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From the Editor

Thoughts on the Electronic JTE

Lately, I have begun to wonder if the *Journal of Technology Education* is a printed journal that is also available electronically, or an electronic journal that is also available in print. Since its inception in 1983, the JTE paid subscription list (for the print version) has grown to about 550 professionals in more than 15 countries around the world. While not a particularly large following for a professional journal, this number represents the majority of those who call themselves "technology teacher educators," the group toward whom the JTE was originally directed. Now, however, with the advent of the electronic version of the JTE, the audience has become quite a bit larger.

In the fall of 1991, Associate Editor Jim LaPorte and I met with the Scholarly Communications Project (SCP) here at Virginia Tech. They were interested in providing technical support for the publication of scholarly electronic journals and we were interested in reaching a larger population. Thus, when Volume 3, #2 of the JTE went to press in early February, 1992, I began working closely with the SCP to publish an electronic version of the JTE (hereafter referred to as the E-JTE). Together, we worked out a variety of formatting and technical considerations that would enable electronic publication of the Journal. Since there were literally only a handful of scholarly electronic journals at that time, we were "making it up as we went along." About a month later, when the hard copy version was rolling off the presses, the electronic JTE was on-line and accessible around the world via an electronic distribution scheme known as "listserv."[1] This fact was noted in the hard-copy version, and promoted on the internet electronically.

The E-JTE was, from the beginning, an experiment of sorts. While only a small percentage of technology education professionals were actively using internet, the idea of worldwide distribution was very attractive. We went into it with a "what can we lose" attitude. What we didn't realize was how much there was to gain!

Now, less than two years later, one *could* describe the Journal as an electronic journal that is also available in print, rather than the other way around. For the first time, I am consciously aware of the fact that the majority of those reading these words are likely reading a computer monitor, rather than the

[1]Listserv is an electronic mail distribution system on the internet.

printed page. If you think that isn't the case, consider the following statistics on electronic access of the E-JTE.

At last count, we had 1160 subscribers to the E-JTE listserv. Each time a hard copy of the JTE is released, these listserv subscribers all over the world (you know who you are) automatically receive an electronic notification of the E-JTE, just as they would receive any other electronic mail message. Listserv subscribers may then use the "get" command to retrieve any of the articles in a particular issue as a file or as an e-mail message.

While there are roughly twice as many E-JTE listserv subscribers as there are subscribers to the JTE in print, listserv access represents only the tip of the iceberg. The E-JTE is also accessible electronically via a number of other now-popular internet access strategies. These include FTP, Gopher, Wide Area Information Server (WAIS) and World Wide Web (WWW).[2]

The electronic access data for calendar year 1993[3] are illuminating. In addition to those who used listserv to acquire the E-JTE, 4679 individuals retrieved E-JTE files using FTP. An additional 6018 "gophered" to the JTE, and 1783 individual WAIS searches resulted in 13,601 E-JTE file retrievals. Thus, a total of 13,640 individuals retrieved some 24,298 E-JTE files during 1993. Dividing by two to take care of the fact the E-JTE is issued twice a year, that suggests about 12 times as many individuals accessed the Journal electronically as picked it up out of their mailbox! And with the exponential increase in internet use of late, these figures will undoubtedly be surpassed in the coming year.

It is important to note the differences between the two audiences. Excluding libraries, virtually all of those who purchase the JTE in print are professionals in the field now known as "technology education." Their primary task is teaching the youth of the world *about* the many different technologies that confront them in their daily lives. These include communication technologies such as computers, print and broadcast technologies; production technologies (e.g. robotics, computer control, the materials and processes of industry, etc.) power and transportation technologies, and so forth.

I mention this for the benefit of the E-JTE readers, most of whom are *not* in the field of "technology education." While I do not yet have hard demographic data on E-JTE readers (I'm currently in the process of finalizing a survey to collect these data), it *appears* from my analysis of the listserv subscription list that you electronic readers are librarians, computer scientists, tech-

[2]For those unfamiliar with these internet access strategies, FTP (file transfer protocol) is an internet utility for transferring files from one computer to another. Gopher is a menu driven system for accessing text and other data on the internet. WAIS is a full text indexing and natural language query system and WWW is a hypertext system that allows access to digital text, graphics, audio and video files.

[3]All data are from January-December 1993, except the Gopher data, which are from March-December 1993.

nologists, computer hackers, and above all, very curious people from all over the world (please forgive me) "hitchhiking on the information superhighway." My guess is that many of you did a keyword search on "technology" which caused a "hit" on the E-JTE or else you thought the E-JTE might be a journal for and about computing education.

Regardless of how and why you internauts landed the E-JTE on your monitor, I am delighted you are giving the Journal a look. Though this Journal is not about computer education specifically, I think you will find articles here that relate to computer education, since technology teachers teach more computing applications in grades 6-12 than do any other school subject teachers. In this issue, for example, you may find Susan Seymour's article on Operative Computer Learning of particular interest. But you will also find articles and research relating to all aspects of technology education, not just the computer component.

Since spring, 1992 when the E-JTE was first released, our subscription list for the printed JTE has roughly doubled, so perhaps some of you are subscribing to the JTE after reading the E-JTE. Obviously, there are advantages to each. The printed version provides "off the shelf" access and a more lasting record, while the E-JTE currently costs nothing and may be accessed readily from around the world.

Electronic distribution of the Journal has thus far been very successful. But it is unrealistic to think that electronic information will remain free forevermore on the internet. The question as yet unanswered is, who will in fact pay for electronic dissemination of information? Or, more specifically, who will pay for the E-JTE? The two professional associations that sponsor the JTE (the International Technology Education Association and the Council on Technology Teacher Education), among others, are interested in the answer to that question. For now, of course, you E-JTE readers don't have to make this call. But sometime soon you may have to decide if you are just hitchhiking, or are willing to pay bus fare. Until then, we are delighted to have you along for the ride.

MS

Letters and editorials relating to the issue of charging for the E-JTE or any other topic of interest to JTE readers may be sent directly to Mark Sanders, JTE Editor via msanders@vt.edu.

Articles

A Comparison of Second-Year Principles of Technology and High School Physics Student Achievement Using a Principles of Technology Achievement Test

John C. Dugger and Ronald L. Meier[1]

Many American companies are now faced with the toughest choices that they will ever have to make. They can continue to surrender entire industries to foreign competition, or make a philosophical break from the past by rethinking and restructuring the way they do business. While a few U.S. companies have made the break from the past, innovative companies like Xerox, Proctor and Gamble, Tektronix, General Mills, and Federal Express have implemented new strategies which emphasize continuous improvement, rapid response to market needs, self-directed work teams, and in-plant employee training and development programs (Orsburn, Moran, Musselwhite & Zenger, 1990).

American companies are seeing a continual blurring of job tasks and assignments which is resulting in a need for more functionally cross-trained employees that can blend both academic and vocational/technical skills with new skills. Companies want employees to possess skills not only in technical areas, administration, and communications (both oral and written), but also group problem solving and statistics.

According to Workforce 2000 and the National Commission on the Skills of the American Workforce, until very recently no society has needed more than 25 percent of its labor pool to possess formalized information handling skills. But, by the year 2000, 75 percent of all U.S. jobs will require not only the three “R's”, but also the four “C's”: communications, computation and computer competency (Edwards & Snyder, 1992).

Today, high school and college graduates are exposed to the basic skills (i.e. three “R's” and four “C's”). However, employers indicate that many graduates do have problems with work tasks (Edwards, 1992). While work tasks are often clear-cut applications of students' basic learning, they are often quite

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complex, densely detailed, and job-specific. The process of how to provide real-world application oriented training in the basic skills has been a well documented research problem since the 1930's, but only recently has it been the focus of federal legislation.

The 1990 Carl D. Perkins Vocational and Applied Technology Act pro--vided $1.6 billion in federal funding to improve vocational programs. The Perkins Act hopes to accomplish this by making vocational funding contingent upon the integration of academics into vocational programs. These programs must be able to prepare our current and future workforce with the skills needed to function in a technologically advanced society. Some vocational education programs are attempting to meet the Perkins guidelines by emphasizing academic concepts in their existing programs.

The academic areas of science and mathematics are being integrated into the vocational curriculum not only to meet Carl Perkins requirements, but as a means of providing students with an increased level of computational and computer experiences. Physics and mathematics principles are currently the primary content for two model programs which stress interdisciplinary content areas and their connections to technology. These two programs are Phys-Ma-Tech and Principles of Technology. Both programs offer content examples which draw heavily from the academic subject areas of math and physics.

Traditionally many vocational/technical programs have components in electricity/electronics, fluid power systems, mechanical systems and occasionally thermal energy systems. These components have been delivered in physics classes, Principles of Technology classes, as well as within traditional vocational/technical education programs. What has been lacking in at least two of these delivery vehicles is the development of an integrated system of principles that allows students to relate similar concepts and utilize transferability of the science and math content being taught (Songer & Linn, 1991).

This process of organizing information into broader categories and into more widely applicable ideas results in knowledge integration. According to Songer and Linn (1991), students develop integrated understanding by:

1. Applying pragmatic principles (conceptual) or abstract principles that summarize experiments and;
2. Analyzing prototypes (laboratory exercises) that familiarize situations that illustrate a class of scientific events.

Currently vocational/technical educators have at least three possible methods to integrate physics concepts into the vocational/technical program. These three options include: 1) adding physics content to existing vocational/technical courses; 2) requiring vocational/technical students to take existing physics courses; and 3) creating a new applications oriented physics course, or developing a course that will give students a foundation for continued learning about technology using a delivery system that focuses on lab experiences to reinforce the course content (Principles of Technology, 1985a). Vocational/technical educators choosing option three often use the Principles of Technology Program.

Principles of Technology utilizes an interdisciplinary approach that combines technology, applied physics, and applied mathematics. Upon examining the organizational matrix of Principles of Technology (see Figure 1) one can see the unifying principles that serve as unit organizers in the curriculum (Principles of Technology Curriculum, 1985b). The interdisciplinary nature of Principles of Technology provides a model for both academic and vocational/technical courses.

First Year Units	Second Year Units
Force	Momentum
Work	Waves and Vibrations
Rate	Energy Converters
Resistance	Transducers
Energy	Radiation
Power	Optical Systems
Force Transformation	Time Constants

Figure 1. Fourteen unified technical concepts.

Many times academic courses can be void of any connection to the "real" world, and vocational/technical courses can be lacking the kind of academic mathematics and science content characteristic of broadly applicable curricula. Involvement with the Principles of Technology indicates a commitment to an interdisciplinary approach that emphasizes physics and mathematics (McCade, 1991).

Purpose

The intent of this study was to examine the impacts of the second year Principles of Technology model on achievement regarding basic physics concepts. This achievement was then compared to the achievement of students who were enrolled in high school physics classes during the year of record. The comparison was examined in light of the results of the first year study (Dugger & Johnson, 1992).

Methodology

A nonequivalent groups' pretest/posttest control group design was utilized with two treatment groups. The following figure depicts this design.

Principles of Technology	T_1	X_1	T_2
Physics	T_1	X_2	T_2
Control	T_1		T_2

T_1 = Pre-
T_2 = Post-
X_1 = PT Treatment
X_2 = Physics Treatment

Figure 2. Research Design Model.

Population and Sample

The population for this study was all secondary vocational programs in Iowa where Principles of Technology was offered. With more than 50 sites of implementation, Iowa was a good location for the study. The sites were at various stages of implementation. Sixteen sites had offered the program for two years or more. In order to obtain a better estimate of the effectiveness of the program, only sites that had offered the program for at least three years were utilized. The sample included five Iowa sites.

Of these sites, four programs were being taught by industrial technology education teachers who had participated in one two-week workshop to prepare for teaching the second year of Principles of Technology. The remaining site was taught by a certified Iowa high school physics teacher. During the data collection two programs taught by industrial technology education teachers failed to complete the study because student attrition did not allow the administration of the posttest. Therefore, the sample for this study consisted of three Iowa high schools where Principles of Technology and physics were taught as a part of the regular curriculum.

Instrument Development

As with the first year study, an item bank was generated by instructors that attended Principles of Technology workshops which provided an orientation to second year Principles of Technology units. This item bank was used as the source for the unit tests. The unit tests were then administered to each of the second year sites and scored and analyzed.

An item analysis of the unit tests enabled the researchers to identify the best questions based on difficulty, readability, and discrimination index ratings. These questions were then formed into a second year achievement instrument which included 120 items and covered each of the year-two PT objectives. Kuder-Richardson Formula 20 reliability estimates for both the unit and second year tests exceeded .90.

This test was then examined by six physics teachers to assure that all terminology and content was consistent with physics content as taught in Iowa high schools. Even though the content was consistent, certain Principles of Technology terms were found to differ from terms taught in physics classes. When this occurred, both Principles of Technology and physics terms were included for that test item.

Data Collection and Analysis

The data were collected from three sites in Iowa where second year Principles of Technology and high school physics were being taught. Phase I of the data collection involved administering the 120 item test at the beginning of the school year to 75 physics students, 24 Principles of Technology students, and a control group that consisted of 61 students who were similar to those enrolled in the principles of technology class. In all cases, the control group was an industrial technology education class with no students enrolled in PT.

The second phase of data collection consisted of posttesting which was completed approximately two weeks prior to the end of the school year. Example questions from the posttest can be found in Figure 3.

When a hydraulic cylinder is activated for 4 seconds, the piston applies a force of 70 newtons to the rod during that time period. The change in linear momentum of the fluid moved is:

a. 17.5 N_sec
b. 28 kg_m/sec
c. 175 kg_m/sec
d. 280 kg_m/sec

An angular impulse of 15 (N_m) sec is given to an object. What is the change in angular momentum of the object?

a. 0.15 kg_m^2/sec
b. 15 kg_m^2/sec
c. 150 kg_m^2/sec
d. 15 (N_m) sec^2

Figure 3. Sample questions from posttest.

A 160 lb. man dives horizontally from a 640 lb. boat with a speed of 6 ft/sec. What is the recoil velocity of the boat? The man and the boat were initially at rest.

a. 0.15 ft/sec in the same direction as the diver
b. 15 ft/sec in the opposite direction to the diver
c. 150 ft/sec in the same direction as the diver
d. 1.5 ft./sec in the opposite direction to the diver

When an empty gas bottle (initially at atmospheric pressure) is filled with carbon dioxide, a maximum *gage pressure* of 250 PSI is eventually reached. The process is described by the following equation for absolute pressure:
$P = 14.7 + 250 \text{ PSI } (1 - e^{-t/1 \text{ min}})$.

Nearly 63% of the change from 14.7 PSIG to 250 PSIG occurs in the time of ______.

a. 1 min.
b. 5 min.
c. 1.63 min.
d. none of the above

Figure 3 (continued). Sample questions from posttest.

Results

The means for both pretests and posttests are reported in Table 1. Students

Table 1
Means, Standard Deviation, and T-scores by Group for Pretests and Posttests

	Pretest		Posttest		
	Mean (SD)	N	Mean (SD)	N	T-score
PT	43.66 (8.33)	24	67.71 (12.34)	21	7.76*
Physics	43.06 (8.88)	75	51.60 (9.69)	40	4.74*
Control	34.26 (5.96)	61	37.03 (8.49)	38	1.72

$*p<.01$

who had completed year-one Principles of Technology had some background and were able to score higher than the control group (43.66 to 34.26). The mean score for students enrolled in physics was similar to that of students who had completed year-one of Principles of Technology (43.06 to 43.66). The raw score mean for the control group was significantly lower than the mean of the Principles of Technology and physics groups.

Further analysis of the means indicated that there was no significant difference between the control group pretest mean (34.26) and the control group posttest mean (37.03). This was expected since control groups by definition are not exposed to content delivered to treatment groups.

The posttest mean for the physics group (51.60) were significantly higher than the pretest mean (43.06) for the same group. Similarly, the posttest mean (67.71) was significantly higher than the corresponding pretest mean for the Principles of Technology group. There was a substantial raw score mean difference (16.11) between the Principles of Technology posttest mean and the physics group posttest mean.

A one-way analysis of variance (ANOVA) was conducted to determine if significant differences existed between three pretest groups and the three posttest groups. Table 2 addresses the pretest groups.

Table 2
Pretest ANOVA Table

Source of variation	SS	df	MS	F
Between treatments pretest	3026.85	2	1513.42	24.85*
Error	9562.46	157	60.91	
Total	12589.31	159		

*p<.01

There were significant differences between the Principles of Technology, physics, and control group pretest scores. Table 3 provides an analysis of the one-way ANOVA procedure for posttest means. An LSD procedure indicated that there was a significant difference between the posttest means for both the control (37.03) and physics (51.60) as well as the physics and Principles of Technology (67.71).

Exposure to traditional physics does produce significant achievement gains on a second-year Principles of Technology achievement instrument. Even greater significant gains occur if these students are exposed to a second year Principles of Technology course.

Table 3
Posttest ANOVA Table

Source of variation	SS	df	MS	F
Between treatments posttest	13051.94	2	6527.97	133.66*
Error	9374.72	96	97.65	
Total	22426.66	98		

*p<.01

Discussion

The results for second year Principles of Technology were similar to those determined by Dugger and Johnson (1992) for year one Principles of Technology. Students enrolled in second year Principles of Technology demonstrated a higher level of initial achievement regarding second-year Principles of Technology content. The control group provided a mean score that was closer to that of random chance on a 120 item pretest.

The posttest results indicated that the control group failed to show any gain while both the physics and Principles of Technology students demonstrated a significant increase in achievement levels regarding Principles of Technology content. The raw score mean for Principles of Technology, however, was more than 16 raw score points higher that the physics posttest mean.

Before discussion continues, two critical questions must be answered. They are; Whether Principles of Technology covers basic physics content and if so, is this content also consistent with the content taught in high school physics classes? The titles of the units covered in the Principles of Technology which consist of force, work, rate, etc. and the titles of the systems which include mechanical, electrical, fluid, and thermal certainly provide a strong *prima facie* case for consistency of content. In addition, six physics teachers have confirmed that the Principles of Technology content is consistent with the portion of the high school physics curriculum in Iowa that covers basic concepts. One may conclude that Principles of Technology does cover basic physics content and that high school physics covers both basic and advanced physics content.

It is the belief of the authors that Principles of Technology provides a more detailed treatment of basic physics content than a typical high school physics class. The taxonomy (units and systems) of concepts and provision for application of each point result in greater achievement regarding these basic concepts. This belief is supported by Songer and Linn (1991) who indicated that students developed a better integrated understanding if pragmatic principles are applied and laboratory exercises analyzed. Considering the three possible methods for integrating physics concepts into the curriculum, the third alternative of creating a new applications oriented physics course is certainly a viable alternative based on the results of this study. One needs to be cautious, however, when discussing the relationship of Principles of Technology to high school physics classes. Even though Principles of Technology content is subsumed by the content taught in these classes, physics is asked to do much more.

Future research might investigate whether the repetition of concepts through each of the four systems (mechanical, thermal, electrical, and fluid) enhances learning or the formal theory presentations followed immediately by applications oriented laboratory experiences. Both the repetition afforded by the four systems and the applications based pedagogical approach are present in Principles of Technology. Future researchers should also consider replacing or combining the 120 item PT test with a standardized high school physics achievement test. These appear to be promising areas for future research and may yield answers that have implications for a wide range of content areas or disciplines.

References

Dugger, J. C., & Johnson, D. (1992). A comparison of principles of technology and high school physics student achievement using a principles of technology achievement test. *Journal of Technology Education, 4*(1), p. 19-26.

Edwards, G. (1992). *Bridging school and skills: Preparing basic skills for the workplace by community-based learning*. Paper presented at the meeting of the Iowa International Technology Education Association, Waterloo, IA.

Edwards, G., & Snyder, D, P. (1992). *America in the 1990s: An economy in transition, a society under stress*. Paper presented at the meeting of the Iowa International Technology Education Association, Waterloo, IA.McCade, J. (1991). A few things technology educators could learn from Principles of Technology. *The Technology Teacher, 51*(3), p. 23-26.

Orsburn, J. D., Moran, L., Musselwhite, E., & Zenger, J. H. (1990). *Self-directed work teams: The new American challenge*. Homewood, IL: Business One Irwin.

Principles of technology administrative guide. (1985a). Bloomington, IN: Agency for Instructional Technology (AIT), & Waco, TX: Center for Occupational Research and Development.

Principles of technology curriculum. (1985a). Bloomington, IN: Agency for Instructional Technology (AIT), & Waco, TX: Center for Occupational Research and Development.

Songer, N. B., & Linn, M. C. (1991). How do students' views of science influence knowledge integration? *Journal of Research in Science Teaching, 28*(9), p. 761-787.

Technology Education: AKA Industrial Arts

Patrick N. Foster[2]

Pullias (1989) identified three viewpoints individuals may take regarding the implementation of technology education. One, which will be referred to as the "revolutionary" position here, proposes "to discard the old and begin fresh." (p. 3-4). Another, perhaps "evolutionary," view prefers "to keep part of the old, install part of the new, and 'ease' into full implementation" (p. 3). The third position "is to disguise what we have been doing for years and try to make it look like a new curriculum" (p. 3).

These viewpoints can be correlated directly to positions one may take relative to the historical relationship between industrial arts and technology education. For example, those who hold a revolutionary historical view find few similarities between industrial arts and technology education. Pullias, for example, argued that "blinders are going to have to be removed and educators are going to have to accept the fact that technology education is something totally new. Technology education is not a remake of industrial arts..." (1992, p. 4).

Those holding the evolutionary point of view also see technology education as something new. But they point to industrial arts as the progenitor of technology education. Dugger (1985) suggested a major event as the cause of technology education when he noted that "industrial arts education has undergone a tremendous curriculum thrust that has become identified as technology education" (p. 2). Echoing Dugger, Waetjen wrote:

> The last decade has witnessed a startling change in what was once Industrial Arts Education and has now evolved into Technology Education. The evolution has been more than cosmetic, and far more than a simple change of names (1989, p. 1).

Intrinsically, the terms "startling change" and "tremendous transition" may suggest revolution, but it bears mention that the evolutionary point of view regards industrial arts as the foundation for the change, while the revolutionary stance considers the change as the foundation of technology education.

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Finally, the last position denies that any major revelations have occured in the field recently. Its adherents contend that the theoretical philosophy and methodology of technology education are not significantly different from those of industrial arts. The notion that technology education is simply another name for industrial arts may be termed an “alias” theory. That theory will be explicated here.

The Alias Theory vs. the Revoltionary and Evolutionary Positions

Both evolutionists and revolutionists ascribe the characteristic of *newness* to technology education. Finely distinguished from another of the qualities enjoyed by technology education, that of being contemporary, the characteristic of newness implies invention, as opposed to simple, linear progress.

Arguably, the profession known only a few years ago as “industrial arts” stands to benefit greatly from a public perception of newness. And, rightfully so, it has appeared to undergo a change in name, change in content organization (and to a certain degree, in content as well) and a change in philosophy.

As Waetjen suggested, more than a change in name will be necessary for the profession to realize its true mission. As for organizational changes with respect to content, or modifications in content itself, these are superficially an indication of a substantial transformation. But in light of the evolving nature of the industrial arts they are by no means earthshaking – they may simply represent a contemporization of the field. What seems to be required to validate and complete this change is a revision of the profession’s philosophy. This, the evolutionists and revolutionists seems to be indicating, has in fact happened.

The objective of this paper is to show that, for practical purposes, technology education is simply the appropriate renaming of industrial arts. What the profession defines as “technology education” – in an attempt to distance it philosophically from “industrial arts” – is essentially the definition suggested many times in the past for industrial arts. Furthermore, many of the major teaching methodologies associated with technology education are not new either – they have been suggested in literature as directives for industrial arts for years.

The Philosophy of Technology Education is Not New

Although the most popular and accepted definitions for “industrial arts” and “technology education” may differ in wording, there has been very little difference in meaning between definitions for the two over the last seventy years.

Bonser and Mossman

> Industrial arts is a study of the changes made by man in the forms of materials to increase their values, and of the problems of life related to these changes (Bonser and Mossman, 1923).

This interpretation of the meaning of "industrial arts" was written seventy years ago by Frederick Gordon Bonser and Lois Coffey Mossman of Teacher's College at Columbia University. Lux (1981), characterizing this definition as "famous" and "widely accepted," credited Bonser with leading "a major thrust to redirect industrial arts away from activities and studies based on discrete materials or selected trade skills and toward broader conceptualizations such as how humankind provides itself with clothing, food, and shelter" (p. 211). The definition has three major elements: education, technology, and society (see Figure 1). Industry is not mentioned.

This definition was hardly obscure in Bonser and Mossman's time or ignored since. Smith (1981) wrote of the definition, "even to this day it has created much excitement and given much direction to curriculum development in industrial arts" (p. 188). However, Smith goes on to note, as the definition originally appeared in *Industrial Arts for Elementary Schools*, "many practitioners have found it difficult to make the transition and apply... Bonser's philosophies to industrial arts programs that have traditionally been established in the secondary schools" (p. 188-189). In fact, acceptance of Bonser's ideas may have been hampered by his reputation as a "leader in the area of *elementary* education" (Luetkemeyer and McPherson, 1975, p. 260-261; emphasis added).

Wilber and Maley

In 1948, shortly after quoting Bonser and Mossman's definition in his *Industrial Arts in General Education*, Wilber defined the industrial arts as "those phases of general education which deal with industry — its organization, materials, occupations, processes, and products — and with the problems of life resulting from the industrial and technological nature of society" (p. 2.) Wilber's definition is constructed similarly to Bonser and Mossman's, but substitutes the concept of industry for technology.

Like Bonser and Mossman's definition, Wilber's was prominent. Martin and Luetkemeyer (1979) credited Wilber with considerable influence in the

	"Industrial Arts"			**"Technology Education"**	
Definition component	Bonser and Mossman, 1923	Maley, 1973 (cf. Wilber, 1948)	Jackson's Mill, 1981	AIAA, 1985	Wright, Israel, and Lauda, 1993
Education	"Industrial Arts is a study	"those phases of general education	"a comprehensive educational program	"A comprehensive, action-based educational program	"Technology Education is an educational program
Technology	of the changes made by man in the forms of materials to increase their values,	which deal with technology, its evolution, utilization, and significance;	concerned with technology, its evolution, utilization, and significance;	concerned with technical means, their evolution, utilization, and significance;	that helps people develop an understanding and competence in designing, producing, and using technology products and systems
Industry	{none}	with industry, its organization, materials, occupations, processes, and products;	with industry, its organization, personnel, systems, techniques, resources, and products;	with industry, its organization, personnel systems, techniques, resources, and products;	{none}
Society	and of the problems of life related to these changes."	and with the problems and benefits resulting from the technological nature of society "	and their social/ cultural impact."	and their socio- cultural impacts."	and in assesing the appropriateness of technological actions."

Figure 1. Prominent definitions of industrial arts and technology education

post-World War II era of industrial arts. Calling it the "basic text for professional courses in industrial arts teacher education" and "famous," they wrote that *Industrial Arts in General Education* was "used by colleges throughout the country" (p. 35.)

Maley's *Maryland Plan* definition was quite similar to Wilber's; the main disparity between the two is Maley's inclusion of a passage concerning technology. This definition is closely related to Bonser and Mossman's as well, and is comprised of four elements: education, technology, industry, and society. Industrial arts, he said, was:

> ...those phases of general education which deal with technology, its evolution, utilization, and significance; with industry, its organization, materials, occupations, processes, and products; and with the problems and benefits resulting from the technological nature of society (1973, p.2).

Jackson's Mill

The definition of the term "industrial arts" evolved further with the publication of *Jackson's Mill Industrial Arts Curriculum Theory* in 1981. As opposed to considering industrial arts "phases of general education," as Wilber had in 1948, and Maley had in 1973, the Jackson's Mill document began the practice of characterizing the study of industrial arts as a "comprehensive" study. Otherwise it is very similar to Wilber's and Maley's: "Industrial Arts is a comprehensive educational program concerned with technology, its evolution, utilization, and significance; with industry, its organization, personnel, systems, techniques, resources, and products; and their social/cultural impact" (Snyder and Hales, n.d., p. 1). The Jackson's Mill definition retains the four-element formula of education, technology, industry, and society.

Definitions of "Technology Education"

Almost ten years after DeVore and Lauda suggested "that the Industrial Arts profession change its name to technology education to reflect cultural reality" (1976, p. 145), the American Industrial Arts Association issued this definition of *technology education*:

> ...a comprehensive, action-based educational program concerned with technical means, their evolution, utilization, and significance; with industry, its organization, personnel systems, techniques, resources, and products; and their socio-cultural impacts (1985, p. 25).

Whereas in wording, the AIAA definition is nearly identical to the one advocated in the Jackson's Mill document, and whereas it retains the educational–technological–industrial–societal formula, the striking difference between the definitions is that one defines *industrial arts* and the other defines *technology education*, while some contend that there are “substantial differences” (Hayden, 1991, p. 30) between the the two.

In addition to its close similarity to the Jackson’s Mill definition, the AIAA’s is a definition that does not vary greatly from Bonser and Mossman’s. In fact, not only do the two essentially emphasize the same points (the main disparity being the AIAA’s greater preoccupation with concepts related to industry), they do so in the same order.

Continuing the trend back toward the spirit and design of Bonser and Mossman’s 1923 definition is Wright, Israel and Lauda’s 1993 definition for technology education, published by the ITEA: “an educational program that helps people develop an understanding and competence in designing, producing, and using technology products and systems and in assessing the appropriateness of technological actions” (p. 4). Although its similarities to the AIAA definition may outweigh its differences, the phrasing of this definition is highly signifcant, as it revisits Bonser and Mossman’s three-element formula, finally eliminating the concept of industry (see Figure 1).

Similarity Of Definition Versus Similarity Of Philosophy

Although these similarities do not authenticate claims that the philosophies suggested by Bonser in 1923 (industrial arts), and by the AIAA in 1985 (technology education) were the same, it is safe to assume that by virtue of their definitions being quite similar, their philosophies may be related. Directly under the heading “The Philosophical Dimensions of Education,” Morris and Pai (1976) state that “one way of simplifying (education) is to separate its basic elements and to let those elements *define* the area of disclosure” (p. 8 emphasis added).

It seems clear that the “famous” and “widely accepted” definition of *industrial arts* and the profession’s official definition of *technology education* contain the same basic elements, thereby defining the same area of disclosure. By extension, then, the “philosophical dimensions” of technology education are not essentially new.

The Strategies of Technology Education Are Not New

If technology education and industrial arts are not significantly disparate philosophically, then perhaps the difference between them, assuming it to be more than nominal, is methodological. Kemp and Schwaller, in editing the 1988 CTTE yearbook, repeatedly (e.g. p. xiii, 36, 205) divided “approaches that are recommended as instructional strategies for technology education” into six categories (and devote one chapter to each): “the teaching of concepts, using an interdisciplinary approach, emphasizing social/cultural impacts of technology, developing problem solving skills, being able to integrate the systems of technology, and interpreting industry. It is suggested,” they went on to say, “that the technology teacher incorporate as many as possible into the classroom and/or laboratory."

Four of those six categories will be used individually to illustrate that, just as the philosophy of technology education is not new, neither are the teaching strategies associated therewith. The origins of other popular methodologies will be discussed as well.

Integration, or the "Interdisciplinary Approach"

> "Teaching technology education with an interdisciplinary approach has been explored by determining the nature of disciplines, discussing the uses of an interdisciplinary approach and planning ways in which to implement an interdisciplinary approach" (Zuga, 1988, p. 71).

An instructional strategy prevalent in technology education is that of integrating technology with other subject areas taught in the public schools. This "interdisciplinary approach"[1] is a recognition in education that subject areas are inherently related and should be taught in such a way so as to suggest this to students. This methodology was suggested long ago in industrial education:

> In the early nineties the idea began to develop that manual training should not be an isolated special subject. Instead, consideration should be given to the mutual influences of this subject and the other studies of the school. Bennett, in 1892, told how manual training, when properly taught, could integrate the other studies of the school (Stombaugh, 1936, p. 148).

Integrating other subjects in problem-solving also has a long history. "Educators know," Marot wrote 1918, "as we all do, that industrial problems carry those who participate in their solution into pure and applied science, the (economic) market..." (p. 110). In listing the general objectives of the industrial arts, Sotzin emphasized the aim "to correlate and vitalize other school subjects" (1929, p. 36). In his 1919 book *Principles and Methods of Industrial Education*, Dooley devotes a chapter each to teaching children science, math, and English "in the shop."

[1]The reader may wonder as to the interchangability of the terms "integration" and "interdisciplinary;" Zuga, in discussing her yearbook chapter, wrote: Recognizing and integrating the knowledge of other disciplines into a technology education course is teaching with an interdisciplinary approach (p. 58). It would seem safe to generalize that these terms may be used interchangeably, and that references in literature using either term may be assumed to refer to the same general concept.

Nowhere has the interdisciplinary approach to industrial arts been more comprehensive than in the elementary school. “In elementary schools, including the first six grades, little or no formal work is now carried on in separate industrial-arts classes. Here the manipulative work is done in close coordination and integration with the total study program of the school” (Ericson, 1946, p. 276). In fact, in 1955, the Nevada Department of Vocational Education stressed that, in elementary schools in that state, there were no separate industrial arts programs. “Industrial arts activities are integrated...” (p. 58). In secondary education, historical examples of integration include the “Industrial Prep” project, a three-year interdisciplinary program operated by the Hackensack, NJ school system for vocational students. In a student’s sophomore year for example, she or he would enroll in a curriculum integrating biology, English, architechture, and industrial education (Hackensack Public Schools, n.d.). The “Richmond Plan” of the late 1950s integrated English, science, mathematics, drafting, and shop subjects (Smith, 1966; Cogswell Polytechnical College, n.d.).

Emphasizing Social/Cultural Impacts of Technology

> “One major difference between traditional industrial arts and contemporary technology education is the inclusion of the social and cultural aspects of technology. This includes how technology influences the social systems of a society. Understanding these relationships will contribute to making students technologically literate” (Kemp and Schwaller, 1988, p. 21).

It is probably true that the inclusion of the social and the cultural did not often take place in *actual* industrial arts but would take place in *ideal* technology education. But certainly it can be demonstrated that the investigation of the socio-cultural aspects of technology, as well as the impact of technology on the natural and social environments, was a major component of the theory and philosophy of the inclusion of industrial arts in general education.

In discussing the place of industries in elementary education ninety years ago, Dopp wrote:

> Whatever activity we consider (for industrial education) of whatever age, if it be a significant one we find that it is because of its relation to the natural and social environment ... It was not an accident that the mariner’s compass, gunpowder, and the printing press appeared when they did. Neither was it an accident that the pyramids were erected in regions abounding with limestone and syenite ...the permanent element in all these is directly related to the natural and social environment of the age and not to that of some other place and time.

Let us apply this truth to the education of the child (Dopp, 1902, p. 100).

"The social and liberal elements in the study of the industrial arts," Bonser said a decade before the publication of his and Mossman's eminent definition, "are more significant than are the elements involved in the mere manipulation of materials" (Bonser, 1914, p. 28). And just as culture was seen as being an important part of industrial arts, industrial arts was viewed as an important part of culture. In 1920, Griffith wrote that "an individual whose education and experience has consisted solely in academic training along some narrow line if intellectual activity can hardly be considered as broadly appreciative (of culture as the) people who make their living thru [*sic*] working with their hands" (p. 57).

Not only *industrial arts* educators felt that there was a strong association between industrial education and the cultural education of children. An analysis during the 1920s by another scholar of the industrial arts revealed that "among the most frequent claims and recommendations listed for the industrial arts by authors of text-books *in the field of secondary education* are the following: a. it is a cultural subject; b. it enriches the curriculum; c. it adds to social intelligence; d. it gives an insight into social end economic values; e. it trains in problem solving ..." (Sotzin, 1929, p. 21; emphasis added).

As Ericson said nearly fifty years ago, "industrial-arts teaching can render a service at this point by assisting in a reinterpretation and enlightenment of the concept of culture to American youth" (Ericson, 1946, p. 260).

Problem-solving

In technology education, "problem solving is a process of seeking feasible solutions to a problem" (Hatch, 1988, p. 91). Although problem-solving may historically have become prominent in industrial arts literature later than other emphases of industrial arts education, Dopp (1902), Bonser (1914), Marot (1918), and Griffith (1920) all considered the topic to be a methodology integral to industrial arts in the first two decades of this century. At the end of the next decade, Sotzin listed "problem-solving" as being among the "claims and recommendations" most often made by educators for industrial arts (Sotzin, 1929, p. 21).

But claims and recommendations in theory do not always correlate to results in practice. Browning and Greenwald recently described problem-solving as "a goal never lived up to in many Industrial Arts programs" (1990, p. 9).

By the end of World War II, the idea of teaching not only problem-solving, but other "minds-on" skills in industrial arts was becoming popular. Wilber, in his *Industrial Arts in General Education*, insisted that "the ability to think critically can be developed only through practice in solving problems" (1948, p. 9); two years earlier, one of his contemporaries suggested that:

> Many other industrial arts teachers now have caught the vision ... Clear thinking, reasoning, creative thinking, problem solving (call it what you may) is a far more important basis of educational objectives in the lives of thirteen, fourteen, and fifteen year-old boys than one centered on skills and information... (Friese, 1946, p. 88).

Calvin M. Street also saw the relation between problem-solving and the scientific method as having a place in the teaching of the industrial arts:

> A further element of general education which is appropriate, not only to the industrial arts teacher, but to all citizens, is that which may be described as the area of important methods and tools of problem solving. Since the scientific method of problem solving is deemed the most valid way that human beings have discovered for solving problems, it becomes obvious that each person should develop...skills in the use of this method" (1956, p. 177).

Interpreting Industry

> "Technology in communication, construction, manufacturing, and transportation will continue to change at a rapid pace... If this is the plan of American industry, technology education teachers must plan to make changes. They must plan to make the curriculum reflect society today" (Bjorklund, 1988, p. 121).

Of all of the approaches to teaching technology education, this may be the best demonstration for the argument that technology education is simply renaming of industrial arts. It seems unlikely that veteran industrial arts teachers will differ with this instructional strategy (defined as such by Kemp and Schwaller, 1988); many may have been trained during the popularity of the *American Industry* or *Industrial Arts Curriculum Project* (IACP) movements of the 1960s, the latter of which Donald Lux, one of its founders, fifteen years later called a "course in industrial technology." "The fundamental question to be answered," he said of the IACP, "was 'What is industry?'" (Lux, 1979, p. 150).

Decades before the inception of the IACP, the interpretation of industry was already considered by some as either the primary purpose, or one of the most important, of industrial arts. Ericson's third objective for industrial arts was to impart to students an "understanding of industry and methods of production, and of the influence of industrial products and services upon the pattern of modern social and economic life" (Ericson, 1946). Various other objectives involved industry as well.

Wilber's first objective for industrial arts was "to explore industry and American civilization;" the manifestation in the instruction of students was that "they will read about and *interpret* industry" (1948, p. 42; emphasis added). Wilber's definition of industrial arts emphasized the interpretation of industry, not only via its common "organization, materials, occupations," and the like, but also through "the problems resulting from the industrial and technological nature of society" (1948, p. 2).

Martin and Luetkemeyer (1979) enumerated various efforts, some more interpretive than others, to include in industrial arts the content of contemporary industry, as suggested by Bjorklund: "If this is the plan of American industry, technology education teachers must plan to make changes" (1988, p. 121). These included one in 1942 in which students across the country produced nearly a million model aircraft for the military in a "new curricular approach" sponsored by the United States Office of Education and the United States Navy.

Other Technology Education Methodologies

These four common strategies are by no means the only teaching methodologies common in technology education which were also used in industrial arts; many other strategies which today might be considered novel have been in use for decades by industrial arts teachers. For example, not long after Sputnik, Jones (1958) noted that group activity was becoming prevelant in industrial education. "It is important that pupils learn to work together. *Many* (industrial arts) instructors," he said, "devise projects that require such group action" (p. 156 emphasis added).

Ten years earlier, Newkirk and Johnson noted that instruction in the industrial arts imparted to students an adaptability not found in other subjects in the school. "Industrial Arts Education gives an over-all training in industrial adaptability that is most helpful to those who find it necessary to change their type of work from time to time because of the technological developments or changes in the needs of society" (1948, p.8). And a quarter-century before that, in investigating industrial education in Minnesota, Smith found that the second most common objective there for the industrial arts was "to afford information and experiences that assure a broader view of the industrial world and make for social adaptiveness" (1924, p. 119). Smith's study was published in the year following the publication of Bonser and Mossman's aforementioned definition for industrial arts.

Years before that publication, Bonser himself emphasized another educational viewpoint that today many leading technology educators are advocating: that this area of education has a specific content associated with it. "The industrial arts, rightly interpreted, contain a body of thought and experience sufficiently vital to human well being to give the subject a place in the elementary and secondary school curriculum on a basis of thorough respectability and validity" (1914, p. 28). Stone (1934) echoed the need to view the industrial arts as a "subject-matter" rather than a "service."

In *Industrial Arts for Elementary Schools*, Bonser and Mossman emphasized that the content of the industrial arts should be an important part of the education of *all* students — another point today recognized but not yet accomplished by technology educators, and often thought of as new. "Is there not also a body of experience and knowledge relative to the industrial arts which is of common value to all, regardless of sex or occupation?" (1923, p. 20).

Similarly, the concept of *experiential* learning has been well established in industrial arts for at least a century. In addition to Dewey's pronouncements on experience and on experimentalism (e.g. Dewey, 1938), other educators emphasized the responsibility of industrial or manual school subjects to provide a forum of experience and experimentation for students. Dopp, in discussing the place of industries in industrial education, sees exploration and first-hand experience as appropriate for industrial education. "In so far as the completion of the situation requires the child to exploit his own environment in the search for real or illustrative materials of industrial processes, ... experimentation (finds its) place" (Dopp, 1902). Marot takes a more negative view of the situation:

> Educators know there is adventure in industry, but they believe that the adventure is the rare property of a few. They believe this so firmly that they surrender this great field of experience with its priceless educational content without reserving the right of such experience even for youth ... They are not alone in their lack of courage to admit that limiting this experience perverts normal desires and creates false ones" (Marot, 1918).

More recently the importance of experience in industrial arts has been stressed in literature pertaining to teacher training as well (e.g. Jones, 1958).

Among the other distinguishing characteristics of technology education which are ascertainable in the literature of industrial arts are team teaching (Bernucci, et al., 1963) and the prohibition of failure (Friese, 1934), as well as the "discovery method" and the "inventive method" of learning (Griffith, 1920). Ericson (1946) confirmed that the "discovery, or problem-solving method" was in "common use" in industrial arts (p. 45).

Conclusion: The Need for Change

Just as the definition and philosophical base for technology education have existed for years as the ideals for industrial arts, so have its teaching strategies and methodologies. Unfortunately, there is little evidence that this philosophy or these strategies have ever been seriously implemented on any large scale or for any perceptible length of time.

Today the profession appears to be aware of the need for a change from industrial arts. That change, however, may not be in philosophy or in strategy; rather, perhaps that change should be away from ignoring the ideal and toward attaining it. Technology education, in this light, can be seen as the final realization of the promise of the industrial arts — not something foreign to it.

This is not a position held by all. “Technology education must be thought of something new,” Pullias wrote recently. “It has no place in an old industrial arts, or shop paradigm. To say that technology education can exist in the old setting is totally inaccurate.” (1992, p. 3)

The distinction that must be made here is between theory and practice, between the real and the ideal — what Colelli (1989), in the context of industrial education, has termed the “theory-practice gap.” Perhaps ideal technology education has no place in the “paradigm” of the way industrial arts has historically been practiced. But the challenge in interpreting past practice is not to criticize it in an attempt to inflate the value of that perceived as new. It is to learn from it in an attempt to recognize the value in that established as eminent.

References

American Industrial Arts Association. (1985). *Technology education: a perspective on implementation*. Reston, VA: AIAA.

Bernucci, V., et. al., (1963). Team teaching and large group instruction in industrial arts. *Industrial Arts and Vocational Education, 56*(5), p. 26.

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

Bonser, F. & Mossman, L. (1931). *Industrial arts for the elementary school*. New York: MacMillan.

Bonser, F. (1914). *Fundamental values in industrial education*. New York: Teacher’s College, Columbia University.

Browning, R. & Greenwald, M. (1990). Critical thinking and problem solving: how much did we learn from our old toy trains? *The Technology Teacher, 49*(7), 9-10.

Cogswell Polytechnical College. (n.d.). *The Richmond plan: a report of a pre-technology program for the “average learner.”* San Francisco: Rosenberg Foundation.

Colelli, L. (1989). *Technology education: a primer*. Reston, VA: International Technology Education Association.

DeVore, P., & Lauda, D. (1976). Implications for industrial arts. In L. Smalley, (Ed.), *Future alternatives for industrial arts.* (p. 137-162). Encino, CA: Glencoe.

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

Dooley, W. (1919). *Principles and methods of industrial education*. Cambridge, MA: The Riverside Press.

Dopp, K. (1902). *The place of industries in elementary education*. Chicago: The University of Chicago.

Dugger, W. (1985). Introduction. In American Industrial Arts Association, *Technology education: A perspective on implementation*. Reston, VA: American Industrial Arts Association.

Ericson, E. (1946). *Teaching the industrial arts*. Peoria: Manual Arts Press.

Friese, J. (1934). Accepted interpretations. In C. Bennett, et. al., (Eds.) *Industrial arts in modern education.* (pp. 142-158). Peoria, IL: Manual Arts Press.

Friese, J. (1946). *Course-making in industrial education*. Peoria: Charles A. Bennett Co., Inc.

Gerbracht, C. & Babcock, R. (1969). *Elementary school industrial arts*. New York: Bruce.

Griffith, I. (1920). *Teaching manual and industrial arts*. Peoria: Manual Arts Press.

Hackensack (NJ) Public Schools. (n.d.). *Industrial prep, volume two, sophomore year*. EDRS ED 063 464 (VT 015 228).

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

Hayden, M. (1991). Implementing technology education. *The Technology Teacher, 51*(2), p. 30-31.

Jones, W. (1958). *Problems in teaching industrial arts and vocational education*. New York: Bruce.

Kemp, W. & Schwaller, A. (1988). Introduction to instructional strategies. In W. Kemp & A. Schwaller, (Eds.) *Instructional strategies for technology education*. (p. 16-34). Mission Hills, CA: Glencoe.

Luetkemeyer, J. & McPherson, W. (1975). "The ideas, philosophy, and contributions of Frederick Gordon Bonser." *Man/Society/Technology 34*(8) p. 260-3.

Lux, D. (1979). The development of selected contemporary industrial arts programs: the Industrial Arts Curriculum Project. In G. Martin, (Ed.), *Industrial arts education: retrospect, prospect.* (p. 132-168). Bloomington, IL: McKnight.

Lux, D. (1981). Industrial arts redirected. In R. Wright & R. Barella, (Eds.) *An interpretive history of industrial arts*. (p. 205-225). Bloomington, IL: McKnight.

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

Maley, D. (1979). The development of selected contemporary industrial arts programs: the Maryland Plan. In G. Martin, (Ed.), *Industrial arts education: retrospect, prospect.* (p. 132-168). Bloomington, IL: McKnight.

Marot, H. (1918). *Creative impulse in industry: a proposition for educators*. New York: E.P. Dutton and Co.

Martin, G. & Luetkemeyer, J. (1979). Movements that lead to contemporary industrial arts education. In G. Martin, (Ed.), *Industrial arts education: retrospect, prospect.* (p. 18-42). Bloomington, IL: McKnight.

Morris, V., & Pai, Y. (1976). *Philosophy and the American school*. Boston: Houghton Mifflin Co.

Nevada Department of Vocational Education. *Vocational education serves Nevada*. Carson City, NV: Nevada Department of Vocational Education.

Newkirk, L. & Johnson, W. (1948). *The industrial arts program*. New York: MacMillan.

Olson, D. (1955). *Industrial arts for the general shop*. Englewood Cliffs, NJ: Prentice-Hall

Pullias, D. (1987). The cost of change in technology education. *The Technology Teacher, 46*(8), p. 3-4.

Pullias, D. (1989). Where do we go from here? *ATTE Journal, Winter 1989*, 3-4.

Pullias, D. (1992). What is technology education? *The Technology Teacher, 51*(4), p. 3-4.

Smith, D. (1981). Industrial arts founded. In R. Wright & R. Barella, (Eds.) *An interpretive history of industrial arts*. Bloomington, IL: McKnight.

Smith, G. (1966). *The pre-technology program: a descriptive report*. San Francisco: Cogswell Polytechnic College.

Smith, H. (1924). *Industrial education in the public schools of Minnesota*. Minneapolis: University of Minnesota College of Education.

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

Sotzin, H. (1929). *An industrial arts curriculum for grades four to twelve inclusive* (Abstract of Doctor's Dissertation), Cincinnati, OH:. University of Cincinnati College of Education.

Stombaugh, R. (1936). *A survey of the movements culminating in industrial arts education in secondary schools*. New York: Teacher's College, Columbia University.

Stone, W. (1934). Recent history and trends. In C. Bennett, et. al., (Eds.) *Industrial arts in modern education.* (pp. 123-141). Peoria, IL: Manual Arts Press.

Street, C. (1956). Concepts of general education. In Hutchcroft, (Ed.), *Problems and issues in industrial arts teacher education*. (pp. 167-194). Bloomington, IL: McKnight and McKnight.

Taylor, J. (1914). *A handbook of vocational education*. New York: MacMillan.

Waetjen, W. (1989). *Technological problem solving*. Reston, VA: International Technology Education Association.

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

Wright, R. (1992). Building a defensible curriculum base. *Journal of Technology Education, 3*(2), p. 67-72.

Wright, R., Israel, E. & Lauda, D. (1993). A decision-maker's guide to technology education. Reston, VA: International Technology Education Association.

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

PHYS-MA-TECH: An Integrated Partnership

Jule Dee Scarborough & Conard White[1]

There is a national movement across the U.S. to reform education, especially for students of average ability and school achievement–the "forgotten majority". Curricular integration across disciplines using teacher teams to broaden learning contexts as well as improving access to academic courses such as physics and mathematics has been a response to the call for reform (see, for example, American Chemical Society, 1988; Benson, 1989; Bottoms, 1989; Edgerton, 1990; Grubb, Davis, Lum, Plihal, & Morgaine, 1991).

There is an increasing amount of literature on the subject of integration, especially literature that describes particular programs and curricula such as Principles of Technology (Center for Occupational Research and Development and the Agency for Instructional Technology, 1986), Tech Prep (Key, 1991), Science-Technology Society (Aiken, 1992), and Project 2061 (Johnson, 1989). However, little research is available regarding the simultaneous integration of physics, mathematics, and technology through interdisciplinary teams and the resulting impact that such an approach has on learning physics.

Most integration endeavors have involved either coordinating curricula or having teachers working cooperatively to reinforce concepts so that learning transfers across two or more contexts. These activities are important steps towards improving education, but possibly a stronger and more substantial approach would entail activities that actually restructure the organization and delivery of content across disciplines, including nontraditional teacher assignments as well as nontraditional teaching methodology.

The PHYS-MA-TECH project was funded by the National Science Foundation, the Illinois State Board of Education, and Northern Illinois University. The goal of the project was to improve high school physics by integrating Physics/Mathematics/Technology (P/M/T) both in content and delivery of instruction. It was proposed that average students have an untapped ability in physics and mathematics. Their potential in these areas cannot be projected merely on the basis of past performance. A basic assumption of this study was

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that average students can not only perform at an acceptable level in physics, but also possibly do better if it is taught in a relevant fashion. In addition, it was felt that average students of the “forgotten majority” may not be getting access to important science and mathematics courses. It also seems that many integration activities have fallen short in addressing the real issues that must be considered before integration can be sustained for any length of time.

The researchers hypothesized that (a) average students who do not take physics *are* interested in the subject, (b) they *can* succeed in physics, and (c) P/M/T integration in content and delivery *will* provide a better route for such students to learn physics.

The study sought to measure the effectiveness of the PHYS-MA-TECH program by seeking answers to the following research questions:

1. Is there any difference in intellectual ability and academic achievement between average students "who would not normally enroll in physics" and those enrolled in a regular physics course?

2. Is there any difference in gain in physics achievement between students enrolled in the PHYS-MA-TECH course and those enrolled in a regular physics course?

Procedure

Letters were sent to fifty school superintendents in northern Illinois describing the project and inviting them to participate. Twelve school districts responded with definite interest and six additional districts were interested in exploring the possibility further.

After an orientation meeting with the superintendents, five schools were identified to participate in the study. These schools represented a broad range of socioeconomic communities, student population (ability, race, ethnicity), and geographic location (rural/suburban/urban).

A team of three teachers (one physics, one mathematics, and one technology teacher) was established at each participating school. After going through a rigorous process of inservice activities, the teachers worked as a group to establish acceptable content for a one-year, standard, high school physics course. The course was analyzed for prerequisite mathematics and a potential technological framework within which physics could be taught. The teams then developed an integrated PHYS-MA-TECH curriculum which included 45 modules.

Each school selected a sample of modules to field test. Each module was field tested by two or more schools. The modules were then revised based upon field-test results and used for the study. They are now available to teachers under the name PHYS-MA-TECH.

Subjects

The study sought to insure that the students chosen to participate were "average" high school students rather than advanced placement or "high achievers." Each of the schools identified one or more classes of students to enroll in the PHYS-MA-TECH course and were defined as the experimental group. The students were selected by teachers and counselors on the basis of those who "would not have taken physics." At least one section of regular placement physics was selected in each school to serve as a control group.

General intelligence scores and overall grade point averages were collected for each student in the sample. As each school did not use the same test of general intelligence, percentile scores were employed in the data analysis. Table 1 reports IQ percentile scores for the experimental and control groups. A *t* test indicated that no significant difference existed.

Table 1
IQ Percentile Scores by Treatment Group

	n	Mean	SD	*df*	*t*	*p*
Experimental Group	43	65.28	22.12			
Control Group	75	72.01	18.65	116	-1.76	0.081

Table 2 reports the mean grade point averages (4-point scale) between the experimental and control groups. Examination of the *t* test results indicated that students in the control group had a significantly higher grade point average than those in the experimental group

Table 2
Overall Grade Point Average by Treatment Group

	n	Mean	SD	*df*	*t*	*p*
Experimental Group	43	2.40	0.59			
Control Group	75	2.86	0.61	116	-4.03	<.01

Since the subjects in the control group had higher grade averages, but equal IQ percentiles, one might conclude that students "who do not normally enroll in physics" are of equal ability but do not perform as well in school as those who do.

Development of the Instrument

During the developmental phase of the program, project teachers adopted a course outline for a typical high school level physics course from one developed by the American Association of Physics Teachers (AAPT) and the National Science Teachers Association (NSTA). This outline was used as a guide in the development of the PHYS-MA-TECH modules, (experimental), and the regular physics course, (control). To assess achievement in the experimental and control groups, the Physics Achievement Test was developed.

The major portion of the Physics Achievement Test was extracted from an achievement test developed by the AAPT/NSTA in conjunction with the course outline described above. Since the achievement test was developed from the course outline, this helped to assure that each of the content areas in the outline would be assessed. Additional test items were developed by the project teachers to assess the additional mathematics and technology concepts included in PHYS-MA-TECH modules.

The Physics Achievement Test consisted of 95 multiple-choice items, each of which had either four or five responses. The test was divided into five unit tests, each coordinated with one of the five major units of instruction. The unit tests were: (a) Mechanics, 34 items; (b) Heat and Kinetic Theory, 17 items; (c) Electricity and Magnetism, 22 items; (d) Waves, Optics, and Sound, 17 items; and (e) Modern Physics, 5 items. The number of items in each unit reflected the proportion of instructional time allotted to them.

Since a large portion of the Physics Achievement Test was developed from the adopted course outline by the AAPT/NSTA, it was assumed that the test would be valid for measuring each of the content areas in the course outline. To augment test validity, a copy of the course outline and each of the test items arranged in a random order was analyzed by a group of five high school physics teachers. They were asked to: (a) select the appropriate content area from the course outline which the item measured, (b) point out any items which were ambiguous, and (c) choose the correct answer for the item. Upon completion of these activities, the instrument was finalized and printed.

The study was conducted during the 1990-91 school year. During the first two weeks of the school year, the unit test for the first unit of instruction (Mechanics) was administered. As each of the five major units of instruction was completed, the physics subtest for the unit just completed was administered as a posttest and the subtest for the unit which was about to begin was administered as a pretest. The tests were administered by project staff and were not seen by the participating teachers to insure that classroom instruction was not “geared” specifically to test items.

Results

Table 3 displays the overall test results of the Physics Achievement Test by treatment group. The number of items correct is displayed in each cell. The raw gain cells depict the mean differences between individual pretest and posttest scores. Residual gain scores were calculated to serve as a dependent variable to indicate an increase in learning from the pretest to the posttest. A regression analysis was completed using the pretest score on each unit test as a predictor of the unit posttest score. Each of the correlations between pretest and posttest was found to be highly significant. The regression weights were then used to calculate a predicted posttest score from the pretest score. The difference between this predicted score and the student's actual posttest score is the residual gain.

Table 3
Physics Achievement Test Scores: Pretest, Posttest, and Gain Scores by Treatment Group

	Unit Test					
Group	Mech.	Heat	Elect.	Waves	Modern Physics	Total Scores
Experimental						
n = 43						
Pretest	9.33	5.26	6.84	4.14	1.72	27.28
Posttest	11.86	6.44	8.14	4.67	1.88	33.00
Raw Gain	2.53	1.19	1.30	0.53	0.16	5.72
Residual Gain	-0.34	-0.41	+0.00	-0.42	-0.08	-1.25
Control						
n = 75						
Pretest	10.52	6.80	7.55	4.00	1.72	30.59
Posttest	13.08	7.80	8.41	5.28	2.01	36.59
Raw Gain	2.56	1.00	0.87	1.28	0.29	6.00
Residual Gain	+0.19	+0.24	-0.00	+0.24	+0.05	+0.72

To serve as a basis for comparison between treatment groups, a two-way multivariate analysis of covariance was utilized to test for differences in mean pretest scores. Student scores on the five physics subtest scores were used as dependent variables. The independent variable was treatment group. IQ percentile score and student grade point average were used as covariates to control for student ability and previous performance in school.

Table 4 reports the results of the multivariate analysis on the pretest data. The value for Pilliai's Trace, a multivariate statistical treatment, has been transformed to a statistic which has an approximate *F* distribution. The significance level for this *F* is shown in the table.

Table 4
Multivariate Analysis of Variance Table for Physics Pretest Scores by Treatment Group

	Multivariate Tests of Significance				
Effect	Pilliai's Trace	Approx. F	*df*	Error *df*	Prob.
Within Cells	0.34	4.55	10	222	0.000
Treatment Group	0.06	1.44	5	110	0.217
Constant	0.18	4.73	5	110	0.001

The *Within Cells* effect indicates that the covariates, IQ and GPA, are significantly related to the dependent variables. This covariate effect is removed prior to testing for the remaining effects, thus controlling for IQ and GPA.

The *Treatment Group* main factor was not significant. This indicates that there was no significant difference in mean pretest scores between the experimental and control groups. Table 3 shows that the control group had an overall mean of 30.59 correct items as compared with 27.28 for the experimental group.

The *Constant* effect indicates that the grand mean of 29.38 correct items was significantly different from zero.

Gain in Physics Achievement

A multivariate analysis of covariance was also utilized to test for a significant difference in mean residual gain between treatment group. The mean residual gain score between pretest and posttest administrations of the physics achievement was used as the dependent variable. These data are reported in Table 3.

Table 5 contains the multivariate analysis of variance for residual gain of the five unit tests between treatment groups. As with the previous analysis, IQ and student grade point average were used as covariates.

The *Within Cells* effect was significant, thus indicating that the covariates, IQ and GPA, were related to the residual gain. This effect was removed before the other factors were taken into consideration. As can be seen from Table 5,

Table 5
Multivariate Analysis of Variance Table for Physics Residual Gain Scores by Treatment Group

Effect	Multivariate Tests of Significance				
	Pilliai's Trace	Approx. F	*df*	Error *df*	Prob.
Within Cells	0.22	2.71	10	222	0.004
Treatment Group	0.02	0.44	5	110	0.822
Constant	0.15	3.79	5	110	0.003

the *Treatment Group* main factor effect indicates that there was no significant difference in mean residual gain between the experimental and control groups.

Discussion

This project seems to be one of the first involving technology educators funded by the National Science Foundation. Because the goal of the project focused on improving physics, some have questioned its implications for technology and vocational education. Rather than question the value or relationship of this project to our fields, perhaps focus should be placed on the positive outcomes.

Students selected for this study would not have enrolled in a physics class on their own volition. Although they displayed intellectual abilities equal to those who normally enroll in physics, their achievement levels were found to lag behind. When physics was taught using an integrated approach, these students exhibited a similar gain in achievement as those enrolled in a regular physics class. This suggests that the integration of physics, mathematics, and technological content provides a valuable teaching tool for helping students grasp subject matter which they might have previously felt was either beyond their reach or was uninteresting.

In addition to the outcomes supported by research data that serve to stimulate repositioning of technology education, or perhaps vocational education, in relationship to physics education, the reader should consider the related outcomes as well. Five schools, after participating in this project, have committed to long-term integration of P/M/T in both content and delivery. Four of these schools have sustained the models and have gone well beyond the integrated course(s) that resulted from the project development and field testing. One school is planning to develop four years of integrated science, mathematics and technology, one course for each grade level. Another school has added a second class of integrated P/M/T and began other integration initiatives while a third school has developed a capstone engineering course using the P/M/T approach.

This school also has an integrated physical science course for ninth-grade students taught *collaboratively by science and technology teachers*.

Finally, another school is utilizing a technological approach for accelerated physics and has introduced an integrated ninth-grade physical science course. Three schools have reported that enrollments in physics *and* technology have increased. They indicated that because more students were exposed to technology and physics content, student interest and enrollment increased in both areas. This question of relevance to technology, therefore, seems insignificant when considering the definite and positive impact this project has had on strengthening the position of technology and vocational education in these high schools.

The outcomes have played a major role in stimulating integration that goes beyond integrated curriculum and coordinated teaching. They have set the stage to question traditional delivery systems. The project has designed models and a curriculum that will work in almost any school. Most importantly, however, is the change in relationships that occurred in the schools among the teachers. Without exception, feedback from teachers documents strong perceptual changes. Technology/vocational teachers were seen more as academic contributors as the project progressed. It seems, then, that this project has provided direction which strengthens the interrelationship between technology and vocational education with its mathematics and physics counterparts.

References

Aiken, G. (1992). *The integration of STS into science education*, *32*(1), p. 27-34.

American Chemical Society. (1988). *ChemCom: Chemistry in the community*. Dubuque, IA: Kendall/Hunt.

Benson, C. (1989, July 27). *On integrating academic and vocational education* (Testimony before the Senate Subcommittee on Education, Arts and Humanities). Washington, DC: U.S. Government Printing Office.

Bottoms, J. E. (1989). *Closing the gap between vocational and academic education*. Washington, DC: National Assessment of Vocational Education. (ERIC Document Reproduction Service No. ED 315 516)

Center for Occupational Research and Development [CORD] and the Agency for Instructional Technology [AIT]. (1986). *Principles of Technology*. Waco, TX: Author.

Edgerton, R. T. (1990). *Survey feedback from secondary school teachers that are finishing their first year teaching from an integrated mathematics curriculum*. (ERIC Document Reproduction Service No. ED 328 419)

Grubb, W. N., Davis, G., Lum, J., Plihal, J., & Morgaine, C. (1991, January). *The cunning hand, the cultured mind*: *Models for integrating vocational and academic education*. Berkeley, CA: University of California, National Center for Research in Vocational Education.

Johnson, J. R. (1989). *Technology: Report of the Project 2061 Phase 1 Technology Panel*. Waldorf, MD: American Association for the Advancement of Science.

Key, C. (1991). *Visualizing tech prep systems geared for the the next century--A research based analysis of Part E, Tech Prep Education of the Carl D. Perkins Vocational/Applied Technology Education Act*. Unpublished doctoral dissertation, University of Texas, Austin, TX.

Operative Computer Learning with Cooperative Task and Reward Structures

Susan R. Seymour[1]

Introduction

America is in a recession that is strangling budgets and challenging educational administrators to stretch existing resources. Compounding this challenge is the ever changing field of computer technology and the dire need to educate a technically competent work force. Currently, the United States is falling behind technological leaders such as Japan and Britain in our attempts to educate a technological work force. Although the reasons for this lack of success in teaching technology are diverse, the most common barriers are financial. These financial barriers are most noticeable in the regional inequities between suburban and rural schools and are manifested in the lack of computer equipment in schools, or outdated equipment not being replaced. (Mruk, 1987) Therefore, the teaching of computer technology is faced with a distinct educational problem: how can we educate more students using limited computer resources without sacrificing student aptitude or enjoyment of the learning event? Cooperative learning provides a plausible solution.

Cooperative learning is a teaching strategy that encourages student success by alleviating overt competitiveness and substituting group encouragement. In cooperative learning, individuals work with their peers to achieve a common goal rather than competing against their peers or working separately from them. Research on the benefits of cooperative learning has shown an increase in academic achievement, positive attitudes towards learning and increased student satisfaction.

Review of the Related Literature

Effects of Cooperative Learning on Student Achievement

The effect of cooperative learning on academic achievement has been well documented and research suggests that cooperative learning produces greater student achievement than traditional learning methodologies. In fact, a review completed by Slavin in 1984, found that 63% of all cooperative learning studies

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analyzed showed increases in academic achievement. Slavin's review isolated the prominent characteristics responsible for increased achievement scores and discovered that cooperative task structures and cooperative reward structures were the two determining factors in the success of cooperative learning. This data is supported again in Slavin's 1990 meta-analysis when he concludes that methods emphasizing group goals and individual accountability are consistently more effective in increasing student achievement than other forms of co-operative learning. Although this holds true for the majority of research, a study completed by Okebukola (1985) included individual accountability and group goals and showed no significant positive effects on achievement. In addition, research conducted by Rich, Amir, and Slavin (1986) incorporated individual accountability and group goals but showed negative effects on achievement.

Cooperative Learning Effects Other Than Achievement

Cooperative learning models have shown effects other than academic achievement that contribute to the overall satisfaction of course participants (Salend & Sonnenschein, 1989). A wide variety of social benefits have been documented. Such benefits include: promotion of positive attitudes toward schooling (Johnson & Johnson, 1978), promotion of group socialization and cohesiveness (Slavin, 1990), decreased prejudicial attitudes (Johnson & Johnson, 1978; Slavin, 1990), encouragement of risk taking (Johnson & Johnson, 1975), fostering of self esteem (Slavin, 1990) and increased ability to see another's perspective (Slavin, 1990).

Cooperative Learning and the Computer

In almost all schools the number of students far exceeds the number of computers, however, individualistic education has dominated the use of computers (Dickson & Vereen, 1983). One student per computer is the tradition and few have challenged this in the research arena, although understanding the effects of cooperation at the computer could have economic as well as academic benefits. One untapped resource for education of computers is peer tutoring. Peer tutoring is the cooperation between two or more students in which one student actively takes on the teaching role. It has been an effective cooperative behavior in fostering intellectual and social growth (Hill & Helburn, 1981). In a recent study by Teer, Teer & McKnight (1988), students using peer tutoring gained greater computer and relational skills than students working independently. Mehan (1985) suggests a natural tendency for students to collaborate at the computer regardless of adult supervision. Mehan states that when students are placed at a computer and “left to their own devices....(they) work out the details of task completion themselves, resulting in voluntary instead of compulsory forms of instructional activity". This tendency for students to rely on each other to work out problems is at the heart of cooperative learning.

Research directly relating cooperative learning with computers is limited, but some excellent studies have been completed by Webb (1984) and Oh (1988). Webb's study evaluated group effectiveness in the teaching of computer programming to 30 students ranging in age from 11 to 14. The study dealt extensively with group planning and processing involved in the breakdown and dissemination of knowledge. Webb also looked at the relationship of cooperative groups to increased academic achievement and found that cooperative group learning was positively related to academic performance for students learning BASIC (a computer programming language).

A study conducted at Illinois State University by doctoral student Hyun-an Oh (1988), looked at the effects of both cooperative and individualistic incentive and task structures on achievement in computer programming. His study ran for seven weeks during which he compared the performance of 114 university students enrolled in a introductory microcomputer course under three treatments. The treatments were variations of cooperative task, cooperative incentive, individualistic task and individualistic incentive. Oh's findings indicated that there were no differences in achievement between cooperative learning with computers and individualistic learning with computers. He also concluded that incentive made no difference in student achievement for either cooperative structures or individualistic structures. This conclusion was drawn from the fact that students who had no incentive performed as well as students with incentive in both cooperative and individualistic treatments.

Purpose of the Study

In keeping with the concept of optimizing computer resources by pairing students at one computer, it is necessary to know if cooperative learning structures affect the academic achievement and satisfaction of students learning about computers. Therefore, the purpose of this study was to analyze the difference in achievement and satisfaction between three groups of post secondary students learning computer aided drafting under three different learning treatments: cooperative task and reward, individualistic task and reward and a combination of cooperative and individualistic tasks and rewards. By manipulating the independent variables (cooperative task, cooperative reward, individualistic task and individualistic reward) significant differences in two dependent variables (student achievement and student satisfaction) were tested.

Research Hypotheses

The following hypotheses were proposed for this study of cooperative learning structures on post secondary, computer aided design students:

1. There is no significant difference in achievement levels between cooperative learning structures and individualistic structures.
2. There is no significant difference in student satisfaction levels between cooperative learning structures and individualistic structures.
3. There is no significant difference in achievement levels between cooperative learning structures combined with individualistic structures and individualistic structures alone.
4. There is no significant difference in satisfaction levels between cooperative learning structures combined with individualistic structures and individualistic structures alone.

The scope of this study was limited in that it encompassed 57 students enrolled in an Introduction to Computer Graphics course at Colorado State University. It was assumed that the time allotted for this study (15 weeks) was appropriate in determining the effects of cooperative learning on student achievement and satisfaction, and that students completed evaluative instruments honestly.

Methodology

The cooperative model studied was based on Slavin's Student Teams-Achievement Divisions (Slavin 1986, 1990). This method of cooperative learning clusters students in four-member learning teams that are mixed in performance level. Performance levels of students were determined by pretest scores and grade point averages, and then students were randomly assigned to a group.

Three sections of an Introduction to Computer Aided Drafting course, consisting of 14, 21, and 22 students, were involved in the study and each group participated in three treatments (cooperative task and reward, individualistic task and reward and a combination of cooperative and individualistic task and reward). The course was divided into nine progressive units designed to introduce new concepts, practice application, and test understanding. A post test, an attitude survey, three quizzes and three drawing assignments were used to determine the level of achievement for each treatment. The post test was a comprehensive test covering information presented during each five week session and which students took at the end of each session. The same attitude survey was used for each of the treatments and was given to students at the end of each five week session. Students were also responsible for completing nine drawings and taking nine quizzes during the course of the semester (three per treatment). All instruments were consistent across teams and course sections.

The population for this study was post secondary students enrolled in an introductory course in computer aided drafting. The research was conducted on a purposive sample which was established through the Colorado State University enrollment system.

Procedures

At the beginning of each unit the instructor presented new material by talking the students through new commands while they worked at the computer. The same presentation was given to all three treatments, but during the combined and cooperative treatments, students were paired while working through the software's commands. Students in the individualistic treatment worked alone at the computer during the presentation of new commands.

Upon completion of the lecture, drawing assignments were given and students in the cooperative and combined treatments were assigned a partner. Drawing partners were rotated each week to give students the opportunity to work with each member of their team during each treatment. In addition, members within a team were responsible for 1 of 4 drawings. This insured that team members would complete their own drawings rather than submit a team member's drawing as their own.

During lab time, students in the cooperative and combined treatments took turns at the computer to complete their drawings. Obviously, while one student was busy working at the computer, the other was passive. However, because this student had a vested interest in the success of their partner (the grades of the teammates were averaged) the drawing became a cooperative task experienced by both members. In other words, while one student was working at the drawing, the other student acted as a coach, making sure the drawing was being done correctly and helping out if mistakes were made. This behavior was encouraged and monitored by the instructor during the cooperative and combined treatments. When students were in the individualistic treatment, they completed their drawings on their own, sitting and working by themselves at the computer. This behavior was also encouraged and monitored by the instructor.

A quiz was given at the end of each unit which covered information presented in lecture, outlined in the reading and practiced in the drawing exercises. Prior to each quiz, students were given ten minutes to review their notes. Students in the cooperative section were encouraged to use this time to study with their team mates to ensure that their team mates were prepared, because the quiz grade awarded would be the average of their team members' grades. The individualistic and combined treatments did not average quiz grades so they were given ten minutes to prepare for the quiz but were not allowed to study together (see Figure 1).

	Individualistic Task	Indivualistic Reward	Cooperative Task	Cooperative Reward
Indivualistic Treatment (3 units)	Quiz Preparation Drawing Completion	Quiz Grade Drawing Grade		
Combined Treatment (3 units)	Quiz Preparation	Quiz Grade	Drawing Completion	Drawing Grade*
Cooperative Treatment (3 units)			Quiz Preparation Drawing Completion	Quiz Grade* Drawing Grade*

*grades are based on the average of the teams' grades

Figure 1. Task and reward structures used in each treatment.

Results

The statistical design chosen for this study was a counterbalanced design. This design is ideal for eliminating threats to internal validity when random assignment of subjects is not possible. Each group receives each treatment, thus eliminating the possibility that non randomized groups might not be equivalent and differences construed as an effect of the independent variable. The counter balance design diminishes potential differences by exposing all groups to the variations of the independent variable, while at the same time ruling out order-of-presentation effects (Isaac & Michael, 1990).

In the counterbalanced design, each group of students was exposed to each variation of the independent variable at different times during the experiment (see Figure 2). After each treatment, the column mean for each variation of the independent variable was computed. These mean scores were then compared using an ANOVA to check for initial differences and sequencing differences in the dependent variables: student achievement and student satisfaction.

Analysis of Student Achievement

Three dependent measures were evaluated to determine levels of significance between and among treatment groups: post test scores, drawing scores, and quiz scores. The maximum score for the post test is 30 and the maximum for both the drawing and quiz scores is 10. Table 1 shows the statistical means of the treatment groups for each of the dependent measures.

Treatment Variation				
	Weeks 1-5	Weeks 5-10	Weeks 10-15	
Section 1	A	B	C	A = Individualistic Treatment
Section 2	B	C	A	B = Combined Treatment
Section 3	C	A	B	C = Cooperative Treatment

Figure 2. Counter balanced design as utilized in the treatment schedule.

Table 1
Mean of Dependent Variables by Treatment Group

	Post Test Scores		Drawing Scores		Quiz Scores	
Treatment	Mean	SD	Mean	SD	Mean	SD
Individualistic	22.7588	3.5613	9.7661	.3147	8.1520	.8798
Combined	21.5263	4.9623	9.8012	.2263	7.8889	1.2477
Cooperative	22.4649	3.8352	9.8538	.2978	8.2378	.5592

The statistical means show little difference in achievement between the treatment groups. For both the quiz and drawing means there is a slightly higher score for the cooperative groups than the individualistic and combined groups. However, the scores for post tests indicate higher achievement in the individualistic groups than in either the cooperative or combined groups. Comparing combined scores to the individualistic and cooperative scores, we find that for both the post test and quiz scores, the combined scores were the lowest. Only in the drawing scores did the combined treatment show slightly higher achievement scores than the individualistic group.

The statistical means of achievement scores show little or no difference between the treatment groups in promoting achievement. However, it is helpful to analyze the standard deviations for each dependent measure to determine the spread of the scores. One-way ANOVAs were run on each of the achievement measures to determine variance between scores for each treatment. This analysis is depicted in Table 2.

The analyses of variance for both the post test scores and the drawing scores show an F ratio less than 1.96 and an F probability higher than 5 percent. It is therefore concluded that neither of these show significant differences within or between the treatment groups.

Due to the lack of significant difference in achievement scores between cooperative, combined and individualistic treatments, the following hypotheses are accepted for this study of cooperative learning structures on post secondary, computer aided design students:

1. There is no significant difference in achievement levels between cooperative learning structures and individualistic structures.
2. There is no significant difference in achievement levels between cooperative learning structures combined with individualistic structures and individualistic structures alone.

Table 2
Analysis of Variance for Achievement Scores by Treatment

Analysis of Variance of Post Test by Treatment

Source	*df*	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	47.2390	23.6195	1.3623	.2589
Within Groups	168	2912.8860	17.3386		
Total	170	2960.1250			

Analysis of Variance of Drawing Scores by Treatment

Source	*df*	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	.2222	.1111	1.3950	.2507
Within Groups	168	13.3816	.0797		
Total	170	13.6038			

Analysis of Variance of Quiz Scores by Treatment

Source	*df*	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	3.8012	1.9006	2.1568	.1189
Within Groups	168	148.0443	.8812		
Total	170	151.845			

Analysis of Student Attitude

Student attitude was tested at the end of each treatment. The attitude survey consisted of twelve questions used to determine the level of student understanding and enjoyment of the course.

In order to determine differences between treatment groups in their responses to the attitude survey, student responses were converted to an attitude score. The scores were based on positive responses to course enjoyment and student understanding. If students responded strongly positive (either with a strongly agree or strongly disagree – they received four points. Positive responses (either agree or disagree) received three points. Two points and one point were rewarded for negative and strongly negative responses respectively. Once the scores were determined, statistical means were calculated for each group (Table 3) and an Analysis of Variance was performed (Table 4) to determine if there was significance between group satisfaction.

Table 3
Means of Attitude Scores by Treatment

	Mean	SD	Cases
Individualistic	40.4035	3.5095	57
Combined	40.4561	3.8502	57
Cooperative	40.1228	3.8641	57

Table 4
Analysis of Variance of Attitude Scores by Treatment

Source	*df*	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	3.6608	1.8304	.1305	.8777
Within Groups	168	2356.0000	14.0238		
Total	170	2359.6608			

Due to the low F ratio and extremely high F probability, it is concluded from this analysis that there is no significant differences in attitude score between the treatment groups. Therefore the following hypotheses are accepted for this study of cooperative learning structures on post secondary, computer aided design students:

1. There is no significant difference in student satisfaction levels between cooperative learning structures and those individualistic structures.
2. There is no significant difference in satisfaction levels between cooperative learning structures combined with individualistic structures and individualistic structures alone.

Observations and Recommendations

One of the immediate benefits of cooperative learning structures over individualistic learning structures in the teaching of computer applications, is that students work two to a computer. This allows twice the number of students to use equipment. Such an obvious benefit would allow lab and course coordinators to enroll twice as many students into microcomputer classes. Observation showed no detriment to students working together at the computer. In fact, those students allowed to complete drawings independently would often leave class early and finish drawings during open laboratory hours. Students working independently also experienced more absences and asked more questions directly of the instructor than did their collaborative counterparts.

Cooperative learning sparked camaraderie throughout the semester and it appeared that most students enjoyed working together. There were many times during individualistic sessions that the instructor had to ask students to stop working together. They seemed hesitant to work at the computer alone and preferred working with a partner. However, the reverse was true as well. Some students balked at working with their team members during the combined and cooperative sessions. There seemed to be a pattern indicating that if students worked together at the first of the semester, as was the case in the combined and cooperative sessions, they wanted to continue working together. Those students who started the semester independently, struggled to get acquainted with their partners once the semester was underway.

With the indication that students liked to work together, the question arises "Why didn't the cooperative and combined treatments produce higher achievement and student satisfaction?". Obviously there may be a number of confounding variables not controlled for by this study, but observations were made which may effect research design considerations of future studies. Most of the students participating in this study seemed to be extremely grade motivated. Regardless of the treatment in which they participated, they appeared more concerned with quiz grades than with understanding how the computer or software worked. It may be suggested that any student highly motivated by grades will consistently perform for the sake of maintaining a grade point average. Conversely, students who appeared apathetic early in the semester regardless of the treatment did not appear motivated to work within their groups. Group members who were good students no doubt felt stress over a team mate not performing well, but those disinclined students seemed unmoved by the fact that they were pulling their teammates down. In fact, a few such students did not show up during quizzes in which their team mates were dependent on group participation.

The counterbalanced design was used for this study because it eliminated most threats to internal validity. However, one aspect of this design may have negatively effected the outcome of the study. One of the assumptions for this research was that five weeks was enough time to test the effectiveness of the treatments, but treatment overlap was not considered during the planning stages of this investigation. Because each student went from one treatment directly into another, most participants experienced a period of confusion and readjustment. Students were perplexed as to how they were being graded and whether or not they should be working with someone else. This added to the already difficult task of getting students to work together who chose to be independent and getting students to work alone who relied too heavily on their partners.

Because of the unique motivations that apply to college and university students, it would be interesting to look at similar research conducted with populations that may be differently motivated. An example of this would be to use cooperative models in a job retraining program for adults over age 30 who are learning a CAD system. Because this population is motivated by getting or keeping a job rather than grades, cooperative learning might affect them differently than those motivated by grades. Another motivation that should be considered is intrinsic motivation. For example, do individuals studying a subject strictly for pleasure and self improvement benefit from cooperative education?

Although statistics in this study show no positive correlation between cooperative learning and increased satisfaction of the learning event, it is possible that students may have enjoyed the cooperative sessions more than the individualistic session. More extensive research which analyzes student's feelings about working together could be helpful in determining the effectiveness of cooperative learning in a university microcomputer class. Qualitative analysis could be helpful in exploring student feelings because it would allow the researcher to focus on the dynamics of the instructional setting rather than achievement scores. Because this area of analysis is virtually unexplored at the post secondary and adult levels, any information gained in the area of student comfort with a computer or opinions about sharing equipment could greatly benefit the field of technology education. As technology continues to grow exponentially, it is essential that research uncovers effective methods to disseminate technological information. Cooperative learning should be extolled as one of these effective methods.

References

Dickson, W.P., & Vereen, M.A. (1983). Two students at one computer. *Theory into Practice, 22*(1), p. 296-300.

Hill, A.D., & Helburn, N. (1981). Two modes of peer teaching in introductory college geography. *Journal of Geographical Higher Education, 5*(145), p. 221-226.

Isaac, S., & Michael, M. (1990). *Handbook in research and evaluation.* 2nd ed. San Diego, CA: Edits.

Johnson, D.W., & Johnson, R.T. (1975). *Learning together and alone: Cooperative competition and individualization*. Englewood Cliffs, NJ: Prentice Hall.

Johnson, D.W., & Johnson, R.T. (1978). Student cooperative, competitive, and individualistic attitudes towards schooling. *Journal of Educational Psychology 100*, 183-199.

Mehan, H. (1985). Microcomputers and classroom organization. *Proceedings of the American Anthropological Association, 12*, 16-20.

Mruk, C.J. (1987). Teaching adult learners basic computer skills: A new look at age, sex, and motivational factors. *Collegiate Microcomputer, 5*(3), p. 294-300.

Oh, H. (1988). The effects of individualistic, cooperative task, and cooperative incentive structures on college student achievement in computer programming in basic (Doctoral dissertation, Illinois State University, 1987). *Dissertation Abstracts International, 49,* 1688.

Okebukola, P.A., (1985). The relative effectiveness of cooperative and competitive interaction techniques in strengthening students' performance in science classes. *Science Education, 69*, 501-509.

Rich, Y., Amir, Y., & Slavin, R.E. (1986). *Instructional strategies for improving children's cross-ethnic relations*. Ramat Gan, Israel: Bar Ilan University, Institute for the Advancement of Social Integration in the Schools.

Salend, S.J., & Sonnenschein, P. (1989). Validating the effectiveness of a cooperative learning strategy through direct observation. *Journal of School Psychology, 27*(1), p. 47-58.

Slavin, R.E. (1984). Meta-analysis in education: How has it been used?. *Educational Researcher, 13*(8), p. 6-27.

Slavin, R.E. (1986a). *Using Student Team Learning.* (3rd ed.). Baltimore: John Hopkins University, Center for Research on Elementary and Middle Schools.

Slavin, R.E. (1990). *Cooperative Learning - Theory, Research, and Practice*. Englewood Cliffs, New Jersey: Prentice Hall.

Teer, H.B, Teer, F., & McKnight, R. (1988). Peer taught microcomputer skills: An untapped resource for stretching the budget. *Computer & Education, 12*, 2, p. 355-357.

Webb, N.M. (1984). Microcomputer learning in small groups: Cognitive requirements and group processes. *Journal of Educational Psychology, 76,* 1076-1088.

Materials Science and Technology: What do the Students Say?

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Introduction

Materials Science and Technology (MST) is a multidisciplinary course developed to replace much of the dreary, tedious atmosphere of many traditional science classrooms with a stimulating environment conducive to learning. The course uses problem solving as the foundation of its approach to studying science and technology. Students learn problem-solving skills as scientists and technologists do through hands-on experimenting, creating, designing, and building. What are student perceptions of this course? This qualitative study examines the perspectives of students in three Materials Science and Technology classes at Desert High, a fictitious name for a large public high school in central Washington State. Like many high schools, Desert High is concerned with curriculum, student interest, parent expectations, and other problems that high schools face daily. The local community supports a university extension campus, many industries related to science, technology, scientific research, and agriculture.

The Status of Science, Mathematics, and Technology Education

As we frequently read, science, mathematics, and technology education are in trouble. The number of students taking these courses beyond the minimum required by state statutes is declining yearly. The National Center for Improving Science Education (NCISE) reports that "at least two-thirds of the nation's high school students typically do not elect science courses or achieve well in those courses they are required to complete" (NCISE 1991, p. 1). NCISE also says that these students are disproportionately women and minorities.

In Washington State alone, Nelson and Hays (1992) report that even in the context of the state's modest expectations in mathematics, science, and technology, students are not succeeding. They say that "although there are pockets of excellence, most science, mathematics, and technology education programs fall short of producing citizens prepared for the 21st Century" (p. 29).

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In light of these findings, Tobias (1991), Roy (1992), Krieger (1992), Hays (1992), and Nelson and Hays (1992) have reemphasized the need for reform in mathematics, science, and technology education. We have a science and technology illiterate society. Americans do not understand enough science or technology to make the political decisions required of them (Haggin 1992).

What is the problem?

Johns Hopkins University biology professor James D. Ebert summarizes well a myriad of descriptions offered by many experts in the field of science:

> In today's schools, science instruction during the elementary school years is infrequent and inconsistent. During the middle school years, a student's window to the natural world is typically a textbook accompanied by dreary worksheets. As a result, students enter high school thoroughly bored by science and give no thought to the subject beyond the required courses, which more often than not affirm their expectations of an unrewarding experience (in Krieger 1992, p. 27).

Methods of instruction appear and reappear as the single most important factor cited in research as the cause of student boredom. Courses generally do not provide hands-on opportunities for students to experience live science. Rather, "the high school curriculum is characterized by strict disciplinary approaches that are limited to the body of knowledge with little attention to how that body of knowledge develops or how it makes an impact on culture and society" (NCISE, 1991, p. 1).

According to Tobias (1991), "what makes science hard may not be the science itself or the unpreparedness or prior alienation of high school and college-level students, but rather how science is packaged and purveyed--something we can all do a great deal to change" (p. 379). If this assumption is correct, a valid conclusion would be that the problem is not studying science, mathematics, or technology, but how these disciplines are being taught.

Therefore, a new curriculum using the active, hands-on learning strategies described below may help alleviate the problem and improve science, mathematics, and technology education:

- manipulation of equipment and materials (Tobin 1990)
- hands-on work to make connections to real life (Leonard, Cavana and Lowery, 1981; Johnson and Johnson, 1985; Tobin, 1986; Farrell, 1991; and Louden 1991)
- real life connections and student involvement in decision making (Cothern and Collins, 1992; Tobin, 1990; Carey, 1986; Hogarth and Einhorn, 1992; Archenhold, Cooke, and Sang, 1987; Farrell, 1991; Johnson and Johnson, 1985; Leonard, Cavana, and Lowery, 1981)

- incremental exposure to new material (Hogarth and Einhorn, 1992)
- use of writing to help students develop understanding (Cothern and Collins, 1992; Kalonji, 1992; Louden, 1991; Fennell, 1991)
- cooperative learning for exchange of ideas and peer teaching (Farivar, 1992; Blosser, 1993; Starr, 1991).

The MST Course

The MST course offered at Desert High, and at more than a dozen other sites around the country, was designed based on some of the strategies de-- scribed above. The course uses materials--broadly defined as the "stuff" that makes modern life possible--to bridge school science and technology and "real life."

The course was developed by Northwest teachers and staff of Pacific Northwest Laboratory (PNL), which is operated by Battelle Memorial Institute for the U.S. Department of Energy. The philosophy/rationale of the course is described as follows:

> The philosophy that underlies this introductory Materials Science and Technology (MST) curriculum has as much to do with how things are taught as with what is taught. The instructional approach is based on the idea that students cannot learn through talk or textbooks alone. To understand materials, they must experiment with them, work with their hands to discover their nature and properties, and apply the scientific concepts they learn by 'doing' to designing and creating products of their own choosing...Students get a chance to use and build their mechanical skills as well as mind skills. We call this approach hands-on/minds-on learning...Students ponder, plan, experiment, goof up, correct, discover, and learn in a laboratory setting. (Pacific Northwest Laboratory 1993, pp. 17-19)

The course focuses on four major units of study--metals, ceramics/glass, polymers, and composites. Table 1 briefly outlines one example of the content of the course related to these units. Table 2 provides student learning objectives related to the example content.

Using a multi-instructional approach that includes elements to appeal to many learning styles, the course is designed to be taught to a wide range of students. Each unit typically focuses on (1) student experiments, individually and in groups, and (2) student projects, where students design, research, create and build individual or group projects. Designing and creating projects is often what draws students to enroll in the MST course, partly because they are attracted to the idea of building and studying something that is current and relevant to them.

Table 1
Outline of Course Content

I. Introduction
   A. Materials - The basic nature and properties of materials
   B. Solid State - Materials divided into two categories: crystalline and amorphous

II. Body of Course
   A. The Nature of Metals - Properties and characteristics of metals
   B. The Nature of Ceramics - Properties and characteristics of ceramics
   C. The Nature of Glasses - Properties and characteristics of glass
   D. The Nature of Polymers - Properties and characteristics of polymers
   E. The Nature of Composites - Properties and characteristics of composites

III. Topics to be Integrated
   A. Physical Properties
      1. Thermal properties of materials
      2. Electrical properties of materials
      3. Strength of materials
      4. Optical properties of materials
   B. Chemical Properties
   C. Periodic Table of the Elements
   D. Methods of scientific inquiry
   E. Significant developments in the history of materials
   F. Application of Materials
   G. Systems of technology development

Beyond MST's basic problem-solving approach through experimenting and creating projects, other fundamental elements of the course include fostering student creativity, developing handiness and journal writing skills, working in teams, and using community resources.

Table 2
Student Learning Objectives (overview)

On completing the course, the student will be able to:
1. Identify materials specific to our environment
2. Classify materials as metallic or non-metallic
3. Classify materials as crystalline or amorphous

Table 2 (continued)

4. Understand the basic properties of materials: mechanical, thermal, chemical, optical, and magnetic
5. Understand that the properties of a material are governed by chemical bonding and crystal structure
6. Understand that the properties of materials can be altered by changing their chemical makeup or physical makeup by treating them in various ways
7. Be able to use particular terms specific to materials science and technology
8. Apply the powers of observation, measurement, and comparison to analyze materials, their properties and applications
9. Understand the basic processes of extracting, preparing, and producing materials used in the course
10. Select materials for specific uses based on the properties, characteristics, and service of the materials
11. Flourish in an environment of creativity
12. Think critically to solve problems in manipulating and controlling the materials used in the course
13. Use writing to record observations, procedures and experiments and as a tool for thinking, studying and learning the subject matter
14. Demonstrate in writing and discussion an appreciation and understanding of significant developments in the history of materials
15. Select, design, and build a project or projects demonstrating the creative and innovative application of materials
16. Work in a cooperative group setting for problem solving.

Fusing Science and Technology Education

An important aspect of the MST course is how it illustrates the natural "fusion" of science and technology education. Hays (Pacific Northwest Laboratory, 1993) says:

> In the MST classroom, the boundaries are blurred between science and technology. It is not easy to know when one ends and the other begins. In this way, the learning environment of MST reflects the scientific and technical enterprise where scientists, engineers, and technologists work together to uncover knowledge and solve problems. In the school environment these overlapping and complementary roles of science and technology are found most often in courses called "technology education" (p. 2.2).

She goes on to say that "taken together, science and technology in the MST classroom are combined to prepare students who not only create, design,

and build, but understand the nature and behavior of the materials used in the building. They have the 'know-why (science)' and 'know-how (technology)' that lead to creativity, ingenuity, and innovation" (p. 2.3)
.

Methodology

Using observations of classroom and laboratory work, taped student interviews, and student journals, this study describes student perceptions of an MST course. The study took place over an eleven-week period starting in September and ending in November 1992. Classroom visits were conducted two days a week for ten weeks. Three separate classes were observed during each visit. Pseudonyms were used for the teacher and students involved in the study.

Observations

On Thursday, September 24, 11:30 a.m., at the end of the students' lunch period, Desert High is a different place than it was during my first visit. The quiet halls are transformed by the boisterous mix of teenage camaraderie. Mr. Mathews's classroom is a typical educational cubicle. Thirty student desks are crammed into a room built for twenty-four. A ten-foot long table with six chairs around sits in front of the room. Mr. Mathews's desk is wedged into the front left corner. Numerous posters cover the walls. Many are examples of different types and uses of materials. A dozen posters state themes on success or provide thinking prompts: "It's OK to Err"; "What did you do today?"; "Errors are our teacher: I hope you're running fast enough to make some"; "How did it go today? Good or Bad and Why"; and "Success means getting up one more time than you fall down." A large periodic chart hangs on the wall. Book shelves are stacked with books and magazines students use as reference sources. At 11:35, the bell sounds beginning class. Roll is taken by one student as others busily chat.

During roll, Mr. Mathews enters and engages in friendly banter with several students as he passes back assignments, commenting on the work as he goes, "Nice job, Jim," or "This is excellent, Sally." He then proceeds to the back of the room and picks up a student journal. All students are required to keep a journal for the MST class. He spends about six minutes going over various parts of the journal, showing examples of what a journal could look like. He stresses the importance of putting sketches, notes, assignments and projects in the journal. He adds emphasis in saying, "It might be a good idea not to throw your homework in the circular file since that stuff was good stuff. It might be used again on a test, and if you have it in your journal, then it could be a neat reference." He introduces me as "a former chemistry and physics teacher from the other side of the state working at Innovations Inc., and working on an advanced education degree." He tells students I will be observing them for the next couple of months and that I have taught the MST course, though not in the same way. He concludes his introduction and dismisses them to the laboratory across the hall to work on experiments and projects they have selected.

This is the manner in which most classes begin. Mr. Mathews is there at the bell. He introduces the topic for the day, goes over any necessary details, and then dismisses students to the laboratory, if that is what is scheduled, or continues with the classroom activity he has planned. The banter with students is expected, and students respond to Mr. Mathews's ribbing in a manner demonstrating their comfort with him. Comments made in the student interviews reflect this comfort.

The laboratory, a former industrial arts/technology laboratory about 30 feet wide and 50 feet long, is where students conduct almost all their hands-on activities. Storage cupboards rim the outside perimeter with work space often holding bench top pieces of equipment. A table saw, band saw, wood lathe, and other wood-working equipment are located on the far side of the laboratory. In an alcove at the rear of the laboratory are glass working materials and equipment. An acetylene torch is in the front of the room, away from the door. Four furnaces for melting and a burn-out oven are in the center of the room. In front of the room, equipment for working on metal projects and jewelry is set up on large work tables. Thematic posters are mounted on the walls as well as another periodic chart, this one with a materials emphasis.

As I enter the laboratory, I am surprised at how quickly the students have dispersed to different areas of the laboratory and begin working. They are working in the glass area, in the woods area, and at work tables with a clay called “FIMO” and on wax molds for metals projects. Students love to be in here, and since they are working on projects that they have chosen, they have an intense interest in them.

Moving around the laboratory I notice many students are writing in their journals describing the processes they follow, what works, what doesn't, and asking why. As I circulate from place to place, students look up, sometimes stop working, sometimes continue; occasionally, if they need help, they ask me a question. From the first day, the students are very open. If they have a question, they do not hesitate to ask. Often, if Mr. Mathews is busy, they seek me out to clarify a technique. Beforehand, I learned that Mr. Mathews likes students to do their own research first, so I am careful to determine if they have sought information from someplace or someone before they ask me. Guiding students to help them solve problems themselves is an important part of the MST course.

Interviews

Students from all three MST classes were interviewed. From each class, Mr. Mathews identified an honors student and an educationally disadvantaged student, and I picked four additional students at random, giving me an 18-stu dent sample population. The interviewees consisted of eleven seniors, three juniors, and four sophomores. Seniors predominated because they have preferential enrollment in the course. Older students were the most verbal, but as always, exceptions existed. Students were candid, open, and often surprised and pleased that I would interview them instead of a “smart kid.” What they had to say was informative, insightful, and entertaining.

Examining student perceptions from the foundational works of John Dewey (1938), Jurgen Habermas (1971), and Edwin Farrell (1991) I strongly believe what students say reinforces theoretical assertions. Student responses revealed some wonderful connections.

Findings

The Learning Environment

Teachers often hear, “Why do we have to know this stuff?” This suggests that the lesson is not making any connections for students. To the contrary, students in MST, describe a stimulating class, a place of adventure, or as Mark, a senior, says, “The material in here is complex, but the way it's presented it doesn't even seem like you're really messing around with the stuff you're doing... You just kind of pick it up, and before long you're using big words like vitrification, ionic and covalent bonding, and VanderWall forces...I mean, at first you don't understand it. But you're just kind of picking it up just through using it...It's different than just reading it in the textbook or learning a principle in chemistry. It really opens your learning to the world. You're doing practical stuff, but you're learning big concepts. It really kind of turned me on to science again.”

Analyzing Mark's comments you begin to appreciate the learning he has done. Experiences have built on one another. The big concepts have taken shape over time by experiencing them, not by reading about them in a textbook. Rather than simply learning the definition for vitrification, Mark followed the process a scientist would. He mixed ceramic materials and tested the results. He now understands the changes that take place when a material vitrifies. The same thing happened with ionic and covalent bonding, terms commonly used in science. Mark understands them because he has seen the results of their influence on crystal structure, metallic bounding, alloying, grain boundaries, and phase changes. The all-important connections between what is to be learned and the experience have occurred.

One of the unique aspects of the MST course is the use of other students as a reference. This gives students who know how to do something a chance to explain and enhance their understanding of an area while allowing receiving students a chance to learn the material from peers.

Often one student helps others, as in the glass working area where I observed one student demonstrating a particular glass cutting method to another.

Student A: “How did you cut that curved piece? Mine keeps breaking.” Student B: “Like this, see.” Student B demonstrates the technique from cutting to tapping to breaking the glass. Student B: “Be sure you tap it with this end to get it to crack. Then use these (holds a pair of nipping pliers) to break the glass.” Student A: “Oh, that looks easy.” Student A then does his piece and Student B watches as he follows her instructions.

A tremendous amount of activity is going on in the laboratory. If the students did not help one another, Mr. Mathews would not be able to allow so many diverse activities to occur simultaneously. Peg, a senior, confirms this saying “You can actually see what they're talking about, and relate that. It's easier to understand if you can see it. It's not just a bunch of diagrams of circles.”

Real-World Connections

Learning in MST also means making connections in other ways. Farrell (1991) suggested that students need to make connections between school and jobs or future careers. Andy, a junior, sees just such a relationship between the MST course and the world of work, “This class interests me, it kind of lets you use your imagination. The way I see it, the more we learn about it now then we'll be able to use it more. Like if we want a career.” Margo, a senior, suggests the same connection saying, “It gets you your seat of experience. You do stuff here and you can take it out. First of all, you learn responsibility...You get experience with equipment that might get you a job sometime later...It's all up to you.”

Real-world connections, understanding from the student's view of the world, is clearly seen in Ken's statement, “Well, I think it's a class where you come and learn about the materials of the world and learn how to apply them to everyday living and how we use them in our everyday lives.”

These students have been able to make a connection between what they are learning, future goals, and jobs. For them, the MST course is a significant place where meaningful experiences occur. They are not likely to become drop-outs.

Working in Teams

Research suggests that students also need social connections in their work. Team work is one social connection that often helps students to understand material. Robin, a senior, identifies the importance for her, stating, “The fact that you don't have to sit in a chair all day and just listen to a teacher say do this and do that. You get to pick out what you want to do and when you want to do it. It helps you too, you can team up with someone.” This student is verifying several important concepts: being actively involved in the material being studied, participating in the decisions on what is to be learned, and working cooperatively. All three are goals of the MST course.

Hands-on Approach

Dewey (1938) stressed the importance of students making an “organic connection between education and personal experience” (p. 12). He further expounded, “education is a development within, by and for the experiences” (p.17). Applied to the MST course, Margo says it this way, “It provides an atmosphere of hands-on, and for me that's something very different. It's not always an atmosphere that's provided in the schoolroom, and it helps me to learn. To be able to touch it, to feel it, to work with it and to be able to experiment with it. I don't always learn everything I'd like to be able to learn from a book or maybe be able to learn as well from a book.”

Sam reinforces the hands-on approach, “Actually,” he says, “being able to do something, hands-on, the hands-on part, that's what I like. I seem to learn, learn things better, I guess, being able to actually do it instead of learning it out of the textbook--actually doing it.” Karen, likewise, sees MST's hands-on approach as important saying, “I took this so I could use what I do learn instead of just knowing it and taking tests.”

As can be readily seen from student comments, the MST course offers the connections, relevance, and hands-on activities that help make science, mathematics, and technology education viable. From student studies of phase diagrams of alloys to applying the concepts of density to actual applications in making alloys, they appreciate the connections to situations where they can use the principles being taught.

Journals and Student Projects

When asked about the use of journals, another important connection between learning and understanding, students interviewed were able to affirm relevance. Each student found writing has a purpose. It gives them a reference, a focus for problem solving, and a way to think. It is significant that journals are not separate from learning in class. Students use their journals as a tool. Journals help develop Dewey's sensitivity, careful and diligent attitudes, and gathering, integrated, centering habits.

Bob says, “I like it because you can look back and see where you have been, you can see it in case you're lost. I like them because they keep you up to date.” Chuck puts journal use in the MST course this way, “You can look over what you've done, and you can see where you've made mistakes and what to do to improve those.” Robin says, “If you messed up on something, you can look back, see where you went wrong and figure it out.”

Even though students stated during interviews that they did not like writing in the journal, their journals gave engaging insights into their understanding of science and how they learn best. What do students actually write in their journals? Are journals the tool students claim them to be? Examining journals, I found that indeed they are just that, a tool.

The examples that follow are representative of student writing. Sample journal entries from interviewed students represent one of the better students, an average student, and a student Mr. Mathews indicated was a poor writer. In the first example we follow Ken, a sophomore, as he begins a project.

> Ken (9/23): Today I outlined the shape of my key chain on my sheet-wax. I also drew the letter "R" (drawn in his journal) and traced it onto another sheet of paper and then cut it out. I plan to engrave the letter into my wax model on both sides using the paper diagram as a guide. I will then trim my model down to size. After I complete my model, I plan to make a mold in the burnout oven. I will then centrifugally cast sterling silver into the mold and come out with a finished product.
>
> (9/24): Today I proceeded to trim the sheet-wax surrounding my model down before I actually cut the model out. However, when I was trimming the remaining excess wax from the model, the model cracked and one of the corners broke off...I'm going to try and fuse the wax back together tomorrow. If the process doesn't work I will have to make an entirely new model.
>
> (9/30): I continued to shape and engrave my wax model today. Unfortunately it broke. Mr. Mathews wants me to make a new model using pieces of thin sheet-wax stacked on top of each other. (Diagrams are drawn in journal to show this new approach.)
>
> (10/6): I began work on my new model...I hope to finish my model tomorrow.

Ken begins, develops a problem, tries a solution, and finally changes strategies. Everything goes smoothly for Ken as he invests his model and prepares to make the sterling key chain. We rejoin Ken's journal with an entry for calculating the amount of metal needed for his project.

> (10/21): Calculating metal density for model

weight of wax	1.7 g
plus 40%	0.68 g
total weight	2.38 g

> (does calculations for silver and copper) and enters the following: need 1.9 g of Cu and 23.1 g of Ag.

This entry shows how Ken makes a connection between what density is and how it can be used. He knows the density of his wax is about 1 g/ml and where to look up the density of sterling silver, which he found has a density of about 10.8 g/ml. Using this information, Ken easily determined the amount of silver and copper needed for his project. The concept of density has a useful connection. It is not just a fact to memorize.

This same process gave several other students a lesson in economics. They wanted to make a sterling silver belt buckle. When they had their wax model finished, completed the calculations for the amount of silver needed, and found the cost, they decided another alloy might be better. Rather than scrap all their hard work, they used another material. They made brass belt buckles.

> Ken continues his work and descriptions, developing a new problem.
>
> (10/22): Today Mr. Mathews helped me in my casting process...My key chain came out quite nicely. I plan to file down the engraved side over the weekend.
>
> (10/27): I plan to fill the engraved "R" with a clear green ceramic material because I can't get the engraved surface flat (a drawing shows the problem area).
>
> (11/12): I have begun pouring the ceramic mixture into the engraved portion of my key chain ornament. All has gone well except that the ceramic leaked out of the designated area and became attached to the reverse side of the ornament. I will attempt to sand off the residue tomorrow.

On November 19, I talked to Ken. He said that the previous day he fired the ornament and the ceramic shrank and cracked in the process. He had another problem to solve. As Ken's problem developed, he was exposed to both the physical conditions of the materials and the results of materials interactions. The expansion and contraction rates of dissimilar materials allowed him to see the results on his project. He developed an understanding of hardness as he began to remove the ceramic from the back of the silver piece. Science terms became science realities with meaning.

Looking at student journals you can clearly see that they are always working, learning and thinking--problems arise, and they have to adjust to them. If journals were not used, mistakes made could occur again. Because students keep a record, though, they seldom repeat errors. As they reflect on the materials and use the correct technical terms in their explanations, they attach meaning and understanding to the terms.

Students Teaching Students

Another student, Ory, enters this in his journal:

> (11/19): Today I finally cast strange-little man. I had strange-little man cooked at 900^{o}, I think. Then I put him in the rotating machine. In this I melted my Ag + Cu. (has a drawing here with arrow to help) And cast my medallion. From there I broke out the medallion and kept him. Next I have to sand and polish.
>
> (11/23): Today I helped three people invest their rings. I feel like a Materials Science genius!

This entry is especially important. It shows the impact that one student teaching another has on the student doing the teaching. “Today I feel like a Materials

Science genius!" He went through the process and was able to show someone else how to do it--an excellent example of connecting to his real world.

Peg solves her problems in this excerpt:

> (9/16-18): In the lab I am in the process of designing a ring. It will be a gold lion's head clasping an emerald or a green stone. I took a block of purple wax (square) and sawed off the chunk I needed.
>
> (9/23-25): Dan and Margo helped me drill a hole into the wax, but it ended up too small. I tried to file it, but it was still way too small. I cut the block into 2 sections - to get the size I wanted. Taking my pencil, I outlined what I would carve onto the side of the wax.
>
> (9/30-10/2): At this point Mr. Mathews showed me how to wrap wax around and melt it together (a drawing clarifies this). Right now I'm in the process of building up enough wax to form my lion's head.
>
> (10/7): Today I will be using inlay wax to shape the finer details of my lion's face. I will be using 4 different tools (drawings of tools are included). In this hour I completed most of the fine details. One problem I've always had is I'll get one side perfect and the other side won't cooperate.

Peg continues with descriptions of the project on which she is working. One last entry shows how ownership in the project affects the student.

> (10/27): Today I added more hair to my lion. I also gave it a beard. Dan said it doesn't look like a lion anymore. That comment didn't bother me because I'm secure with my decision. The hair broke off the left side. Tomorrow I will fix it and start working on putting a jewel in the mouth.

Students do use their journals, and they use them consistently. Their journal entries give you a glimpse of the hands-on and minds-on understanding and learning taking place as the students proceed with their projects--concurrent with the findings of Kalonji (1992). Even though this study does not examine student outcomes, journal entries give a strong indication of active student learning.

Conclusions

Clearly, students respond with enthusiasm to the MST course at Desert High. Their reflections indicate that connections are being made between real life and school. Student choices, cooperative learning, daily journals, and hands-on activities make this class highly student recommended. Judging from twenty years of teaching experience in two states and in five different districts, I do not see the students of Desert High to be significantly different from students at many high schools. They have classes they don't like. Some are bound for college, others are not. One significant difference I did notice was that these MST classes had few discipline problems because students are actively engaged in learning. Neither gender, ethnicity, nor academic predisposition affected student performance or enthusiasm in this class. Because of the limited scope of this preliminary study, I was not able to observe the students in other classes, so I cannot say that these students were as industrious in all their classes. In fact, several indicated that indeed they were not.

Many questions can be raised from this study about student achievement. Does this class truly allow students to better learn science, mathematics and technology as a result of their participation in the MST class? This study cannot answer that question because its focus was on student attitudes toward science, not outcomes. Students' responses confirm they enjoy science; for many, MST revived positive attitudes toward science. In Mark's words, “It's really interesting...It really brought me back toward the science fields.” While few students interviewed will likely pursue science as a major, the majority do feel good about science and appreciate their experiences. This, in itself, is a major step toward developing a science literate society.

This pilot study demonstrates ways that students are learning how science, mathematics and technology and the strategies used--writing, experimenting, designing and building--can help them relate science and technology to their lives. The problem-solving approach, with students making projects of their own choosing, using a hands-on/minds-on strategy, gives all the students a measure of success. Focused through the connections that they have established through ownership, working, and writing, the students talk to each other, help one another, and begin to enjoy learning. Science, mathematics, and technology move from the piecemeal, tedious atmosphere of a text-driven classroom to an adventure, a place to come, explore, and learn. Individual student interests establish projects. Laboratory activities develop concepts. These activities, coupled with group work, and writing, not working in isolation, allow students to share successes and learn from their errors. As they learn, they share, teaching and explaining to one another. Unanticipated results are learning experiences, not something to hide.

MST students are not just learning vocabulary and concepts; they use the terms and ideas to develop understanding. For example, the periodic chart becomes a reference. Bonding is used in relationship to crystalline and amorphous materials. They use the mole concept to calculate the amount of material they need to make a particular type of glass. Ductility, grain boundaries, work hardening, and slip plains develop significance as they draw wire. Phase diagrams and melting points for alloys have applications to the solder they make and use. Students see real life connections between their learning and perceptions, and the jobs that they read about, talk about, hear about, and eventually pursue.

Guest speakers share their experiences and discuss such topics as team work, problem solving, and networking. Students understand the team approach because they have worked together. They realize that there is more than one way to attack a problem, since they have shared their solutions to problems with one another. They know that each person brings to the team an area of expertise. Some are better with their hands and others with ideas. Some can draw and represent ideas graphically and others in words. Each person can be, and is, a contributor to success.

Dewey's experiences, Farrell's self-as-my-work, and Habermas's particular interests are all reflected in the words, work, and actions of the students in these three Materials Science and Technology classes. The learning theories of today are being applied in the class and the students are clearly responsive as Margo illustrates, stating, “I'm into art, I'm not into math or anything like that. But, I can apply what I've learned here, as far as all the different chemical make ups and nature of materials because they're studying the Stradivarius violin and the finish that they put on the violin and the wood that they used, and now they're trying to replicate that using chemicals and trying to come up with the rich sound and tone. So even in the realm of music you can use it.” By listening to what students say, we as educators, using the strategies and concepts of MST, are taking a giant step toward our goal of developing a science literate society.

References

Archenhold, W.F., Cooke, B.J., & Sang, D. (1987). Physics of materials: A technological component for A-level physics course. *Physics Education*, *22*(2), p. 73-76.

Blosser, P.E. (1993). *Using cooperative learning in science education*. (ERIC Document Reproduction Service No. ED 351207).

Carey, S. (1986). Cognitive science and science education. *American_Psychologist*, *41*, 1123-1130.

Cothern, N. & Collins, M. (1992). An exploration: Attitude acquisition and reading instruction. *Reading Research and Instruction*, *31*(2), p. 84-97.

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

Farivar, S. (1992). *Middle school math students' reactions to heterogeneous small group work: They like it*. Paper at annual meeting of the American Educational Research Association (San Francisco, CA April 20-24, 1992. (ERIC Document Reproduction Service No. ED 352366).

Farrell, E. (1991). *Hanging in and dropping out: Voices of at-risk high school students*. New York: Teachers College Press.

Fennell, F. (1991). Diagnostic teaching, writing and mathematics. *Focus on Learning Problems in Mathematics*, *13*(3), p. 39-50.

Habermas, J. (1971). *Knowledge and human understanding.* Boston: Beacon Press.

Haggin, J. (1992). Efforts to promote public understanding of science continue. *Chemical and Engineering News*, *70*(16), p. 31-32.

Hays, I. (1992). Materials science and Technology: A model for achieving national education goals. *MRS Bulletin*, *17*(9), p. 27-31.
Hogarth, R.M. & Einhorn, H.J. (1992). Order effects in belief updating: The belief-adjustment model. *Cognitive Psychology, 24*(1), p. 1-55.
Johnson, R.T. & Johnson, D.W. (1985). Student-student interaction: Ignored but powerful. *Journal of Teacher Education*, *36*(4), p. 22-26.
Kalonji, G. (1992). Alternative assessment in engineering education: The use of journals in a core materials science subject. (In *Engineering Education: Curriculum Innovation and Integration*, p. 215, proceedings of the Engineering Foundation Conference, Santa Barbara, Jan. 1992.)
Krieger, J. (1992). Push to restructure precollege science education gets more emphasis. *Chemical and Engineering News*, *70*(17), p. 27-30.
Leonard, W.H., Cavana, G.R. & Lowery, L.F. (1981). An experimental test of an extended discretion approach for high school biology laboratory investigations. *Journal of Research in Science Education*, *18*, 497-504.
Louden, W. (1991). *Understanding teaching: Continuity and change in teachers' knowledge*. New York: Teacher College Press.
National Center for Improving Science Education (NCISE). (1991). *The high stakes of high school science*. Andover, MA: Network.
Nelson, G., & Hays, I.D. (1992). *Washington Systemic Initiative in Mathematics, Science and Technology Education*. Seattle, WA: University of Washington.
Pacific Northwest Laboratory (PNL). (1993). *Materials science and technology handbook--1993*. Richland, WA: Pacific Northwest Laboratory.
Roy, R. (1992). The relationship of technology to science and the teaching of technology. *MRS Bulletin*, *17*(3), p. 5-9.
Starr, E.M. (1991). *Cooperative Learning: Effects on geology achievement and science attitudes of preservice elementary teachers*. (Doctoral dissertation, Washington State University, Pullman, WA.)
Tobias, S. (1991). What makes science hard? *American Journal of Pharmaceutical Education*, *55*, 378-382.
Tobin, K. (1986). Student task involvement and achievement in process-oriented science activities. *Science Education, 70*, 61-72.
Tobin, K. (1990). Research on science laboratory activities: In pursuit of better questions and answers to improve learning. *School Science and Mathematics*, *90*, 403-418.

Book Reviews

David H. Hopper. (1991). *Technology, Theology, and the Idea of Progress.* Louisville, KY: Westminster/John Knox Press:$14.99, (paperback), 153 pp. (ISBN 0-664-25203-6)

Reviewed by Richard A. Deitrich[1]

Technology, Theology, and the Idea of Progress explores the notion that the idea of progress has itself "progressed." Until the Reformation, the idea of progress was primarily spiritual, otherworldly and theological; now, it is predominantly material, this-worldly, and technological in content.

By referencing an expressive assortment of scholarly works, this book has six strongly framed chapters, each of about 20 pages. The chapter headings are as follows: Has Technology Become Our History?, Technology and the Idea of Progress, Disillusion and Power, Technology and Values, Technology and Theology, Summation and Theological Postscript.

In Chapter 1, Hopper asks "Has technology come to embody our chief values – the things we most want out of life? Does it not, in fact, represent our basic commitment?" He is not questioning America only, but all of Western Civilization.

To gain our affirmation the author cogently discusses several technological events such as the Moon landing, the Challenger and the Chernobyl disasters as well as the critique of public education in the A Nation At Risk report of 1972. His conclusion is that the idea of public education for cultural progress championed by people like Jefferson, Mann and Webster (i.e., education for both private virtue and public citizenship) has been supplanted by the idea of public education for technological progress.

Hopper next discusses the cultural idea of progress in Chapter 2. Early on he states his chapter theme:

> Technology did not give rise to the idea of Progress any more than it established the American republic. It certainly helped to broaden support for the idea of providing an abundance of material goods in the nineteenth century, but the formulation of the idea itself was another matter. (p. 33)

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True to his word, Hopper examines the idea of Progress without allowing technology a casual role. He does this by drawing upon what he calls "the pioneering work" of J.B. Bury in *The Idea of Progress*, published in 1920. In an engaging tour through Bury's work, we are led to the conclusion that it was the European Enlightenment – through men like Fontenelle, Condorcet, and Comte – which bore the idea of cultural progress.

However, we are awakened from nodding approbation to Bury's thesis by confrontation with the thesis of Robert Nisbet in his *History of the Idea of Progress,* published in 1980. This sword-crossing sparks delightful and important analysis as Bury's claim of an Enlightenment birth for the idea is challenged by Nisbet's thesis that the idea of progress is even older than classical antiquity.

To resolve this confrontation Hopper refers to an article by George G. Iggers titled "The Idea of Progress in Historiography and Social Thought Since the Enlightenment." Iggers reaffirms the Enlightenment nativity of the idea of Progress, but criticizes Bury's study as lacking sufficient account of the social and historical factors.

The replacement of the Enlightenment idea of cultural Progress by the contemporary idea of technological Progress is the focus of Chapter 3, Disillusion and Power. Most of the chapter is spent discussing this replacement through examining the thought of Carl L. Becker concerning Progress and the Enlightenment.

At this point Hopper inserts the theme that disillusionment from World War I and the emergence of science-based technology combined to shift the meaning and spirit of the idea of Progress.

The remaining several pages of this chapter are spent elaborating this theme in a stimulating discussion of works by B.F. Skinner, Marshall McLuhan, Seymour Papert, Sherry Turkle, Langdon Winner, Jacques Ellul, and Lewis Mumford, among others. The author closes Chapter 3 with these questions which serve as heuristics for the last three chapters: "What then has become of Progress when the only form in which we have it is technology?" and, "Whither does the pursuit of power lead when it is no longer centered in a stated social goal?"

Hopper prepares us for addressing the above questions by dealing with values in Chapter 4. We begin by examining Jacob Bronowski's argument that the practice of science (which for him includes technology) establishes the "prime values" of civilization. Next, Lyman White, Jr., contra Bronowski, argues that religious values nurtured the growth and spread of science and technology in the Middle Ages; but White is not clear whether religion sustained them into our present century.

From here, Hopper's examination of technology and values continues with Daniel J. Boorstin's notion of technology-fostered republican values, then to

John Kasson's caution concerning the American difficulty with “civilizing the machine.” The final note on technology and democratic values is sounded by Lewis Mumford who warns that the end of modern technology is “to transfer the attributes of life to the machine and the mechanical collective.”

Finally, this initially unfocused but tightly argued chapter closes with a powerful application of Martin Buber's far-reaching fundamental thesis concerning I-Thou and I-It relationships. Hopper uses Buber's insights to establish a reference point within democratic values with which to critique technology.

Chapter 5 addresses one of the questions which ended the third chapter: “What then has become of Progress when the only form in which we have it is technology?” In his first sentence, Hopper confronts us with White's well-known thesis of Judeo-Christian blame for Western society's “exploitative and abusive attitude toward nature.” We then encounter Thomas S. Derr and Lewis Mumford who attempt to counter White's thesis.

After this opening volley, the central player, Paul Tillich, is introduced. The idea of technological Progress is analyzed by Tillich's penetrating notion that "meaninglessness” is the prime malaise of modernity. He sees technological “progress” as in many ways threatening to human freedom, dignity, and meaning.

The author next compares Tillich's insights, with Moltmann's thought. For Moltmann, an important counterpoint to technological “progress” comes from future potentials which constantly transform present and past social realities into “new beginnings.”

Hopper concludes this chapter by offering his own reading of the situation by asserting:

> The challenge to theology of technology's coming-of-age is for theology to affirm its own proper counterproject of life-in-community...it must speak from an isness and not – as Tillich would have it – from an idealistic “valuating sense of essence” or – with Moltmann – from the perspective of some “final hope” (p. 113).

Chapter 6 develops the theme of life-in-community in the author's Summation and Theological Postscript. Hopper begins by voicing strong convictions about his two thematic questions of Chapter 3 (What has become of Progress? and Where does the pursuit of power lead?).

In answer to the question concerning Progress, Hopper's ironic conclusion is this: when the idea of cultural Progress has been sufficiently replaced by the idea of technological Progress, then a point is reached where there is social regress in the face of naked technological power.

In answer to the question regarding the pursuit of power, Hopper pens a powerful theological postscript. Where *does* the pursuit of power lead when it is no longer centered in a stated social goal? With prophetic rhetoric he warns:

> "Progress" once had a goal in human community; but technology has now claimed "progress" for itself and is leading the community ever closer to global death... Meanwhile, the corporate-technological complex moves on to introduce ever new innovations in pursuit of economic advantages and power (p. 126).

This constructive and thoughtful eleven page postscript is the book's tour de force. In it, Hopper exploits a weakness in the idea of technological "progress" and breaches the wall with Calvin and Barth as field commanders.

The above postscript as well as the copious inclusion of well-integrated materials from within the philosophy of technology genre make this book important reading for technology education.

Womack, James, Jones, Daniel, & Roos, Daniel. (1991). *The machine that changed the world*. New York: Harper-Collins: $12.00, (softcover), 323 pp. (ISBN 0-06-097417-6)

Reviewed by Harvey Fred Walker[1]

The automobile industry may appropriately be characterized as having produced machines "that changed the world." While some changes have been positive and some negative, the impact has been truly global in nature. James Womack, Daniel Jones, Daniel Roos, and others at the Massachusetts Institute of Technology (MIT) formed the International Motor Vehicle Program (IMVP) and engaged in a five-year, five-million dollar research project directed at identifying production factors leading to success in the global automobile manufacturing industry. The goal sought by the IMVP was to synthesize success factors, document their effect on organizational operations, and to develop a strategy guiding production of this machine more efficiently. Previous work by the IMVP toward this goal produced, *The Future of the Automobile* (1984), a book devoted to summarizing research on evolving trends and practices in the automobile industry.

The Machine That Changed the World is a well-written book that highlights comparisons and contrasts among automobile manufacturers. The book is written for a general audience interested in the topic of automobile production. Of particular relevance to the technology educator however, is the time frame and scope of the book. A chronological history of global automotive development and manufacture, from the industrial revolution to the present, provides many useful insights to the technology educator. Among the most important of these insights are discussions of the origins and future of manufacturing technology. In addition to high-school, undergraduate, and graduate educational relevance, technology educators would personally benefit from reviewing this material.

The book identifies "lean production" as a technology that is reshaping automobile manufacturing. While lean production may have originated in Japan under the concept of shared destiny, the authors emphasize that it is no longer confined to Japan.

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Lean production, as an emerging technology, is being adopted at varying rates by automobile and other manufacturers of the world. The driving force behind adoption is the need to provide more product variety at less cost with shorter development cycles. The adoption rate of lean techniques, however, differs from organization to organization and from country to country. Particularly noteworthy is that no one country, Japan included, may be characterized as being totally lean.

Lean production strategy synthesized managerial and manufacturing theories used in industry and academia. Primarily, lean production integrated product design, supply, distribution, manufacturing, accounting, marketing, and management under an umbrella of concurrency. Other related topics were identified and discussed in the book, including political, legal, and social concerns. Ironically, many of the theories comprising lean production are currently a part of technology curricula and technology-teacher preparation.

The book suggests that an ideal lean production system consists of all members within the system sharing information and resources in a team-oriented, multi-functional environment. The skills and abilities to share and work in multi-functional teams are key underpinnings and goals of current technology education. The authors discuss how an organization may begin the lengthy process of achieving leanness. The process of achieving leanness could be modeled in technology curricula to increase the effectiveness of student preparation for the realities awaiting them in industry.

In retrospect, *The Machine That Changed the World* provides useful insights into integrated product design, supply, distribution, manufacturing, accounting, marketing, management, and concurrency. The insights are particularly relevant to the technology educator when considering their political, legal, and social ramifications. Technology educators, particularly those responsible for teaching manufacturing concepts, will find this book most useful in updating their understanding of current manufacturing technologies.

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