinking of the profession on what industrial arts programs should be and how they could be improved at the time of their publication. In 1981, the Industrial Arts Program at Virginia Tech released *SIAP* to the American Industrial Arts Association (AIAA) for more comprehensive dissemination. The *SIAP* was published in 1981 by Goodheart-Willcox Co., Inc.

Standards for Technology Education Programs (1985)

The *SIAP* was revised by AIAA in 1985 to reflect technology rather than industry. Funding was provided by the Technical Foundation of America. The revised document, entitled *Standards for Technology Education Programs* (AIAA, 1985), had 241 standards and was disseminated by AIAA/ITEA and printed by Goodheart-Willcox Co., Inc. It was during this time that the AIAA changed its name to the International Technology Education Association (ITEA).

ITEA's Technology for All Americans Project (1994–2003)

Motivated by the growing need for technological literacy for all citizens, ITEA formed the Technology for All Americans Project to provide formal structure for technology education programs across the country. The project's goal was to create standards for technology education for grades K–12. Funded by the National Science Foundation and the National Aeronautics and Space Administration, the project commenced in 1994 with the first of three phases.

- **Phase I—*Technology for All Americans: A Rationale and Structure for the Study of Technology* (*RSST,* 1994–1996)**

RSST (ITEA, 1996) established the fact that technological literacy is much more than just knowledge about computers and their application. It defines technology as "human innovation in action" (p. 16) and creates a vision where each citizen should have a degree of knowledge about the nature, behavior, power, and consequences of technology from a broad perspective. Inherently, it presents educational programs where learners become engaged in critical thinking as they design and develop products, systems, and environments to solve practical problems. This phase provided a firm foundation for Phase II of the project, the development of content standards.

- **Phase II—*Standards for Technological Literacy: Content for the Study of Technology (STL* 1996–2000*)***
  STL (ITEA, 2000) was released at the ITEA conference in Salt Lake City in April 2000. In the review and consensus-building process, more than 4,000 people contributed to the improvement of the document as it was developed and refined, including educators, administrators, and experts from the fields of science, mathematics, and engineering, among others. *STL* is endorsed by both the National Research Council and the National Academy of Engineering. There are 20 technology content standards (see Table 1). They are divided by the grade levels of K–2, 3–5, 6–8, and 9–12 and consist of written statements about what is valued in the study of technology. These standards set forth goals to be met in five major categories of technology: the nature of technology, technology and society, design, abilities for a technological world, and the designed world.

Nearly 300 benchmarks play a vital role in *STL*. Benchmarks are statements that enable students to meet a given standard. They are articulated or "ramped" from grades K–12 to progress from very basic ideas at the early elementary school level to the more complex and comprehensive ideas at the high school level. The benchmarks contain certain core content "concepts," such as systems and processes, that extend across various grade levels to ensure continual learning of an important topic related to a standard (see Table 2).

Table 1. The Standards for Technological Literacy

The Nature of Technology (Chapter 3)
Standard 1. Students will develop an understanding of the characteristics and scope of technology.
Standard 2. Students will develop an understanding of the core concepts of technology.
Standard 3. Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Technology and Society (Chapter 4)
Standard 4. Students will develop an understanding of the cultural, social, economic, and political effects of technology.
Standard 5. Students will develop an understanding of the effects of technology on the environment.
Standard 6. Students will develop an understanding of the role of society in the development and use of technology.
Standard 7. Students will develop an understanding of the influence of technology on history.

Design (Chapter 5)
Standard 8. Students will develop an understanding of the attributes of design.
Standard 9. Students will develop an understanding of engineering design.
Standard 10. Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Abilities for a Technological World (Chapter 6)
Standard 11. Students will develop the abilities to apply the design process.
Standard 12. Students will develop the abilities to use and maintain technological products and systems.
Standard 13. Students will develop the abilities to assess the impact of products and systems.

The Designed World (Chapter 7)
Standard 14. Students will develop an understanding of and be able to select and use medical technologies.
Standard 15. Students will develop an understanding of and be able to select and use agricultural and related biotechnologies.
Standard 16. Students will develop an understanding of and be able to select and use energy and power technologies.
Standard 17. Students will develop an understanding of and be able to select and use information and communication technologies.
Standard 18. Students will develop an understanding of and be able to select and use transportation technologies.
Standard 19. Students will develop an understanding of and be able to select and use manufacturing technologies.
Standard 20. Students will develop an understanding of and be able to select and use construction technologies.

Table 2. A Representative Standard and Its Benchmarks

Standard 11. Students will develop abilities to apply the design process.
As part of learning how to apply design processes, students in grades 6-8 should be able to
H. Apply a design process to solve problems in and beyond the laboratory-classroom. Perform research, then analyze and synthesize the resulting information gathered through the design process. Identify and select a need, want, or problem to solve, which could result in a solution that could lead to an invention (an original solution) or an innovation (a modification of an existing solution). Identify goals of the problem to be solved. These goals specify what the desired result should be.
I. Specify criteria and constraints for the design. Examples of criteria include function, size, and materials, while examples of constraints are costs, time, and user requirements. Explore various processes and resources and select and use the most appropriate ones. These processes and resources should be based on the criteria and constraints that were previously identified and specified.
J. Make two-dimensional and three-dimensional representations of the designed solution. Two-dimensional examples include sketches, drawings, and computer-assisted designs (CAD). A model can take many forms, including graphic, mathematical, and physical.
K. Test and evaluate the design in relation to pre-established requirements, such as criteria and constraints, and refine as needed. Testing and evaluation determine if the proposed solution is appropriate for the problem. Based on the results of the tests and evaluation, students should improve the design solution. Problem-solving strategies involve applying prior knowledge, asking questions, and trying ideas.
L. Make a product or system and document the solution. Group process skills should be used, such as working with others in a cooperative team approach and engaging in appropriate quality and safety practices. Students should be encouraged to use design portfolios, journals, drawings, sketches, or schematics to document their ideas, processes, and results. There are many additional ways to communicate the results of the design process to others, such as a World Wide Web page or a model of a product or system.

- **Phase III—Companion Standards to *STL* (2000–2003)**
  The final phase of the Technology for All Americans Project is to develop a companion document for *STL* articulating the standards for assessment, professional development, and programs. The assessment standards are designed to address specific goals and purposes and define who to test, when to test, and what kind of test to use. Professional development standards are performance based and describe the attributes and skills that teachers should acquire as the result of professional development. They apply to every teacher in the schools who is teaching any aspect of technology. And finally, program standards address the totality of the school program across grade levels.

The Future

In 2003, the companion standards to *STL*—assessment, professional development, and programs—will be completed and mailed to approximately 6,500 classroom technology teachers, supervisors, and teacher educators. An additional 2,000 copies will be mailed to key school administrators and policymakers. The standards will be published by ITEA as well as placed on ITEA's Internet site (*www.iteawww.org/TAA/TAA.html*).

STL and its companion standards do not present an end but a beginning. In other fields of study, the development of standards has often proven to be the easiest step in a long and arduous process of educational reform. Getting *STL* and the three sets of companion standards accepted and implemented in grades K–12 in every school is a challenge ITEA intends to accept in striving for technological literacy for all citizens.

References and Resources

American Industrial Arts Association. (1985). *Standards for technology education programs*. Reston, VA: Author.

Dugger, W. E., Jr., Bame, A. E., Pinder, C. A., & Miller, D. C. (1981). *Standards for industrial arts education programs*. Reston, VA: International Technology Education Association.

Dugger, W. E., Jr., Miller, C. D., Bame, E. A., & Pinder, C. A. (1980). *Report of survey data* (as required by Task 9c of RFP 78-129). (Available from William E. Dugger, Jr., Technology for All Americans Project, 1997 South Main Street, Suite 701, Blacksburg, VA 24060)

International Technology Education Association. (1996). *Technology for all Americans: A rationale and structure for the study of technology*. Reston, VA: Author.

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

Dr. Ernest N. Savage, dean and professor of the College of Technology, Bowling Green State University, is the trustee of Alpha Gamma Chapter of Epsilon Pi Tau.

A Conceptual Framework for Technology Education: A Historical Perspective

The idea for *A Conceptual Framework for Technology Education* (Savage & Sterry, 1990) came about as a result of a walk between conference venues at the Tulsa International Technology Education Association (ITEA) conference in 1988. Len Sterry and I were discussing the changes that were occurring in the professions of technology and the inability of the professions to react to those changes. We both felt that the front end material of the Jackson's Mill document was timeless but that the content organizers and processes were beginning to become dated. Also, we felt that the field was beginning to ask, "What comes after Jackson's Mill?" Certainly the work that Tom Wright spearheaded with the Chicago 10 Curriculum Implementation Project operationalized Jackson's Mill, but it could go no further than the work that it was attempting to "hang" a curriculum upon. At the Mississippi Valley Industrial Teacher Education conference that following November, we approached Gene Martin for his perspective regarding the possibility of having the Technical Foundation of America (TFA) fund such an effort. Due to his encouragement to us to submit a proposal, the TFA funded our effort and allowed us to begin the process at the ITEA conference the following spring of selecting 25 leaders in the field to participate. Tom Erekson, Tom Wright, and Kendall Starkweather served as trustees for the project and assisted greatly in the selection process. Walter Waetjen served as facilitator for each session, and Len Sterry and I served as codirectors. Among the participants, there were representatives from 15 states, 18 colleges or universities, 2 state departments of education, 1 high school, and 1 national organization. The commitment of the participants was to meet for three 3-day periods to create a product that would provide a framework for the study of technology in the 1990s.

A Conceptual Framework for Technology Education endorsed the human adaptive systems and domains of knowledge of the *Jackson's Mill Industrial Arts Curriculum Theory* (Snyder & Hales, 1981) while also focusing on the human as a problem solver who, through the application of the technological method model, could identify and address problems and opportunities and solve problems using resources and technological processes while considering the outcomes and consequences of such activity. The significant contributions of this document are the listing of the universal attributes of technology; the comparison of the features of the body of knowledge of technology to the features of science and the humanities/arts (see Figure 1); the development of the technological method model (see Figure 2) and its "spin-off"—a model for technology education (see Figure 3); the inclusion of a broader base of content for the study of technology: the recognition of educational philosophies and bodies of knowledge related to technology, science, and the arts/humanities (see Figure 4); identification of the methodological and content characteristics of a quality technology education program; and a process model for a course of study. As with any document of this kind, it was recognized that this work represented a new departure or "paradigm shift" for our profession.

	TECHNOLOGY	SCIENCE	HUMANITIES/ARTS
DEFINITION	STUDY OF THE HUMAN MADE WORLD	STUDY OF THE NATURAL WORLD	STUDY OF VALUE STUDY OF HUMAN BEHAVIORS
METHOD OF INQUIRY	TECHNOLOGICAL METHOD	SCIENTIFIC METHOD	ECLETIC METHOD SCIENTIFIC PHENOMENOLOGICAL METHODS
CONTENT EXAMPLES	BIO RELATED COMMUNICATION PRODUCTION TRANSPORTATION ETC.	BIOLOGY CHEMISTRY PHYSICS MATH ETC.	HISTORY PHILOSOPHY LANGUAGE SOCIOLOGY ANTHROPOLOGY PSYCHOLOGY ETC.

Figure 1. Features of bodies of knowledge.

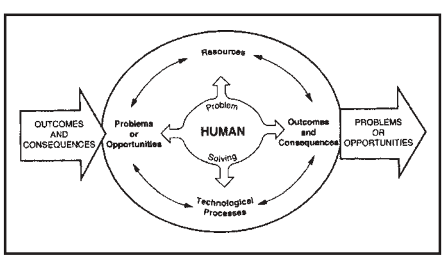


Figure 2. The technological method model.

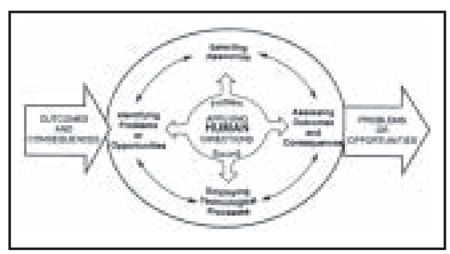


Figure 3. A model for technology education.

	SCIENCE	TECHNOLOGY	HUMANITIES/ARTS	
INDIVIDUAL NEEDS	NUTRITION	RESEARCH AND DEVELOPMENT	CIVIC RESPONSIBILITY (VOTING)	CREATIVE WRITING PAINTING
SOCIAL PROBLEMS	ENVIRONMENTAL STUDIES	ENERGY EFFICIENCY	GLOBAL STUDIES	VALUES CLARIFICATION CENSORSHIP
ACADEMIC RATIONALISM	CHEMISTRY	PROCESSING	HISTORY	ENGLISH LITERATURE MUSIC THEORY
TECHNICAL PROFICIENCY	MATHEMATICS	MANUFAC-TURING	DEMOGRAPHICS	JOURNALISM PHOTOGRAPHY
INTELLECTUAL PROCESSES	HYPOTHESIS GENERATION	INVENTION	TECHNOLOGY ASSESSMENT	ART APPRECIATION EPISTEMOLOGY

Figure 4. Examples of educational philosophy and bodies of knowledge.

Context and Significance

A Conceptual Framework for Technology Education represents pieces and parts of many curricular ideas, educational philosophies, and ideologies that preceded it. Figure 5 is an attempt to contextualize those parts. Any effort of this kind, and with the experts who were involved, will spring from a diverse and multigirded philosophical base. Of prominence is the philosophy of social reconstructionism which recognizes that the human, armed with the knowledge of resources and processes, can interact with necessary constituents to solve problems. The work of Bonser almost 90 years ago (Andrews & Erickson, 1976) provided the framework for industrial arts focusing on technologies of the home. This was in contrast to Selvidge's (1909) work that resulted in the Standards of Attainment for the Industrial Arts as part of vocational education. Bonser's perspective was modernized by Snedden and Warner (1927) and then refocused to reflect the technologies of dominant industries by Warner et al. (1952). Warner et al. also supported Wilbur's (1948) definition of industrial arts, which was paraphrased in Maley's (1973) definition leading to the Maryland Plan. The Industrial Arts Curriculum Project (IACP; Towers, Lux, & Ray, 1966) also has some Warner influence as does the American Industry Project (Face & Flug, 1967). Both those projects influenced the Jackson's Mill effort which in turn influenced the Conceptual Framework effort. Some might say that this interpretation of our curricular efforts has provided evidence of the incestuous nature of our field. I find it difficult to deny that perspective. With the exception of IACP and the Standards for Technological Literacy Project (ITEA, 2000), there have never been substantive funds to "go outside" of our field for different views of industry or technology. We are still in our infancy as a discipline and, as such, are still trying to determine what we want to be when we grow up.

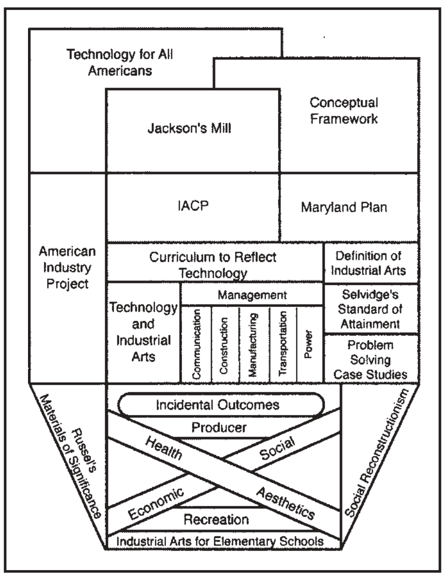


Figure 5. Foundation for the conceptual framework.

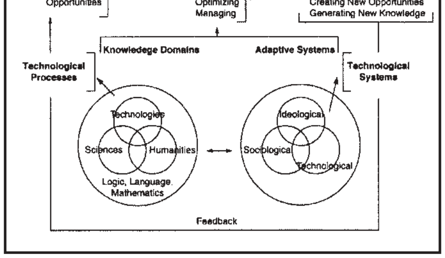


Figure 6. Technological method (Sterry) model.

Content That Reflects Technology

The coauthor of *A Conceptual Framework for Technology Education*, Len Sterry, has reflected on the place that our document has in its linkage with contemporary initiatives. With his permission, I am presenting his perspective in the next several paragraphs. Note that Len calls his model "the technological method," a potential for confusion on the part of the reader, but Len was clear about his commitment to the new model as his view of the evolving representation of technology. Therefore, the term will be used with (Sterry) tagged to the model for clarification purposes.

The ITEA (2002) and its Technology for All Americans Project developed and published *Standards for Technological Literacy: Content for the Study of Technology*, with funding from the National Science Foundation and the National Aeronautics and Space Administration. Technology content standards are designed to help ensure that all students receive an effective education about technology by setting forth a consistent content for the study of technology. More specifically, the standards include the nature of technology, technology and society, design, abilities for a designed world, and the designed world. All five standard categories and all 20 standards are of equal importance.

The Technological Method (Sterry)

The technological method (Sterry) is a model by which we "do" technology. By definition, technology is "know-how that extends human capability." It is more than just knowing; it is knowing and being able to do! It is based on a human desire to produce an outcome. So how does it work?

As individuals, organizations, countries, and a world community, we are constantly faced with challenges, problems, and opportunities. To address these challenges, we draw upon our individual and collective knowledge bases along with other resources to produce a desired result. When we are short of ability, we try to learn more through research and study. As we meet a challenge we usually create new problems and opportunities. In the process we also generate new knowledge that is added to our collective knowledge pool. And thus, the cycle continues, exponentially.

Technological Processes

The body of technological knowledge, according to our frameworks and standards, includes our ability to manipulate matter and information. According to Negroponte (1995) in his book *Being Digital* and other curricular models, the world can be classified as consisting of atoms and bits. Atoms account for the physical world of living and nonliving matter while bits make up the world of information. Information and materials technology represent, therefore, the know-how we apply to manipulating our world. These processing concepts apply to all situations as we provide goods and services ranging from health care to automobiles, from entertainment to structures, from travel to education, and from family life to our global community. They are fundamental processes that apply universally. Therefore, they are concepts that, if taught and understood by students, will be transferable to many situations. Conceptual understandings will also provide students with an ability to deal with technological change in the future, both personally and professionally. While information and materials technology could appear in the school program as technological systems of the designed world, these technologies are significant to the extent that they will also be a major part of the total curriculum design.

Technological processes are a result of the knowledge domain in the technological method. The processes usually include processing information and processing matter/materials, both living and nonliving. Depending on a person's perspective, instrumentation is sometimes included as a part of processing information and energy is often separated from the bigger concept of processing matter. In a practical sense, either way will get the job done. Design is sometimes considered as a universal technical concept and included as a technological process. Again, this is not correct in a pure sense but does work well as a practical application.

Technological Systems

As stated earlier, *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000) identified seven systems for the designed world. The U.S. Department of Education identifies 16 clusters associated with occupational education. Others have their own set of favorites.

The technological method (Sterry) model identifies a category of human adaptive technological systems that could include any number of systems, depending on how one might choose to organize this part of the model. However, according to Sterry and Hendricks' (1999) *Exploring Technology*, there are generic concepts that apply to human adaptive technological systems:

- Designing/determining products and services—Making decisions about what product or service will be produced.
- Planning production—Determining how the product or service will be delivered.
- Obtaining resources—Securing materials, energy, personnel, financing, and information.
- Tooling for production—Procuring or constructing the necessary apparatus and equipment.
- Actuating the process—Making it happen.
- Controlling production—Monitoring and adjusting the process.
- Packaging—Containerizing the product or service for protection, appeal, and transport.
- Distributing—Marketing and moving the product or service to storage or the consumer.
- Maintaining—Servicing products and relationships.

Using these concepts as a framework, different technologies or systems can be outlined. Some examples include communication; transportation; manufacturing; construction; information; materials; food and fiber; air, land, water, and environmental; energy; medical; and entertainment and media.

Summary

Each of our efforts, if they continue to build on the works of our best thinkers and doers, will contribute to the puzzle that will become our recognized field of study. The recommendations from the conceptual framework document sheds some light on our future. Among other things, they speak to the need to be multidisciplinary in our approach to technological literacy and our charge to provide essential knowledge at all levels of society, including the workforce. Technology will never go away. We should assume that our field will ultimately become recognized as an essential component of education for all learners.

References

Andrews, R., & Erickson, E. (1976). *Teaching industrial education: Principles and practices.* Peoria, IL: Bennett.

Face,W., & Flug, E. (1967). *The establishment of American industry as a traditional subject between general and vocational education.* Menominee, WI: Stout State University, American Industry Project.

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

Negroponte, N. (1995). *Being digital.* New York: Knopf.

Maley, D. (1973). *The Maryland plan.* New York: Bruce.

Savage, E., & Sterry, L. (1990). *A conceptual framework for technology education.* Reston, VA: International Technology Education Association.

Selvidge, R. W. (1909). *Our unscientific attitude.* Presentation to the Manual Arts Conference, Peoria, IL.

Snedden, D., & Warner, W. (1927). *Reconstruction of industrial arts courses.* New York: Columbia University, Teachers College.

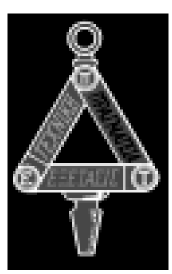
Snyder, J., & Hales, J. (1981). *Jackson's Mill industrial arts curriculum theory.* Charleston: West Virginia Department of Education.

Sterry, L., & Hendricks, R. (1999). *Exploring technology.* Menomonie, WI: T&E Publications.

Towers, E., Lux, D., & Ray, W. (1966). *A rationale and structure for industrial arts subject matter.* Columbus: The Ohio State University.

Warner, W., Gary, J., Gerbracth, C., Gilbert, H., Lisack, J., Kleinties, P., & Phillips, K. (1952). *The curriculum to reflect technology.* Columbus, OH: Epsilon Pi Tau.

Wilber, G. (1948). *Industrial arts in general education.* Scranton, PA: International Textbook.



Teaching Design for Manufacturing of Plastics Using Computer-Aided Engineering

Tao C. Chang

Plastic manufacturing is one of the largest industrial areas in the United States. It accounts for approximately $304 billion in annual shipments and 1.5 million jobs (Society of Plastic Industry, Inc., 2000). Today's business environment is driving manufacturers to bring better products to market faster, with higher quality and lower cost. This is true in the plastics molding and manufacturing industries, as stressed in a 1999 industry trend report prepared by the Plastics Molders & Manufacturing Association of the Society of Manufacturing Engineers. This trend forces original equipment manufacturers, molders, toolmakers, machine manufacturers, and material suppliers to work together and be involved at the earliest stage of product development in today's intensely time-conscious, competitive environment. In developing a new product, the design stage will typically cost 5% of the total cost breakdown (see Figure 1). However, studies by various companies (Boothroyd, Dewhurst, & Knight, 1994) have shown that design decisions made during new product development directly affect 70% to 80% of the final manufacturing cost (see Figure 2). Therefore, the workforce needs to be attuned to designing with manufacturability in mind to avoid difficult and costly situations in later stages.

Today, technology tools such as computer-aided design/manufacturing (CAD/CAM), computer-aided engineering (CAE), computer numerical control (CNC) machining, solid modeling, and stereolithography (SLA) are available to help manufacturers achieve the goal of an ever-decreasing life cycle of a product from concept to market. CAE has been widely used by the plastic injection industry to verify the manufacturability of a design, as evidenced

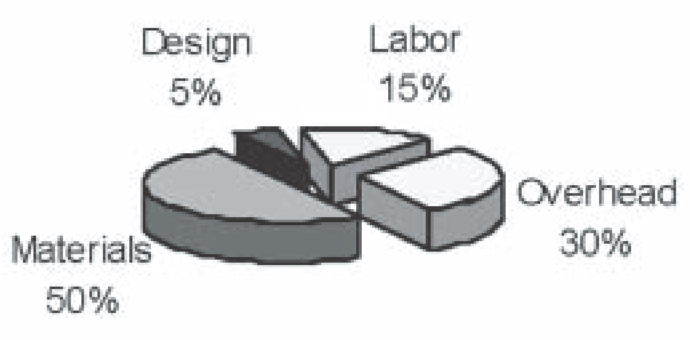


Figure 1. A typical breakdown of total manufacturing cost of a new product development (Boothroyd, Dewhurst, & Knight, 1994).

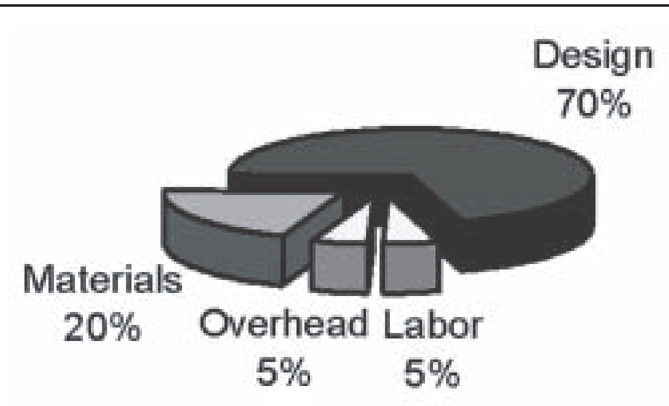


Figure 2. The percent influence on overall manufacturing cost of developing a new product (Boothroyd, Dewhurst, & Knight, 1994).

Table 1. Summary of Commercial CAE Packages Available to Plastic Industry

Company Name	Headquarters Location	Telephone
Axsys	Wixom, MI	248-926-8810
C-Mold (purchased by Moldflow in 2000)	Louisville, KY	502-423-4350
Cadkey	Marlborough, MA	508-229-2020
Injection Molding Ind.	Orion, MI	248-391-1405
ITI	Milford, OH	513-576-3900
M-Base	Aachen, Germany	+49 (241) 9631450
Madison Group	Madison, WI	608-231-1907
Moldflow	Wayland, MA	508-358-5848
Plastics & Computer	Dallas, TX	972-934-6705
SDRC	Milford, OH	513-576-2400
Stress Engineering	Mason, OH	513-336-6701

Note. Adapted from "Software, CAE," 2001.

by the number of commercial software packages available today (see Table 1; "Software, CAE," 2001).

Injection Molding and Product Development

Injection molding is a process that softens a plastic material with heat and forces it to flow into a closed mold. Then, the material cools and solidifies, forming a specific product. The manufacturing of quality injection-molded parts depends on the successes of part and mold design, process control, and material selection. A study identified more than 200 different parameters that had a direct or indirect effect on the complicated process (Bryce, 1996).

Traditionally, experienced molding personnel have relied on their knowledge and intuition acquired through long-term experience, rather than the theoretical and analytical approach to determining the process parameters that is used today. The length of the time in finding the right conditions to manufacture quality parts was dependent on the experience of molding personnel. Furthermore, the development of new products and part and mold designs as well as selection of materials and machines also remained a matter of personal judgment. It was considered normal that a mold be returned to the mold maker for modification at least once or twice before it could produce parts meeting the user's specifications. About 20% of the cost of a mold commonly went into redesign and remaking (Bernhardt, Bertacchi, & Moroni, 1984).

The development of computer-aided engineering simulation in the injection molding industry has eliminated various trial-and-error practices and greatly streamlined the product development cycle. CAE can be used to check process feasibility, evaluate runner systems, determine optimal process conditions, and estimate the cost of processing a part. Its application can provide the industry with benefits such as resource saving, reduced time to market, and improved quality and productivity. However, one of the causes for reluctance to make use of and realize the whole advantages of CAE is that a significant portion of the industry still lacks the technical skills needed to apply the simulation technology (Berhardt, Bertacchi, & Kassa, 2000). Integration of CAE into higher education should provide trained personnel to reap the benefits of simulation in the injection molding industry.

The Course

This article shares the highlights of teaching the integration of CAE packages with hands-on activities in the laboratory and covers issues of designing for manufacturability in injection molding in a course taught by the author. The major points of this article are teaching methods, tools available, competencies for designing for manufacturability in injection molding, and students' feedback about the effects of the integration of CAE on their learning.

The course *Polymer and Composite Processing* covers polymer and composite processing, each receiving eight weeks of coverage. Since industrial technology students have previously learned about plastic materials and available industry processes in a course on *Non-Metallic Manufacturing Materials and Processes*, it is logical to provide a systematic view of plastic manufacturing that focuses on the design for manufacturability using a specific and popular process such as injection molding. This broadens their view of industrial practices, since 60% of manufacturing processes within the plastic process industry are injection-molding types (Michaeli, Kaufmann, Greif, & Vosseburger, 1992).

Teaching strategies were concentrated on presentation and demonstrations, team environment with limited cooperative learning experience, and hands-on experimentation in laboratory. The recent introduction of a new injection molding machine and three CAE packages provided the author ample leverage to include simulations in teaching, as well as to redesign the contents of the class. The addition of field trips and seminars by industrial experts in the class further enhanced students' learning experiences. Available for laboratory experiences are:

1. A new Boy 22M electronic fully closed-loop controlled injection-molding machine. This machine features a microprocessor-based control system, which includes programmable injection and holding pressures, variable injection speed, capability of monitoring 12 processing parameters simultaneously, and statistical process control.

2. CAE packages, including:

2.1 Dr. C-Mold, from Advanced CAE Technology, Inc., also known as C-Mold Company. Dr. C-Mold is an early version of the desktop CAE tool. It uses seven steps, which are listed in Table 2, to optimize the design. Although it does not provide graphical presentation in mold filling, the seven steps offer the typical sequence a designer uses in checking the manufacturability of injection molded plastic parts.

2.2 3D QuickFill, also from C-Mold Company. This advanced package can read a solid model from its stereolithography (STL) file into the program and perform injection simulations. By choosing injection points, the analysis provides not only advice and specifications for the design, but also graphical presentations regarding melt-front advancement, pressure and temperature distributions, cooling time, orientation, weld lines, and vent locations.

Table 2. Summary of Seven Steps in the Design Process

Design Objective	Criteria to Achieve Objective
1. Enter Design Parameters	Enter the design description, and the part and mold geometry.
2. Compare Resins	Compare resins and select one that can reach a maximum flow length greater than the target flow length, under suggested processing conditions.
3. Compare Machines	Compare machines and select one that has enough clamp tonnage under suggested process conditions, or determine the number of cavities that can be accommodated by the selected machine.
4. Minimize Nominal Thickness	Most parts are designed thicker than they need to be. Determine how thin the nominal thickness can be, while still achieving a feasible process window of reasonable size (runners are not included in the calculation of the feasible process window).
5. Optimize Injection Conditions	Determine optimal injection conditions based on an optimal process window of adequate size.
6. Optimize Cooling Conditions	Determine cooling conditions that will achieve the shortest possible cooling time.
7. Optimize Holding Conditions	Determine holding conditions that will minimize part shrinkage without overpacking.

Note. Adapted from *Dr. C-Mold User's Guide,* 1998, p. 29.

2.3 Moldflow Advisors, from Moldflow, Inc. This package offers all the features of 3D QuickFill. It also gives designers the ability to find the optimal injection points, build runner systems, check the balance of the runner systems, and share and report the results through the Web templates built in the program. It is the most sophisticated desktop CAE package for injection molding in the industry.

The Projects and Design Issues

The competencies of design for manufacturability for injection molding that should be covered in students' learning experiences were derived from several resources (Boothroyd et al., 1994; Bryce, 1996, 1997, 1998; Malloy, 1994; Menges & Mohren, 1993). The major headings are listed below. (A complete outline is available from the author on request.)

- Concurrent Engineering vs. Sequential Engineering
- Materials Selection
- Process Parameter Control
- Part Design Considerations
- Mold Design Considerations
- Cost Estimation

The intended learning outcomes for students were to gain knowledge of the above competencies, to possess the necessary skills to utilize CAE packages to check designs for manufacturability, to obtain hands-on appreciation of the injection molding process and important parameters, and to be able to deal with real-life projects by integrating the aforementioned knowledge, skills, and experience. With these outcomes in mind, the assessment activities not only included quizzes and tests but also asked students to work on seven design projects.

The first four projects required students to go through tutorials in the three CAE packages in order to familiarize themselves with the tools and their applications such as checking process feasibility, evaluating runner system, determining optimal process conditions, and estimating the cost of processing a part. The fifth project asked students to apply various design and processing parameters such as materials, gating schemes (numbers of gates used and locations of gates), melt and mold temperatures to experience their effects on other operating variables such as sizing machine, weld line formation and location, injection pressure, cooling time, etc. The simulation results provided students with an understanding of the complexity of injection molding product development within a short period of time without lengthy injection operations in the lab.

Austin (1996), the founding chairman from 1978 to 1994 of Moldflow Pty Ltd., noted that CAE simulation is just a tool for an extensive design. Molding experience is required for effective and efficient use of CAE in design for manufacturability of plastic parts. The last two projects challenged students to verify their simulation results with hands-on injection molding operations. A four-cavity mold is available in the lab (see Figure 3). The

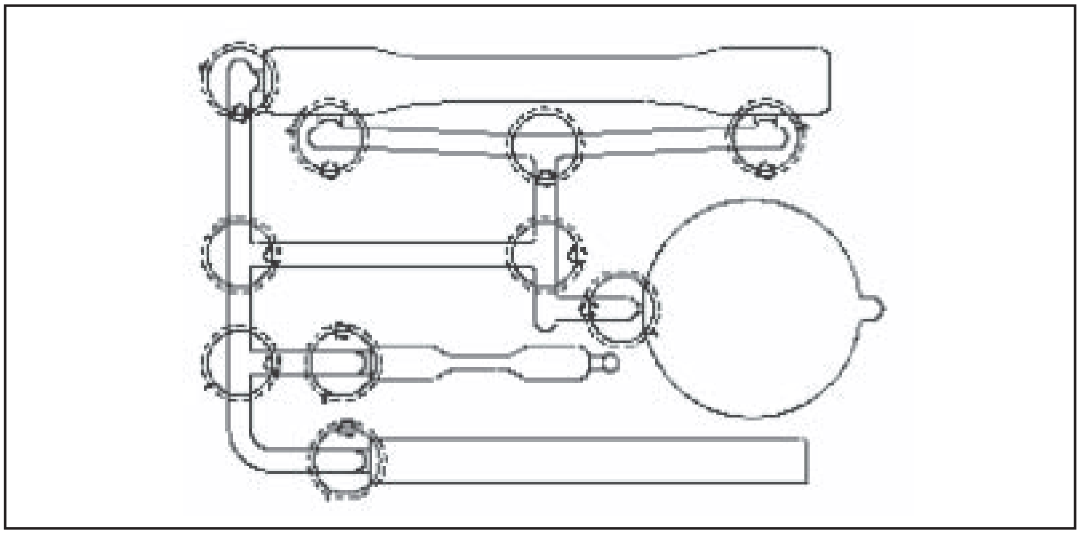


Figure 3. The four-cavity mold available in the lab. (The dash-lined circles represent shut-off valves enabling the selection of various combinations of the four cavities.)

mold is equipped with shut-off valves in its runner system, allowing the four cavities and their combinations to be selectively chosen for different groups in the class. In the sixth project, students then used Dr. C-Mold following the seven steps listed in Table 2 to generate a machine set-up sheet as shown in Figure 4. Students then used the information listed in the set-up sheet, such as melt and mold temperatures, injection and holding pressures, and injection and holding times, to set the process parameters and run the injection operation. During injection molding, they made adjustments on various molding parameters to get quality products.

The last project asked students to construct the assigned cavities in a CAD solid model form and then to run simulations using the Moldflow Advisors package. The results were then verified through the real-life injection molding process. Figure 5 shows the simulation result for a two-cavity molding at two molding conditions. The Confidence of Fill result, one of many simulation results from the CAE software, displays the probability of a region within the cavity filling with plastic by three colors: green, yellow, and red. Green means that the part is easily molded and part quality is acceptable; yellow predicts that the part may be difficult to mold or quality may not be acceptable; and red indicates the part will be extremely difficult to mold or quality may be unacceptable. Figure 6 shows the progression toward a quality product by adjusting the processing parameters such as melt temperature and injection pressure in an injection molding

Description: 2-cavity C & D mold				Date: 12/11/99			
Resin: PE-LD (base)							
Machine: Boy 22M 24mm							
				Suggested Value		Set Value	
Temperature	Melt Temperature		(F)	428			
	Barrel Temperature	Nozzle	(F)				
		Front	(F)				
		Middle	(F)				
		Rear	(F)				
	Mold Temperature		(F)	104			
	Coolant Temperature	Fixed Plate	(F)				
		Moving Plate	(F)				
	Ejection Temperature		(F)	176			
Time	Injection Time (Filling Time)		(s)	0.5			
	Cooling Time (s)	Holding Time	(s)	12.4	2.5		
	Mold Open Time		(s)				
	Cycle Time		(s)				
Pressure	(P_r : P_h) Resin/Hydraulic Pressure Ratio			9.1	:1	9.1	:1
	Injection Pressure (psi-b)	P_r	P_h	6527	721	$P_{r,max}$	$P_{h,max}$
	Holding Pressure (psi-b)	P_r	P_h	3336	369		
	Back Pressure		(psi-b)				
	Screw Rotation		(RPM)				
Position	Cushion		(in)				
	Switch-Over Position		(in)				
	Shot Size		(in)				
	Decompress		(in)				

Figure 4. A machine set-up sheet generated by Dr. C-Mold simulation.

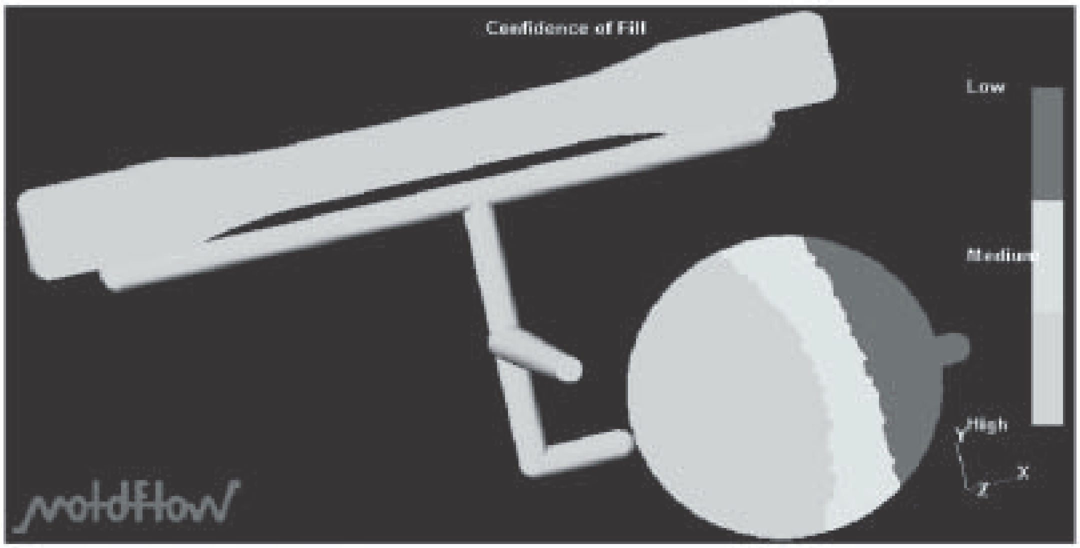
operation carried out by the students in the lab. The results are compatible with the prediction of the simulation shown in Figure 5.

A presentation about the up-to-date plastic database, the Prospector of IDES, Inc., and various plastic parts from an industry expert further enhanced students' understanding of the diversity of plastic materials and related processes. At the end of the semester, a field trip to a nearby custom molder using CAE in its operation further improved students' connection of what they had learned in class to the application in a real industrial setting.

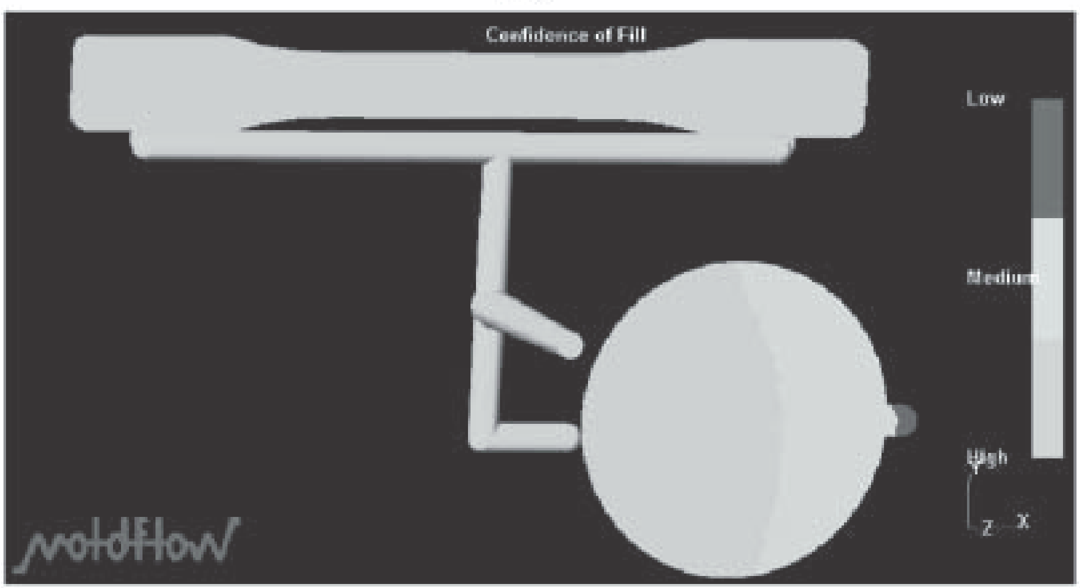
Response to the Course and Future Plans

I conducted basic attitude surveys in Fall 2000, Spring 2001, and Fall 2001 classes to determine student attitudes toward their learning experience in class and toward a career in the plastics industry, and to seek their inputs for improvement. Thirty-two students rated 11 questions on a scale of 1 to 10 and provided comments as shown in Table 3.

Most of the students thought they were proficient users of computers and gave a very high mark for the department's hardware



(a)



(b)

Figure 5. The simulation results of Confident of Fill by Moldflow Advisors at two different molding conditions; the cavities are progressively filled up by adjusting the melt temperature from (a) at low temperature to (b) at high temperature.

Table 3. Survey Summary of 32 Industrial Technology Students

Survey Questions	Average	Standard Deviation
I am a proficient computer user.	8.17	1.67
I was proficient in using computer-aided engineering (CAE) packages before I took this class.	3.56	2.87
The departmental computer facilities are among the best at the University.	8.03	1.45
It was interesting to learn to use the CAE software.	8.56	1.27
CAE lab projects helped me build competence in using the CAE software.	8.63	1.19
CAE helped me to gain insight into the behavior of molten plastics during the injection molding process.	8.16	1.55
The CAE packages enhanced my ability to design injection-molded parts for optimum manufacturability.	7.84	1.55
CAE can help plastic companies to cut cost, improve product quality, and shorten lead-times for new products.	9.34	0.83
The class helped me to improve my understanding of the plastics manufacturing industry.	8.84	1.22
What I learned in this class will help me to be successful in manufacturing.	8.47	1.44
I think that it would be interesting to pursue a career in the plastics industry.	7.30	1.52

Note. A scale of 1 to 10 was used to rate each question (1 = *strongly disagree* and 10 = *strongly agree*).

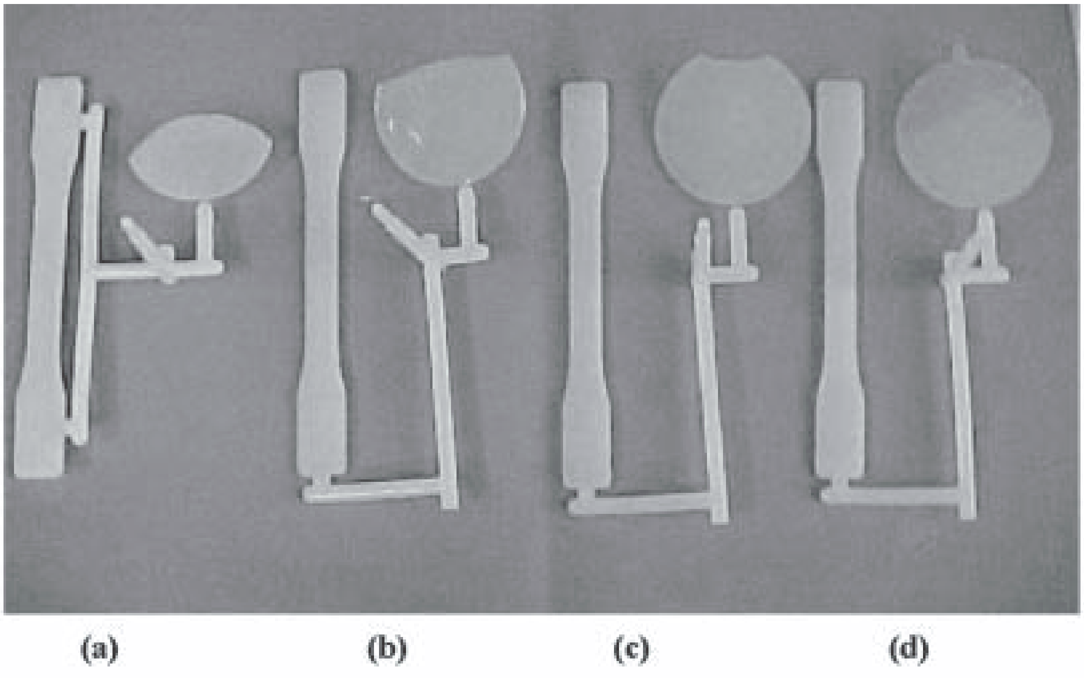


Figure 6. The progressive results of students' injection molding operation by adjusting the molding conditions following the simulation results of Moldflow Advisors. The melt temperature is progressively increased from low (a) to high (d).

facilities. Most of the students had CAD experience, but not CAE, before enrolling in the class. The survey results indicated that students liked the learning experience as well as its usefulness for their study. From their own experience and the demonstrations by industrial personnel during the seminar and the field trip, students perceived the usefulness of CAE for the plastic industry. Also, the contents seemed to promote students' understanding and career interest of the plastic industry.

The advanced desktop CAE simulations are effective and economic tools to teach the injection molding process and control since they provide visible presentation of how plastics behave in the mold during the process. Furthermore, their capability to address design issues in product development of injection molding makes them the ideal apparatus for students in learning the design for manufacturability and concurrent engineering practices. A preliminary survey has shown that their applications along with hands-on lab exercises, seminars, and field trips are an effective way to enhance students' learning experience in the area of injection molding process and product design.

To enhance students' learning experience in the area, the following content will be incorporated in future classes:

- Acquire an advanced CAE package such as Moldflow Plastic Insight analysis software to conduct in-depth study of injection process and product development.
- Continually evaluate and modify current projects and solicit industrial projects so students can make a connection of learning experience with current industry practices.
- Research the impact of CAE teaching on the effectiveness of students' learning the competencies of design for manufacturability of plastic parts.

Dr. Tao C. Chang, PhD, was an assistant professor in the Industrial Education and Technology Department at Iowa State University. He is a member of the Alpha Xi Chapter of Epsilon Pi Tau.

References

Austin, C. (1996). Lean molding: Faster=Better=Cheaper. In J. F. Stevenson (Ed.), *Innovation in polymer processing: Molding* (pp. 453–483). New York: Hanser.

Bernhardt, A., Bertacchi, G., & Kassa, N. (2000, October). CAE of injection molding. *Plastics Engineering*, pp. 49–53.

Bernhardt, E. C., Bertacchi, G., & Moroni, A. (1984, January). Computer-aided engineering is ready for injection molding. *Plastics Engineering*, pp. 33–34.

Boothroyd, G., Dewhurst, P., & Knight, W. (1994). *Product design for manufacture and assembly*. New York: Marcel Dekker.

Bryce, D. M. (1996). *Plastic injection molding: Manufacturing process fundamentals.* Dearborn, MI: Society of Manufacturing Engineers.

Bryce, D. M. (1997). *Plastic injection molding: Material selection and product design fundamentals*. Dearborn, MI: Society of Manufacturing Engineers.

Bryce, D. M. (1998). *Plastic injection molding: Mold design and construction fundamentals*. Dearborn, MI: Society of Manufacturing Engineers.

Dr. C-Mold user's guide. (1998). Ithaca, NY: Advanced CAE Technology.

Malloy, R. A. (1994). *Plastic part design for injection molding: An introduction*. New York: Hanser.

Menges, G., & Mohren, P. (1993). *How to make injection molds*. New York: Hanser.

Michaeli, W., Kaufmann, H., Greif, H., & Vosseburger, J. (1992). *Training in plastics technology.* Cincinnati, OH: Hanser/Gardner.

Plastics Molders & Manufacturers Association. (1999). *Plastics molding & manufacturing industry trends.* Dearborn, MI: Society of Manufacturing Engineers.

Society of Plastic Industry, Inc. (2000). *The SPI economic report*. Washington, DC: Probe Economics.

Software, CAE. (2001, January). *Injection Molding Magazine*. Retrieved January 8, 2001, from http://www.immalmanac.com/getCompanyList.php3

Computer Modeling and Visualization in Design Technology: An Instructional Model

Stan Guidera

Computer aided drafting (CAD) has largely supplanted manual drafting in the workplace. As new technologies and practices are adopted in industry, they should also be incorporated in academic curricula (Stephens, 1997). Consequently, CAD has also become the standard in academic environments, and coursework emphasizing manual drafting has been largely eliminated or relegated to introductory classes. However, the increasing use of 3D parametric modeling programs such as Solidworks and Mechanical Desktop is bringing about a fundamental shift to a model-centric paradigm that may ultimately have a similar impact on electronic drafting. The shift from computer drafting to computer modeling is also making it possible to extend the use of CAD beyond its role as a production tool to include analysis and communication with software emphasizing design visualization. While in the past the use of visualization software has been limited and specialized, recent enhancements in interoperability with CAD software have made its application more feasible for a wider range of disciplines. Therefore, students in design fields must be prepared to leave colleges and universities with skills in design visualization technologies as well as with CAD in order to be competitive in the marketplace.

The role of visualization technologies is to provide an efficient mechanism for communication by enabling the nontechnical person to see and understand design (Mealing, Adams, & Woolner, 1995). Disciplines such as mechanical design and architecture have traditionally utilized orthographic drawings such as plans, sections, and elevations as the primary medium for design communication as well as documentation. Orthographic views are discreet 2D images that, when perceived collectively, communicate the design as a whole (Ching, 1996). The images are projected straight or parallel to the viewing plane with only two dimensions, such as length or width, visible at one time (Ethier & Ethier, 2000). Orthographic drawings require the viewer to conceptually assemble the discreet views in order to visualize the proposed design. For the unskilled observer, orthographic views have perceptual limitations since the design elements are represented without forshortening. Mitchell (1992) noted that these parallel views inherently flatten perceptions of space and volume and that "a limitation of this parallel-projection procedure is that it destroys all z-coordinate information; that is, information about depth back from the picture plane. This often results in spatial ambiguity" (p. 125).

Graphic techniques such as shading and variation in line-weights have been used in drafting and technical illustration to communicate depth and distance in orthographic drawings. However, 3D drawings such as para-line drawings and perspectives have significant communication advantages in that they represent form and space in a more realistic manner (Ching, 1996). While more visually "realistic," these drawings cannot document the entire object since a single viewpoint or viewing angle must be selected. Therefore, providing informationally complete representation requires either 3D drawings to be viewed in conjunction with orthographic drawings or the creation of multiple para-line drawings to show multiple 3D views. Additionally, these drawings are also usually time consuming to create in a drafting-centered environment and, since they must be constructed using the measurements and related information provided by the orthographic drawings, must be continually updated as the design evolves. This is why creating realistic 3D representations had been perceived as feasible only after the design was complete.

With the introduction of CAD software, little changed in this process. Modeling of any complexity required the computing power of expensive workstations, and the limited modeling capabilities available on early versions of PC-based CAD applications were often difficult to use and typically too slow on most hardware installations. For most designers and drafting technicians, CAD was used as an electronic version of the manual drafting processes they were already familiar with and the expected productivity increase from computer drafting failed to materialize (Bhavani & John, 1996). The emphasis remained on documenting the end product of the design process rather than facilitating the design process itself. Conceptual development of a design remained a distinct phase in the design process that was perceived to be limited by the precision-driven features of CAD. According to Van Elsas and Vergeest (1998), "it is this ability to allow design of detailed products that makes conventional CAD systems difficult to use during earlier design stages, when not the complexity of the design, but the creativity of the designer, is of dominant importance" (p. 82). CAD applications were seen as most useful at the end of the design process and for representation of complex, finished product models (Van Elsas & Vergeest, 1998).

However, the 3D capabilities now available on PC platforms is closing the gap with high-end workstations (Brown, 1997). Advances in processing power have enabled software vendors to incorporate sophisticated computer modeling tools in software running on desktop computers. This has brought high-end processing power within the reach of the majority of users and is replacing electronic drafting with a model-centric process in which the designer creates a virtual object, assembly, or building as a 3D digital model. These modeling processes are typically parametric. For example, a set of parameters can be established that will control relationships, such as relative size and position, between different components of the model. The designer can modify one component and the other components automatically update in compliance with the specified parameters. The model then functions as the base for all 2D and 3D graphic communication. Increased accuracy, elimination of errors, efficiency in collaborative design processes, and faster design cycles are only a few of the benefits.

The parametric model-centric paradigm provides additional advantages over 2D electronic drafting in that it enhances the potential for computers to be used as both a design tool and a communication medium early in the design process. Since designing is inherently evolutionary in nature, using digital modeling as the primary design tool enables the designer to generate 3D representations from multiple viewpoints throughout the project's development. In contrast to manual drafting, both 2D and 3D images can be generated relatively easily over the course of a model-centric design process. Therefore, the same model can be used for both production drawing and for visualization and communication (Boardman & Hubbell, 1998). Additionally, since digital models can be rotated, moved, changed, and viewed from different vantage points (Goldman, 1997), they afford greater efficiency in producing any number of views for analysis and communication as the design evolves.

The advantages of a model-based process are not limited to increased efficiencies in drawing production. Mitchell (1992) observed that where viewpoint selection with traditional representation mediums can be constrained by technical difficulties in constructing 3D images such as perspective views, this limitation is removed with images generated from computer models. Further, while accurate representations can be produced with "hand-made" perspectives, computer-generated perspectives may be interpreted as more "valid" since automated perspective-synthesis procedures eliminate "the effects of human error, wishful thinking, and dishonest fudging" (Mitchell, 1992, p. 118).

Demand for visualization capabilities has led CAD software vendors to include visualization tools as standard features. However, developing coursework that maximizes the visualization potential of computer modeling requires skills that are more interdisciplinary than those developed in conventional 2D or 3D CAD courses. Computer-based design visualization has been described as a combination of computer graphics, computation, communication, and interaction (Brown, 1997). Design visualization is distinguished from computer modeling by two key objectives: the articulation or rendering of a model with a high degree of realism and the communication of the sequential or temporal characteristics of the design concept. Rendering refers to the process of enhancing an image. However, computer rendering refers to an automated digital process that takes digital models and applies user-defined enhancements to provide a more realistic view (Goldman, 1997), including "taking a 3 dimensional model and applying color, material, and light (or darkness) to its surfaces or faces" (Ethier & Ethier, 2000, p. 8). Sequential or serial visualization involves a series of individual renderings created as an object or viewpoint is moved through or around the computer model over time. These renderings can be physically assembled as a series of still images and displayed as a "storyboard," assembled electronically in a file, or recorded to video to create animations. A significant benefit of design visualization is its potential for increasing awareness of larger issues related to perceptual and psychological aspects of design to which CAD and computer modeling alone may not be conducive. Integrating visualization technologies into design coursework can enhance our students' potential for exploration of these issues.

Core Skills for Design Visualization

The interdisciplinary nature of the skills associated with design visualization requires that content and information be drawn from design disciplines, computer graphics, photography and print media, physics, and geometry. For example, Brown (1997) proposed that "if the visualizations we produce are to be informative and effective, we must understand principles of design, how colors interact, and how we perceive information" (p. 2). Therefore, students must develop a skill set that is more diverse than developed in the scope of conventional CAD coursework utilizing computer modeling.

Knowledge and skills acquired from diverse subject matter outside of technology courses make up the first of three knowledge areas proposed by DeLuca (1991):

1. Related Knowledge: Knowledge gained from classes other than technology classes.
2. Prior Technological Knowledge: Knowledge and skills gained from previous study in technology classes.
3. Knowledge Seeking: Ability to identify missing information and obtain relevant information. (p. 6)

These knowledge areas can be directly associated with the competencies required to effectively utilize digital design visualization technologies. Introducing design visualization within a discipline-specific context requires students to synthesize core coursework, and the interdisciplinary nature of skills necessary for effective design visualization will require students to draw upon learning from other courses outside of technology. By using design visualization technologies as an analysis and assessment tool, students can more effectively evaluate design decisions and therefore support the "knowledge seeking" process. The core skill set for design visualization encompasses three general skill categories: modeling, simulation, and representation. In this context, modeling refers to competency using any software application used to create 3D geometry. This includes nonparametric solid and surface-based CAD as well as the parametric or feature-based 3D applications that are now being widely adopted in industry. However, modeling skills can also include the modeling capabilities that are provided in many design visualization applications.

Simulation refers to the competencies related to the computer rendering process. At a basic level, rendering may be limited to color gradients and shading. These capabilities are available in nearly all CAD software. More advanced rendering processes can attempt to simulate materials and lighting. However, design visualization software is characterized by sophisticated lighting and control of materials that can render the model in a way that is indistinguishable from a photograph. This process, referred to as photo-realism, can "accurately simulate complex textured surfaces under the kinds of lighting conditions that are encountered in real 3 dimensional scenes" (Mitchell, 1992, p. 161). Depicting objects as "real" requires the designer to manipulate 2D images or maps to emulate materials and textures, understand and manipulate color properties and transparencies, and create and control lighting for shade and shadow. Simulation is not simply an automated process. According to Mitchell (1992), "in modeling a scene, a computer artist must decide what to geometrically describe in terms of surfaces and what to treat as texture on those surfaces" (p. 145). However, the primary benefit of increased realism is a reduction in the abstract nature of the design process. The manipulation of materials and lighting produce output that is far more concrete and closely aligned with the physical reality than with the 2D or wire-frame world displayed on the computer screen. The understanding that design decisions have real implications for how objects or spaces are used or experienced in the real world is reinforced by the hyperrealism of the representation.

Simulation also includes animation. Animation skills enable students to analyze and communicate the temporal and sequential issues related to their design proposals. In addition to animations of part assemblies, manufacturing processes, and architectural walk-throughs, these issues can also be used to illustrate conceptual processes such as 3D flow charts. Since animations are a sequential display of still renderings, competency in this area is closely tied to skills in articulation and rendering. Students must also develop a knowledge base of terminology and techniques associated with video and film not only for purposes of composition but also to address technical issues associated with output, storage, and display of animations.

The third skill category, representation, requires students to synthesize rendering and animation output with other graphical mediums into a coherent format for presentation and communication and involves competency with 2D graphics skills. Representation skills with digital media entail high levels of critical thinking. While digital media affords the opportunity to create highly realistic images, students must develop skills for evaluating the level of detail and realism appropriate for the level of development of their proposals. Overly realistic images at an early stage of the design process may detract from the formal issues being presented for consideration. According to Goldman (1997), "the purpose of a rendering should dictate the degree to which there are consistent levels of abstraction and resolution within the image" (p. 232). Similarly, decisions regarding rendering highly detailed objects must be considered in the context in which they will be presented since attention is usually focused on the part of the image with the greatest detail (Goldman, 1997). Composition skills required for visualization must draw on other graphics courses within the curriculum, particularly 2D digital media courses when available. The emphasis on the integration of 3D information as 2D communication can foster development of analytical and critical thinking skills essential for student success in technology and design fields.

Application of the Course Model

An experimental design visualization course recently conducted at a midwestern university was based on this model. The class included students enrolled in the architectural design and interior design programs. Course assignments were structured to culminate in a final project based on a design problem that would provide students with experience applying their modeling, rendering, and animation skills in a context that would parallel the use of design visualization in professional practice.

The use of design visualization is particularly relevant in architectural design courses. Architecture and the product of its practice is inherently public in nature (Scrutin, 1979). This gives rise to a design process that requires an active dialogue between the architect and engineer and individuals and constituencies who will be impacted by the completed project. It is common for those outside of the architecture, engineering, and construction fields to have difficulty interpreting architectural drawings. Campbell (2000) stated that the communication media used by architects "is dominated by highly symbolic, orthographic drawings and text based specifications" (p. 129). Visualization technologies provide a way to bridge this communication gap.

Architecture has historically relied on perspective drawings for nontechnical design communication, a tradition dating back to the development of the science of perspective in the early renaissance (Honour & Fleming, 1982). Mitchell (1992) suggested that the role of the perspective has been to "predict the visual effect that will result from execution of the design" (p. 118). Similarly, Goldman (1997) referenced the importance of the perspective in stating that "there is no image or drawing type used by architects, interior designers, planners, and other members of the building design team that can more accurately or more clearly show what a building or a space will be like in relation to the observer" (p. 150). The ability to efficiently generate these views with computer models enables the designer to evaluate the spatial implications of the design and then use the model as a tool to communicate decisions and receive feedback from those who will use it. Additionally, experiencing architecture is highly temporal and sequential:

> One of the principle concerns of architectural design is space: the internal spaces of a building and its setting. One does not react to space from a static position, as one might view a painting. To obtain a deeper understanding of architectural space it is necessary to move through the space, experiencing new views and discovering the sequence of complex spatial relationships. (Greenburg, 1974, p. 99)

The use of sequential perspectives and animations generated with design visualization technologies provides an opportunity for architectural designers to communicate these characteristics in ways in which no analog exists in traditional mediums.

Course Detail

Enrollment in the class was limited to students in the final year of their academic program. This was intended to ensure that students had completed an appropriate number of "related knowledge" courses (physics and graphic communications) and "prior technological knowledge" courses (architectural design courses, construction courses, and basic CAD) in order to make the necessary conceptual associations between these knowledge areas and the course material presented in the class. AutoCAD 14 was used as the primary modeling application and 3D Studio Viz 2.0 was used for design visualization. This dual-application approach was selected because the combination of conventional CAD applications for modeling and separate visualization applications for rendering and animation is common in professional design fields (Boardman & Hubbell, 1998). 3D Studio Viz provided advanced rendering and animation tools, including an extensive material library. It was anticipated that the combination of the software's extensive library of materials and its advanced lighting-simulation capabilities would enable students to create highly realistic representations. It was also selected for its drawing-linking feature. Rather than importing the CAD geometry into the visualization application, drawing-linking maintains an active connection between the CAD file and 3D Studio Viz. This link is dynamic and can be continuously updated as the project evolves, eliminating the need to re-import the geometry as the CAD model is updated. This increases the integration of CAD and visualization operations and allows design visualization to be introduced earlier in the design process.

The first eight weeks of the semester concentrated on the core skill sets relating to modeling and simulation. Initial course activities were structured to introduce basic modeling, animation, and rendering concepts using 3D Studio Viz. These skills were developed using lecture/lab instruction with a series of five short assignments. Modeling using 3D Studio Viz was limited. Assignment parameters required students to demonstrate competency with lighting, materials, and animation using preconstructed models or with simple 3D scenes created with modeling tools available in the visualization software. Concurrently, other activities were structured to develop competencies with 3D modeling using AutoCAD through lecture/lab exercises focusing on creating increasingly detailed computer models. These activities were used to introduce more advanced modeling techniques and the process associated with linking AutoCAD geometry with 3D Studio Viz.

The second half of the course was focused on an "application project." This design problem required students to synthesize modeling and simulation skills, and provided a context for focusing on the use of design visualization as an analysis, assessment, and communication tool. The students formed groups and were then given the project requirements for three interior renovation projects under consideration on campus. The selection of a potential "real-world" project also provided a "client" the students would need to communicate with as their designs evolved. Limiting the assignment to interior spaces ensured that the scope of the project would be manageable within the class timeframe. The modeling for the final project was developed using AutoCAD. This approach allowed students to utilize the drawing-linking features of 3D Studio Viz while further developing their AutoCAD modeling skills with more detailed modeling.

The students worked in groups of three or four which enabled them to divide modeling tasks among the group members. Each group maintained a single "master-model" CAD file with each of the members' components inserted as an AutoCAD block, which would be updated as they made revisions and then reinserted their file. Throughout the process, the master-model was linked to 3D Studio Viz and viewed for analysis and further development.

The final submission requirements were structured to allow them to demonstrate competencies in all three areas of the core skill areas. Parameters for the solutions included material selection and furnishings. In addition to floor plans and other 2D documentation, the final submission required the students to produce four photo-realistic high resolution still images (defined in this assignment as output of 1024x768 pixels) and a 30-second animation. Both the still image renderings and the animations were to include realistic lighting and shadows. The final drawings, still images, and animations were then made available to the "clients" and others on campus.

Outcomes

The students' success in meeting these objectives was largely consistent across all the groups. While all were able to produce images that could be considered photo-realistic, greater difficulty was encountered by the groups with the highest level of detail in their computer model. The hardware used by the students had sufficient memory and processing power to create relatively complex 3D models with AutoCAD. However, even though the installed memory met the minimum requirements of the visualization software, there was significant performance degradation when students attempted to create renderings and animations using complex and detailed models, particularly at higher resolutions. Calculations associated with rendering processes increase proportionally as the geometry of the computer model becomes more detailed and complex and as the output resolution increases. Additionally, the use of the drawing-linking features in 3D Studio Viz is more memory-intensive than simply importing the CAD file (Boardman & Hubbell, 2000). Therefore, this placed even greater demands on the hardware and resulted in lengthy rendering times. Where added detail in the computer models significantly increased file size it proved to be unfeasible to create animations exceeding more than a few seconds in duration. Incorporating lighting and shadows, which is also computationally intensive, proved to be impractical for animations on the installed hardware since the processing time would increase to several minutes per frame.

This required adjustments to the assignment parameters and resulted in a reduced emphasis on the animation portion of the application project. The length of the animation submission was reduced from 600 to 450 frames. Additionally, the required resolution of the animation submission was also reduced. For the more complex models, the use of lighting and shadows in the animations was also eliminated since these elements also required additional processing power and rendering time. However, the use of lighting and shadows was determined to be essential for the still renderings since longer rendering times of 10 minutes or more were not prohibitive for a single frame.

Despite these limitations, most students expressed satisfaction with course content and final output. The organizations that served as clients found the visualization output to be helpful in understanding proposed solutions, although the still images proved to be more useful to them than the animations. This could be attributed to a range of factors, including the photo-realism of the image, the added detail of the models, and the ease with which still images could be distributed either electronically or in hard copy.

Recommendations and Summary

The experience of teaching this class did lead to several recommendations for faculty or instructors considering teaching courses using CAD and visualization software. Faculty should consider including content covering basic lighting theory and color-composition theory. While students in this course had been exposed to this subject matter in other required courses, including a required physics class and classes using Photoshop, the need to review this content was not anticipated. Given the importance of this subject matter for effective use of lighting and materials in visualization software, it is recommended that time be allocated for its review.

Similarly, retention of skills and material from the prerequisite CAD course was less than anticipated. Many students were not proficient with some of the CAD operations that were integrated into the assignments. For example, several students were not familiar with the use of AutoCAD blocks to redefine updated geometry. This was an essential technique for updating the master-model in the group assignment. Consideration should be given to allocating class time to review key CAD operations necessary for the design visualization class. Instructors should also consider providing specific guidelines regarding managing CAD data, including providing students with written standards for naming files, layers, and blocks as well as project directories. While it may be desirable to have the students develop these conventions themselves, specifying these standards as part of the project assignment may prevent time-consuming errors and allow students to focus on the core course content.

It is also recommended that even though features such as file-linking are intended to make managing design visualization processes more efficient, this benefit may be offset by an unacceptable decrease in software performance in instructional labs with limited hardware. Therefore, instructors may find it necessary to consider alternatives such as limiting file-linking to early stages of the design process when models may be less complex.

Instructors should also carefully consider the necessity of animation assignments in the context not only of hardware resources but also in terms of the intended class outcomes. Options such as "storyboard" rendering (renderings of key frames along a path of movement through the space) can provide an effective alternative to hardware-intensive and time-consuming animations and still serve to develop student abilities in conceptualizing and communicating sequential design issues. In educational settings, assignments involving lengthy animation requirements should likely be avoided in favor of shorter, less realistic animations that still provide a way to include animation-related content in the course. This approach may prove more effective when the less realistic animations are accompanied by more detailed, higher resolution single frame images. Figure 1 provides a comparison between a higher resolution still that included detailed materials, lighting, shadows, and reflections and the identical model rendered at a lower level without materials, lighting, and shadows. The detailed image took over 6 minutes to render on the installed hardware and would have required over 44 hours of processing time to create a 400 frame animation. In contrast, the lower resolution rendering without lighting and shadows was completed in 8 seconds and the full 400 frame animation was completed in less than an hour. The combination of the animation files and the detailed single images used to document key points through the design can prove very effective for communicating design intent.

It should be noted that the limited computing power did provide an unexpected benefit. Students were forced to be more selective in their modeling and rendering strategies. This required them to be more cognizant of what features of their design solution were most significant to communicating their design intent. As a result, students prioritized their design elements earlier in the process in order to selectively add detail to the model in the areas they determined to be most significant. This level of critical analysis was consistent with the intended learning outcomes for the course.

As demand for visualization skills increases, faculty will be challenged to add new learning objectives related to visualization competencies while maintaining pre-existing educational goals. An instructional model based on an integrative approach to mastering the required skills provides a framework for the synthesis of visualization skills and the core skill-set of the discipline (see Figure 2). While hardware limitations that may be commonly encountered in educational facilities must be a consideration, this should not necessarily be the primary determinant in the decision to incorporate design visualization into technology courses and curricula.

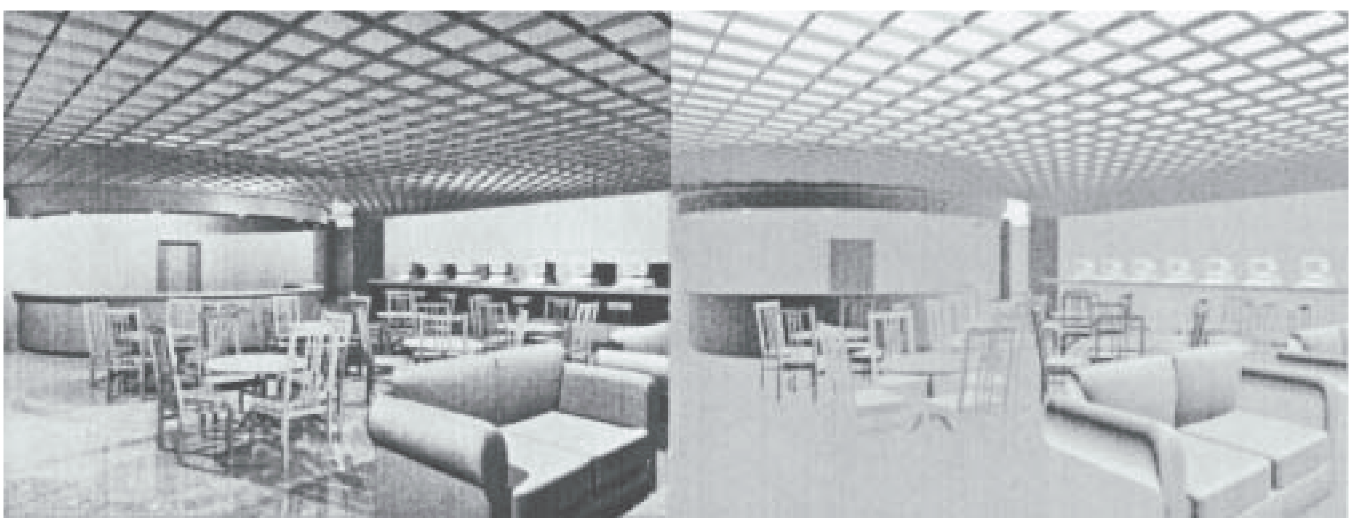


Figure 1. Left image is rendered as a single image at higher resolution with materials, lighting, and shadows. Right image is rendered as one frame in an animation at lower resolution without lighting, shadows, and materials.

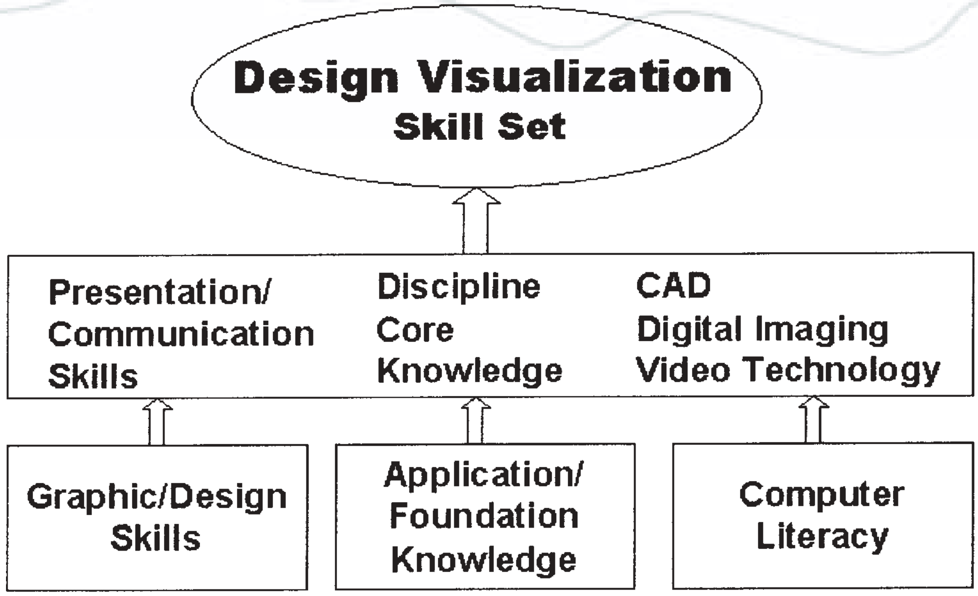


Figure 2. Design visualization skill set framework.

Dr. Stan Guidera is an associate professor in the Department of Visual Communications at Bowling Green State University, Bowling Green, Ohio. He is a member of Alpha Gamma Chapter of Epsilon Pi Tau.

References

Bhavani, S., & John, B. (1996). Exploring the unrealized potential of computer-aided drafting. *CHI96 Electronic Proceedings.* Retrieved January 12, 2000, from http://www.acm.org/sigchi/chi96/proceedings/papers/Bhavnani/bs_txt.htm

Boardman, T., & Hubbell, J. (1998). *Inside 3D Studio MAX2: Modeling and materials.* Indianapolis, IN: New Riders.

Boardman, T., & Hubbell, J. (2000). *Inside 3D Studio Viz 3.0: Modeling and materials.* Indianapolis, IN: New Riders.

Brown, J. (1997). Visualization and scientific applications. In E. Earnshaw, J. Vince, & H. Jones (Eds.), *Visualization and modeling.* London: Academic Press.

Campbell, D. (2000). Architectural construction drawings on the web: VRML as a case study. *Automation and Construction,* **9**, 129–138.

Ching, F. (1996). *Architectural graphics.* New York: Van Nostrand Reinhold.

DeLuca, V. (1991). Implementing technology education problem solving activities. *Journal of Technology Education,* **2**(2), 5–15.

Ethier, S., & Ethier, C. (2000). *3D Studio Max in motion.* Upper Saddle River, NJ: Prentice Hall.

Goldman, G. (1997). *Architectural graphics: Traditional and digital media.* Upper Saddle River, NJ: Prentice Hall.

Greenburg, D. (1974). Computer graphics in architecture. *Scientific American,* **230**(5), 98–106.

Honour, H., & Fleming, J. (1982). *The history of the visual arts.* Englewood Cliffs, NJ: Prentice Hall.

Mealing, S., Adams, B., & Woolner, M. (1995). *Principles of modeling and rendering using 3D Studio.* Exton, PA: Swets & Zeitlinger.

Mitchell, W. (1992). *The reconfigured eye: Visual truth in the post photographic era.* Cambridge, MA: MIT Press.

Scrutin, R. (1979). *The aesthetics of architecture.* Princeton, NJ: Princeton University Press.

Stephens, M. (1997). Computer simulation in the workplace and technology classes. *Journal of Technology Studies,* **23**(1), 6–13.

Van Elsas, P., & Vergeest, J. (1998). New functionality for computer aided design: The displacement feature. *Design Studies,* **19**, 81–102.

Whose Property Is It Anyhow? Using Electronic Media in the Academic World

Diana W. Sanders and Michael D. Richardson

Background and Importance

This article describes a study that examined the intellectual property policies at four-year higher education institutions in the Southern Regional Education Board (SREB) states to determine how these institutions assign ownership of distance learning and online courses and how they disperse income of intellectual property. Intellectual property has long been an issue of debate among colleges and universities (Heathington, Heathington, & Roberson, 1986). It is not surprising considering the controversial nature of determining ownership and income dispersion of creative works. To make matters worse, many institutions do not have adequate policies to govern the determination of rights to copyrightable materials (National Association of College and University Business Officers [NACUBO], 1980). As a result, intellectual property policies have been formed ad hoc and modified as problems arise (Nelsen, 1998).

Policies regarding patents have raised fewer questions in higher education institutions than those regarding copyright, perhaps because patents have been lucrative for a longer period of time or the law is clearer for patents than for copyrights (Gorman, 1998). Although President Clinton signed the Digital Millennium Copyright Act in October of 1998, this legislation did not update the current copyright law to facilitate the development and implementation of distance learning and other forms of technology. Hence, the inadequacy of copyright law has become increasingly evident with the growth of the Internet (Berg, 1999).

In academe, books and articles written by faculty members have traditionally been considered the intellectual property of the faculty members (Nelsen, 1998). Perhaps this explains why most higher education institutions do not address the issue of ownership of courses and curriculum materials in faculty contracts or policies (Harney, 1996). However, the potential economic value of multimedia and online course materials has raised the stakes for colleges and universities and prompted them to reexamine their intellectual property policies (McIsaac & Rowe, 1997). In some ways, online courses and course materials are like inventions, and in other ways they are like textbooks. The law is still unclear as to who owns traditional scholarly materials at the university, and making the distinction for online materials would mean the difference between the institution retaining ownership of instructional materials or ownership residing with faculty (Guernsey & Young, 1998).

The distribution of funds resulting from the creation of intellectual property is of equal or greater concern. Higher education institutions retaining ownership must decide how much of any proceeds will be given to the individual creator. Universities must then decide how the university will invest its share of the revenue. For instance, will the revenue go to a general operating budget; to the inventor's college, department, or laboratory; or be used solely for the support of future research (Cate, Gumport, Hauser, & Richardson, 1998)? Undoubtedly, some faculty not receiving what they feel is their fair share of the revenue will protest and possibly seek compensation through the court system (Guernsey & Young, 1998).

According to the U.S. Office of Education, "Universities particularly should establish written policies setting forth the respective rights of the university and its staff members in anticipated copyright royalties" (NACUBO, 1980, p. 12). Salomon (1994) recommended that intellectual property agreements provide for any situations that may arise in the future, such as the medium of distribution. Additionally, institutions must be prepared to answer questions such as, "What model of ownership should be followed with respect to electronic course material development?" They must determine if a traditional textbook model will be applied or if a patent model will be developed ("Current Issues for Higher Education," 1997-1998). Most important, issues regarding intellectual property make it vitally important that university professors, educational technologists, legal support staff, and university administrators stay in close communication with each other to develop policies that are acceptable to everyone involved (Lan & Dagley, 1999).

The increasing use of technology in education has significantly changed the face of intellectual property. While most institutional policies are stable in dealing with patent issues, many are not as reliable when determining ownership of copyrightable works. The law is unclear as to who owns traditional scholarly materials, which historically have been considered the property of their creators. However, the potential economic value of distance learning and online course materials has gained the attention of university administrators who realize that treating such works as traditional scholarly material may mean great loss in potential institutional revenue. Beyond ownership of intellectual property, institutions must determine how income will be dispersed to the creator(s) and among the institutional divisions. Colleges and universities are challenged to define guidelines that adequately compensate institutional colleges, offices, departments, and individuals so as to encourage the continued creation of intellectual property while covering expenses.

The Importance of Ownership

The current inadequacy of copyright law to address ownership of materials created for distance and online education has forced colleges and universities to make their own interpretations and determinations of intellectual property ownership. The stakes are high, and all sides want their fair share of the pie. Colleges and universities make substantial investments in intellectual property through faculty incentives and institutional resources. Likewise, faculty put a substantial amount of time and effort into the creation of course materials with the expectation that they will retain ownership should they pursue opportunities at other institutions. Furthermore, income from intellectual property that is retained by the institution must be dispersed within the institution to support future research and encourage continued creation of intellectual property.

This examination of intellectual property policies at four-year institutions in the SREB states will provide administrators with valuable information as to how prepared these institutions are to deal with issues regarding ownership and income disposition of intellectual property and how well these policies address intellectual property issues in an electronic environment. Furthermore, it will allow administrators to compare their institution's intellectual property policy with that of comparable institutions and provide a framework upon which they can base revisions to their own policies.

Review of Related Literature

In 1980, a NACUBO report suggested that institutional copyright policies and procedures should include a (a) statement of institutional copyright policy, (b) definition of copyrightable materials, (c) determination of rights, (d) determination of equities, and (e) copyright administration. The institution's statement should recognize the rights of faculty, staff, and students to write or generate copyrightable materials on their own individual initiative and retain sole rights of ownership and disposition. The statement should also outline the disposition of rights to materials created as a result of assigned institutional duties. Finally, it should define royalty sharing and describe the administrative body that will be responsible for interpreting and administering the copyright policy (NACUBO, 1980).

In determining rights to copyrightable materials, NACUBO (1980) recommended that materials be assessed within a framework that accounts for the following categories: (a) individual effort, (b) institution-assisted individual effort, (c) institution-supported efforts, and (d) sponsor-supported efforts. It suggested that rights to works created as a result of individual initiative with only incidental use of institutional facilities and resources reside with the author. Furthermore, joint rights to ownership and disposition should be given when partial institutional support is provided through the contribution of considerable faculty time, facilities, or institutional resources. Additionally, rights of copyrightable material that result from work assigned by the college or university should reside with the institution, while sharing of royalty income with the author may be deemed appropriate in certain circumstances. Finally, ownership of copyrightable materials created under a grant or contract should be negotiated and specified at the time of the agreement and prior to signing the agreement and beginning work.

When determining disposition of income resulting from royalties or assignment of copyrighted materials for individual efforts, income should accrue to the author alone (Nelsen, 1998). However, some degree of income sharing should be determined for institution-assisted individual efforts. Although institutional policy may specify that derived income go exclusively to the college or university in institution-supported efforts, many institutions have a royalty-sharing policy on patents and may choose to adopt a similar policy for copyrightable materials that credits all or part of the royalty to authors and academic departments. As with assigned ownership of copyrightable materials created from a sponsor-supported effort, royalty income distribution should be examined thoroughly at the outset of the project. The terms should be written, understood, and mutually satisfactory to the author, institution, and sponsor (NACUBO, 1980).

Intellectual property policies are remarkably varied at institutions of higher learning (Piali & Banks, 1996). For instance, at the University of Toronto, faculty are given the choice of claiming ownership of intellectual property or assigning it to the university. In either case, according to who paid patenting and development costs, the author and school share proportionately in the potential revenue. At the University of British Columbia, all intellectual property rights and responsibility for intellectual property lie with the institution. At the University of Waterloo, however, ownership of all intellectual property falls to the author. John Reid, president of the Canadian Advanced Technology Association, argued that intellectual property policies like those at the University of Toronto and the University of Waterloo provide the greatest potential reward, thereby creating an incentive to bring creative works to the market (Piali & Banks, 1996). After all, copyright law was written not only to protect the holders of copyright, but to encourage or stimulate "creative genius" that can be shared with the public after termination of the creator's exclusive control (Lan & Dagley, 1999). By maintaining ownership of intellectual property, institutions will discourage the development of creative works and stifle the amount of commercialization that occurs. On the other hand, Lorne Whitehead, associate professor of physics at the University of British Columbia, preferred the "institution-first" policy because it allows faculty, who typically would not patent their inventions themselves, to worry about obtaining patent protection while the university pays for it (Piali & Banks, 1996).

Many institutions employ the "works for hire" doctrine. A "works for hire" is any material prepared by an employee within the scope of his or her employment and is solely owned by the organization for which it was created. Naturally, it is in the best interest of the organization to enter into "works for hire" agreements or agreements that assign copyright to the organization or university (Salomon, 1994). However, some would argue that the principle of academic freedom which allows faculty members to freely produce work that represents their own views and not the views of the university makes "works-for-hire" a poorly suited doctrine to higher education (Alger, 1998).

About the Study

In the SREB states, 210 four-year higher education institutions were asked to participate in this study. All of the SREB states were represented in the study and included Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia (see Table 1). Surveys were completed by one administrator at each institution. Although the academic vice presidents were initially asked to respond to the survey, surveys were, in some cases, completed by another institutional administrator more familiar with the institution's intellectual property policy.

The Instrument

The survey instrument used in this study was a modified version of a survey used in 1978 by NACUBO to investigate patent and copyright policies at selected universities. The instrument consisted of 30 multiple-choice and open-ended questions regarding intellectual property policy at institutions of higher learning. A general definition of intellectual property was provided at the top of the first page of the survey, and detailed definitions of the intellectual property components were provided on the last page of the survey. A World Wide Web (WWW) version of the survey was also created to offer respondents an electronic option for submitting responses. The Uniform Resource Locator (URL) of the Web survey was provided at the top of the printed survey, and surveys submitted

Table 1. Intellectual Property Ownership Questions

1. Does your institution currently offer distance learning and online courses?
   a. Yes
   b. No

   If yes, are the materials created for use in these courses covered by the institution's intellectual property policy?
   a. Yes
   b. No

   If yes, who retains control of the intellectual property created?
   a. The institution
   b. The creator
   c. Joint ownership
   d. Negotiated
   e. Other: ____

electronically were e-mailed to the researcher when respondents clicked a "Submit" button provided at the bottom of the Web survey.

How It Was Done

Surveys were mailed out to the academic vice presidents at each of the four-year institutions within the SREB states and were accompanied by a cover letter and self-addressed stamped envelope. The cover letter explained the purpose of the study and requested that the vice president either respond voluntarily to the survey or direct the survey to an administrator within the institution who could more accurately address the issues of intellectual property. The letter also discussed the electronic version of the survey as an alternative means for submitting responses and referenced the Web version's URL for anyone preferring that method of reply.

What We Learned

The study had a 39.5% response rate with 83 of the 210 institutions responding. Interestingly, only 14.5% of the surveys were returned electronically, indicating a preference for the paper version of the survey despite the generally widespread use of technology in higher education. At least one institution from each of the 15 states surveyed responded. Of those institutions, eight reported being unable to answer the survey questions because either their institution did not have an intellectual property policy in place or they were in the process of revising the current intellectual property policy and expected drastic changes to result.

On Ownership

When respondents were asked if the materials created for use in distance learning and online courses were covered by the institution's intellectual property policy, 82.1% responded yes, 16.4% responded no, and 1.5% did not know. When asked who retained ownership of such materials, 54.7% of the institutions reported that the institution or university system retained control; 17.0% reported that ownership was negotiated between the university and the creator of the intellectual property; 13.2% responded that ownership of intellectual property was joint between the university and the creator; 9.4% reported that the creator of the intellectual property retained ownership; and 5.7% were not sure who retained ownership and were currently researching that question.

On Sharing

Respondents were also asked what share of intellectual property royalties is paid to creators when the institution retains intellectual property rights (see Table 2). At 57.4% of the institutions, a share ranging from 25% to 100% of the net royalties is paid to creators; 30.9% of the institutions distribute royalties to creators by using some type of sliding scale; and 11.8% of the institutions pay creators a share ranging from 15% to 50% of the gross royalties.

Respondents were then asked what disposition is made of the institution's share of the royalties (see Table 2). At 41.9% of the institutions, royalties are divided among the

Table 2. Intellectual Property Income Disposition Questions

1. If the institution retains intellectual property rights for distance learning and online course materials, what share of income (if any) is paid to the creator(s)?
   a. 0% - 25% of net
   b. 26% - 50% of net
   c. 51% - 75% of net
   d. 76% - 100% of net
   e. Sliding scale on net
   f. 0% - 25% of gross
   g. 26% - 50% of gross
   h. 51% - 75% of gross
   i. 76% - 100% of gross
   j. Sliding scale on gross
   k. Negotiated
   l. Other: ____

2. How is the institution's share of the income generated for distance learning and online course materials dispersed? (Circle all that apply)
   a. To the creator's department
   b. To the creator's college
   c. To the research office/department
   d. To an institutional office/fund
   e. To cover expenses
   f. To promote research and instructional development
   g. To the system/chancellor's office
   h. Other: ____

creator's department and/or college, the research office or department, and another institutional office or fund; 30.6% of the institutions use intellectual property royalties to cover expenses and promote research and instructional development; and 27.4% distribute intellectual property royalties to the institutional system office, the chancellor's office, and the inventor's department.

What It All Means

Distance learning is still relatively new to higher education, and although a large majority of the institutions reported that their intellectual property policy covers materials created for use in distance learning and online courses, it is doubtful that their current policy has been challenged by copyright issues related to such materials. For instance, the majority of those responding stated that the institution retained ownership of online and distance-learning course material. However, many faculty produce such materials with the intention of taking them when they leave the institution for other employment opportunities. Faculty are becoming more and more concerned that they will not be allowed to keep online course materials and, for that reason, are electing not to teach distance-education courses. Faculty are also insecure about the fact that distance-learning courses can be videotaped and reused, thereby eliminating the need for the future services of professors. Concerns raised by faculty regarding intellectual property are justified and advocate the need for institutions to consider ownership policies that provide for joint or negotiated ownership agreements.

Institutional policies regarding disposition of income to creators were extremely diverse among the institutions. Not only did responses differ in how institutions chose to determine income disposition (i.e., percent of the net, percent of the gross, sliding scale), but they differed in the selected percentages and types of sliding scales used. Lack of consistency among institutions regarding income disbursement indicates little or no communication between colleges and universities when establishing intellectual property policies. By sharing intellectual property policies, institutions will become exposed to a variety of issues regarding intellectual property and will gain access to a broader range of ideas for dealing with those issues. Institutional consistency in intellectual property policies may make the policies more stable and better able to deal with challenges should they arise.

Institutional disbursement of intellectual property income was more consistent among institutions with funds being distributed to the creator's department or college, the institution's research office or department, and the institution's system office. While some institutions used the funds to "reward" the department or college with which the creator belonged, others used the money exclusively to promote future research and instructional development. Regardless of how intellectual property income is distributed, institutions must look for ways to encourage its development. Faculty may be less likely to generate intellectual property if they are not able to enjoy the benefits, directly or indirectly, of their labor. Furthermore, departments and colleges may be less likely to encourage their faculty to create intellectual property if intellectual property income is transferred to a research or institutional system office that others can benefit from. When the income generated from intellectual property is used expressly for the support of future research endeavors, faculty must be assured that their own research will not suffer at the expense of other ventures being pursued on campus. Likewise, institutional system offices receiving intellectual property income should recognize institutions responsible for the generation of such income during budget allocations.

Ownership and income are two very important factors when it comes to creating intellectual property. Many faculty create intellectual property that has no real market value, but does represent many hours of hard work. However, time is money for the institution as well, and in most cases, institutional resources and other faculty incentives (release time, decreased course load) are provided for faculty creating intellectual property. Policies must be developed that adequately address intellectual property issues for faculty and institutions. Variations in institutional policies indicate that colleges and universities are taking very different positions on the issue with some favoring faculty and others favoring the institution. Institutions should work with faculty, staff, and students to find a middle ground that encourages all groups to create and support the development of intellectual property.

Based on what we learned from the study, we observe that:

1. Higher education institutions must develop policy governing intellectual property.
2. Intellectual property will be increasingly defined by legal precedent due to the influx of financial considerations.
3. Financial considerations will become increasingly important as more institutions become active players in the "for-profit" virtual university explosion.
4. As higher education institutions are increasingly finance driven (attempting to locate scarce resources from a wide variety of sources), potential revenues from sale of intellectual property will become increasingly important.
5. Intellectual property is a relatively untapped market for higher education institutions. Since the creators of intellectual property are largely unaware of its potential value, creative higher education administrators will attempt to acquire intellectual property rights for sale and distribution.
6. Because creators of intellectual property are largely unaware of its worth, many will lose their creative work by signing away their rights.
7. The increasing pressure of higher education institutions in the "for-profit" world of the virtual university will create an inflated demand for intellectual property materials.
8. Just as many early "rock" musicians never realized monetary compensation for their creative work, many in the higher education environment will lose their creative works until the courts decide on the technicalities of intellectual property financial considerations.
9. The availability of technology has created an artificial marketplace for intellectual property. Unlike the companies that have sold "hard copies"

of term papers for years, the new marketers have an instant market and instant system of distribution which quickly enhances the financial incentives and potential rewards.

10. Creators of intellectual property should become more financially sophisticated and learn their rights.

Diana Sanders is the director of Information Technology Services at Ogeechee Technical College, Statesboro, Georgia.

Michael D. Richardson is a professor of educational administration and coordinator of the doctoral program at Georgia Southern University, Statesboro, Georgia.

References

Alger, J. R. (1998). Going global with your work—Or is it yours after all? *Academe,* **84**(3), 80.

Berg, G. A. (1999). Digital copyright policy issues in higher education. *WebNet Journal,* **1**(2), 5–6.

Cate, F. H., Gumport, P. J., Hauser, R. K., & Richardson, J. T. (1998). Copyright issues in colleges and universities. *Academe,* **84**(3), 39–45.

Current issues for higher education information resources management [Editorial]. (1997-1998). *CAUSEEFFECT,* **20**(4), 4–7, 62–63.

Gorman, R. A. (1998). Intellectual property: The rights of faculty as creators and users. *Academe,* **84**(3), 14–18.

Guernsey, L., & Young, J. R. (1998). Who owns on-line courses? *Chronicle of Higher Education,* **44**(39), A21–A23.

Harney, J. O. (1996). Copyrights and the virtual classroom. *Connection: New England's Journal of Higher Education and Economic Development,* **11**(3), 47–49.

Heathington, K. W., Heathington, B. S., & Roberson, A. J. (1986). Commercializing intellectual properties at major research universities: Income distribution. *Journal of the Society of Research Administrators,* **17**(4), 27–38.

Lan, J., & Dagley, D. (1999). Teaching via the Internet: A brief review of copyright law and legal issues. *Educational Technology Review,* **11,** 25–30.

McIsaac, M. S., & Rowe, J. (1997). Ownership and access: Copyright and intellectual property in the on-line environment. *New Directions for Community Colleges,* **25**(3), 83–92.

National Association of College and University Business Officers. (1978). *Patent and copyright policies at selected universities.* Washington, DC: Author. (ERIC Document Reproduction Service No. ED 187 195)

National Association of College and University Business Officers. (1980). *Copyrights at colleges and universities.* Washington, DC: Author. (ERIC Document Reproduction Service No. ED 216 570)

Nelsen, L. (1998). The rise of intellectual property protection in the American university. *Science,* **279**(5356), 1460–1461.

Piali, R., & Banks, B. (1996). My research, your development. *Canadian Business,* **69**(11), 13.

Salomon, K. D. (1994). A primer of distance learning and intellectual property issues. *West's Education Law Quarterly,* **4**(2), 313–321.

Teacher Research: The Key to Understanding the Effects of Classroom Technology on Learning

Karen Kortecamp and Kathleen Anderson Steeves

As teacher educators we're particularly interested in what research on technology reveals about its value in promoting learning. The early reviews of technology studies by Clark (1983) and Kozma (1991) revealed that most research on technology and learning does nothing more than compare media in which the central questions are which is faster, lasts longer, or holds more data. They cautioned that this kind of research does not tell us anything about the influence of technology on learning. Not surprisingly, our review of studies conducted over the last decade indicates that research on the use of technology in education continues to be misguided. Our analysis did not provide any support for the positive value of technology alone as the medium that enhances student learning. In this regard, educators are largely operating on perceptions of what technology will do for learners and learning rather than evidence.

Does this mean that spending money to put computers into classrooms is akin to tossing coins into a bottomless well? Are technology advocates simply engaging in wishful thinking? On one level, it would be fair to answer yes to both questions because the connections between technology and improved learning are not well supported. Yet, our feeling is that such a response is misleading. Researchers have failed to show new ways technology can promote learning because they continue to ask the same questions in the same way. Studies in which we examine which medium is better for which learners and for what purpose may well provide different results and, in fact, this proved to be the case in Kozma's (1991) review. Micro studies that include the characteristics of learners and the learning environment and that address multimedia have a greater opportunity to provide valuable information about technology and learning.

Teachers as Researchers

We entered our study with the belief that the teacher plays a critical role in promoting learning with technology. This belief is supported by our understanding that computers provide information—not knowledge. Significant differences between the two exist. Information is discrete; knowledge is arranged in meaningful webs. Information can be transmitted; knowledge needs to be constructed. Information is demonstrated by reproduction; knowledge is demonstrated by novel application. Transforming information to knowledge requires tutelage and a community of learners (Salomon, 2000). If knowledge is the goal of education, the teacher as tutor, facilitator, and manager of the transformative process is essential. This view was confirmed in the *Research Report on the Effectiveness of Technology in Schools* (Sivin-Kachala & Bialo, 2000): "A growing body of research shows...that the effectiveness of educational technology depends on a match between goals of instruction, characteristics of learners, the design of the software and technology implementation decisions made by educators" (p. 15). We urge further research on the role of the teacher in developing media and methods to promote learning. Technology use in education settings must be based on its ability to support rather than determine desired outcomes. The aim ought be uncovering *what technology should be doing and how we should be using it* in order to prepare learners who are independent and mindful thinkers able to solve complex problems. Who better to do this research than teachers?

To some extent, teachers engage in research whenever they're in their classrooms working with students. As a function of preparing, delivering, and assessing lessons, teachers gather data, through formal and informal means, from their students, colleagues, and others in order to make sound instructional and managerial decisions. For example, did students' responses to questions demonstrate their understanding of new material? Will my colleague's approach to motivating students work as effectively with my students as it does with hers?

The point is that the process of asking questions followed by gathering and examining data in order to make informed decisions is a natural function of teaching. We argue the need for teachers to formalize this process by applying the tenets of action research in order to better understand the role of technology in the classroom and its potential impact on student learning.

Action Research

Action research, by its nature locally appropriate, cyclical in process, and cooperative in execution, is the most important type of research for the questions of technology and learning. Kurt Lewin, credited with suggesting this type of research in the 1940s, believed that knowledge should be created from problem solving in real-life situations (Anderson, Herr, & Nihlen, 1994).

Several features of action research make it particularly appropriate for teachers. All actors in the research are equal participants. The students who respond to the survey are as involved as the teacher asking the questions. The research is typically done in a unique context—one classroom, rather than many classrooms or many schools.

Action research is cyclical in nature, with four phases: plan, act, observe, and reflect. (The last phase may lead to planning for further action.) Because the research relies a great deal on observation, it is important to triangulate data sources—where interviews are balanced against surveys and observations against documents. There is less reliance on the trappings of traditional research such as validity, reliability, and generalizability. In the case of a teacher researcher, the results of an action research study can provide enough contextualization to guide another teacher in his or her own study. Working within one department or one school, teachers can process the outcomes of their research to benefit their local areas. "There is an expectation with action research that it will result in some practical outcome related to the lives or work of the participants" (Stringer, 1996, p. xvi).

Research Model for Teachers

The model we propose for teacher action research follows the cyclical structure outlined by Kemmis and McTaggart (1988). The four "moments" of action research defined by Kemmis and McTaggart guide our model: (a) develop a plan of action to improve what is already happening, (b) implement the plan, (c) observe the effect of the implementation in the context of your classroom, and (d) reflect on the effects as a basis for further planning or other action.

Our focus is computer technology and its impact on learning, though action research need not be confined solely to this arena. The model we propose is designed specifically for teachers who are experienced using computers and who want to know if using that technology in certain ways enhances the learning of students. While this model consists of six parts, they fall within the four "moments" described by Kemmis and McTaggart.

- Developing an action plan involves:
  1. Assessing current use of technology.
  2. Formulating research question(s).
  3. Establishing a research framework.
- Implementing the plan requires:
  4. Gathering data in a variety of ways.
- Observing the effect of the implementation relies on:
  5. Thorough data analysis.
- Reflecting on the effects as a basis for further action enhances:
  6. Informed decision making.

Developing an Action Plan

Teachers and students utilize computer-based technology in numerous ways for instructional and managerial purposes. Our interest is with instructional use that may include basic-level applications such as integrating curriculum-related software and using Web-based resources or more advanced applications such as generating computer-assisted presentations and creating and maintaining Web sites to support classroom instruction.

Assessing Current Use of Technology

In order for teachers and students to begin an assessment, they should address the following questions:

- *What* technology do you currently use in your classrooms to promote learning?
- *How* do you use that technology?
- *Why* do you use it in that way?
- *How do you know* that using technology in this way leads to desired outcomes?

By way of example, suppose a teacher in a high school physics of technology class has recently learned about WebQuests[1]. A WebQuest is an inquiry-oriented activity in which students conduct a focused search of the Internet to find specific information. The WebQuest provides a clearly defined task, the

[1] Developed by Bernie Dodge with Tom March. See San Diego State University Web site *(http://webquest.sdsu.edu/webquest.html)* for information.

process students will use, and predetermined resources needed to complete the task. Over the course of a year, our high school teacher engages his students in 30 experiments designed to help them understand how physics is applied to modern problems. He often introduces new experiments by requiring students to design and create a product that will be used to conduct the experiment. He challenges them by providing little or no guidance about the process or about the technology needed to complete the task. His expectation is that students will use the Internet and/or library resources *(what)* to figure it out. This method has worked fairly well in the several years he has been teaching this course, but he is intrigued by the WebQuest approach *(why)* and would like to try it with the next experiment. The teacher decides that he will design a WebQuest *(how)* on constructing pinhole cameras to measure distance to the sun as part of the unit on light and optical systems. After implementing this new approach, he wonders if the time he spent creating the WebQuest will make a difference in students' ability to grasp the content and produce the product *(how he knows)*.

Formulating Research Questions

Uncertainty about a new approach can lead to questions about its value, encouraging a teacher to develop some measure of its impact. In our example, the *primary question* is, Will the use of a WebQuest that identifies the resources that students need to complete the task versus leaving the process open to the students' discretion make a difference in the students' ability to create the pinhole camera? Additional evidence of the value of the WebQuest will be available when students use the cameras they've created because the accuracy of the instrument impacts the outcome of the experiment. In developing a framework to research this, additional *(secondary)* questions arise: How will the teacher measure change in students' knowledge about the topic? Will this question best be answered by a survey; observations; student products? What role will students play in answering these questions?

Establishing a Research Framework.

The structure of the research will influence the value of the findings. Therefore, it is important to consider multiple measures, as well as who needs to be informed and what conditions need to be met prior to implementation. Questions to be answered are:

- *What measures* are best suited to this study?
- *What population* do you intend to study?
- What is the *timeframe* for this study?
- Are there any *conditions* that need to be met prior to implementation (e.g., parental permission, administrative support)?

Initially, our teacher decides that administering a simple survey to his students will provide him with the information he needs. After sharing his research plan with his department chair, he recognizes that relying on a single source of data may not be sufficient to establish confidence in the results. He modifies his framework to include pre and posttests and observation.

Since this is our physics teacher's first attempt at action research, he decides to focus his study on a single experiment for one of his physics of technology classes *(population)*. He chose this as a first step in determining the value of a WebQuest before using it as regular practice for all experiments. He would like to explore the possibility that this method will improve students' learning about the topic and their ability to produce the required product. Since these students have completed several experiments this year already, the teacher has some basis for comparing the effectiveness of this new approach (structured inquiry) to what he's done with previous experiments (independent inquiry).

Decisions about when he will implement the study *(timeframe)* are influenced by when the material is addressed within the unit of study. In this case, he plans to spend one 90-minute class session with the WebQuest, allowing two additional class periods for construction of the pinhole camera and another for conducting the experiment. Our teacher enlists the support of an assistant principal in conducting the observation. He informs students that they will be involved in a research project at some point during the semester and he will be asking them for their input. As a final step, he confers with administrators about the need for student permission to participate in the research project before proceeding *(conditions)*.

Implementing the Plan

Gathering the Data

Once the research framework is established and the measures identified and/or constructed, a teacher is ready to move to data collection. In our sample case, the teacher administers a pretest measure of students' content knowledge about pinhole cameras and their use in measuring great distances and their attitudes about that subject. Content questions capture the major themes and concepts of the experiment. Questions about content ask for open-ended responses to measure what students already know about the topic and where they learned it. Students use a Likert scale to respond to questions about their attitudes toward the subject of light and optical systems as a topic of study. The teacher does not look at the pretest data prior to presenting the WebQuest to assure the validity of his research.

Our teacher presents the lesson, explaining the parameters of the WebQuest process and providing students with guided instruction. Students complete the WebQuest, then conduct the experiment using their cameras. Following this, the teacher administers a posttest that includes both content knowledge and attitude toward the subject measures. He also examines the students' products (pinhole cameras) for accuracy. To gauge the degree to which students found the process effective, he constructs and administers a brief survey asking questions specific to the WebQuest. He also has data from the observation conducted by his assistant principal who agreed to sit in on the WebQuest and experiment class sessions and take notes about students' level of engagement as indicated by attention to instruction, active questioning, active participation, and on-task behavior *(process)*.

Observing the Effect of the Implementation

Data Analysis

In this phase, the researcher reviews and analyzes the test and observation data in order to draw conclusions. For our teacher, the focus is on whether the use of a WebQuest helped students develop an accurate instrument through structured inquiry *(content)*.

In part, this can be determined by the accuracy of students' measurements using the pinhole cameras. Additionally, our teacher wants to know whether the students acquired content knowledge and how they felt about the new approach. The pre and posttests give the teacher information on knowledge gained about the concepts and themes presented in the experiment and product developed. In his analysis of the tests, the teacher looks for changes in the amount of information students included in their responses and the degree to which those responses reflect an understanding of the scientific principles embedded in the experiment. In analyzing student attitudes about the topic, the teacher develops a frequency distribution of pre and posttest Likert scales in order to make comparisons. The student responses on the survey to the method of presentation are compared with the observations of the assistant principal.

Formulate Conclusions

Before formulating any conclusions, researchers need to assess the strength of the evidence. Multiple measures, as in our example, increase the trustworthiness of the findings. Complementary results allow the researcher to have confidence in the conclusions, whereas conflicting results suggest a need for further study.

Our physics of technology teacher has multiple measures, both quantitative and qualitative. He believes the evidence is strong enough that he can draw some preliminary conclusions. He determines there is an increase in student knowledge. The observation of the students supports their on-task behavior. However, he is not certain that this change is a result of the WebQuest method because the additional information about student attitudes toward the process is mixed. Table 1 is a summary of our framework for action research.

Reflecting on the Effects as a Basis for Planning

Informed Decision Making

At this point, the teacher researcher reflects on the conclusions of the analysis to determine future actions. What are the implications for one's own practice and continued study? The purpose of reflecting on the analysis is to better inform instructional decisions. While this type of research is limited regarding its generalizability to large populations, it can be effectively applied to make informed decisions at the classroom level, share at the team or department level, and expand to a system level through replication.

Table 1. Framework for Teacher Action Research on Classroom Technologies and Learning

Steps of the Plan	Example
■ **Develop a Plan of Action:** ✧ 1. Assess Current Technology Use ✧ 2. Formulate Research Question(s) ✧ 3. Establish Research Framework	■ **Develop a Plan of Action:** 1. The teacher answers questions about what type of technology he uses at present; why he thinks this works; & *how he knows.* Leads to other questions. 2. The teacher's new knowledge about WebQuests raises questions about how or if this newer method might be better. In particular, will the use of a WebQuest make a difference in students' ability to learn the content or develop the product? *(research question)* 3. The teacher now decides: which classes to study *(population)*; what time it will take to conduct the study *(timeframe)*; how to gather data (*measures*—surveys, observation); what permissions or support are needed *(other conditions that need to be met)*.
■ **Implement the Plan** ✧ 4. Gather Data	■ **Implement the Plan** 4. The teacher *applies the pretest* to learn about prior knowledge and attitudes; The teacher *uses the Webquest* to support instruction on the topic under study; The teacher and administrator *observe* during lesson; The teacher *administers posttest* of content and attitude; The teacher *administers survey* of attitude toward process.
■ **Observe Effect of Implementation** ✧ 5. Data Analysis	■ **Observe Effect of Implementation** 5. The teacher *compares* pre and posttest data about students' attitudes and content; Observations and surveys are *analyzed* to confirm or challenge students' responses; Multiple measures make teacher more confident of results and teacher *draws conclusions* about the value of this method.
■ **Reflect on Effects as Basis for Planning** ✧ 6. Informed Decision Making	■ **Reflect on Effects as Basis for Planning** 6. The teacher *finds* results are not definitive. This encourages the teacher to study the method further and share information with colleagues and administrators as the basis for planning about technology use in their school.

Note. Model follows the structure outlined by Kemmis and McTaggart (1988).

In light of his analysis and conclusions, our teacher acts in several ways. Since the data are not definitive, he is encouraged to do further research with other classes and other experiments. He explains the results of the study to his colleagues and encourages them to do similar studies so they may compare the results. He also shares the results with the administrator observer and with the student participants.

The administrator, recognizing that she has a teacher interested in doing research on technology and its impact on instruction, can now facilitate a number of related opportunities for the teacher. The students as participants in this action research benefit by having a new knowledge of the way the teacher thinks about instruction and the importance of their role in his decision making.

Conclusions

Because comparison studies have yielded little substantive data on the impact of computer technology on student learning and earlier reviews by Clark (1983) and Kozma (1991) led them to urge researchers to focus on the teacher as the mediator of instruction, we devised a scheme that involves the teacher.

The action research model we outline here involves the teacher and his or her students in the analysis of technology use for classroom learning. In this case, the importance of the role of teachers as researchers and students as participants cannot be overstated. Anyone familiar with teaching recognizes that teachers are making decisions in their classrooms daily as they plan, deliver, and assess instruction. Typically those decisions have relied on anecdotal data, as has much of the research on technology and learning. We recognize that the questions about instructional technology are going to continue to be important in discussions of education practice. It is incumbent upon teachers to get involved in those discussions. The action research model establishes a framework for more deliberate consideration of the role of technology in the learning process; teachers work with their students to develop their own answers to the questions about technology use for instruction. Learners, not technology, are the focus of the study, an approach Clark (1983) and Kozma (1991) endorsed. We believe this type of research will provide more consistent and reliable data on the impact of teacher-mediated technology on student learning.

Karen Kortecamp is an assistant professor in the Graduate School of Education and Human Development at The George Washington University, Washington, DC.

Kathleen Anderson Steeves is an associate professor in the Graduate School of Education and Human Development at The George Washington University, Washington, DC.

References

Anderson, G. L., Herr, K., & Nihlen, A. S. (1994). *Studying your own school: An educator's guide to qualitative practitioner research.* Thousand Oaks, CA: Corwin Press.

Clark, C. E. (1983). Reconsidering research on learning from media. *Review of Educational Research,* **53**(4), 445–459.

Kemmis, S., & McTaggart, R. (Eds.). (1988). *The action research planner.* Victoria, Australia: Deakin University.

Kozma, R. B. (1991). Learning with media. *Review of Educational Research,* **61**(2), 179–211.

Salomon, G. (2000, July). *It's not just the tool, but the educational rationale that counts.* Paper presented at the annual meeting of ED Media 2000, Montreal, Canada.

Sivin-Kachala, J., & Bialo, E. R. (2000). *Research report on the effectiveness of technology in schools* (7th ed.). Washington, DC: Software and Information Industry Association.

Stringer, E. T. (1996). *Action research: A handbook for practitioners.* Thousand Oaks, CA: Sage.

Technology Education in New Zealand

Alister Jones and Judy Moreland

Technology in New Zealand schools is a new area of learning that is now compulsory for all students (years 1–10). Technology education policy was first developed in 1992 (Jones & Carr, 1993). Since then there has been a sustained research and development focus to inform the structure of the curriculum, its subsequent national implementation, and classroom practice. This article discusses the structure of the technology curriculum, programs that were developed to inform teachers of the curriculum and its content, and strategies to enhance the classroom practice of technology.

The New Zealand Curriculum Framework and the Technology Curriculum

The New Zealand curriculum framework defines seven broad essential learning areas rather than subject areas. They describe the knowledge and understanding that all students need to acquire in health and well-being, the arts, social sciences, technology, science, mathematics, and language(s). Schools have flexibility in how the curricula are delivered and have the responsibility for making implementation decisions. The curriculum framework requires that the essential learning areas specify clear learning outcomes against which students' achievements can be assessed. These learning outcomes or objectives must be defined over eight progressive levels and be grouped in a number of strands.

The general aims of technology education in *Technology in the New Zealand Curriculum* (Ministry of Education, 1995) are to develop technological knowledge and understanding, technological capability, and an understanding and awareness of the interrelationship between technology and society.

Technological Knowledge and Understanding

It is impossible to undertake a technological activity without technological knowledge and using and transforming other knowledge bases. Students need to develop an understanding of the principles underlying technological developments such as aesthetics, efficiency, ergonomics, feedback, reliability, and optimization. The specific knowledges and principles are dependent on the technological area and context within which students are working. The understanding of systems is essential in developing knowledge in technology. Students also need to develop an understanding of the nature of technological practice and how this has similarities and differences in different technological communities of practice. It is important that students have an understanding of a range of technologies and how they operate and function. An understanding of strategies for the communication, promotion, and evaluation of technological ideas and outcomes is integral.

Technological Capability

Technological activity responds to the identification of some human need or opportunity. Within the identification of needs and opportunities students need to know and use a variety of techniques to determine consumer preferences. In technological activities students develop implementation and production strategies to realize technological solutions. Part of this involves students in generating ideas that lead to solutions as well as developing and using strategies to realize these ideas. Students need to manage time, resources, and people to produce the outcome that meets the identified needs and opportunities. Students should communicate their designs, plans, and strategies and present their technological outcomes in appropriate forms. Part of this process is the devising of strategies for the communication and promotion of ideas and outcomes. Throughout the technological activity students should continually reflect upon and evaluate the decisions they are making.

Interrelationship Between Technology and Society

Students should develop an understanding of the ways in which beliefs, values, and ethics promote or constrain technological development and influence attitudes towards technological development. Students should also develop an awareness and understanding of the impacts of technology on society and the physical environment.

Technological Areas

The practice of technology in the world outside the classroom covers a diverse range of activities from agriculture to electronics and the production of synthetic materials. Technology education must reflect this diverse practice and not limit itself to designing and making with a limited range of materials. Each technological area has its own technological knowledge and ways of undertaking technological activity. It is important, therefore, that students experience a range of technological areas and contexts to develop an understanding of technology and technological practice. To develop a broad curriculum a number of technological areas relevant to New Zealand were included: materials technology, information and communication technology, electronics and control technology, biotechnology, structures and mechanisms, process and production technology, and food technology.

Interpreting the Curriculum for Teachers: Professional Development

The introduction of a "new" learning area in schools, such as technology, has been somewhat problematic in New Zealand. Teachers' existing subcultures in terms of teaching and learning, subject area, and school, in association with their concepts of technology, influence the development of classroom environment and strategies, and consequent student activities. In order to introduce technology into the classroom, it is important not only to have a developed concept of technology but also awareness and understanding of technological practice. Two different programs have been developed and trialed in the New Zealand context: the Facilitator Training program and the Technology Teacher Development Resource Package program.

National Facilitator Training Program

The year-long Facilitator Training program was run twice. It involved training a total of 30 educators (15 each year) from all over New Zealand. The program stressed the importance of developing theoretical perspectives in technology education, particularly when having to discuss implementation issues with school managers and boards. The participants also stressed the importance of learning about the techniques and practices of the different technological areas. After the training program these participants then worked with teachers on a national basis. The evaluations from the teachers on these programs show that the majority of teachers who participated perceived the facilitators' programs very positively. The very common call from teachers' personal comments was for more teacher development of this type. This, along with 87.2% of the responses rating the program as above average or excellent, reflects clearly the success of the facilitators' programs, and of the training program overall. Most of the teachers (83%) considered the programs developed by the facilitators had helped them with their understanding of technology education generally and the technology curriculum specifically. Over half of the teachers (63%) also found the program helped them with their understanding of the concept of technology itself. Approximately three quarters of the teachers (76%) considered the areas of school and classroom implementation had been helpful, and over half of the teachers (66%) had found the program helpful in providing them with ideas for classroom activities even though this was not a primary focus of the programs (Jones & Compton, 1998).

National Technology Teacher Development Resource Package Program

The Technology Teacher Development Resource Package program was trialed in 14 schools over a 3 to 6 month period in 1996 and includes video material of technological practice, classroom practice, and accompanying explanatory text as well workshop activities. All the evaluations both in the trial schools and from subsequent general use indicate the successful nature of these programs and the usefulness of the model as a basis for the development of teacher professional development in technology education. This resource package (Ministry of Education, 1997) is now used in most schools and forms the basis of nationally funded professional development in New Zealand.

Key Features of Teacher Professional Development

Experience to date suggests that the following key features should be taken into account when developing technology education teacher professional development programs consistent with both the New

Zealand national curriculum statement in technology and past research findings. All focus on the importance of developing the following:

- Robust concept of technology and technology education.
- Understanding of technological practice in a variety of contexts.
- Technological knowledge in a number of technological areas.
- Technological skills in a number of technological areas.
- Understanding of the way in which people's past experiences both within and outside of education impact on their conceptualization of, and in, technology education.
- An understanding of the way in which technology education can become a part of the school and classroom curriculum.

From Curriculum to Enhancing and Sustaining Classroom Practice

A major research program (Learning in Technology Education research projects 1992–1995, 1998–2001; Moreland & Jones, 2000) has been examining classroom practice in technology. In 1998 there appeared to be significant problems for teachers in assessing technology. Teachers commented that their difficulties were not just confined to technology but were also related to other subjects. In comparison with earlier research (Jones & Carr, 1992) it was found that teachers had developed broader concepts of technology as a result of the teacher development models discussed earlier and the trialing of curriculum material in classrooms (Moreland, 1998). These concepts, though, were still not broad or detailed enough to take into account many conceptual and procedural aspects. The teachers' lack of understanding about conceptual and procedural aspects of technology appeared to be confining their assessment in technology to assessing affective aspects of learning such as *did they enjoy it* and the social and managerial aspects such as *working in groups, turn taking, sharing.* Technology had yet to become an integral part of the talk of classroom teachers and the community. In their planning of technology, teachers were focusing on the activities rather than on specific learning outcomes.

Also impacting on teacher assessment practices in technology were the existing subcultures in schools and schoolwide policies, teacher experiences, and teacher subject expertise. What teachers relied on for assessing in technology was largely dependent on what they already did and knew in other curriculum areas. All teachers in primary schools have common understandings of teamwork, leadership, turn-taking, discussing, depicting ideas, gathering information, describing, reflecting, etc., and these common understandings of social and managerial skills had became the focus of assessment in technology. Therefore in terms of the technology curriculum, teachers focused on aspects of the achievement objectives that aligned with social and managerial aspects, for example, discussing, exploring, and sharing.

The next stage of the research program was undertaken during 1999–2000 and was designed to enhance formative interactions between the teachers and students. The conceptual and procedural aspects of learning in technology were highlighted as the means to enhance the formative interactions of the teachers and the learning outcomes for the students. This resulted in teachers moving from using general concepts about technology to more specific concepts within different technological areas. For the first time teachers were able to identify the specific technological learning outcomes they wished to assess. Teachers' developing conceptual and procedural knowledge enabled them to write specific learning outcomes, and they began to move with more confidence between the general area of technology and the specific technological learning outcomes.

The teachers were able to choose more suitable tasks that had the potential to develop student learning in technology. This shift in focus from providing a technology experience to providing opportunities for students to develop technological learning outcomes was significant. By investigating a wide range of learning outcome possibilities and then selecting particular learning outcomes teachers pursued a more appropriate approach to technological learning. They became focused on the technological learning of their students. Teachers' talk about technology education had a higher profile and was increasingly embedded in teacher conversations. Teachers demonstrated greater confidence with formative assessment, particularly in relationship to providing appropriate technology feedback to the learners. Direction was given where deemed appropriate, which led to more appropriate interactions. Not only was there more emphasis on providing feedback and assistance to students to develop particular technical skills, there was also more emphasis on conceptual and procedural aspects rather than social and managerial aspects. Additionally, there was less emphasis on praise as the sole formative interaction and more emphasis on assisting students to move on, to reflect, and to assess their own progress. These are illustrated in one of the teachers' comments below:

> Dividing planning into conceptual, procedural, societal, and technical allowed me to more effectively hone in on the technology involved.

The number of appropriate pedagogical approaches also increased. A variety of methods were employed by the teachers, including student interviewing, conferencing, observation, use of considered portfolios, and analysis of appropriate learning outcomes. The use of the assessment models also enabled the teachers to differentiate between the different levels of effectiveness of student learning and to justify the differentiation. The teachers also noticed enhanced student learning in technology. Their comments were illustrative of this:

> Children's differences in learning can be better identified with specific learning outcomes, with more effective children coping with more variables.

This research project has developed intervention strategies that encourage teachers to identify the conceptual, procedural, societal, and technical aspects, task definition, and aspects of holistic assessment. The results are very encouraging with the focus at the conceptual and procedural levels rather than in terms of an activity. Teachers have moved from thinking about progression in terms of a series of activities to examining the conceptual and procedural aspects of student learning. In summary, the assessment models that were developed, coupled with the intervention by the research team, had a major impact on improving teachers' formative interactions and understanding of summative outcomes. As a consequence student learning has been significantly enhanced in technology.

Progress So Far

For a new curriculum to be introduced and be sustainable a strong emphasis needs to be placed on a coherent and long-term research and development program that is then able to inform classroom practice. Curriculum implementation requires informed teachers who are able to develop sustainable programs in order to enhance student learning in technology. This has involved research and development on teachers' existing practices and student initial experiences, teacher development, resource development both in terms of teacher professional development and classroom material, and strategies for the enhancement of teacher knowledge and student learning. Associated with this is the development of effective mechanisms for the dissemination of the research findings to inform all teachers. This has occurred through teacher professional organizations such as TENZ (Technology Education New Zealand) and the Ministry of Education. However, this is only the beginning of this process, and more research and development work is required to develop sustained classroom practice in technology consistent with the New Zealand technology curriculum.

Dr. Alister Jones is the director of The Center for Science and Technology Education Research at the University of Waikato, Hamilton, New Zealand. He is a member-at-large of Epsilon Pi Tau.

Dr. Judy Moreland is a lecturer in The Center for Science and Technology Education Research at the University of Waikato, Hamilton, New Zealand.

References

Jones, A., & Carr, M. (1992). Teachers' perceptions of technology education: Implications for curriculum innovation. *Research in Science Education,* **22,** 230–239.

Jones, A., & Carr, M. (1993). *Towards technology education. Vol 1.* Hamilton, New Zealand: University of Waikato, Center for Science and Technology Education Research.

Jones, A., & Compton, V. (1998). Towards a model for teacher development in technology education: From research to practice. *International Journal of Technology and Design Education,* **8**(1), 851–865.

Ministry of Education. (1995). *Technology in the New Zealand curriculum.* Wellington, New Zealand: Learning Media.

Ministry of Education. (1997). *Towards teaching technology: Know how 2.* Wellington, New Zealand: Learning Media.

Moreland, J. (1998). *Technology education teacher development: The importance of experiences in technological practice.* Unpublished master's thesis, University of Waikato, Hamilton, New Zealand.

Moreland, J., & Jones, A. (2000). Emerging assessment practices in an emergent curriculum: Implications for technology. *International Journal of Technology and Design Education.* **10**, 283–305.

Technology Education and Modular Labs

Anthony Schwaller

The field of technology education is changing very rapidly. Nationally, more and more middle and secondary schools are converting traditional industrial arts programs to contemporary technology education programs. One of the major changes is the use of *modular* technology systems, also called modular technology education environments. Modular technology systems are now used in many of the middle and secondary technology education programs throughout the United States. These systems use self-contained modular units of technology instruction in the classroom. For example, a typical unit in the area of fluid power would include a modular unit that has a hydraulic trainer, hydraulic valves, gauges, hydraulic circuit boards, and various consumable supplies, tools, and accessories including the main computer and associated software.

Students complete various assignments throughout the modular unit and continue to advance to higher level content. Various modular units are available for middle and secondary school programs. Some of the more popular modular technology units include aerodynamics, computer problem solving, fiber optics, computer graphics, flight simulation, electronic music, robotics, CAD/CAM technology, fluid power, computer integrated manufacturing, satellite communications, desktop publishing, virtual reality, biotechnology, video editing, CO^2 raceway, space and rocketry, air-track vehicle, radio broadcasting, artificial intelligence, and weather satellite.

Although not completely matched, each unit of instruction within a modular program can be linked to the *Standards for Technological Literacy* (International Technology Education Association [ITEA], 2000). The module areas or content are also related to accepted technology themes that have been established within the National Council for the Accreditation of Teacher Education (NCATE) and Council for Technology Teacher Education's (CTTE) technology education specialty area guidelines (ITEA, 1997).

Modular technology systems guide the student to conceptualize, experiment, and examine the principles of the major content themes of transportation, communications, construction, and manufacturing. They also incorporate a multilevel curriculum that promotes the development of critical skills of teamwork, decision making, critical thinking, logical reasoning, troubleshooting, problem solving, independent research, and career exploration. Modular technology instruction helps students understand and assess the impact of technology on society today in order to make informed decisions about how they will use, manage, and even create technologies for the future.

Why Talk About Modular Instruction?

There are several reasons for this exposition on modular technology and modular environments. First, there are many instructional strategies that can be used in the technology education classroom. Modular environments are one of many instructional strategies that could be used by the contemporary technology teacher. Second, in the past several years, modular technology has become more and more popular in middle and high school classrooms. Today's newly prepared technology teachers may very well accept a teaching position in a school that has a modular environment. Also, there seems to be somewhat of a limited research base concerning modular technology classrooms. And finally, there appears to be a direct link between the use of modular technology as an instructional strategy and the incorporation of the Standards for Technological Literacy (ITEA, 2000) in the technology classroom.

Consequently, how modular environments work and operate is reviewed. How to better prepare teachers in the field of technology education to teach successfully and thus accomplish the goals of a modular technology education environment is discussed. Additional life skills learning opportunities other than technology content as well as some of the advantages and disadvantages of teaching in modular laboratories are described. Finally, how modular technology environments help to meet the Standards for Technological Literacy is reviewed.

Program Characteristics and Operation

The characteristics and operation of modular technology environments will vary considerably depending upon the school. Variations will occur in the level of the program, the length of program, the number of modules available to the students, the academic level of the students, the number of students in class, and how the course operates among other things.

Modular technology classrooms exist in Grades 6 to 12, but most are found at the 6 to 9 grade level. Although there is modular technology equipment for senior high school, it tends to be more technically in-depth and in such areas as manufacturing or information technology. There seems to be more interest and excitement about modular classrooms at the middle school level.

The number of modules that a school offers will vary. Generally, schools have anywhere from 3 to 16 or more modules available for student use. For example, middle schools in some states have from three to four modules. When schools have only a few modules, the course curriculum is often supplemented with various types of additional technology education strategies and activities. For example, if a particular school had a module on a CO^2 car, the instructor may develop additional activities that parallel the module in such topics as friction, engines, thrust, and manufacturing.

In other cases, middle schools may have from 10 to 24 modules for the students to use. For example, in California, modular technology programs are designed so that there is one module for each of the 16 state standards (Schwaller, 2001).

Another interesting component concerning the operation of modular technology classrooms is the use of a "student expert." In many modular classrooms the technology teacher uses a student expert to help during the classroom period. Usually, the student expert has taken the class the previous year and is already very knowledgeable about the modular units and topics. In many cases the teacher has worked with the administration to allow such students to leave other classes and help out in the modular technology classroom. These student experts can help when current students have a problem with a module or have difficulty understanding the directions on how to use a module. In general, student experts help the teacher whenever they are needed.

There are many other characteristics of modular technology classrooms that help to explain their operation. One characteristic is the number of modular technology classroom sections being taught. The number of sections that are being taught in schools may range from one to six sections. In some cases teachers are responsible for six sections with 25 to 35 students in each section. In other cases the technology education teacher may teach fewer sections but often there still may be approximately 25 students in a section.

Another characteristic of a modular technology classroom is the length of the semester for a modular course. Modular courses can vary from 15 to 18 weeks of time, and it is important to have the right number of modules in relationship to the length of the course. To this end, often the modular technology education teacher will set up a rotation for the students. The length of time that each student rotates from one module to another will vary from 2 to 10 days. The exact number of days of rotation will depend upon the length of the semester and the number of modules that are available.

Most modular technology teachers set days aside between each rotation. Called discover days, creative days, problem time days, enrichment days, or catch-up days, these extra days may vary from one day to several weeks of time. For example, schools that have fewer modules may have 7 to 10 discovery or creative days for the students to work on other technology activities. On the other hand, in schools that have a greater number of modules, the teacher may only give the students one or two days for discovery and creative time. These discovery or creative days are very important because they give time for the students to internalize the module concepts and knowledge, and students are able to try out the module concepts learned by using other technology instructional strategies such as competition, design projects, and problem-solving activities.

Some of the more popular module suppliers and vendors include Lab-Volt Systems, Synergistics, Depco, Learning Labs (Applied Technology), and Scan Tech. There are also teacher-created modules. Rather than evaluating the suppliers or vendors in this article, those procuring modular technology equipment are encouraged to become thoroughly familiar with each product. Some of the variations between vendors and companies include:

- The depth of the software—Some companies design their software with more technical depth while other companies have less technical depth to the software.
- The levels within the software—Some companies have only one level of depth while other companies have up to three levels of depth with the third level being oriented toward creative design within the content of the module.
- The quality of the physical equipment—It is very important for teachers to be familiar with the quality of the physical equipment of the module. Some companies have high quality while other companies have less quality built into the physical equipment that supplements the software.
- The ability to alter or change the software—Some suppliers of modular equipment allow technology teachers to alter and adjust the software to their particular course needs and instructional techniques.

Each modular course often has its own title. Course titles can vary across the spectrum. Some common titles include Technology I, Technology II, Applied Technology, Exploring Science and Technology, Technology Education, Technology Applications, and Technology Design. It is important that the course title be appropriate for the particular school as well as act as a marketing tool to draw students to the course.

Teacher Competencies Needed

New teachers and experienced technology teachers should possess the necessary classroom management competencies to be successful in a modular environment. The following shows a list of the most common teacher competencies needed to function successfully in a modular environment.

Teachers must know the equipment. It would be very difficult to instruct in a modular technology environment if the teacher did not have a working knowledge of the modules. This can often be accomplished by having colleges and universities offer courses on modular technology in an undergraduate or graduate program. As part of this experience, future teachers come to know and understand the depth that is programmed into the software for each module. Knowing this can help the teacher better plan the modular technology program, including the extra activities and discovery and creative days. Also, part of the cost of purchasing a modular laboratory includes teacher training on the modules.

While classroom management is a competency all technology teachers should have, it takes on particular importance in a modular environment. The teacher must know how to manage a classroom with modular equipment and know how to keep all students challenged, on target, focused, and on task. The teacher must also know how to repair the equipment when broken and how to troubleshoot the software. When to add in the discovery or creative days, how to develop the creative activities, and how to keep each student challenged based upon the diversity within the classroom must also be managed. The management skills needed to teach modular technology tied with other instructional strategies help to develop an integrated learning system to teach technology.

Teachers who use modular technology must also be able to think in an interdisciplinary manner. Most of the modules that are sold today weave mathematics, reading, history, social studies, and science into the module software. This is especially true at the middle school level, where the modular technology teacher must have a "big" picture of technology. Modular technology at this level is very exploratory and not highly in-depth.

Computer literacy and program network competencies are also very important for modular teachers to possess. Since many of the companies that develop modular technology components use computers and networking for test-taking and grading purposes, these two competencies are very important. The teacher must be able to understand computer networks, troubleshoot problems in such systems, load software, and be comfortable with computer systems in general.

Teachers must also have a general knowledge in the technical area of each module. It is not necessary to have an in-depth technical knowledge in each of the module topics at the middle school level, but more technical depth in the subject area of the modules would certainly be very helpful at the high school level.

The modular technology teacher must also have ability to repair the hardware of the module. As with any other type of laboratory situation, technology teachers are often called upon to repair the laboratory equipment. In this case, rather than repairing a production machine, the modular technology teacher may have to repair the physical hardware that is part of the module.

The teacher must also know how to get technical support quickly. In a modular environment, there are times when the teacher must contact the company or vendor for technical support, and often it is needed quickly. Thus, the teacher needs to have the ability to contact suppliers and vendors when a problem arises. If all the software, curriculum, and module equipment is obtained from the same company, repair of the modules and access to service personnel are greatly enhanced.

As with any other technology laboratory, the teacher must have an organized system for inventory control of the parts used on different modules. Depending upon the module, there may be different parts such as bolts, gears, valves, electrical components, weights, string, belts, and plastic stock that may be needed and which the instructor must organize as part of the inventory control system.

Lifelong Skills and Knowledge

Modular technology learning environments should include (a) the technology content delivered in a variety of instructional strategies and (b) modules representing a wide assortment of technology fields such as communications, construction, transportation, manufacturing, and bio-related systems. The modules should be designed to provide a contextual and relevant environment in which technical skills and knowledge and lifelong learning skills and knowledge are developed (Secretary's Commissionon Achieving Necessary Skills [SCANS], 1991). For example, since in all cases students work in groups, a great deal of cooperative learning is taking place and this helps to develop various social skills, including respect for and getting along with others. In the modular environment, students also learn how to be self-directed learners, a major skill for being successful in today's society. And time management skills, as part of self-directed learning, are also developed. These skills tend to develop an increased sense of responsibility within the students.

Other lifelong learning skills that may be developed in a typical modular laboratory include accountability (getting things done on time), staying on task (making sure to finish the module), computer literacy (familiarity with computer software), research skills (especially true in the high school modules), problem solving (students often must solve module problem by themselves), and respect of technological equipment.

Advantages

Modular learning systems have several advantages. The design of the software and its content allow students to see technology as a very broad field that ties directly to the *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000). There are several standards that deal with technology from a very broad point of view. For example, Standard 1, The Characteristics and Scope of Technology; Standard 2, The Core Concepts of Technology; and Standard 3, Relationships Among Technology and the Connections Between Technology and Other Fields all emphasize the broad nature of technology. Standards 4, 5, 6, and 7, which deal with Technology and Society, also emphasize the broad nature of technology.

Students also learn a variety of technical topics in the field of technology. Depending upon the number of modules, students can learn exploratory content in the areas of manufacturing, transportation, construction, communications, energy, and bio-technology, all of which are part of the Standards for Technological Literacy (ITEA, 2000)

Learning can also be more efficient in a modular laboratory environment as compared to the traditional laboratories. In a survey done by Schwaller (2001), teachers indicated that students could learn in one week what it took six weeks to learn before. One of the reasons for decreased learning time is that the software used in modules and the instructional strategies have been carefully and deliberately designed by technology education experts in the field.

Modular technology has a variety of other strengths. For example, there are always times set aside for creativity in the discovery time, which students enjoy and learn a great deal. Also, the creative or discovery time gives students the ability to try out new concepts just learned in the module. It should be noted that the teacher must facilitate this creative or discovery time very carefully. Such time should not be "down time," but a time in which the student can engage in higher order thinking skills concerning the content of the module. What is said about creative or discovery time in modular technology instruction also applies to other excellent instructional strategies that should be integrated.

That parents are often impressed with modular learning environments is another advantage. When parents enter a laboratory during parent/teacher conferences, for example, they see that technology instruction is much broader than previously thought. This can change the parents' perception concerning their definition of technology education to a positive and contemporary image.

Software and network systems in some modular technology classrooms use the computer to select student groups. This allows the teacher to be objective about how groups are selected, which in turn encourages collaborative work as well as group dynamics skills.

Limitations

As with any existing technology education program, there are also limitations. Equipment breakdown is probably the biggest limitation of modular technology. This is true whether it be a traditional, contemporary, or modular technology laboratory. When equipment breaks down or a module is no longer usable, this causes a serious change in the organizational structure and management of the course. Since the students are on a rotation, it becomes necessary for the teacher to readjust the rotation when a module fails. In many cases, however, a teacher will plan for this by having one or two additional modules to help offset the problem.

Another limitation when using a modular environment concerns the discovery days. Without the discovery days, students tend to become bored with the continuing process of rotating from one module to another. We must remember that modular technology is not designed to do all the teaching. It must be an integrated system. The teacher must still be a facilitator and design meaningful creative and discovery times for the students. As already indicated, some schools maximize the creative and discovery times and use modules to supplement the discovery days.

If the modular laboratory is equipped with modules from several vendors, the teacher must learn the software depth, equipment, and operation of each company's products. Among other things, this means more preparation time for the teacher before the class begins.

When grouping students (usually two students per module), there may be a limitation if the students are at different academic levels. For example, if an academically bright student is paired with an academically slower student, the brighter student might be held back while the slower student might learn more. On the other hand, this type of problem causes students to develop leadership and social skills as well. Often this type of grouping occurs in the real world and, thus, can be used as an advantage for the academically brighter student.

Other limitations deserve mention:

- There needs to be continued administrative support from the school district including additional money to keep the module software up-to-date.
- The average costs of a modular laboratory will range from $80,000 to $125,000. Although this may appear to be a disadvantage, there seems to be little problem getting the administrative support for such a classroom.
- There needs to be improved follow-up in the senior high school. Often there is not an articulated system for students moving from the middle school to the high school. However, some vendors have developed more in-depth modules and more problem-solving exercises and activities to help offset this problem.

Modular Technology and the Standards for Technological Literacy

I predict that the *Standards for Technological Literacy; Content for the Study of Technology* (ITEA, 2000) will change the field of technology education dramatically. This is also true with any type of instructional strategy. Schwaller (2001) conducted a survey to determine the relationship between modular technology instruction at the middle school and the Standards for Technological Literacy. This survey tapped the opinions of 20 modular technology teachers regarding the amount of learning taking place in reference to the Standards for Technological Literacy. Using a bi-polar scale from 1 to 5, with 5 representing *a great deal of learning in their classroom* and 1 representing *no learning in their classroom,* each teacher was asked to respond to a 20-question survey. To aid the teacher in this process, the question was asked how much learning is taking place (in their opinion) concerning each of the Standards for Technological Literacy. The results are shown in Table 1.

Although not without problems, modular technology continues to expand into more and more middle schools throughout the United States. The survey results and other professional experiences suggest:

- Modular classrooms and environments work well if used as one of many instructional strategies in the classroom.
- Modular systems should be considered an integrated system. It should not be considered the one and only way to teach technology education.
- Before teachers are placed in modular classrooms they need to be trained and

Table 1. Relationship of Modular Technology to the Standards

NATURE OF TECHNOLOGY		
Standard 1 —	The characteristics and scope of technology	3.90
Standard 2 —	The core concepts of technology	3.30
Standard 3 —	The relationship among technology and the connections between technology and other fields	4.45
	Standard 3 was high because the software in each module deals with math, science, etc., as well as technology.	
TECHNOLOGY AND SOCIETY		
Standard 4 —	The cultural, social, economic, and political effects of technology	3.10
Standard 5 —	The effects of technology on the environment	3.80
	Some laboratories had environmental module topics.	
Standard 6 —	The role of society in the development and use of technology	3.70
Standard 7 —	The influence of technology on history	4.15
	In most cases, each module started with historical information about the specific topic being addressed.	
DESIGN		
Standard 8 —	The attributes of design	4.45
Standard 9 —	Engineering design	4.15
Standard 10 —	The role of troubleshooting, research and development, invention, innovation, and experimentation in problem solving	4.30
	Concerning Standards 8, 9, and 10, since many of the modules allow the students to design and test a product, these three standards were rated very high.	
ABILITIES FOR A TECHNOLOGICAL WORLD		
Standard 11 —	Apply the design process	4.20
Standard 12 —	Use and maintain technological products and systems	4.10
Standard 13 —	Assess the impact of products and systems	3.40
	Standard 13 was rated a bit lower than other design standards because often the module didn't go far enough in assessment of the product that was designed.	
THE DESIGNED WORLD		
Standard 14 —	Medical technology	1.80
Standard 15 —	Agricultural and related biotechnologies	2.80
Standard 16 —	Energy and power technologies	4.50
Standard 17 —	Information and communications technologies	4.60
Standard 18 —	Transportation technologies	4.25
Standard 19 —	Manufacturing technologies	4.80
Standard 20 —	Construction technologies	4.00
	Ratings within the designed world in most cases were higher because there were complete modules that were related to Standards 16 to 20.	

prepared correctly to be successful.

- Many additional lifelong learning skills can be developed in most modular classrooms.
- Modular classrooms help to meet many of the Standards for Technological Literacy (ITEA, 2000).
- Modular equipment seems to be the biggest concern for many teachers in terms of keeping the equipment in good working order and up-to-date.

Dr. Anthony Schwaller is a professor and the chair in the Department of Environmetal and Technology Studies at St. Cloud State University in Minnesota. He is a member of the Iota Chapter of Epsilon Pi Tau.

REFERENCES

International Technology Education Association. (1997). *NCATE-approved curriculum guidelines: Initial program in technology education.* Reston, VA: ITEA/CTTE.

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

Schwaller, A. (2001). *Modular technology education.* Speech presented to the 89th Mississippi Valley Teacher Education Conference, Chicago.

Secretary's Commission on Achieving Necessary Skills. (1991). *What work requires of schools: A SCANS report for America 2000.* Washington, DC: U.S. Department of Labor.

Technology Education Curriculum Designs in Michigan Secondary Education

Phillip Cardon

As changes have occurred over the past decade in the field of technology education, the transition from industrial arts to technology education has brought new curriculum designs and approaches for implementing the new concepts and ways of teaching about technology (Herschbach, 1996). Teachers could change to the new design of technology education, remain with the industrial arts design, or adopt a hybrid curriculum design while still calling the new curriculum technology education (Wicklein, 1997b). These curriculum designs were implemented across the United States.

Technology education programs in Michigan secondary schools have increased over the past decade. The increase can be attributed to changes in the Michigan curriculum framework established by the Michigan Department of Education (1998), innovative secondary education teachers, state technology education organizations, the development of the Standards for Technological Literacy (International Technology Education Association [ITEA], 2000), and the development of university technology education programs (Jennings, Napthen, & Sypniewski, 1997). As technology

Table 1. Predominant Technology Education Curriculum Theories and Designs

Theory	Design	Subdesign	Authors and Dates of Recommendations
Social Efficiency	Academic		DeVore, 1964, 1980 McCrory, 1980 Maley, 1982 Yost, 1988 Zuga, 1988
	Technical	Task Analysis	Selvidge, 1923 Bollinger & Weaver, 1955 Fryklund, 1956, 1970
		Systems Analysis	Towers, Lux, & Ray, 1966 Witherspoon, 1976 Ritz, 1980 Schwerkolt & Spontelli, 1987 Wescott, 1988 Jones, 1988 Bjorklund, 1988 Snyder & Hales, 1981 Savage & Sterry, 1990
		Performance Objectives	Wilber, 1948 Almost all authors have focused on objectives
Human Development	Intellectual Processes		Sarapin & Starkweather, 1981 Maley, 1982 Moss, 1987 Hatch, 1988
	Personal		Maley, 1973 Mentioned by: Sarapin & Starkweather, 1981 Maley, 1982 Moss, 1987
Social Meliorism	Social		Pytik, 1981 Wright, 1988

Note: Adapted from Zuga, 1993, p. 15.

education programs developed in Michigan, each program followed a curriculum design influenced by its school district and region needs. The designs they followed are not generally known to researchers because a state database of curriculum designs was not maintained. This article reports and discusses a study that examined the implementation of technology education curriculum models in Michigan secondary schools (Michigan Department of Education, 1996).

Technology Education Curriculum Designs

The five main curriculum designs in technology education are described by Hansen (1995), Wicklein (1997a), and Zuga (1989, 1993) as academic rationalism, technical curriculum, intellectual processes, social adaptation or reconstruction, and personal relevance (see Table 1).

The academic rationalism curriculum design tends to focus on a body of knowledge, which is grouped into disciplines, subject matter, or broad fields of study. This design is reflected in the way in which curriculum focuses on technology as the basis of content and also focuses on taxonomies of technological concepts, as discussed by DeVore (1964).

The technical curriculum design is based on the analysis of process or performance, using a job and task analysis or the identification and sequencing of a highly structured behavioral outcome approach (Zuga, 1989). This design is very popular in vocational education, industrial education (Allen, 1919; Fryklund, 1956, 1970; Lux, 1979; Selvidge, 1923; Selvidge & Fryklund, 1946), and industrial training curricula.

The intellectual processes design makes development of either cognitive processes such as critical thinking and problem solving or human processes and traits such as creativity and self-confidence the focus of the curriculum, rather than a structured discipline or a sequence of tasks. The primary goal of this design is to increase the student's learning ability through the utilization of problem-solving activities in order to transfer problem-solving abilities to all areas of the curriculum and life (Wicklein, 1997a).

The personal relevance curriculum design centers on the student with a focus on the individual's needs and interests. The primary goal of this design is to put the student in control of the curriculum instead of allowing subject matter specialists to dictate the curriculum for the student (Maley, 1972; Zuga, 1989).

The social curriculum design focuses on the application of knowledge in realistic or real world situations. This design includes two distinct and opposing views: the adaptation side to social curriculum and the reconstruction side. The social adaptation side of the design comes from the work of Bobbitt (1918), which focuses on preparing students to fill specific occupational roles in society. The social reconstruction end of the design focuses on the way in which the future of society can be changed as a result of the educational activities of current students (Zuga, 1992). The technology education curriculum tends to follow the social reconstruction design to the extent that it tries to incorporate the works of Dewey (1916) and Counts (1932) as well as the works of Apple (1979, 1990), Anyon (1980), and Pinar (1981).

Primary Curriculum Theories

Although the previous five designs are considered to be the primary curriculum designs in the technology education field, these curriculum designs can be simplified into three curriculum theories offered by Kliebard (1985), which are relevant to this discussion (Zuga, 1993). These are the social efficiency theory, the human development theory, and the social meliorism theory (see Table 1).

The social efficiency theory consists of two primary thrusts, namely, the academic thrust and the vocational thrust. Although the academic rationalism and vocationalism thrusts tend to be split as a result of the ongoing influence of Greek philosophy, they can be united through the concept that "the goal of education and curriculum is to reproduce, efficiently, the existing culture" (Zuga, 1993, p. 10). As Zuga (1993) stated, much of the technology education curriculum theory and design discussions are in this area.

As for the human development theory, it has been a part of curriculum circles since the late 18th century. Some major works in this movement include Dewey's (1916) *Democracy and Education,* Rousseau's (1979) *Emile,* and Herbart's (1914) *Herbart's ABC of Sense Perception and Minor Pedagogical Works.* The human development theory is based on the creation of a curriculum from the ways in which children normally develop (Kliebard, 1985). The focus of this curriculum paradigm is on higher-order thinking skills and problem solving. It is believed that "learning to solve problems and investigating topics and problems of personal interest are the keys to a successful education" (Zuga, 1993, p. 12). This paradigm rejects the social efficiency theory of filling empty heads and molding raw material. The technology education intellectual processes and personal relevance curriculum designs are included in this theory (Zuga, 1993).

The social meliorism curriculum theory focuses on the changing of the existing society (Kliebard, 1985). The social meliorism theory implies that "society needs to be changed and students should plan and implement ways in which to change it" (Zuga, 1993, p. 13). The concept of social meliorism began almost 70 years ago with the social reconstruction philosophies of John Dewey (Bode, 1933; Counts, 1932; Dewey & Childs, 1933) and is active today with the work of curriculum theorists such as Apple (1979, 1993, 1995) and Pinar (1981). The technology education social adaptation and reconstruction curriculum designs fit into this theory (Zuga, 1993).

Lack of Consensus in Technology Education

Over the past 40 years, the technology education field has been evolving out of an industrial arts background (Lux, 1981). During this evolution, the implementation of a technology education curriculum in technology education programs has varied greatly. At one end of the spectrum, programs have completely thrown out the old industrial arts influences of the past and adapted state-of-the-art laboratories and technologies (Neden, 1990). At the other end of the spectrum, programs have merely changed their name without changing any of the curriculum or facilities, focusing on a hybrid of industrial arts curriculum laced with technology education ideas (Oaks, 1989).

Because of the wide variety of programs that existed in the United States, the call for national standards in technology education increased, resulting in the Standards for Technological Literacy (ITEA, 2000). Although national standards in technology education have been established, technology education programs in Michigan remain diverse in relationship to one another with respect to their curriculum designs. Because of the continued inconsistency among technology education programs, there was a need to understand the diversity of technology education programs in Michigan secondary schools and the curriculum design that each school embraced.

Purpose

The school districts in Michigan enjoy relative curriculum autonomy granted to them by the state constitution. Although the districts are encouraged to follow state benchmarks and goals, each district can decide the curriculum designs it wishes to follow. The purpose of this study was to learn the types of technology education curriculum designs that exist in the public secondary schools within Michigan and to what extent the designs varied among programs. Knowledge of the types of technology education curriculum designs implemented in schools throughout the state of Michigan would help to show a need for an increase in federal and state funding to all Michigan technology education programs.

What We Did and How We Did It

To obtain information regarding the technology education programs in Michigan secondary schools, the best design was determined to be a survey research design.

All certified secondary technology education teachers in the state of Michigan were targeted. They were certified to teach technology education or industrial education in Grades 7 to 12 during the 1999–2000 school year. At the time of the study, 865 certified teachers in Michigan were teaching in a program related to their certification. We were careful to prevent teachers from duplicating the survey.

All 865 certified technology education or industrial education teachers in the state of Michigan were eligible to take part in the study. Since the demographics in Michigan were quite varied, a stratified random sample technique was used to select the sample, based primarily on population density. Since the population of eligible persons was less than 1,000, 33.3% of each demographic population of certified individuals was selected to participate in the survey, resulting in 260 randomly selected people.

We adapted an instrument from a study performed by Engstrom (2000). The major emphasis of the instrument was to obtain information from the participants regarding their current curriculum. Some of the demographic questions related to gender and age were removed, leaving the majority of the instrument untouched. The coefficient alpha internal reliability coefficient for this instrument was .83, similar to the reliability coefficient reported by Engstrom.The Technology Education Component Rating Matrix (TECRM) survey instrument developed by Engstrom focused on determining the components necessary in a technology education program versus an industrial arts program. This survey asked people to respond to activities categorized as industrial arts or technology education in nature. Engstrom determined the categories through research and a review of available literature. Engstrom's survey questions, or components, relating to each category were determined by a review of literature and by panel review.

This study did not cover detailed information within each program. Only people certified in technology education or industrial arts in the state of Michigan were selected to participate in the study. Also, the study was not meant to influence teachers to change their technology education program curricula to follow a specific curriculum. Confidentiality was ensured through a coding system.

The survey instrument, along with instructions for completing and returning it, was mailed to 260 participants during the second week in May 2000, with a second mailing distributed the first week of June 2000. Ten blank surveys were returned due to address changes, resulting in a modified sample size of 250. One hundred and fourteen surveys, or 45.6%, were completed and returned. Of the surveys returned, 5 were unusable due to respondents not completing large portions of the survey. This resulted in 109 usable surveys. Nonresponse correction was performed on 22, or 15%, of the nonrespondents.

What We Learned

The data obtained through the instrument were analyzed using SPSS version 9.0 computer software. To summarize the findings of the study, it appears there was an elevated emphasis on technology education and problem solving and the integration of mathematics, science, and technology education, with 71.0% of the respondents indicating they offered a technology education program. One aspect of the data that was somewhat enlightening was the fact that woodworking laboratories were indicated as the most prevalent laboratories used in the field, at 67.9%. This may indicate that industrial arts and industrial technology curriculum designs remain popular in Michigan schools.

The nondemographic information gathered from the survey was converted into numerical data via an interval scale. Therefore, a multidimensional chi-square was performed using SPSS version 9.0 to compare teacher responses to the questions on the questionnaire to test our hypotheses. The software was also used to correlate question responses to curriculum theories and designs and to crosswalk responses back to industrial arts and technology education activity categories. The alpha levels were set at .05 and .01 for this study.

Data Related to Curriculum Design

The research questions were revisited to help in the direction of the analysis. Question 2: Are technology education curriculum designs implemented differently at the secondary school level in the state of Michigan? In order to answer the question, the survey questions needed to be related to the various curriculum designs indicated by Zuga (1993). This was completed with the assistance of professionals in the field of technology education, who reviewed the questions and helped to relate them to the five general curriculum designs.

Question 1: What different curriculum designs for secondary technology education exist within Michigan schools? The data indicated that all five technology education curriculum designs existed in Michigan secondary education schools.

When the responses to the questions were reviewed, the academic, technical, personal, and social curriculum designs had a higher rating for technology education related questions than for industrial arts related questions. The intellectual processes curriculum design was rated slightly higher for industrial arts related components. A possible explanation for industrial arts related components being rated higher than technology education components could be that technology education teachers may have confused industrial arts intellectual components as being related to technology education.

Component Ratings

As determined by Engstrom (2000) through a review of literature, there are four levels for rating a component: (a) *irrelevant* component rated less than 2.5 on a scale of 1 to 4, (b) *desirable* component rated from 2.5 to 3.25, (c) *more* desirable component rated from 3.25 to 3.49, and (d) *essential* component rated from 3.5 to 4.0.

Of the four items rated as *essential* (3.5 or higher), three were from the technology education category (safely use tools and machines, select proper tools and materials appropriately, and receive formative and summative feedback from teacher) and one was from the industrial arts category (use drawings for illustration and construction purposes). Eleven components were identified as *more desirable*. Eight components were related to technology education (e.g., design a solution to the problem, build a solution to the problem, and test and evaluate the solution) and three were related to industrial arts (acquire some degree of dexterity when working with tools, appreciate good design, and develop hand-eye coordination).

Thirty-five components were identified as *desirable* by the respondents. Twenty-one were related to technology education (e.g., use the same principles as a technologist to solve problem, solve a problem that has a practical solution, and integrate information from other academic studies), and 14 were related to industrial arts (e.g., develop an appreciation for good craftsmanship, build a project that is based on student interest, and identify common hand tools). Two of the components were rated as *irrelevant* by the respondents, both of which were related to industrial arts (make something that is useful around the home and make plans for a home workshop).

When looking at the ratings of the components, 32 (61.5%) were rated as *essential, most desirable,* or *desirable* related to technology education, whereas 18 (34.6%) were rated as *essential, most desirable,* or *desirable* for industrial arts. The two components rated *irrelevant* were related to industrial arts. These ratings indicate a significant difference between the number of components related to technology education compared to industrial arts. This shows a definite difference in the curriculum designs being used in secondary technology education programs. More information was obtained related to this difference in the analysis of the hypotheses.

Revisiting Our Hypotheses

The null hypothesis indicated that there was no significant difference in the implementation of technology education curriculum designs among secondary schools within the state of Michigan. The alternative hypothesis indicated that there was a significant difference in the implementation of technology education curriculum designs among secondary schools within the state of Michigan. When performing a chi-squared analysis of the data as related to the five designs referenced above using ∂^2 = .01, there appeared to be a significant difference between the designs according to the data, with ∂^2 = 6.635 and 1 degree of freedom. Therefore, the null hypothesis was rejected. A significant difference existed between curriculum designs among secondary schools in Michigan. The *essential* ratings of the data supported the alternative hypothesis for the academic (∂^2 = 12.41), intellectual processes (∂^2 = 24.23), and social (∂^2 = 19.75) curriculum designs. The *more desirable* ratings supported the alternative hypothesis for the technical (∂^2 = 14.31) curriculum design. The *desirable* ratings of the data supported the intellectual processes (∂^2 = 26.56) and social (∂^2 = 13.75) curriculum designs. The *irrelevant* ratings supported the technical (∂^2 = 32.22) and intellectual processes (∂^2 = 21.79) curriculum designs.

According to the data, there appears to be a significant difference regarding the curriculum designs being used among technology education programs in Michigan. Some programs follow the newer technology education design while others continue to follow the industrial arts mode. There is a significant difference in the types of curriculum designs being used among secondary schools in Michigan, supporting the alternative hypothesis.

What It Means

The initial review of literature suggests that technology education curriculum designs are being implemented in technology education programs across the United States and in Michigan. However, the types of curriculum designs being followed in Michigan secondary schools were not known.

With the completion of the national standards for technology education (ITEA, 2000) and the need of state funding for technology education programs, information was needed regarding the curriculum design that each technology education program endorsed. The certified technology education teacher respondents in Michigan told us that there was a significant difference in the types of curriculum designs being used among secondary schools in Michigan, supporting our alternative hypothesis, that there was a significant difference in the implementation of technology education curriculum designs among secondary schools within the state of Michigan.

The most common curriculum designs being used in secondary technology education programs in Michigan were the intellectual processes and personal designs. The intellectual processes curriculum design supports the use of problem solving in the curriculum and focuses on traits such as creativity and self-confidence. The personal curriculum design focuses on the student's individual needs and interests. Both of these designs are used extensively in current technology education curricula.

The technical and academic curriculum designs were less prominent, indicating less emphasis on technical knowledge and taxonomies of technological content within secondary technology education programs in Michigan. The social curriculum design was rated the lowest, showing a lack of interest in social adaptation and education reform.

Another issue that became apparent from the data is the fact that most of the teachers in the field are nearing retirement. Over half of all the teachers in the field have more than 20 years of service in Michigan. This hints toward an increase in the demand for technology education teachers in the near future.

It was hoped that this study would help to show if there is a shift occurring in technology education secondary programs within Michigan. From the observed data, this shift has been a migration from the industrial arts curriculum design to the contemporary technology education curriculum design.

Although it was not the initial focus of this study, the issue regarding reasons for variability among technology education programs has become evident. Some of the demographics data related to responses to the ratings data indicate a possible link to regional vocational or economic needs. For example, 29% of respondents said their program had a career emphasis, followed closely by 27% who said they focused on design and problem-solving skills.

The variability among programs can also be attributed to the fact that Michigan certifies teachers for technology education and industrial arts or industrial technology programs. In the more rural and agricultural areas of Michigan, school districts tend to promote industrial arts or industrial technology programs, as indicated by the data. Technology education programs were more prominent in urban and suburban areas of Michigan. This indicates a desire for both industrial arts or industrial technology programs and technology education programs in Michigan. In order to discuss this phenomenon in further detail, a more in-depth study would need to be performed.

As technology education professionals in other parts of the United States, may we ask that you consider replicating a study similar to this one in your state or region. Although this study cannot be generalized beyond the target population within Michigan, the significance of the study indicates the possibility that other states and regions may have similar characteristics to Michigan technology education secondary curriculum designs. The time is ripe to learn more about the development of technology education throughout the country as we move forward with the incorporation of the national technology education standards into the K–12 and postsecondary education curricula.

Dr. Phillip Cardon is a professor in the Department of Business and Technology Education at Eastern Michigan University, Ypsilanti. He is a member of the Alpha Chapter of Epsilon Pi Tau.

References

Allen, C. R. (1919). *The instructor, the man, and the job.* Philadelphia: Lippencott.

Anyon, J. (1980). Social class and the hidden curriculum of work. *Journal of Education,* **162**(1), 67–92.

Apple, M. W. (1979). *Ideology and curriculum.* Boston: Routledge & Kegal Paul.

Apple, M. W. (1990). On analyzing hegemony. In W. M. Apple (Ed.), *Ideology and curriculum* (pp. 1–25). New York: Routledge.

Apple, M. W. (1993). *Official knowledge: Democratic education in a conservative age.* New York: Routledge.

Apple, M. W. (1995). *Education and power.* Boston: Ark.

Bjorklund, L. R. (1988). Interpretation of industry approach. In W. H. Kemp & A. E. Schwaller (Eds.), *Instructional strategies for technology education* (pp. 110–122). Mission Hills, CA: Glencoe.

Bobbitt, F. (1918). *The curriculum.* New York: Houghton-Mifflin.

Bode, B. H. (1933). The confusion in present-day education. In W. H. Kilpatrick (Ed.), *The educational frontier* (pp. 3–31). New York: Appleton-Century.

Bollinger, E. W., & Weaver, G. G. (1955). *Trade analysis and course design for shop teachers.* New York: Pitman.

Counts, G. (1932). *Dare the school build a new social order?* New York: Day.

DeVore, P. W. (1964). *Technology as an intellectual discipline* (Bulletin No. 5). Washington, DC: American Industrial Arts Association.

DeVore, P. W. (1980). *Technology: An introduction.* Worcester, MA: Davis.

Dewey, J. (1916). *Democracy and education.* New York: Free Press.

Dewey, J., & Childs, J. L. (1933). The social-economic situation and education. In W. H. Kilpatrick (Ed.), *The educational frontier* (pp. 32–72). New York: Appleton-Century.

Engstrom, D. E. (2000). *Identifying the essential and desirable components of technology education activities.* Unpublished doctoral dissertation, Duquense University, Pittsburgh, PA.

Fryklund, V. C. (1956). *Analysis techniques for instructors.* Milwaukee, WI: Bruce.

Fryklund, V. C. (1970). *Occupational analysis: Techniques and procedures.* New York: Bruce.

Hansen, R. E. (1995). Five principles for guiding curriculum development practice: The case of technological teacher education. *Journal of Industrial Teacher Education,* **32**(2), 30–50.

Hatch, L. (1988). Problem solving approach. In W. H. Kemp & A. E. Schwaller (Eds.), *Instructional strategies for technology education* (pp. 87–98). Mission Hills, CA: Glencoe.

Herbart, J. F. (1914). *Herbart's ABC of sense perception and minor pedagogical works.* New York: Appleton.

Herschbach, D. R. (1996). On the proposition that technology education leaders have neglected important qualities of industrial arts education. *Journal of Technology Studies,* **22**(2), 4–14.

International Technology Education Association. (2000). *Standards for technological literacy.* Reston, VA: Author.

Jennings, G. L., Napthen, M., & Sypniewski, M. (1997). *A study to determine the demand for teachers of technology education in the state of Michigan.* Unpublished study, Eastern Michigan University, Ypsilanti.

Jones, R. E. (1988). Integrating the systems of technology approach. In W. H. Kemp & A. E. Schwaller (Eds.), *Instructional strategies for technology education* (pp. 99–109). Mission Hills, CA: Glencoe.

Kliebard, H. M. (1985). Three currents of American curriculum thought. In A. Molnar (Ed.), *Current thought on curriculum.* Alexandria, VA: Association of Supervision and Curriculum Development.

Lux, D. G. (1979). Trade and job analysis: The scourge of I.A. *School Shop,* **38**(7), 2.

Lux, D. G. (1981). Industrial arts redirected. In T. Wright & R. Barella (Eds.), *An interpretive history of industrial arts* (pp. 205-226). Bloomington, IL: McKnight.

Maley, D. (1972). The Maryland plan. *School Shop,* **32**(8), 52–54.

Maley, D. (1973). *The Maryland plan.* New York: Bruce.

Maley, D. (1982). Putting theory into practice. *Man, Society, and Technology,* **41**(8), 3–11.

McCrory, D. L. (1980). Content structure for technology education: Toward new curricula for the 1980s. *Journal of Epsilon Pi Tau,***13**(1), 27–34.

Michigan Department of Education. (1996). *Michigan curriculum framework.* Lansing, MI: State of Michigan.

Michigan Department of Education. (1998). *Overview of technology content standards.* Retrieved data from http://cdp.mde.state.mi.us/MCF/ContentStandards/ Technology/default.html

Moss, J., Jr. (1987). Technology education: Subject- or student-content? *The Journal of Epsilon Pi Tau,* **13**(1), 40–43.

Neden, M. (1990). Delta County technology project. *The Technology Teacher,* **50**(3), 25–28.

Oaks, M. M. (1989). Making the change: Key issues in moving to technology education. *The Technology Teacher,* **48**(5), 5–8.

Pinar, W. F. (1981). The reconceptualization of curriculum studies. In H. Giroux et al. (Eds.), *Curriculum and instruction* (pp. 87–97). Berkeley. CA: McCutchan.

Pytik, E. C. (1981). Technology education and human values: A course for high school students. *The Journal of Epsilon Pi Tau,* 7(2), 36–42.

Ritz, J. M. (1980). Systematic curriculum development for industrial education. *Man, Society, and Technology,* **40**(1), 11–13.

Rousseau, J. J. (1979). *Emile.* New York: Basic Books.

Sarapin, M. I., & Starkweather, K. N. (1981). Curriculum development: Placing the learner at the center of the instructional process. *The Journal of Epsilon Pi Tau,* 7(1), 60–66.

Savage, E., & Sterry, L. (1990). *A conceptual framework for technology education.* Reston, VA: International Technology Education Association.

Schwerkolt, E. A., & Spontelli, C. (1987). A practical model for developing instructional systems. *The Journal of Epsilon Pi Tau,* **13**(2), 51–56.

Selvidge, R. W. (1923). *How to teach a trade.* Peoria, IL: The Manual Arts Press.

Selvidge, R. W., & Fryklund, V. C. (1946). *Principles of trade and industrial teaching.* Peoria, IL: Manual Arts Press.

Snyder, J. F., & Hales, J. F. (1981). *Jackson's Mill industrial arts curriculum theory.* Charleston: West Virginia Department of Education.

Towers, E. R., Lux, D. G., & Ray, W. E. (1966). *A rationale and structure of industrial arts subject matter.* Columbus, OH: Ohio State University, Industrial Arts Department of Education. (ERIC Document Reproduction Service No. ED 013 955)

Wescott, J. W. (1988). Teaching concepts: A challenge for technology educators. *The Technology Teacher,* **48**(1), 21–25.

Wicklein, R. C. (1997a). Curriculum focus for technology education. *Journal of Technology Education,* **8**(2), 72–80.

Wicklein, R. C. (1997b). Mental methods of inquiry: Challenges to the curriculum paradigm. *The Technology Teacher,* **56**(4), 43–45.

Wilber, G. O. (1948). *Industrial arts in general education.* Scranton, PA: International Textbooks.

Witherspoon, E. L. (1976). Effecting curriculum change in industrial arts. *Man, Society, and Technology,* **35**(7), 207–209.

Wright, J. R. (1988). Social/cultural approach. In W. H. Kemp & A. E. Schwaller (Eds.), *Instructional strategies for technology education* (pp. 72–86). Mission Hills, CA: Glencoe.

Yost, C. E. (1988). Conceptual learning approach. In W. H. Kemp & A. E. Schwaller (Eds.), *Instructional strategies for technology education* (pp. 37–55). Mission Hills, CA: Glencoe.

Zuga, K. F. (1988). Interdisciplinary approach. In W. H. Kemp & A. E. Schwaller (Eds.), *Instructional strategies for technology education* (pp. 56–71). Mission Hills, CA: Glencoe.

Zuga, K. F. (1989). Relating technology education goals to curriculum planning. *Journal of Technology Education,* **1**(1), 34–58.

Zuga, K. F. (1992). Social reconstruction curriculum and technology education. *Journal of Technology Education,* **3**(2), 53-63.

Zuga, K. F. (1993). A role for alternative curriculum theories in technology education. *Journal of Industrial Teacher Education,* **30**(4), 7–25.

 IDEAS

The Electric Vehicle Experience

Thomas E. Kraft

Two words, experience and education, immediately bring one man to mind—John Dewey. Regarding experience and technology education, Hansen (2000) said that studies of technological teachers in Germany, England, and Canada indicate there is a preconception and tendency that these individuals bring to the profession with them. That is, these teachers reveal a "strong bias towards experience as a frame of reference for learning" (p. 23). This article emphasizes the role of experience as a foundation for a specific technology education program that is ongoing in a number of states. Additionally, from this foundation springs a natural flow of problem-solving activities, cognitive science strategies, and subject matter that addresses several ideals from the history of technology education. The present educational emphasis on problem solving, thinking, and social interaction arguably is also found in past Deweyan literature. Thus, his words seem appropriate as a starting point.

> It is possible to find problems and projects that come within the scope and capabilities of the experience of the learner and which have a sufficiently long span so that they raise new questions, introduce new and related undertakings, and create a demand for fresh knowledge. (Dewey, 1964, p. 423)

There are a number of projects in technology education today that potentially adhere to this statement from Dewey. Examples in transportation technology are suggested by electric, fuel cell, and solar powered vehicles as well as human powered submarines. Based on my own experience, the construction of electric vehicles (EVs) in secondary and postsecondary schools is an exciting addition to the technology education curriculum. Even more exciting is the competition of these vehicles following construction.

EV guidelines are typically based on ELECTRATHON™ AMERICA design rules and events that are held around the country. As an industrial technology educator in both Hawaii and Nebraska, I have seen these programs grow rapidly over the past few years. In both of these states, public power districts serve as sponsor or cosponsors for these activities. Participating schools develop their vehicles around electrical components and a one horsepower electric motor provided by the sponsor. Towards the end of the school year, endurance competitions are held so participants have the opportunity to display and enter their vehicles in hour-long races. Since endurance is the name of the game, vehicles must be designed for efficiency and aerodynamics rather than short bursts of speed. The objective of the competition is to drive an electrically powered vehicle as far as possible for one hour on a closed-loop course. Competitions are held annually, thus schools have the opportunity to rework last year's vehicle or start fresh each year. The number of schools participating annually in a particular state points to the success of this program thus far. For example, the Hawaii Electric Company (HECO) cosponsors the electric vehicle competition with the state's Department of Education. According to HECO's Office of Education and Consumer Affairs, the number of schools participating has increased threefold to 33 for 2002 in comparison to 11 for the first year in 1996.

When one takes a closer look at the overall aspects of this program, I see an exemplary model of experiential learning for technology education. As a principal means of organizing a curriculum, these programs are project based and activity oriented. The progression from design through competition mirrors Dewey's (1973) pattern of inquiry, where "inquiry is the directed or controlled transformation of an indeterminate situation into a determinately unified one" (pp. 237-238). Moreover, this experiential curriculum provides numerous activities for developing problem-solving and cognitive science strategies. In the search for excellence in technology education, Zuga and Bjorkquist (1989) indicated that the way in which the course is organized and conducted demonstrates a type of educational activity that attempts to prepare students to be independent thinkers and problem solvers. The specific content of the course becomes a secondary issue; the activities provided for the student become the primary issue.

Electric vehicle activities generally unfold into two phases: one being construction and design, and the other is testing and competition.

Construction and Design: A Progression in Inquiry and Reflection

Normally, the construction of EVs involves an amalgamation of different parts adapted primarily from bicycles or go-karts. It can be constructed from a variety of approaches such as designing and building from scratch, building from predesigned plans, and building the vehicle from a preconstructed subframe. Whatever method is chosen should be based on the experience or the lack of experience of the students and the teacher. For example, in a high school setting where students are new to tools and technology, a pre-constructed frame would structure the activity to solve initial conceptualization problems. Additionally, this would provide a starting point for students to visualize the construction and placement of certain components such as the motor, driver's seat, and a body. In this case, the instructor directs the project to a point where students take over and begin visualizing how different parts of the vehicle might be constructed. At this time, students can actively engage in an experimentation process—identifying relationships, formulating ideas, testing hypotheses, and proposing solutions to vehicle construction problems and anomalies. This progression in inquiry provides grounding for development of cognitive and problem-solving strategies such as reflection and reflective thought. The laboratory setting allows ample time for teachers and students to thoroughly think through problems. As a result, alternative means of vehicle design and construction can be considered for their consequences. According to Dewey (1933), "reflective thought allows for systematic preparation, the invention of better solutions and meaningful enrichment of life, problems and experiences. Reflective thought gives increased control and expanded valuing sensitivities" (p. 21). In short, the value of these reflections are that students begin to see connections between the actions they take and the results that occur and they realize that these connections give them more control over the project and their environment.

As a cognitive process, reflective thought is further described as having a "chaining" feature, meaning "not simply a sequence of ideas, but a consequence—a consecutive ordering in such a way that each determines the next as its proper outcome, while each outcome in turn leans back on, or refers to, its predecessors" (Dewey, 1933, p. 4). In a laboratory setting, this chaining feature resembles the assembly/problem-solving phase of EV construction. As parts and components are initially installed, a psychomotor process of hands-on and minds-on interaction can be observed. This trial-and-error process includes the manipulation of components and parts, assembly and disassembly of components from the vehicle, and tool and vehicle manipulation to approach various tasks from different angles or perspectives. Through these physical problem-solving activities, students are learning which ideas and components will work and those that will not. They also learn that this problem-solving process is grounded in a minds-on physical manipulation followed by reflection. As progress is made, links or the chain is slowly completed in the design, construction, and assembly of the vehicle. From my observations, these are technological problem-solving processes that are thoughtful and can be described on a continuum as somewhere between tinkering and invention. Moreover, I suspect this chaining-like feature in technology is a learned behavior that students imitate from watching teachers or other skilled technologists.

As students grow in their problem-solving skills, reflection following manipulative experiential activities becomes automatic. Reflection as a cognitive science strategy is described as "those intellectual and affective activities in which individuals engage to explore their experiences in order to lead to new understanding and appreciations" (Boud, Keough, & Walker, 1985, p. 18). As a specific mode of thinking, Dewey's reflective thought process needs to be part of this cognitive strategy, particularly if problems remain from vehicle construction or assembly. Problems create a mental dilemma or a "forked-road situation" causing perplexity, confusion, and ambiguity. "Demand for the solution of a perplexity is the steadying and guiding factor in the entire process of reflection" (Dewey, 1933, p. 14). Thus reflective thought, "the kind of thinking that consists in turning a subject over in the mind and giving it serious consecutive consideration" (Dewey, 1933, p. 3), provides a pathway or a solution out of the confusion or dilemma. Frequently, we need to step away from the hands-on activity just to reflect. This allows the mind to consider alternatives and potential courses of action. Once a solution is mentally defined, it needs to be tested during future laboratory sessions when the students return to manipulative activities. The result is purposeful planning, meaning these experiences of thoughtful manipulation, reflection, and reflective thought develop self-direction in the student.

Students and teachers new to EV design and construction will find that initially this is a daunting task. As mentioned earlier, predesigned plans and subframes will facilitate assembly and construction. However, the complete assembly of vehicle parts, components, and subsystems implies that no one can do it all. Ideally, student groups will take on different construction tasks such as brake assembly, motor mounting, electrical wiring, etc. This approach capitalizes on models of socially distributed expertise. Each group and each student within the group becomes a resident expert on a certain system. Accordingly, "students are responsible for doing collaborative research and sharing their expertise with their peers within and between classroom groups" (DeMiranda & Folkestad, 2000, p. 7). Later these pools of expertise will be valuable during EV testing and competition.

Testing and Competition: Having an Experience

> Everything depends on the quality of the experience which is had. The quality of an experience has two aspects. There is an immediate aspect of agreeable or disagreeableness, and there is its influence upon later experiences. (Dewey, 1938, p. 27)

Like other technology education projects and experiences, EV design and construction begins in a school setting—the shop or laboratory. From here testing and competition are authenticated during real-world events, outside the classroom. These aspects, particularly testing and competition, are key to the EV process. They round out the experience and make it "whole" by taking the project to completion in a cultural context. An EV competition is a public performance. For the student, learning has made a dramatic shift from the classroom or laboratory to the community where performance will be observed by a variety of spectators. Inevitably these spectators value the knowledge and understanding demonstrated by the performers. Here, Dewey's concern for the quality of an experience and how it influences later experiences is right in line with situated cognition. It is believed that situating learners in social contexts where understanding is valued and socially acquired enhances the probability of transfer and application of that knowledge to contexts in the realm of practice outside the classroom (Schell & Black, 1997; Stern, 1998). As the instructor, the competition becomes a matter of balance and coaching. In other words, when problems arise, how much do I stand back and how much do I actively participate in student problem solving? Coaching requires teachers to monitor and regulate student attempts at problem solving so they don't go too far into the wrong solution yet allowing students to have opportunity to experience the complex process and emotions of real problem solving (Bransford & Vye, 1989; Sternberg, 1998). My own approach is to stay out of the problem-solving process as much as possible and only get involved when push comes to shove, particularly with college-age students. During the annual EV competition in Hawaii, this aspect of teacher involvement is regulated by local guidelines. Teachers are not allowed in the pits during active competition, period. Thus, forcing these high school students to rely on themselves and each other.

EV competitions are ongoing yearly events. In Hawaii, this is the seventh consecutive year for the EV Electron Marathon. In Nebraska, prior to a final competition there are several regional EV competitions. This repetition of events provides continuity allowing schools to compete over a series of competitions. The nature of Hawaii's island state lends itself to only one annual competition, understandably so due to the expense and logistics of transporting vehicles between islands for the competition. For land-locked Nebraskans, regional events are held prior to a final, giving participants the opportunity to debug their vehicles during earlier competitions. In either case, these events provide an experience continuum. For Dewey (1938), this experience-continuum was seen as a means for evaluating the educational significance of varying experiences. He said that "continuity and interaction in their active union with each other provide the measure of the educative significance and value of an experience" (pp. 44-45). Additionally, the two principles of continuity and interaction "intercept and unite"; they are "the longitudinal and lateral aspects of experience" (Dewey, 1938, p. 44). What students and teachers learn during one EV competition will be carried on to other competitions as well as other similar experiences in life, a longitudinal aspect. This might be a lesson in hands-on technological awareness such as the importance of checking all electrical connections for tightness prior to the event. When these same students learn from these experiences and then apply them to different situations, that is a lateral aspect. An example here might be lessons in proper planning, group cooperation, and problem solving. Beyond these contemporary EV activities, this program makes several connections with historic ideals formulated for technology education.

History and Concluding Thoughts

> The simile of new wines in old bottles is trite. Yet no other is so apt. We use leathern bottles in an age of steel and glass. The bottles leak and sag. The new wine spills and sours. No prohibitory holds against the attempt to make a new wine of culture and to provide new containers. Only new aims can inspire educational effort for clarity and unity. (Dewey, 1964, p. 426)

Dewey's simile for new wines and old bottles has been used by a number of scholars to criticize educational practices that turn out to be the same old stuff with just a new name. In 1942, Bode coined a similar phrase as a metaphor for industrial arts curriculum saying that it was "time to stop putting old wine into new bottles" (pp. 8–9). He was referring to industrial arts not having realized certain ideals of progressive educators of the 1920s and 1930s, more specifically the ideal of a reconstructionist mission. A close examination of the EV experience indicates this activity falls short of having a reconstructionist curriculum. Zuga (1992) illustrated what a social reconstructionist curriculum orientation is not. She indicated that "it is not having the teacher choose course content or the social problem" (p. 8). In this case, the social problem (designing and creating less polluting power systems for vehicles) has been driven from the top down, so to speak, and students do not have a choice. In Hawaii, HECO in collaboration with the Department of Education initiated the EV program. The choice by individual schools, teachers, and students is whether to participate in EV activities.

In a recent historical analysis, Petrina and Volk (1995) examined ideals formulated for industrial arts by progressive educators including a reconstructionist mission, philosophical basis of experience, and unitary organization of curriculum. They argued that these formative ideals "provided meaning and mobilized support for the industrial arts movement" (p. 24), but in reality these principles were accepted only rhetorically, eventually being discarded and lost. Additionally, they indicated that "within these areas are keys to resolve contemporary problems and shape a vision for the future" (p. 24). The EV experience described herein may not completely fulfil these historical ideals. But it does have a social significance, a basis in experience and potential for an integrative or unitary organization of curriculum. This educational activity is, in my view, a new aim from technology education. It is not the same old practices disguised with a new cover. It develops an experiential foundation that is personally relevant to the students and at the same time draws them into a deep thinking process. How many 15 or 16-year-olds do you know who are not interested in driving, let alone competing with a motorized vehicle? Moreover, this is a new approach because it allows for flexible curriculum designs with more than just the single goal of technical competency. As I have illustrated in this article, the project base becomes a task in team problem solving leading to reflective thought and the use of cognitive science strategies. However, it still includes a traditional hands-on, skills-based orientation. This is necessary because you just cannot "make" an EV without certain skills, knowledge, and tools from the "old" areas such as metalworking, electricity, plastics, and automotive. So to be trite I will conclude by saying the EV experience is "new wines from old bottles," and so far this wine has served its customers well.

Dr. Thomas E. Kraft is an instructor in the program of industrial education at The University of Nebraska, Kearney.

References

Bode, B. (1942). *Industrial arts and the American tradition*. Founders Day address, Epsilon Pi Tau, Columbus, OH.

Boud, D., Keogh, R., & Walker, D. (1985). Promoting reflection in learning: A model. In D. Boud, R. Keogh, & D. Walker (Eds.), *Reflection: Turning experience into learning* (pp. 18–40). New York: Nichols.

Bransford, J., & Vye, N. J. (1989). A perspective for cognitive research and its implication for instruction. In Y*earbook of the Association for Supervision and Curriculum Development* (pp. 173–205). Alexandria, VA: Association for Supervision and Curriculum Development.

DeMiranda, M. A., & Folkestad, J. E. (2000). Linking cognitive science theory and technology education practice: A powerful connection not fully realized. *Journal of Industrial Teacher Education.* Retrieved from http://scholar.lib.vt.edu/ejournals/JTE/v37n4/demiranda.html

Dewey, J. (1933). *How we think* (Rev. ed.). New York: Heath.

Dewey, J. (1938). *Experience and education.* New York: Heath.

Dewey, J. (1964). John Dewey on education (R. D. Archambault, Ed.). Chicago: The University of Chicago Press.

Dewey, J. (1973). *The philosophy of John Dewey* (J. J. McDermott, Ed.). Chicago: The University of Chicago Press.

Hansen, R. E. (2000). The role of experience in learning: Giving meaning and authenticity to the learning process in schools. *Journal of Technology Education,* **11**(2), 23–32.

Petrina, S., & Volk, K. (1995). Industrial arts movement's history, vision, and ideal: Relevant, contemporary, used but unrecognized—Part I. *Journal of Technology Studies,* **21**(1), 24–32.

Schell, J. W., & Black, R. S. (1997). Situated learning: An inductive case study of a collaborative learning experience. *Journal of Industrial Teacher Education,* **34**(4), 5–28.

Stern, D. (1998). Situated learning in adult education. Retrieved from http:www.ed.gog/databases/ERIC_Digests/ed418250.html (ERIC Digest No. 195, ED 418250)

Sternberg, R. J. (1998). Principles of teaching for successful intelligence. *Educational Psychologist,* **33**(2–3), 65–72.

Zuga, K. F. (1992). Social reconstruction curriculum and technology education. *Journal of Technology Education,* **3**(2). Retrieved from http://scholar.lib.vt.edu/ejournals/JTE/v3n2/html/zuga.html

Zuga, K. F., & Bjorkquist, D. C. (1989). The search for excellence in technology education. *Journal of Technology Education,* **1**(1). Retrieved from http://scholar.lib.vt.edu/ejournals/JTE/v1n1/zugabjor.jte-v1n1.html

Problem-Solving Abilities Produced in Project Based Technology Education

Jun Moriyama, Masashi Satou, and Cyril T. King

The purpose of this study was to determine and clarify the relationships between the structure of learning activities and the development of problem-solving abilities in project based technology education in Japan.

There is a range of approaches that support teaching-learning processes in technology education, for example, the project based approach, modular approach, integrated approach, and so on. One of the most popular and current approaches in the United States is the modular approach, which typically provides students with guidance and resources for activities and evaluation. Students rotate from station to station, for example, CAD, CNC, robotics, and so on (Daugherty, 1998). The integrated approach is an instructional method that incorporates the idea of unity between forms of knowledge and respective disciplines (Pring, 1973). This approach also emphasizes the need for inter-disciplinary learning and its connection with the real world (Loepp, 1999).

On the other hand, the project based approach is a method that gives students the opportunity to work in a "plan-do-see" manner, using tools, machines, materials, and processes. The project can be defined as a constructive activity with a purposeful action. This well-established approach, the origin of which can be found in the American progressive education movement, expanded throughout the world during the 20th century as a result of international reforms in education (Knoll, 1997). In Japan, most technology teachers in junior high schools have adopted the project based approach rather than the modular approach or integrated approach.

The Japanese Ministry of Education, Science, Sports and Culture (MESSC) published the *Course of Study* in 1998. This publication has provided the framework for the current curriculum in Japan (MESSC, 1998a). The objective of technology education in Japan is "to make students understand the role of technology, acquire knowledge and skills of manufacturing, energy utilization and computing, and develop the abilities and attitudes to use the knowledge and skills effectively." The *Course of Study* also recommended instruction based on practical and empirical projects and purposeful problem solving. It was also expected that, through this strategy, students would develop a sense of pleasure in undertaking projects.

One example of the project based approach was implemented in Nagano Junior High School, attached to Shinshu University. Within the scope of the project, students decided that they would send some gifts to students in a special school near the junior high school. The students visited the special school in order to research the requirement. They were divided into six teams of six students, and each team developed its plans for the gifts and manufactured the products. The students spent a total of three months on the project. On completion of the project, they sent the gifts, consisting of shoe boxes, shelves, a magazine rack, and so on, to their handicapped friends in the special school (Moriyama et al., 2001). Further projects, involving the development and making of a CD rack, pencil holder, Web site, lamp, and moving toys, were implemented throughout Japan. At the same time, student involvement in other design and implementation projects, particularly a robot contest, also increased gradually The project based approach, such as that involved in the above examples, has various learning activities, and students can develop their problem-solving abilities through experience in each learning activity. However, it is obvious that the project based approach needs particular levels of student competencies. Jyou (1992) examined the structure of students' self-evaluation competencies and suggested that these competencies supported learning activities as metacognition. These relationships can be demonstrated as outlined in Figure 1.

Practices adopted in the project based approach need to be evaluated

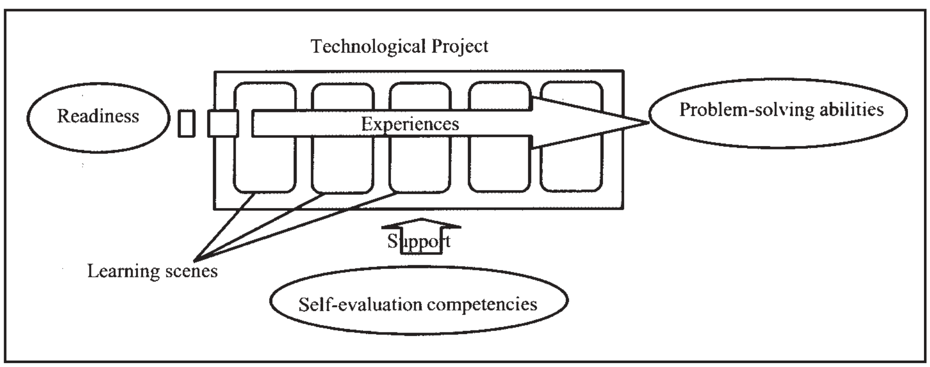


Figure 1. The search model.

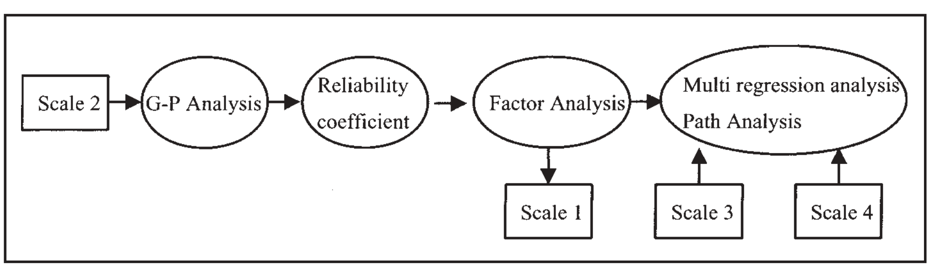


Figure 2. The procedure for data analysis.

from the viewpoint of whether they succeed in promoting problem-solving abilities or not. However, so far there have been no studies that have tried to clarify the influences of each of the factors shown in Figure 1. It is expected that the relationships should suggest the feature of the project based approach. Therefore, the goal of this study was to answer the following questions:

- What kind of learning activities are involved in a technological project at the junior high school level?
- How do students' self-evaluation competencies support their learning activities?
- How do students' learning activities contribute to the development of their problem-solving abilities?

Methodology

Subjects

The subjects for the study were 544 junior high school students (1–3 grades) in Nagano Prefecture, Japan. These subjects had studied woodworking in Grade 1, electronics in Grade 2, and agriculture, metalworking, and information basics in Grade 3.

Instruments

Three scales used in the study measured (a) students' learning activities, (b) students' self-evaluation competencies, and (c) students' problem-solving abilities. Following is a description of the scales used in this study.

Scale 1: Learning Activities

According to the DeLuca (1992) problem-solving model, five activities are related to workers' technological projects: trouble shooting, scientific process, design process, project management, and research and development. While the process of R&D is not included in Japanese technology education at the junior high school level, trouble shooting, scientific process, design process, and project management are included. Therefore, four activities and 19 associated statements, excluding reference to the R&D, were selected for this study as follows:

- Trouble shooting: Isolate the problem, identify possible causes, implement a solution, test the solution.
- Scientific process: Observation, develop hypotheses, experimentation, draw conclusions.
- Design process: Ideation, brainstorming, identify possible solutions, prototyping, final design.
- Project management: Identify tasks to reach goal, develop a plan to accomplish tasks in each classroom activity, plan a sequence of procedures in each task, implementation of the plan, evaluation of the implementation, modification of the plan.

Subjects answered the 19 statements, choosing one of the four responses: 4 (*I have experienced that a lot*), 3 (*I have experienced that a little*), 2 (*I have almost no experience of that*), 1 (*I have not experienced that at all*).

Scale 2: Self-Evaluation Competencies

According to the results of an investigation by Jyou (1992), three factors are involved in students' self-evaluation competencies. In this study, six statements that would obtain a high factor loading from each factor were selected. The three factors and associated statements included:

- Competencies in self-monitoring: Analyzing myself objectively, understanding my own characteristics, understanding my own abilities.
- Intentions to reach the goal: Progressing to learn individually, strong motivation, investigating unknown things individually.
- Competencies of creating criterion: Understanding functions of self-evaluation, utilization of results of self-evaluation, discovering the learning strategies by myself.

Subjects answered the statements, choosing one of the three responses: 3 (*I think I have that competence very much*), 2 (*I think I am average*), 1 (*I think I don't have that competence at all*).

Scale 3: Problem-Solving Abilities

MESSC (1998b) defined concepts of problem-solving abilities in Japanese technology education as abilities in discovering tasks from daily life, considering various solutions, gathering information, decision making, implementing according to the selected plan, evaluating the results of implementation, and having the responsibilities for these results. Based on these concepts, the following eight

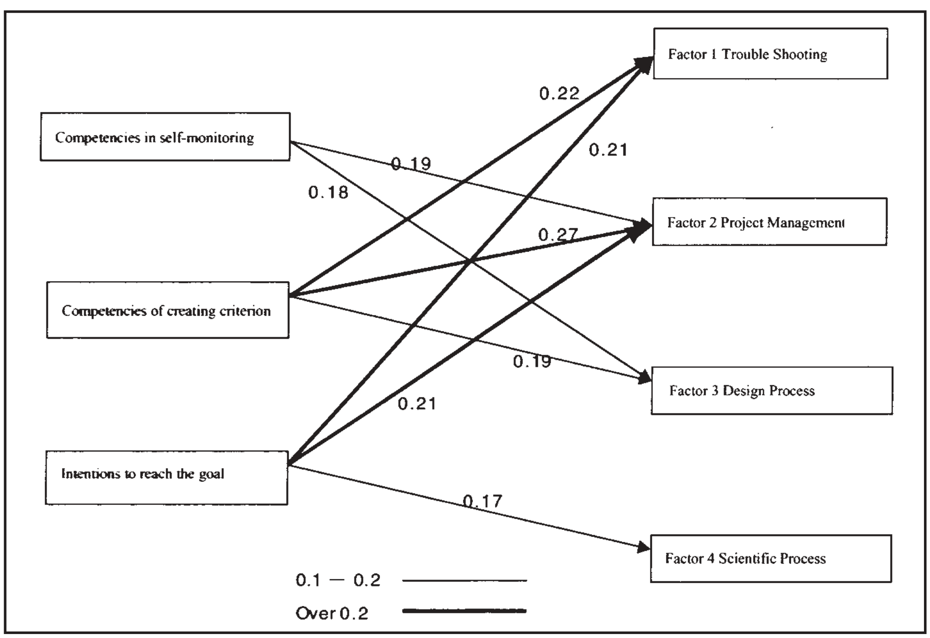


Figure 3. Path diagram between self-evaluation competencies and structure of learning scenes.

statements were prepared for this study:

- An ability in observing from daily life.
- An ability in discovering tasks by oneself.
- An ability in developing new ideas.
- An ability in judging the correct method.
- An ability in making the plan adequately.
- An ability in implementing effectively.
- An ability in devising improvements.
- An interest in technological equipment or devices.

Subjects answered these statements, giving one of the following responses: 3 (*I think I get that ability through my project*), 2 (*I think I am average*), 1 (*I think I don't get that ability through my project at all*).

Data Analysis

The procedure for data analysis is shown in Figure 2. First, the item discriminating powers of each statement in Scale 1 were analyzed by G-P analysis (both 50%). Also, the reliability of this scale was confirmed by the reliability coefficient obtained by using the KR-20 (Kuder-Richardson) formula. Next, a factor analysis using the principal factor method and normal varimax rotation was implemented in order to determine the structure of learning activities in students' projects. Additionally, path analyses were employed for considerations of contributions of the self-evaluation competencies to the learning activities and the learning activities to the problem-solving abilities.

Results and Discussion

As a result of the investigation, we obtained 472 effective answers (86.8% of the total). The item discriminating powers and reliability were confirmed on Scale 1 (KR-20 = 0.83).

The Structures of Learning Activities in the Project at the Junior High School Level

As a result of factor analysis, four factors were found: Factor 1: Trouble Shooting, Factor 2: Project Management, Factor 3: Design Process, and Factor 4: Scientific Process (see Table 1). However, brainstorming, prototyping, and drawing conclusions were not loaded on each factor. The mean scores of brainstorming and prototyping were indicated as low level, and it appeared that Japanese technology teachers were not giving students enough opportunities for these learning activities. By contrast, the mean score of drawing conclusions was indicated as high level and seemed to be an everyday occurrence in the classroom. It was evident that the structure of learning activities in the project based approach was coincident with that of the modified DeLuca model which was constructed from four factors. Also, the order of mean scores of these factors indicated that manufacturing activities were central to the students' projects. However, scientific or analytical exploration, associated with technological concepts, was only slightly experienced by students, $F(3,1884) = 52.12, p < 0.01$.

Self-Evaluation Competencies Support the Learning Activities

In the path analyses between self-evaluation competencies and their learning activities, strong paths from *competencies of creating criterion* and *intentions to reach the goal* to Factor 1 (Trouble Shooting) were obtained. Also, the paths to Factor 2 (Project Management) were obtained from all self-evaluation competencies. Regarding Factor 3 (Design Process), there were weak paths from *competencies of self-monitoring* and *competencies of creating criterion*. However, the only path to Factor 4 (Scientific Process) was from *intentions to reach the goal*, whose effect was weak (see Figure 3).

These results suggest that the students' projects were supported by self-evaluation competencies and, especially, that students' strong motivation to reach their goals and generating their own criteria contributed to their performances in the areas of trouble shooting and project management.

Project Based Approach Produces Problem-Solving Abilities

Trouble shooting and project management. The results of path analyses between the learning activities and the problem-solving abilities, contributions of Factor 1 (Trouble Shooting) and Factor 2 (Project Management), are indicated in Figure 4. The strong paths from Factor 1 (Trouble Shooting) are directed to *an*

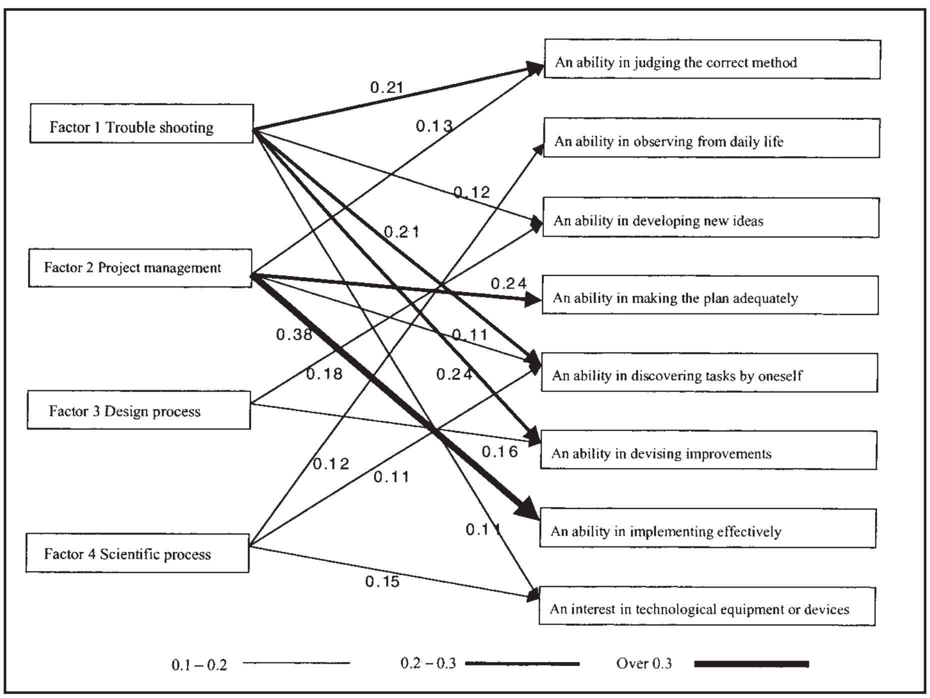


Figure 4. Path diagram between learning scenes and problem-solving abilities.

ability in judging the correct method, *an ability in discovering tasks by oneself*, and *an ability in devising improvements*. Weak paths from Factor 1 to *an ability in developing new ideas* and *an interest in technological equipment or device* were also obtained. Strong paths from Factor 2 (Project Management) to *an ability in implementing effectively* and *an ability in making the plan adequately* were obtained. Weak paths from the same factor to *an ability in judging the correct method* and *an ability in observing from daily life* were also obtained.

It is particularly obvious that students' experiences of project management and trouble shooting, which were supported by their competencies of creating criterion and intentions to reach the goal, indicated strong and wide effects on the development of abilities in discovering the task, planning, improving, and judging.

Design and scientific processes. Additionally, the results of path analyses on Factor 3 (Design Process) and Factor 4 (Scientific Process) are shown in Figure 4. The weak paths from Factor 3 (Design Process) were directed to *an ability in developing new ideas* and *an ability in devising improvements*. It is evident that students' experiences of design process, which were supported by their competencies in self-monitoring and creating criterion, indicated distinctive effects on the development of creative problem-solving abilities. There were also weak paths from Factor 4 (Scientific Process) to *an ability in observing from daily life*, *an ability in discovering tasks by oneself*, and *an interest in technological equipment or devices*. It is conjectured that scientific process, which was supported by their intentions to reach the goal, indicated the effects on development of abilities in exploring daily life from the viewpoint of technology. In previous analyses, it was suggested that scientific or analytical learning was not easy to adopt into a technological project that gives weight to manufacturing. However, this result means scientific process can give students the start points of their technological projects.

Concluding Comments

In this study, the relationships among the structure of learning activities, students' self-evaluation competencies, and problem-solving abilities in a project based approach of Japanese technology education were investigated. The main findings of the analyses are as follows:

1. Students' projects at the junior high school level were constructed from four types of learning activities: design process, scientific process, troubleshooting, and project management. However, scientific and analytical exploring of technological concepts was not significantly experienced by students in their projects.
2. It was suggested that students' projects were supported by self-evaluation competencies, especially students' strong motivation to reach their goal and generating their own criteria, contributing to their performances in trouble shooting and project management.

Table 1. Results of Factor.

Item	Rotated factor loading*				Communality	Score	
	Factor 1	Factor 2	Factor 3	Factor 4		Mean	S.D.
Trouble Shooting							
Isolate the problem	-0.60				0.45	2.70	0.96
Identify possible causes	-0.71				0.55	2.53	0.94
Implement a solution	-0.66				0.48	2.57	1.00
Test the solution	-0.63				0.51	2.31	0.96
Project Management							
Identify tasks to reach goal		0.54			0.40	2.59	0.83
Develop a plan to accomplish task in each classroom activities		0.57			0.34	2.71	0.89
Plan a sequence of procedure in each task		0.58			0.37	2.64	0.90
Implementation of the plan		0.59			0.42	2.77	0.87
Evaluation of the implementation		0.47			0.27	2.43	0.90
Modification of the plan		0.41			0.30	2.65	0.86
Design Process							
Ideation			0.68		0.51	3.05	0.95
Identify possible solutions			0.54		0.41	2.75	0.94
Final design			0.64		0.49	2.82	0.91
Brainstorming					0.23	1.95	0.97
Prototyping					0.14	1.97	1.17
Scientific Process							
Observation				0.53	0.41	2.34	0.85
Develop hypotheses				0.54	0.39	2.06	0.92
Experimentation				0.44	0.20	2.56	1.01
Draw conclusions					0.10	2.72	1.08
Eigenvalue	2.08	2.06	1.60	1.23			
Contribution	0.11	0.11	0.08	0.06			
Cumulative of contribution	0.11	0.22	0.30	0.37			

*Only loadings with values > |0.40|

3. It was suggested that the accumulation of experiences of these learning activities in students' projects promoted the development of technological problem-solving abilities related with plan-do-see. It was particularly evident that students' experiences of project management and trouble shooting have strong and wide effects on the development of the abilities of discovering the task, planning, improving, and judging. Also, design and scientific processes contributed to promoting abilities of creative problem solving and exploring daily life with a technological view, respectively.

These results show the features of the project based approach. When the aim is to develop students' technological concepts with scientific exploration, the modular approach has an advantage, as clear objectives, guided procedures, and well-prepared resources are set in place. However, this approach is not adequate for the development of the abilities of practicing plan-do-see over a period of a few months, because such an approach is designed to last for a period of 5 to 10 days. On the other hand, when the aim is to link the learning content of technology education with other disciplines, a project based approach is so specialized that learning content cannot be systematized. However, these two different approaches can be integrated into the curriculum as an interdisciplinary project. Another possible approach is the close linking of science and technology education as an alternative solution that may compensate for the absence of the project based approach.

From this viewpoint, it can be assumed that the most effective approach is the combination of various teaching-learning processes, where the disadvantages of one approach are supplemented by the advantages of other approaches. For the future, methods of combining different types of teaching-learning processes must be considered, and methodology for curriculum evaluation, from the viewpoint of promoting technological abilities, must be developed in Japan.

Dr. Jun Moriyama is an associate professor in the Department of Information and Technology Education, Faculty of Education at Shinshu University, Nagano, Japan. He is a member of the Omicron Field Chapter of Epsilon Pi Tau.

Dr. Masashi Satou is a technology teacher at Achi Junior High School, Nagano, Japan.

Dr. Cyril T. King is a technology adviser at South Eastern Education and Library Board, Northern Ireland, U.K. He is a member-at-large of Epsilon Pi Tau.

References

Daugherty, M. K. (1998). *Introduction to teaching technology*, Normal, Illinois State University.

DeLuca, V. W. (1992). Survey of technology education problem solving activities. *The Technology Teacher,* **51**(5), 26–30.

Jyou, H. (1992). Structure and development stage of students' self-evaluation competencies. *Journal of Japanese Society of Technology Education*, **34**(1), 7–14. (In Japanese)

Knoll, M. (1997). The project method: Its vocational education origin and international development. *Journal of Industrial Teacher Education,* **34**(3), 59–80.

Loepp, F. L. (1999). Models of curriculum integration. *Journal of Technology Studies*, **25**(2), 21–25.

Ministry of Education, Science, Sports and Culture of Japan. (1998a). C*ourse of study for junior high schools in Japan.* Tokyo, Japan: Printing Office of Ministry of Financial Affairs. (In Japanese)

Ministry of Education, Science, Sports and Culture of Japan. (1998b). *Development of instruction for promoting students' problem-solving abilities in industrial arts and home making education—Agriculture and information basis*. Tokyo, Japan: Kaibundo. (In Japanese)

Moriyama, J., et al. (2001). A curriculum evaluation of collaborative project based on the analysis of learning activities for problem-solving in technology education. In *Annual reports of joint research of faculty of education and attached schools* (pp. 197–203). Nagano, Japan: Shinshu University. (In Japanese)

Pring, R. (1973). Curriculum integration. In R. S. Peters (Ed.), *The philosophy of education* (pp. 123–149). London: Oxford University Press.

The 2001 Paul T. Hiser Exemplary Publication Award Recipients

Anthony I. Akubue
"Gender Disparity in Third World Technological, Social, and Economic Development"
and
Marie Hoepfl
"Alternative Routes to Certification of Technology Education Teachers"

The Board of Editors of *The Journal of Technology Studies* and the Board of Directors are pleased to announce the recipients of the Paul T. Hiser Exemplary Publication Award for Volume XXVII, 2001.

The Board of Directors established this award for deserving scholars. In recognition for his exemplary service to the profession and to the honorary as a Trustee and Director, the award bears Dr. Hiser's name. It is given to the author or authors of articles judged to be the best of those published each year in this journal.

Selection Process

Each member of the Editorial Board recommends the manuscript that he or she considers the best of those reviewed during the year. The editor forwards copies of nominated manuscripts to the members of the board for their evaluation against the criteria.

A majority vote of the editors is required for the award to be made. The honorary's Board of Directors renders final approval of the process and the award.

Criteria

1. The subject matter of the manuscript must be clearly in the domain of one or more of the professions in technology.

2. The article should be exemplary in one or more of the following ways:
   - Ground-breaking philosophical thought.
   - Historical consequence in that it contains significant lessons for the present and the future.
   - Innovative research methodology and design.
   - Trends or issues that currently influence the field or are likely to affect it.
   - Unique yet probable solutions to current or future problems.

A $300 award recognizes the recipient(s) for the year and is presented during an Epsilon Pi Tau program at an annual professional association conference.

GUIDELINES FOR AUTHORS

The Journal of Technology Studies

A refereed publication of Epsilon Pi Tau the international honorary for professions in technology.

Members of the technology and related professions are invited to submit manuscripts for consideration by our referees and editors. The journal is an open forum for the exchange of relevant cutting-edge ideas. Although sponsored by Epsilon Pi Tau, membership status plays no role whatsoever in the review, acceptance, rejection, or editorial interaction with prospective authors.

BACKGROUND

These guidelines reflect the commitment and interest of the Board of Editors to team with authors in developing their manuscripts to meet the standards of excellence of *The Journal of Technology Studies*.

Topics spanning the breadth of technology are welcome and are measured by the extent to which they contribute to the fulfillment of Epsilon Pi Tau's purposes. These are to:

- promote and recognize the achievement of academic excellence;
- promote the values and contributions of professionals in technology;
- provide a medium for the professional development and recognition of individual members for leadership and achievement;
- enhance the status of practitioners and professionals in technology;
- foster the ideals of technological competence and skill, social and professional proficiency, and valuing research and using its products wisely; and
- advance appreciation and awareness of technology as both an enduring and influential human endeavor and an integral element of culture.

MANUSCRIPTS SHOULD

- conform to the standards specified in the Publication Manual of the American Psychological Association's (APA) latest edition.
- avoid writing that is pedantic and follows traditional research report format with figures and tables in favor of professional level scholarly writing that is journalistically lively, effectively descriptive, and in a format that is original, fitting, and unique to the particular content.
- not be published in any form (other than conference presentations or proceedings) prior to scheduled publication in *The Journal of Technology Studies*. If your manuscript is under consideration by another publication, you must communicate that fact to the editor when you submit your article.
- cover the topic adequately with appropriate citations, illustrations, reference lists, and (only if absolutely necessary) figures and tables, and fit in one of the following categories:
  1. 15 to 20 pages, with the font set in 12 point Times, double spaced, 3,500 to 5,000 words.
  2. 10 pages or less double spaced, no more than 2,000 words. Articles of this length may be included in the journal's IDEAS section. These provide a quick focus or "bite" on events, issues, trends, or refreshing points of view.

PREPARING AND SUBMITTING YOUR WORK

1. Use a word-processing program to prepare your manuscript. We prefer Microsoft Word. Save your document as a Rich Text Format (RTF) file, which retains your formatting and can be read across PCs and Macs. We will also accept Microsoft Works and Pagemaker. Do not imbed figures, tables, photographs, and illustrations into your word-processing document. They must be separate and individual items whether on disk or email attachments. They should be saved as .eps or .tiff files. They should have 300 dpi resolution so they reproduce well.
2. Submit your work using one of the following methods:
   - 2.1 by regular mail: send three double-spaced hard copies and a diskette with your RTF file to the mailing address below.
   - 2.2. via email: send manuscripts as attachments to email messages to the email address below.
3. Provide your current position title/rank, institution, organization or company name, research interests, and if an Epsilon Pi Tau member, chapter name or member-at-large.
4. All items that you submit are nonreturnable.

Send manuscripts and other inquiries to:

The Journal of Technology Studies
International Office of Epsilon Pi Tau
Technology Building
Bowling Green State University
Bowling Green, OH 43403-0305
or
jots@bgnet.bgsu.edu

REVIEW AND EDITORIAL PROCEDURES

The Journal of Technology Studies

A refereed publication of Epsilon Pi Tau the international honorary for professions in technology.

The editorial board and staff see themselves as part of a team with authors who submit informative, topical, and cutting-edge manuscripts. The following outlines the collaborative process and procedures we follow as we work with authors.

THE BEGINNING

When we receive your work, we conduct a preliminary review to ensure that you have followed our guidelines. Approximately one month after receipt, we send you an acknowledgment that includes the editor's views of your work. At this point, you are not expected to make any changes in your material. The manuscript is then entered into the referee process.

THE REFEREE PROCESS

1. Your manuscript will be carefully reviewed by at least two referees and the editor.
2. Referees make an initial assessment of the topic. If it is considered inappropriate for *The Journal of Technology Studies*, we will inform you that we have stopped our review work.
3. If the topic is appropriate, referees will continue their review basing it on the qualitative aspects of our guidelines. They will apply such criteria as timeliness, clarity of ideas, importance of the topic and research question, value to our readers, accuracy, style and/or organization of presentation and/or research design, and format.
4. Three to four months after receipt of your manuscript, you will receive a report of the referee process that will include one of the following:
   - 4.1 A **disagreement** among the reviewers that requires us to obtain a third review. You will be informed that it will take two to three additional months to complete the review.
   - 4.2 **Publish with revisions.**
   - 4.3 **Publish.**
   - 4.4 **Do not publish.** We will provide you with a complete report of the review and suggestions regarding possibilities for the material including major revision that if undertaken and resubmitted, will be treated as a new submission. We may recommend other venues you may pursue to have your work published.

TOWARD PUBLICATION

1. When you are notified that the article has been accepted (the reviewers and editor have recommended **"Publish"** or **"Publish with revisions"**), you will receive recommendations.
2. You should follow the suggestions and recommendations in our report, make all corrections and revisions, and provide all information requested.
3. You should resubmit the revised material. Refer to our "Guidelines for Authors" for the proper procedures to send your revised article.
4. We check your work and then put your article in journal format as a "galley."
5. We send you the "galley," any additional queries we have, and "sign-off papers." You respond to the queries, fine-tune, and make last-minute changes and suggestions about the galley (these should be minimal at this stage). You return your work on the galley and the "sign-off papers."
6. Our editorial team will make final corrections.
7. As soon as the article is ready, we publish it on the World Wide Web (www) and provide the author(s) with a hard copy.
8. Our production coordinator will assemble an issue from articles accumulated on the Web during the calendar year.
9. We do a final editorial review of the assembled issue.
10. We will publish the assembled issue on the www and also print and mail copies to authors and our subscribers.

In all processes, the editor of *The Journal of Technology Studies* will be the final arbiter should any professional disagreement arise. Authors are assured that the editor will approach this responsibility in an objective and professional manner.

Send inquiries and manuscripts to:
The Journal of Technology Studies
International Office
Technology Building
Bowling Green State University
Bowling Green, OH 43403-0305
or
jots@bgnet.bgsu.edu