Journal of Technology Education

Volume 6 Number 2 Spring, 1995

Journal of Technology Education

ISSN 1045-1064

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From the Editor

Technology for All Americans

As this issue of the JTE goes to press, Phase I of the International Technology Education Association's "Technology for All Americans" (TAA) project is just getting underway. With support from the National Science Foundation and the National Aeronautics and Space Administration, the project represents a unique opportunity for our profession to broadly communicate the belief that *every* student should have the benefit of some formal education *about* our technological world. This is our profession's best singular opportunity to carry that message to the educational establishment and to share with them the relevant ideas and models we've developed since Warner (1947) first proposed a "A Curriculum to Reflect Technology" nearly half a century ago.

The stated goal of Phase I of the TAA project is to develop a long-term vision that includes a "rationale and structure for technology education in the future." In a sense, our profession has been working on that task for at least fifty years. This time around, however, there are several factors working to the advantage of the TAA project. First, the project's title explicitly communicates the belief that technology education should be required content for *all* students. Second, the project suggests this vision ". . . should interface with science, mathematics, engineering, and other disciplines." Toward that end, the project has drawn about half of the participants for its National Commission from *other* disciplines. Most importantly, these other disciplines—particularly science and mathematics education—have recently begun to recognize the relevance of technology as *content* in the curriculum. Likewise, engineers are understandably supportive of this notion.

While some fear these "outside" contributors might distort the "vision," it is ludicrous to continue the dialogue without their input. Their participation in the TAA project lends it credibility and the "vision" will undoubtedly benefit from these fresh perspectives. The fact that we have been developing ideas and models for technology education for so long provides us with a substantive point of view to "bring to the table." If the educational establishment in America is indeed serious about the inclusion of technology in the curriculum (as nearly all educational reform efforts to date would suggest), it behooves them to listen to our ideas on the subject. Few understand the issues involved as we do, and none outside our field have developed better curriculum models for this purpose. Thus, the TAA project provides the vehicle for *our* perspective to be heard.

There is considerable concern in our profession that we will lose some degree of control with respect to the curriculum and delivery mechanisms for technology education. That horse left the gate some time ago! In the move from industrial arts to technology education, we redefined the scope of our profession very broadly. Technology teachers should no more expect to monopolize the teaching of technology than should English teachers hope to corner the market on writing. Not only should other disciplines be teaching *about* technology, but they would be remiss in not doing so. The unique perspective each of these disciplines brings to the task is already beginning to result in different models of "technology education."

Rather than deny others their options in this regard, we should welcome those different models while unabashedly promoting those which have made us so successful for the past century. Our methods have been characterized by hands-on activities and individualized instruction supported by a general laboratory that allowed students countless options for creative problem-solving. We must be sure that others understand that there is no better substitute for this hands-on approach to technological problem-solving. Regrettably, we seem to have forgotten this ourselves, as "modular technology education" rolls across the countryside. As we replace our general laboratories with pre-packaged modules, we *willingly* exchange an incredibly rich constructivist environment/curriculum for lesser facilities and questionable curriculum. While these turnkey solutions represent *an* approach to "technology education," I think we should promote more robust models as we continue the discussion with others outside our field.

The TAA project gives us a unique opportunity to promote whatever models we feel appropriate for technology education. While only a small number of professionals in our field serve on the project's National Commission, the project has begun and will continue to solicit input from the profession as a whole. Let your voice be heard.

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Articles

Industrial Arts/Technology Education as a Social Study: The Original Intent?

Patrick N. Foster

It is not difficult to provide considerable support for the contention that as a general-education subject, industrial arts had its start at Teachers College, Columbia University (Feirer & Lindbeck, 1961; Towers, Lux & Ray, 1966; McPherson, 1978). The term *industrial arts* (as a replacement for *manual arts*) was proposed by Teachers College professor Richards (Bawden, 1950; Smith, 1981); the "first…and only" definition of the subject was written by faculty members Bonser and Mossman (Brown, 1977, p. 2) in their book *Industrial Arts for Elementary Schools*; and the social-industrial theory of industrial arts was developed at Teachers College by Bonser and College Dean Russell (Snedden & Warner, 1927).

Within a quarter-century of the publication of *Industrial Arts for Elementary Schools*, Bonser and Mossman became an important part of the history of general-education industrial arts. Winslow (1922), Vaughn and Mays (1924), Newkirk (1940), and Wilber (1948) acknowledged or referred to Bonser and Mossman's work in describing the subject of their industrial arts texts. Within four years of his death, Bonser's early life and work had already been chronicled in a major work by Phipps (1935). Bawden (1950) characterized Bonser and Mossman's ideas as "receiving a great deal of attention and popular support . . . it was a formula for a new concept of industrial arts" (p. 40).

It is clear that Bonser and Mossman (1923) intended industrial arts to be general education for boys and girls of all ages and grade levels. Industrial arts, they wrote, "is not a special subject . . . but, quite the contrary, it is rather the most general of all in its far-reaching relationships" (p. 74). It is also certain that modern technology education can be traced directly back to this philosophy and to Bonser and Mossman (Householder, 1989; Volk, 1993; Lewis, 1994). Finally, it is clear that their work built directly upon the

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"Social-Industrial Theory" of Bonser and Russell, and Dewey's psychology of occupations (see McPherson, 1972, Chapter V); and consequently that it was an expression of the philosophy of Teachers College in the 1920s. It should also be noted that modern technology education has been shown to be a linear extension of this original philosophy of industrial arts (Foster, 1994b).

What was the nature of that philosophy? Wygant (1959) performed an in-depth study of the Fine and Industrial Arts department of Teachers College. He determined that, under Dean Russell and Director Bonser, "industrial arts became an adjunct to what we now know as social studies" (p. 221). Wygant did not, however, offer evidence to support this conclusion.

Wygant's Assertion

This paper will be a defense of Wygant's contention. The profession of technology education is at present emphasizing the technical aspects of industry, not social considerations. Emphases such as math/science/technology, the "modular approach," engineering technology, and "tech prep" are currently in favor (Petrina, 1994; Foster, 1994a). If Wygant's interpretation reflects the intentions of Russell, Bonser, and Mossman, the field of technology education has surely drifted from its original course. Pertinent works will be considered here in an attempt to demonstrate the validity of Wygant's contention.

Specifically, this paper will demonstrate that industrial arts was originally intended to be part of the "social studies."

The "Industrial-Social Theory"

"The social aspects of industrial arts as a school subject, under the leadership of James Earle Russell and Frederick Gordon Bonser, came to mean a more vital and inclusive study of reality than the manual training movement meant" (Mossman, 1938, p. 173).

Perhaps one of the best-known and most straightforward descriptions of the social conception of industrial arts is the Teachers College publication *Industrial Education* (Russell & Bonser, 1914). It was comprised of "The School and Industrial Life," written by Russell, and "Fundamental Values in Industrial Education," by Bonser.[1] Snedden and Warner (1928), respectively Professor and doctoral student at Teachers College, termed the philosophy espoused therein "The Russell-Bonser Plan" and "The Industrial Social Theory—" interchangeable terms that would appear repeatedly in later literature (McPherson, 1972).[2]

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[1] cf. Russell, 1909, n.d.; and Bonser, 1910, respectively.
[2] In biographing Bonser, McPherson shed considerable doubt on the suggestion made by some industrial arts historians that both Russell's and Bonser's contributions to *Industrial Education* originated with Russell alone. While assigning authorship to this document certainly has historical importance, it will be assumed here that both Russell and Bonser contributed to the development of the industrial-social theory.

Russell began his paper with an overview of the school curriculum and its problems. He identified two prevailing classifications of school subjects: humanistic, including language, art, and the like; and scientific, including mathematics, geography, and what would today be considered the natural sciences (Russell & Bonser, 1914). He judged the curriculum of the day to be "culpably bookish" (p. 2), albeit including a few additional subjects, such as gymnastics and the practical arts (including manual training), the latter mistaken for "fads and frills" (p. 4). But he was not an advocate of state-of-the-art manual training which, he regarded "in fact . . . little more than applied design" (p. 4).

As a replacement he suggested "economic studies . . . to provide instruction in the industries:"

> Of course I do not mean economic studies in the elementary school for the sake of technical training in any industry . . . I mean the study of industries for the sake of a better perspective on man's achievements in controlling the production, distribution, and consumption of the things which constitute his material wealth" (p. 6).

Russell went on to advocate a "threefold division of the curriculum" that was to include not only the humanistic and scientific studies, but the "industrial" as well (p. 7). He concluded "that industrial education is essential to the social and political well-being of a democracy" (p. 19). Immediately following Russell's treatise in the publication was Bonser's "Fundamental Values in Industrial Education." Bonser's plan was "very similar" to Russell's (Stombaugh, 1936, p. 129).

Like Russell, Bonser began his paper with criticisms of both the educational system and the industrial education of the day. "When the American people become fully conscious of an idea for reform, the idea expresses itself in practical application with astonishing rapidity," he began. " . . . the present day conduct of industrial education may be an illustration of this tendency" (Russell & Bonser, 1914, p. 23). In place of the system of the time Bonser suggested that

> a subject of study can be developed largely taking the place of the four subjects, drawing, manual training, domestic science, and domestic art, which will include the really most vital and fundamental values in all of these. It is also offered that this subject will . . . [develop] a knowl

> edge and understanding of social and economic relationships essential to every child (p. 29).

Bonser devoted the next several pages to practical examples of units which demonstrated the integration of the four subjects.

Throughout his paper Bonser advocated a social treatment of, and provided a social rationale for, industrial studies in general education. "Industrial Arts, as a school subject, is the distilled experience of man in his resolution of natural materials for his needs" (p. 50).

The social-industrial theory of Russell and Bonser was described Anderson (1926) as "cultural industrial education" (p. 221). Anderson, Fisher (1967), and many other historians of industrial education defined the Russell-Bonser plan by contrasting it with the theretofore prevailing asocial manual and industrial studies–as, for example, a "reaction against the tendency to exalt the importance of hand training *per se*" (Anderson, 1926, p. 221)–"a most serious indictment against 'manual training'" (Stombaugh, 1936, p. 128).

Lest the ingenuity of the plan be exaggerated, it should be pointed out that as Toepfer (1966) indicated, parts of Russell's contributions to the industrial-social theory were based on Dewey's 1900 book *The School and Society*; Fisher (1967) made similar suggestions regarding Bonser's contributions. Nonetheless, the Russell-Bonser plan was a significant departure from the industrial education of the day.

Their proposal received widespread notice and favorable attention (Smith, 1981; Miller, 1979), but industrial education was slow to react (Bawden, 1950; Smith, 1981). Nonetheless the field has recognized the industrial-social theory as a defining event in its history. "It did much to revolutionize the industrial arts" (Stombaugh, 1936, p. 129).

Olson (1963) called it "epoch-making," (p. 9); most other recent histories regarded it as one of the most significant publications in the field. The implementation of the plan at a Teachers College laboratory school in 1910 notwithstanding, and despite the significant lip service the industrial-social theory has received in the literature of industrial arts and technology education, there is no indication that it has been practiced to any large degree, or for any significant period of time.

Bonser and Mossman's Industrial Arts for Elementary Schools

In 1923 Bonser and Mossman published a book which further described the social-industrial theory. As such, *Industrial Arts for Elementary Schools* was quite influential. "This book has served well as the basis of our present day philosophy for correlation of industrial arts activity with subject matter content" (ACESIA, 1971, p. 50). Scobey referred to it as "probably the most influential basis for the present emerging concept of industrial arts" (1968, p. 5); to Olson, it was "nothing short of amazing" (1963, p. 8). "This position established guidelines for 65 years of curriculum development in Technology Education" (Householder, 1989, p. 11).

As will be discussed later, *Industrial Arts for Elementary Schools* has been considered by some to be vague in some practical aspects; yet its theoretical basis was very clear. Bonser and Mossman (1923) defined *industrial arts* as:

> . . . 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 (p. 5).

More importantly, they reasoned, these physical changes beget social change:

> By considering the changes in the well-being of man resulting from each invention, it will become increasingly apparent how fully man's progress in civilization and wealth has been parallel with his development of new tools and machines (p. 453).

Their social study of industry had a related methodology–children would actually engage in changing the forms of materials in order to learn not only about the processes of manufacture, but, more importantly, to gain a perspective on history, an appreciation of cultures, and an ability to cooperate with others. Construction in the classroom was viewed as "a means to a higher end—" an "approach to higher forms of industrial studies" (p. 17). "Gradually through [industrial arts in the middle and upper elementary grades] those values are brought out which are important in relationship to health, economy, taste in living, and which should be instrumental in making for greater efficiency in social cooperation" (p. 84).

Bonser and Mossman's basis for industrial arts as a study of culture and society was a prominent part of their book, and since its publication, curriculum developers and historians have recognized Bonser and Mossman's intentions. "As *content*, industrial arts was conceived as helping children to develop an appreciation and understanding of industry in the culture–a study of the related and resultant social problems" (Miller, 1979, p. 50). Unfortunately, action did not follow that recognition.

Mossman's Philosophy of Industrial Arts

Lois Coffey Mossman (1877-1944) is known in the technology education profession almost exclusively for her work with Bonser in their aforemen--tioned *Industrial Arts for Elementary Schools* (1923). It is quite common, however, for that book and its major ideas to be attributed to Bonser alone;

Bawden (1950), Sredl (1964), Smith (1981), and Foster (1993) hardly constitute a majority of those who have incorrectly attributed the book's definition of *industrial arts* solely to Bonser. When Mossman is mentioned at all in the history of industrial arts, it is only very rarely without Bonser.

Her other writings demonstrate that in the early 1920s she viewed, as Bonser did, industrial arts as a separate area of study which should be integrated with the total school program, including history and geography. But by late in that decade, Mossman clearly espoused the views that industrial arts was inseparable from the other social studies, and that industrial arts was a *methodology* necessary to the study of society.

At the outset of the 1920s, Mossman jointly defined the terms *industrial arts* and *household arts* in a manner similar to her aforementioned 1923 definition with Bonser for the former. "By the terms industrial and household arts we mean considerations of changes made in the forms of materials to increase their value for human use" (1921, p. 322). "The social studies," she wrote toward the end of the decade:

> . . . have to do, then, with those considerations affecting human living which are involved in…contact with the work of the world and its laws in (a) procuring and producing raw materials, (b) manufacturing these raw materials into more useful commodities, and (c) distributing these materials and commodities to the people who consume them (1929b, p. 322).

Mossman (1929b) specified that this aspect of the social studies related directly to foods, clothing, shelter, records, containers to hold one's possessions, and tools and machines (p. 328). Her interpretation of *industrial arts* was nearly identical: it was to be a study of food, clothing, shelter, records of human experience, containers to hold possessions, and tools and machines (Mossman, 1927, p. 287).

Her book *Principles of Teaching and Learning in the Elementary School* (Mossman, 1929a) was in large part a consideration the subjects of the elementary school curriculum. Therein the term "industrial arts" was listed in neither the table of contents nor the index. What most would consider "industrial arts" was wholly included in the social studies. As part of this subject, she wrote, "we should have … manufacturing; a little of this is inadequately included in industrial arts or manual training, and in the household arts" (1929a, p. 143). She again specified the needs of people to furnish themselves with food, clothing, shelter, and the like in describing the content of the social studies.

It bears repetition that in her major book concerning the elementary school curriculum, Mossman considered industrial arts an integrated part of the social studies curriculum.

Throughout her career, Mossman specified that social industrial arts subject matter was best learned through constructive activities: "genuine participation in the processes of making the products may develop respect for work and for man's inventive achievement" (1938, p. 60). Her rationale for the inclusions of social studies and industrial arts in the elementary curriculum were highly interdependent:

> Children are interested in questions about how people live and what people do. . . . Genuine social appreciation is furthered if one understands the simple hand process and the steps in the evolution to the complex machinery processes. . . . Therefore, the simple weaving of a rug for the doll house in the first grade does more than contribute to natural tendencies of children at that age. It provides a bit of detailed experience in a process—a detail that is fundamental in appreciating the weaving industry of the world of all time. When the child comes in contact with woven products and when he has become old enough to consider the changes brought about in society by the development of machinery, the bit of weaving experience may contribute toward the meanings involved (1929b, p. 329-330).

If social studies objectives were furthered, in Mossman's views, by industrial arts methodology, so was industrial arts content inseparable from the cultural studies (1927, p. 289).

As one of the founders of the general-education industrial arts in the United States, Mossman clearly held the view that industrial arts was a part of the social studies.

Bonser's Philosophy of Industrial Arts

Although industrial arts was only one of many educational concerns of Frederick Gordon Bonser (1875-1931), he has been identified as one of the most prominent molders of modern *technology education* philosophy (Kirkwood, Foster & Bartow, 1994). As previously indicated, Bonser was involved in the conception and writing of perhaps the two most important documents in the elucidation of the general-education interpretation of industrial arts.

Bonser viewed the industrial arts as part of the "practical arts" below the sixth grade. He emphasized "the elements of social purpose and human value" in studies of the industrial arts (1920b, p. 243). The related study of home economics, in this interpretation, was a social subject as well (Bonser, 1929). In 1922 he provided this definition and explanation of *industrial arts*:

> Definition–industrial arts is a study of
>
> 1. The changes made by man in natural materials to increase their value in meeting needs for material supplies–food, clothing, shelter, etc.
>
> 2. The effects upon individual and social life by the means used to make these changes.
>
> . . . I would emphasize the second part of the definition is worthy of much more attention than is given to it (Bonser, 1922, p. 121).

Like Mossman, Bonser favored an active, progressive, project-oriented classroom. Although he specifically advised against making industrial arts the core of the elementary curriculum (Bonser, 1927a), he emphasized exactly the same qualities in classroom projects as he did in objectives for industrial arts. As Mossman (1931) put it, “he believed that . . . the study of industry is truly cultural” (p. 4).

> The projects selected should in themselves be cooperative, socialized life situations in which the individual contributions will derive their worth from the measure in which they promote the common interests of the group (Bonser, 1920a, p. 116).
>
> The study of industrial arts is a factor in educating for citizenship in just the degree that it yields an understanding of meanings and an appreciation of values significant for the direction of conduct in individual and social life” (Bonser, 1922, p. 125).

In light of an article he wrote in 1927 for the journal *School and Society*, it is hardly necessary to repeat the perhaps hundreds of passages which would demonstrate Bonser’s social conception of industrial arts. In that article, Bonser plainly stated his opinion:

> The social studies *Trivium*—history, geography, and civics—should expand itself into a *Quadrivium* by adding industrial arts as a representative of the basic social activities, more vital to immediate social participation than many of the questions of the other three fields or of any fusion of them into one (Bonser, 1927b, p. 679).

The Contributions of Others at Teachers College

Bonser, Mossman, and Russell probably did more than any three individuals of the time to advance the social theory of the industrial arts. But a cursory overview of related works demonstrates plainly that their work was augmented and extended by many other educators.

Although their contributions to the field have been largely ignored, more than a few women associated with industrial arts and elementary education at Teachers College and its laboratory schools at the time produced scholarly works on industrial arts. Clara Stilmar's (1912) fifth-grade industrial-arts plan for the College's Speyer laboratory school was one of many published under Bonser's direction of the school. In addition, books by Alice Krackowizer (1919) and Margaret Wells (1921) discussed in detail the need for industrial arts activities to have a social perspective.

A few years earlier, Sara Patrick completed her master's degree at Teachers college. Her master's essay (Patrick, 1916) was written on the topic of the "problem" method in industrial arts and its relation to efforts by individuals and societies to furnish themselves with records of their accomplishments. Patrick was a full-time instructor of industrial arts education for 25 years at Teachers College, in all teaching many more elementary industrial arts courses than Bonser and Mossman combined. In fact, while Bonser and Mossman taught courses in various areas, including curriculum design and elementary education, "the courses to prepare teachers for this type of work [industrial arts as a social study] at the elementary level were continued at Teachers College by Sara Patrick" (Wygant, 1959, p. 222). Her interpretation of the purpose of industrial arts was as part of the "social studies" (Welling & Calkins, 1923, p. viii), and her Industrial Arts Cooperative, which she founded in 1924, provided thousands of teachers with industrial and fine arts ideas over several decades. It was the first teacher's cooperative in the United States.[3]

Theresa C. Gunther (1931) performed her well-known doctoral research under Bonser and Mossman. In that study, which compared manipulative and nonmanipulative industrial arts, she wrote that "in initiating this experiment, it is assumed that the elementary industrial arts involve a body of subject matter of value and of interest to the children. Their questions and chance remarks give evidence that they are interested in *man and man's work*" (p. 3; emphasis added).

Perhaps the most extensive such work was the 1923 book *Social and Industrial Studies for the Elementary Grades* by Jane Welling and Charlotte Calkins. It contained more than 300 pages explicating the teaching of the industrial arts–food, clothing, shelter, implements, and records–organized in three classifications: social life and the family, modern and historic background, and problems of modern life. Welling and Calkins (1923) acknowledged their "indebtedness" to Bonser and Patrick, "who are the inspiration of their study and investigation of 'industrial arts' and related 'social studies'" (p. viii). Throughout the book, the authors referred to the topic as "the social and industrial studies."

[3]From information on file at the Special Collections Department, Milbank Memorial Library, Teachers College, Columbia University, New York.

Why the Intentions Were Never Realized

As mentioned previously, the Bonser-Mossman-Russell social-industrial approach to industrial arts was never implemented on a large scale. But whether the subject could have been widely practiced is wholly unrelated to the fact that the original conception for industrial arts was as a social study. The failure of industrial arts historians to recognize works such as that of Welling and Calkins, Patrick, and other women with point-of-practice concerns for the elementary school has done more than simply obscure the role of women in the development of industrial arts. It has relegated the comparatively theoretical work of Bonser, Mossman, and Russell, upon which they were based, to the mounting collection of ivory-tower philosophies—laudable, but entirely impractical.

In explaining why the social philosophy was never implemented, Towers, Lux and Ray (1966) noted that "Bonser spelled out the major subdivisions of content, such as the activities to provide food, clothing, and shelter, but he did not develop a complete subject matter structure" (p. 106). But others, such as Welling and Calkins (1923), Wells (1921) and Krackowizer (1919) fleshed out Bonser and Mossman's theories. By focusing only on Bonser, historians have been able to rationalize the profession's lack of attention to the social-industrial conception thusly: forced to choose between Bonser's weak and incomplete content structure and the established, proven, and well-regarded practices in manual education, the profession's only chance for survival was to ignore some or all of Bonser's theories. Towers, Lux, and Ray went on to credit Warner with continuing the Bonser and Mossman tradition (p. 107), but Petrina and Volk (in press) provided a different view which deserves attention. They suggested that the profession generally, and Warner specifically, had the opportunity to implement a more progressive, cultural industrial arts. Warner clearly regarded the Bonser-Mossman-Russell interpretation as his prime influence (e.g. Warner, 1928), but he "disregarded much of their vision" (Petrina & Volk, in press)—including the social-industrial conception.

Hoots (1974) cited an "out-of-context application of the Bonser philosophy" (p. 234) as the root of the problem, adding that "the manner of presentation utilized by Bonser was somewhat difficult to follow and somewhat difficult to implement" (1974, p. 227). Bawden (1950) pointed to the "problem of organization" as to why "it was inevitable that Dr. Bonser's proposals should meet a varied reception" (p. 44). Again, the question may be raised as to whether Bonser alone could have been expected to develop a broad vision *and* a plan for implementation. Olson (1963) noted that "inconsistencies" between traditional ideas and Bonser's interpretation "became increasingly annoying to teachers and leaders in these fields" (p. 9-10).

To be fair, it should be mentioned that Bonser himself may have been regarded by his colleagues as "somewhat difficult to follow." Well-known educator William Kilpatrick frequently wrote in his diaries of Bonser, often complimenting his ideas, but criticizing their organization or presentation. For example, in 1912 Kilpatrick went "to hear a discussion on Bonser's 'Industrial Arts.' He was good, but in my opinion there is yet need of study to clarify the ideas involved" (1912, p. 78).

To some degree, the ideas involved *were* clarified—but not by Bonser alone. The burden placed on Bonser to do so is unreasonable per se; it is more unreasonable in light of the facts that he did not develop either of his two major works on industrial arts alone; that he died at the height of his career; and that he had many educational concerns other than industrial arts.

This last point deserves more detailed attention. In the history of industrial arts/technology education is has been repeatedly noted that Bonser had no background in shopwork or drafting, had never worked in industry, had not been trained as a teacher of industrial subjects, and had never taught those subjects to schoolchildren (e.g. Mossman, 1931).

Two letters from Maurice Bigelow, Teachers College Director of Practical Arts, to Dean Russell illustrate that as early as seven years before the publication of *Industrial Arts for Elementary Schools*, the breadth of Bonser's interests was causing considerable trouble in assigning him to a school within the college. Bigelow argued that "we very much need Professor Bonser [in industrial arts] …even if some of his attention is in the future to be centered on Elementary Education" (Bigelow, 1916, p. 1). This request was granted by the Board of Trustees. Even so, and despite Bonser's being "the best man in the country on Practical Arts Education in general," his main concern was not industrial arts, Bigelow would write later to Russell. "Teachers College and Professor Bonser made a great mistake when it was decided that he should be transferred to Elementary Education" (Bigelow, 1920, p. 1).

Implications and Conclusions

Bonser and Mossman defined *industrial arts* as "a study of the changes made by man in the forms of materials…and of the problems of life related to those changes" (1923, p. 5); *technology education* is an "educational program concerned with technical means. . . with industry . . . and their socio-cultural impacts" (AIAA, 1985, p. 25).

In the general-education interpretation technology education clearly claims as its heritage, industrial arts was to be a study of society and of cultures, present and past. It seems clear that historically, technology education has chosen the Teachers College philosophy of technology and industrial edu cation over other available models. Lamentably, it has also chosen to ignore the rationale for including the subject in the public school curriculum.

It might be argued that a seventy-year-old philosophy may not be most appropriate today. After all, seventy years ago technology was different; society, certainly, was different. In the US, the study of education was still in its infancy. "Social studies" was a new subject in schools; so was industrial arts. But for whatever reason, the technology education profession continues, as exemplified by the above definition of *technology education*, to recognize the fundamental importance of social-industrial education. Mathematics is not mentioned in the definition of technology education. Science is not mentioned in the definition of technology education. The study of society and culture is.

At some point, the profession must decide its identity (Lewis, 1994). So far it has chosen "high-tech" content over methodology (Zuga & Bjorkquist, 1989, p. 69) and "largely ignored" the "social purpose" advocated by Bonser and Mossman (Zuga, 1994, p. 83). In addition to the profession's abandonment of social-industrial content, the Mossman-Bonser "units of work" methodology has been replaced by "the modular approach" in many programs (see also Petrina, 1994). The implication of this is that the content of technology education is so technical and asocial that its components can be presented in isolation from each other and in random order to achieve the desired effect. In fact, the only large-scale remnant of the social orientation of industrial arts is in official definitions.

Can it be put more plainly? The entire idea behind the inception of industrial arts was that it should be a social study to replace the disjointed, acultural, overly technical manual training *status quo*. It is highly ironic that the profession which adopted this radical philosophy is today returning to the state which demanded its very creation.

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Student Cognitive Styles in Postsecondary Technology Programs

John W. Hansen

Much of the published research on cognitive styles focuses on the differences in cognitive styles of students pursuing different majors in either a four year institution or a two year institution. For example, Witkin, et al. (1977) conducted a ten year longitudinal study in four year institutions which sought to determine if field dependence/independence was related to a student's (1) initial major choice (science, education, and other) and final degree major and (2) achievement in various major courses. The study determined that the selection of a major was influenced by cognitive styles and that students who initially selected majors that required a particular cognitive style which was different than their own were more likely to change to a major which complemented their cognitive style. The study also found a tendency for students to receive higher grades in fields that were compatible with their cognitive style.

Frank (1986) found that field dependence/independence of female education majors varied depending on the particular area of specialization within an education major (home economics, nursing, science, and special education). His results indicate that within an apparently homogeneous group characterized by a college major such as education, differences in cognitive styles may exist.

No research was found which assessed the cognitive styles of students pursuing technology majors and their specializations. When attempting to utilize cognitive styles research to improve instruction, educators should not assume that, within the field of technology, student cognitive styles are the same. Neither should they assume that the cognitive styles of students pursuing different technical specializations, such as electronics and mechanics, are different.

Technology teacher preparation programs continue to be arranged around the unit shop model (Clark, 1989). Brown (1993) suggests that technology educators acquire technical knowledge by taking technical courses: (1) exclusively in technology programs designed to prepare educators, (2) derived from

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industry oriented majors, i.e. industrial technology or engineering technology, and (3) which form a core of technical knowledge for both groups and then taking courses unique to education. An additional means for acquiring technical content not mentioned by Brown is to take the technical courses at the community college level and transferring the courses to a four year program. Assessing the cognitive styles of students solely within a four year teacher preparation program while neglecting the community colleges may not be an effective strategy for determining the cognitive styles of technology educators.

Cognitive Styles

Cognitive styles can generally be described as the manner in which information is acquired and processed. Cognitive style measures do not indicate the content of the information but simply how the brain perceives and processes the information. Cognitive styles can be described in a variety of ways, including hemispherical lateralization (left versus right brain), sequential or parallel processing, field dependence/independence, and spatial visualization. This study focused on only two of the cognitive style constructs: field dependence/independence and spatial visualization.

Field dependence represents the tendency to perceive and adhere to an existing, externally imposed framework while field independence represents the tendency to restructure perceived information into a different framework (McGee, 1979). The field dependence/independence construct is also associated with certain personality characteristics (Olstad, Juarez, Davenport, and Haury, 1981) which may have important instructional and learning ramifications. Field dependent individuals are considered to have a more social orientation than field independent persons since they are more likely to make use of externally developed social frameworks. They tend to seek out external referents for processing and structuring their information, are better at learning material with human content, are more readily influenced by the opinions of others, and are affected by the approval or disapproval of authority figures (Castaneda, Ramirez, and Herold, 1972).

Field independent individuals, on the other hand, are more capable of developing their own internal referents and are more capable of restructuring their knowledge, they do not require an imposed external structure to process their experiences. Field independent individuals tend to exhibit more individualistic behaviors since they are not in need of external referents to aide in the processing of information, are better at learning impersonal abstract material, are not easily influenced by others, and are not overly affected by the approval or disapproval of superiors (Frank, 1986; Rollock, 1992; Witkin et al., 1977).

The construct of spatial abilities was originally investigated in connection with the study of mechanical aptitude in the 1920s. In addition to the many factor analysis studies that have been conducted since the mid 1920s, many predictive studies were conducted to assess the role of spatial abilities in predicting job success (Ghiselli, 1966, 1973; Smith, 1964) and course grades in vocational and technical education (Lichert and Quasha, 1970; Martin, 1951). Occupations which have a strong correlation with spatial visualization included auto mechanics, aircraft construction supervisors and inspectors, plumbers, machine operators, and managerial occupations (Ghiselli, 1973; Lichert and Quasha). Lichert and Quasha also found statistically significant correlation between spatial visualization abilities and grades in several vocational-technical education courses such as drafting, electricity, machine shop, and printing. Eisenberg and McGinty (1977) suggest that students with different spatial abilities enter different professions.

Spatial visualization is the ability to mentally rotate or manipulate a visual image (McGee, 1979). It involves the ability to recognize relevant visio-spatial information, retain the information, cognitively manipulate the information, and predict the final position of the visual image.

Purpose

The purpose of this study was to describe the field dependence/independence and spatial visualization skills of postsecondary students enrolled in technology programs, which provide opportunities for technology educators to acquire technical knowledge, specifically, an industrial technology program at the four year level and a vocational education program at the two year level. The study sought to determine: (1) if there were significant differences in cognitive styles of students with different ethnic origins, (2) if there were significant differences in the cognitive styles of four year industrial technology and two year vocational education students, (3) if there were significant differences in the cognitive styles of students specializing in a mechanical or an electrical field of study, (4) if there was a significant relationship between academic achievement and cognitive style, and (5) if students who had completed a significant number of their major courses had significantly different cognitive styles than did novice students in the major.

Methodology

Design and Instrumentation

A causal-comparative study with two response (dependent) variables and five research (independent) variables was established to compare the cognitive styles of students in different technology majors and specializations. The two response variables consisted of the field dependent/independent score provided by the Group Embedded Figures Test (GEFT) (Witkin, Oltman, Raskin, and Karp, 1971) and the spatial visualization score Part VI, Spatial-Visualization (S-V), of the Guilford-Zimmerman Aptitude Survey (Guilford and Zimmerman, 1981).

The Group Embedded Figures Test is an 18 item instrument which requires the subject to identify a simple geometric shape in a complex figure. The instrument is visually oriented and requires reading for the instructions only. Subjects who correctly identify most of the simple figures are considered field independent while subjects who cannot identify the simple figure in the complex figure are considered field dependent.

The Spatial Visualization instrument is a 40 item test which requires the subject to mentally rotate a figure in a specified direction, magnitude, and sequence and determine its final resting position. This instrument is also visually oriented and requires reading only for the instructions. Students who correctly identify the final position of the object have higher spatial visualization skills than those who cannot.

Data Collection

The cognitive style instruments were administered to 95 industrial technology and vocational education students attending a central California university and the two community colleges which provided the largest number of transfer students to the university. At each of the instrument administration sessions, exact procedures were followed. Subjects were read, verbatim, the instructions provided by each of the instrument administration manuals. Practice problems provided in the administration manuals ensured comprehension of the directions. The subjects first completed the Group Embedded Figures Test and then the Spatial-Visualization test.

Data Analysis

The individual scores for the Group Embedded Figures Test and the Spa--tial Visualization test were used as the two dependent variables in a multivari--ate analysis of variance (MANOVA). A MANOVA was utilized since the cognitive style constructs of field dependence/independence and spatial visualization, even though they are highly correlated, may measure different constructs and that the joint analysis of the scores, rather than a series of one way analyses of variance, may provide additional insights into the cognitive style construct (Barker and Barker, 1984). A MANOVA essentially develops a synthetic variable (or vector) from the dependent variables. Thus, a single score or vector is used to represent the scores of multiple dependent variables. The means of the synthetic scores (sometimes referred to as centroids) are then analyzed for significant differences. In addition, the joint analysis of the cog nitive style scores may tend to stabilize the variances and could reveal significant differences between the groups when neither of the individual scores detect any differences (Barker and Barker).

The Group Embedded Figures Test and Spatial Visualization scores were jointly analyzed for a multivariate normal distribution and homogeneity of variance-covariance matrices. No violations of assumptions were detected. Significant multivariate differences ($p \leq .05$) were followed up with an analysis of variance utilizing Student-Neuman-Keuls (SNK) post hoc comparisons to determine which groups were significantly different. Effect size (η^2) was also calculated to indicate the relative strength of any significant group differences.

The low number of African American and American Indian (two) and female (two) students required a decision as to whether they should be combined into a single group for statistical purposes. Since a hypothesis of this study was to determine if ethnic origin mediates cognitive styles, it was decided that the consolidation of ethnic groups and male and female groups was not justifiable from a philosophical perspective (Ogbu, 1987). As a result, the ethnic groups of Asian, Hispanic, and White and males were the only groups utilized in the analyses. The other ethnic groups and female students were deleted from the sample.

Findings

Table 1 provides the means and standard deviations for the two cognitive style instruments grouped according to the research question under investigation. The GEFT and S-V had a maximum possible score of 18 and 40 respectively.

The cognitive style scores were first analyzed jointly with a multivariate analysis of variance. The results of the multivariate analyses of variance are provided in Table 2. The joint analysis of the cognitive style scores revealed significant differences between the groups based on ethnic origin, four or two year educational major, GPA, and novice/advanced standing. There were no significant differences in cognitive styles of students studying different technical fields and no interaction of educational origin and specialization.

The one-way analysis of variance of cognitive style scores (Table 3) based on ethnic origin revealed that the Asian and Hispanic groups had significantly different cognitive style scores than the White group (Table 1). The Asian and Hispanic groups were not significantly different from each other.

Table 1
Cognitive Style Score Means and Standard Deviations by Hypothesis

		GEFT		S-V	
Variable	*n*	*M*	*SD*	*M*	*SD*
Entire Sample	87	10.15	5.81	13.01	9.62
1. Ethnic Origin					
Asian	15	6.93_a	5.16	6.03_a	7.55
Hispanic	24	8.13_a	5.21	8.21_a	6.75
White	48	12.17_b	5.56	17.59_b	9.01
2. Major					
Voc. Educ.	56	8.29	5.52	10.17	8.61
Indust. Tech.	31	13.52	4.76	18.14	9.33
3. Specialization					
Mechanical	49	9.51	5.41	11.37	8.73
Electrical	38	10.97	6.26	15.13	10.39
4. Major GPA	72	10.72	5.75	13.44	9.53
Below 2.0	23	7.83_a	5.47	8.09_a	7.62
2.0 to 3.0	24	10.58	5.07	14.30_b	9.67
Above 3.0	25	13.52_b	5.43	17.55_b	8.95
5. Novice/ Advanced	73	10.74	5.71	13.56	9.52
Below 31 units	43	10.19	5.82	11.25	8.53
Above 31 units	30	11.53	5.56	16.88	10.01

Note: Means with different subscripts in a column differ significantly at $p < 0.05$ by the Student-Neuman-Keuls test.

Table 2
Multivariate Analysis of Variance for Cognitive Style Scores by Hypothesis

Effect	Multivariate Tests of Significance			
	T^2	Approximate F	Hyp. df	Error df
Ethnic Origin	0.41	8.33***	4	164
Major (M)	0.23	9.53***	2	82
Specialization (S)	0.02	0.70	2	82
M X S	0.00	0.01	2	82
Major GPA	0.26	4.32**	4	134
Novice/Advanced	0.11	3.81*	2	70

*$p < 0.05$. **$p < 0.01$. ***$p < 0.001$.

Table 3
Analysis of Variance of Cognitive Style Scores and Ethnic Origin

Source	*df*	*SS*	*MS*	*F*	Effect Size
GEFT					
Ethnic Origin	2	448.83	224.42	7.69***	0.155
Error	84	2452.23	29.19		
Total	86	2901.06			
S-V					
Ethnic Origin	2	2076.14	1038.07	14.72***	0.244
Error	91	6425.29	70.61		
Total	93	8501.43			

*$p < 0.05$. **$p < 0.01$. ***$p < 0.001$.

The one-way analysis of variance based on major GPA (Table 4) indicated that the GEFT only detected differences between the "below 2.0" and "above 3.0" group, while the S-V instrument detected significant differences between the "below 2.0" group and the "2.0 to 3.0" and "above 3.0" groups (Table 1). The "2.0 to 3.0" and "above 3.0" groups were not significantly different from each other.

Table 4
Analysis of Variance of Cognitive Style Scores and Major Grade-Point-Average

Source	*df*	*SS*	*MS*	*F*	Effect Size
GEFT					
GPA	2	389.07	194.53	6.86**	0.166
Error	69	1957.38	28.37		
Total	71	2346.44			
S-V					
GPA	2	1182.81	591.40	7.63***	0.169
Error	75	5814.40	77.53		
Total	77	6997.21			

$^{*}p < 0.05$. $^{**}p < 0.01$. $^{***}p < 0.001$.

The analysis of variance of the cognitive styles scores and the novice or advanced classification (Table 5) revealed that there was a significant difference between the groups for the Spatial Visualization instrument and not on the Group Embedded Figures Test.

Table 5
Analysis of Variance of Cognitive Style Scores and Novice/Advanced Standing

Source	*df*	*SS*	*MS*	*F*	Effect Size
GEFT					
Novice/Advanced	1	32.08	32.08	0.98	
Error	71	2315.98	32.62		
Total	72	2348.05			
S-V					
Novice/Advanced	1	698.07	698.07	8.42**	0.162
Error	77	6382.62	82.89		
Total	78	7080.69			

*$p < 0.05$. **$p < 0.01$. ***$p < 0.001$.

Discussion

The similarities in the results of the Group Embedded Figures Test and the Spatial Visualization test may be attributed to an order effect. In all cases, the GEFT was administered first and then followed with the spatial visualization test. The test sequence was established based on the perception that the GEFT was easier to complete than the S-V test. This may not have been true for the field dependent subjects. Replication of this study or studies that assess cognitive styles with multiple instruments should control for order effect.

The results of this study confirm the findings of a number of researchers regarding the differences in cognitive styles of ethnic minorities and white students (Castaneda, Ramirez, and Herold, 1972; Kagan and Zahn, 1975; Ramirez and Price-Williams, 1974). In most cases, these studies found that the ethnic minority students where more field dependent than the white students.

The administration procedures for both instruments includes several practice problems to ensure that the directions are understood. In particular, the GEFT includes seven problems that are administered at the beginning of the test to determine if the subject understood the directions. If these seven items were not completed correctly, the scores from these subjects were eliminated from the sample. The students who completed the seven control problems correctly appeared to have a sufficient level of English proficiency to complete the remaining portions of the test and, as a result, English language deficiencies do not appear to be the source of variation between the ethnic groups.

The comparisons between groups based on ethnic origin indicated that the Hispanic and Asian groups were significantly more field dependent and had lower spatial visualization skills than the White group. The differences in cognitive styles due to ethnic diversity in the technology classroom introduces a learning factor which has, in all likelihood, been ignored by most faculty. This suggests that as postsecondary institutions experience shifts in ethnic diversity, instructors and students need to be aware of the different cognitive styles of the students. Faculty should recognize that their students' learning processes may have changed and that they need to determine how they can best assist the learning of their new students (Berthelot, 1982; Brodsky, 1991; Sinatra, 1983).

The relationship of cognitive style and major and specialization selection and achievement is an important issue since universities and colleges have undertaken major recruitment efforts seeking to increase minority and female student enrollment and retention in underrepresented programs, such as math, science, and technology. The newly recruited minority and female students may not, though, succeed in the program due to their cognitive styles. In fact, students may have originally preselected themselves out of a particular major or specialization due to past failures in courses that did not match their cognitive style strengths.

Pettigrew and Buell (1988) found that preservice and experienced teachers could not correctly diagnose the learning styles of their students. This suggests that instructors are not aware of differences in the ways in which students process information differently. Teacher educators, existing teachers, and new teachers should be informed of the potential differences in cognitive styles of their students and the ways by which they can facilitate the learning of their students.

The classification scheme used in this study grouped many ethnic subgroups into major categories such as Asian, Hispanic, and White. This was done to conform to the standard ethnic categories provided by the university. In retrospect, this was an error, since there may have been an extreme amount of heterogeneity within each major ethnic group (Knott, 1991; Ogbu, 1987) which could be attributed to factors such as culture. The classifying of Japanese Americans and Hmong immigrants into a single Asian group may not be justifiable with a student population that is possibly more culturally diverse than ethnically diverse.

Differences in student cognitive styles based on a four or two year major were found in this study. The findings of this hypothesis, the cognitive style differences between four and two year programs, were unexpected and introduce an additional variability factor into the technology classroom. Future technology teachers enter teacher education programs by enrollment in either a four year university or transferring from a two college to a four year university.

The selection of a four or two year institution is based on a variety of factors such as location, cost, high school achievement, and SAT scores. One factor which has not been reported in the literature is the role of cognitive styles in determining enrollment in a four or two year institution. From an instructor's perspective, differences in cognitive style may come from differences due to culture and also differences in the educational origin of the student. Transfer students may have different cognitive styles than the students who began their educational endeavors in a four year institution.

Differences in cognitive styles do not indicate differences in learning ability or memory (Witkin, Moore, Goodenough, and Cox, 1977). Cognitive styles indicate the preferences an individual has for perceiving and processing information, not the ability to learn the material. Thus, students with equal learning abilities but different cognitive styles may experience different levels of success in the same environment. This suggests that the "screening" mechanisms of GPA and, potentially, SAT scores for enrollment in a four year institution may be preventing students with different cognitive styles from entering four year institutions.

The results of the comparisons of cognitive styles and specialization indicated that there were no significant differences in cognitive styles between students pursuing mechanical and electrical specializations.

The significant relationship of cognitive styles and academic achievement is interesting when one considers the importance of grades and continued enrollment in postsecondary programs. A review of the research involving field dependence/independence and spatial abilities of postsecondary students reveals that existing studies were conducted in either a two year or a four year college. None of the studies attempted to compare the spatial abilities of students studying identical specializations in four and two year programs. This is an interesting omission considering that a function of the two year college is to provide a path by which students can transfer to a four year college.

Students who start their postsecondary education in the two year programs and intend to transfer to a four year college may have a difficult transition due to the incongruities between their cognitive styles and the cognitive styles required to succeed in their new major. The findings that major grades and continued enrollment in a major are related to cognitive styles supports this concept.

Students who start a two year program and achieve success in the program, based on their existing cognitive style, will probably continue in the major. At the completion of the two year program the students may elect to continue their studies by transferring to a four year college. Once there, the students may find that they can no longer maintain the same level of academic performance and may drop-out of the four year program or change their majors to coincide with a more cognitively appropriate academic demand (Witkin et al., 1977).

Possible explanations for the differences in the spatial visualization skills of students based on the number of major units completed include attrition and a training effect. Attrition may occur when students with cognitive styles different than the cognitive style required in the major drop-out or change majors (Witkin et al., 1977). As a result, the student populations in a particular major become more homogeneous, reflecting a distinct cognitive style within the major or specialization.

A training effect may occur as students complete more of their major courses. Students who initially had cognitive styles different than the major requires may have adapted or trained themselves to process information more effectively. If this is true, it lends credence to the concept that students who are aware of their learning styles and how they can adapt their learning styles to the learning situation can achieve higher grades (Cook, 1989; Halpin and Peterson, 1986).

Holtzman, Goldsmith, and Barrera (1979) suggest that cognitive styles may become more important as the level of instruction increases. They suggest this as a possible explanation for the low enrollment of ethnic minorities in advanced level or graduate classes. Since this was not a longitudinal study, little can be ascertained about the source of the differences in cognitive styles between novice and advanced students. Both theories are plausible, although the attrition theory is supported by Witkin et al. (1977).

With the establishment of the relationships between cognitive styles, ethnic origin, grade-point averages, novice/advanced standing, and educational origin, students with diverse cultural and educational origins may hit a "cognitive style glass ceiling." Efforts to increase the ethnic diversity in many academic and occupational arenas will be limited since a four year degree is an essential entry-level requirement.

A consideration of the secondary student and the selection of a major or specialization is also germane to this issue. A current and popular emphasis in technical education at the secondary level is Tech Prep. Tech Prep is an innovative program designed to encourage secondary students who are not following a four year college preparation path to consider a technical career. This is accomplished by allowing selected two year college credit for technical courses taken at the secondary level.

Could it be that the two academic paths, college prep and Tech Prep, are determined by the cognitive styles of the students? Evidence to support this idea is the correlation between field dependence/independence and SAT scores (Witkin et al., 1977). Since SAT scores are a fundamental selection criteria by which students enter into a four year institution, secondary students with differ ent cognitive styles may be prevented from directly entering into a four year program. If this is true, cognitively diverse students may be prevented from obtaining a four year degree since they could not immediately enroll in a four year college because of their SAT scores and neither could they utilize the stepping stone of a two year college program to transfer to and complete a four year program. Attempts to eliminate the overt selection bias of ethnic origin in enrollment in postsecondary technology related four year programs may have been thwarted by a covert selection bias of cognitive styles.

Efforts to achieve diversity in education, and eventually the workplace, by enticing students into specific areas of technology may be destined to fail since they are not addressing the individual learning needs of the student, in fact, they may not be addressing the very reasons the students had preselected themselves out of the major. If attention to factors, such as cognitive styles, can improve the achievement of all students and the retention of underrepresented students in technology education programs technology educators must address the cognitive style differences of the learner in the instructional design process.

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Teacher Socialization in Technological Education

Ronald E. Hansen

In a recent technological education teacher development study, two elements of teacher socialization–the process of formally preparing to become a teacher (Ginsburg, 1988, p.1)–were singled out for review. First, the study set out to examine the influences on teacher socialization prior to formal teacher education. Second, the impact of pre-service teacher education itself, was explored. The socialization process for technological education teachers was felt to have two dimensions: The first concerns the adjustment would-be teachers make when initially preparing for the profession. Feiman-Nemser (1990) refers to this adjustment as a transformative one because teachers come to the profession with a range of preconceptions that may or may not be effective in the classroom instruction component of a teacher's work. The second element of socialization is identified in the occupational socialization research literature (Schein, 1985) and involves the adjustment a teacher makes as she/he becomes an educator in a broader context, i.e., the adjustment of the individual to the culture of the profession. The purpose of this paper is to report the results of the teacher development study undertaken at the University of Western Ontario (UWO), Faculty of Education.

Problem Statement

Concerns that prompted the UWO investigative group included a perceived tendency on the part of technological education teachers a) to adopt a much broader spectrum of curriculum goals, e.g., preparing students for jobs, than their counterparts in general education subjects and, b) the tendency on the part of technological education teachers to congregate with peers from their own program area, making opportunities for contributions to the school culture and the profession generally, problematic. In the absence of formal research to validate these two perceptions but armed with a Ministry of Colleges and Universities grant and mandate, a conventional technological teacher education program was modified. Teacher development project team was formed and a study,

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which was to inform the program change process, designed and executed. The broader issues in technological teacher education are relatively well understood by technology teacher educators. First, technology and the way knowledge about it in schools is transmitted, is changing. Second, substantive analysis of past practices in technological teacher education, is overdue. And third, teacher development is a complex human and professional process which combines personal and environmental factors that are often poorly understood.

The UWO teacher development project was guided by two questions. To what extent is successful socialization into the teaching profession a function of the knowledge, skills, and values that candidates bring with them to the teacher preparation process? And, what impact does the formal teacher preparation process have, if any, on the predispositions of teachers? From a program change viewpoint investigators wanted to know if there was some way to predict what candidate characteristics and experiences would be valuable in ensuring a smooth transition into the profession. The research team also wanted to know if technological education teacher candidates were unique in their socialization patterns. The research findings and post-study insights into research design, proved to be particularly revealing.

The Teacher Socialization Literature

Zeichner and Gore (1990), who define teacher socialization as the process whereby the individual becomes a participating member of a society of teachers, are skeptical about the impact a teacher education program can have on teachers' predispositions to teaching. Studies (Lortie, 1975; NCRTE, 1988b) suggest that, at best, teacher candidates become socialized into the profession during the practice teaching component of teacher preparation and in the first two years of teaching. Whether or not the socialization process for technological education teachers is any different than it might be for general education program area peers, is not identified in the teacher socialization literature. There is some evidence, (Burden, 1990), which implies technology teachers' development should be similar to the norm for all aspiring teachers. Zeichner and Gore (1990, p. 332) organize a literature review around three career stages: Prior to formal teacher education (pre-training influences); during pre-service teacher education; and during the in-service years of teaching. The first two of these stages are used as a structure for the following analysis of the research.

Pre-training Influences on Teacher Socialization

Zeichner and Gore (1990, p. 334), categorize the theories on pre-training influences as follows: evolutionary, psychoanalytic, and apprenticeship of observation. Evolutionary influences, first proposed by Stephens (1967), provide an interesting way to account for the socialization of teachers. Stephen's theory, while largely ignored by scholars of teacher socialization, emphasizes the role of primitive spontaneous pedagogical tendencies in explaining why teachers act as they do. According to the evolutionary view, teachers bring to teacher education a set of predispositions that are present in all individuals to varying degrees.

A second position (Wright & Tuska, 1967), the psychoanalytic view, suggests that teacher socialization is affected to a considerable extent by the quality of relationships teachers had as children with important adults, e.g., mother, father, teacher, and that becoming a teacher is, to some extent, a process of trying to become like significant others in one's childhood or trying to replicate early childhood relationships. According to this view, teachers are governed by the effects of this early childhood heritage on their personalities.

The "apprenticeship of observation" explanation, offered by Lortie (1975), suggests that teacher socialization occurs largely through the internalization of teaching models during the time spent as pupils in close contact with teachers. Formal teacher education, according to Lortie, has little impact on cumulative effects of this anticipatory socialization. Lortie's argument, according to Zeichner and Gore, is based on several studies in which teachers attested to the tangential role of their formal training and in which they frequently referred to the continuing influence of their earlier mentors. Such role models, as many students know from experience, can be both positive and negative.

The three explanations, as a collective, do provide a powerful argument for looking at the experiences and predispositions of teacher candidates prior to entry into teacher education institutions, and for developing greater insight into the relationship between teacher preconceptions about teaching and teacher socialization.

Program Influences on Teacher Socialization

A review of the literature in the field of technological teacher education revealed a paucity of formal study on the impact of pre-service education and on technological teacher development generally. As a result, insights into the impact of pre-service teacher education in the field of technology could not be established. The situation in teacher education research (no reference to specific subject areas), is somewhat different. Where research has been conducted, the results regarding the effectiveness of pre-service teacher education are inconclusive. Pre-service teacher education programs (campus-based methods and foundations courses in particular), according to Mardle and Walker (1980), have little impact on the values, beliefs, and attitudes students bring with them to the profession, and influence little their subsequent actions in the classroom. What is known about the impact of university programs on students, is that it is difficult to isolate cause and effect (Zeichner and Gore, 1990).

While evidence on the effect of practicum experience is equally weak and ambiguous, Hoy and Woolfolk's (1990) research [cited in Zeichner and Gore] is helpful. They examine the influence of the student teaching experience on three teacher perspectives: orientations toward control, social problem-solving style, and efficacy. Orientation toward control was defined as the ability of a teacher to establish and maintain order in the classroom. Social problem-solving style was defined as the teacher's approach to student/teacher relations. These researchers found that teachers who encouraged student autonomy and responsibility tended to have students who were more intrinsically motivated and better problem solvers. Efficacy was defined as the teachers' sense of his/her own ability to affect student learning. The assumption is that the more efficacious the teacher, the higher the students' achievement (p. 280).

Research Design and Methodology

The research design adopted is used extensively in social work studies where the position and role of the investigator vis-à-vis the subjects under study, must always be considered. The case study approach was used to document student life-history information (Cole, 1991), to engage student participants in thought and reflection about program changes, to verify and record those reflections, and to measure the impact of the program. A group of students were invited to participate in the study for information gathering and feedback purposes. The participant-sensitive design is described by Rossi and Freeman (1989), and Goodson (1988). The participants in the study varied in age from the early twenties to late thirties, and represented technical specializations in architectural drafting, graphics, automotive, art, and electricity. They were female and male, had from five to fifteen years experience in business and industry, and ranged in formal education background from grade twelve to university graduation.

The method used to engage the teacher candidates in the study was ethnography. Borrowing from the discipline of anthropology, it was felt that the best way to glean information about the culture of aspiring technological education teachers was to explore the concepts, beliefs, and practices that could be found to characterize members of such a collective. Ethnography means, literally, a picture of the "way of life" of some identifiable group of people (Woolcott, 1988.) An anthropologist's task, as an ethnographer, would be to learn about, record, and ultimately portray the culture of the group (p. 188). The information collected in the study was derived from three sources, each of which could be used by itself or in combination so as to identify possible points of consensus or conflict. The data collected were from a pre- and post-program questionnaire, student journals, and pre- and post-interviews. These methods are described by Patton (1980), and Lincoln and Guba (1985).

The Process

Several stages were established for collection and documentation of experiences prior to and during the program. In the first stage a group of thirteen students was selected for individual case study (Merriam, 1988; Yin, 1989) to represent the diverse academic backgrounds, technological specializations, ages, and stages of career development. Out of the original sample of thirteen, eleven remained as participants throughout the academic year. To provide a contrast with this core group, base line data were also collected from the total student population (forty-five students) participating in the technological education program. Orientation meetings were held with the core student group to introduce the case participants to the project and explain the level of commitment that would be expected.

In stage two, two different methods were used to collect information that would assist the students serving as case studies in documenting their experiences. These students were encouraged to keep a journal of each week's school activities and to submit weekly memos to the project team on how things were going (Strauss, 1987). Life-history interviews were conducted to help establish a path of activities and experiences that led to the current choice of becoming a teacher (Cole, 1991; Connelly & Clandinin, 1990; Jones, 1983). Initial information on perceptions of being a teacher and career goals was collected during the Fall term using a flexible interview guide (McCracken, 1988). Each candidate was interviewed early in the pre-service teacher preparation process as well as during, and after it. Plans to interview these candidates in two years time constitute a part of the research design.

In stage three, a follow-up interview was conducted at the end of the Spring term which again asked students about their perceptions of being a teacher and also collected more detailed information on the structure and components of the program. In stage four, the research team read transcripts of the case study interviews and information from the weekly memos, and developed key themes for sorting and analyzing the information. Organizing and categorizing techniques described by Miles and Huberman (1984) were used to further sort the contextual data and pull together quotes highlighting major themes and recommendations for program changes.

The techniques included coding of themes from weekly memos, narrative reflections from investigators, and development of a path analysis tracing individual decisions to become a teacher. Stage five, yet to be completed, will analyze follow-up interview transcripts to assess the evolving beliefs of the participants.

Research Findings

The following data describe the diverse backgrounds, perceptions, tendencies, and expectations of the participants in the study. These data are organized into three categories. The first includes observations about the field of technological education teaching generally, the second about the practice teaching component of the pre-service program, and the third about the teacher education program at the Faculty. A short description of George (a pseudonym for one case study) provides a further illustration of themes that recur in the data.

The Field of Technological Education Teaching

Investigators found that teaching has dramatically different meanings among students in the technological education program. The only evidence which could be cited to explain this finding is that the teacher candidates came from varied business and industry backgrounds with many different technical specializations and formal education levels, as well as apprenticeship and work experiences. A wide range of expectations about teaching was also expressed by the student teachers who participated in the Fall and Spring interviews.

Student teachers in the program were pro-active about the human development aspect of education. They felt, because of their past experiences, they could empathize with high school students facing personal problems and difficulties in school. They expressed a commitment to take guidance counseling courses or to complete further studies so they would be better equipped to help students facing a variety of problems. There was a strong desire among the respondents to get more specialized training in their field, special education, and pedagogical skills.

Students were concerned about the low status assigned to technological education teachers and the curriculum in secondary schools. Most participants in the study felt technological education had clearly been short-changed. One student stated, for example: "There is so much you can take from my field and apply to mathematics and even English [courses]." Some students claimed technological education offered a model of work within the school environment which benefits a broad range of high school students with varying levels of learning abilities and competencies. Individual desires regarding career goals varied in nature and magnitude.

Perceptions During Practice Teaching

The practicum experience was different for every student: different types of schools, ability levels, associates, and programs. Despite these differences, students were generally positive about the benefits they received from the practicum experience. One student believed " . . . the practicum is much more valuable than the Faculty of Education experience. Learning does not mean much until you try to apply it." The same student had two associates who used different approaches to teaching; she was able to see the advantage and disadvantage of each approach. Another student commented: "I think the practicum is much more of an influence on your career because you actually learn how to work with kids . . . I think that's something they just cannot teach in the classroom at the Faculty."

Practice teaching helped many student teachers grasp the realities of the classroom. They realized teaching was a craft that combined competence within a specialized area of technology and service to a profession. One of the most interesting discoveries was that in education, one spends more time on the process than in the product-oriented business and industry environment. "The main objective is not to teach a technical specialization, but to provide an education." And, in one classroom, "kids may have varying levels of ability." There was also a realization that teachers face "political and social issues in schools" such as impractical school board decisions, student family needs, and discipline problems.

Perceptions of the Teacher Education Program

Perceptions of the way the technological education program at the Faculty was structured, varied. Most students felt that grouping the many technical specialists into broad fields such as communication, production, and transportation technology was a good program design feature. However, many students believed there to be little consistency in student assessment from one faculty member to another: "All students must be evaluated for the same things in the same ways and they are not; the program seems to be too loosely organized . . . a lot of changes back and forth." One student complained about confusion over what was required for an assignment or report. Another student felt the program " . . . needs a female instructor and more female students." There was also the perception that technological education students had more course-work requirements than general education students. First impressions of the program ranged from "shock" to "satisfaction". First round interviews showed that a few students found the transition, from working in business and industry to attending school, very difficult. "Courses [at The Faculty of Education] are set up for people who have degrees . . . some of us have a very different background and sitting down writing essays . . . we're used to practical things and concrete things and these are abstract ideas . . . why are we doing it anyway?"

One-third of the students felt that coming to the Faculty was " . . . almost like high school" and that the program was not responsive to students' interests and concerns. Their perception was that faculty members [foundation course professors primarily] undervalue the views and experiences of technological education students. There were also some negative comments about the teaching approaches used. One participant felt fellow students in his panel were treated as if in a high school simulation.

George's Preconceptions

The connection between individual preconceptions and program impact was captured quite succinctly in the profile of George. George's attitudes, expectations, and concerns were shaped by his experiences in the "real world." As such, he viewed himself as a unique commodity (in a positive sense) entering an academic milieu. His model of teaching was based on his work experience and his own experiences as a student. He saw himself as a subject specialist whose vocation it was to train students for a job (as opposed to more liberal educative purposes). There was no evidence from the analysis of transcripts that George drastically changed his model of teaching in the eight months while at the Faculty of Education.

George continued to be immersed in most of the activities and relationships which he was involved with prior to teacher education. His place of residence was the same. He continued to work part time. He was surrounded by wife, family, and friends. All of these factors helped to entrench his views rather than alter them. Although he found some of the new ideas and ideals espoused by professors at the university appealing, there is no evidence to indicate that he bought into any of them.

George chose teaching by chance, a career which would enable him to enjoy a better life style. It appears that there was not enough in the curriculum of the technological education program that helped George to critically look at his values and beliefs on and about teaching and learning, and the assumptions on which they were founded.

Discussion

The above viewpoints represent a sketch of what investigators found during their interviews, through participant journals, and from pre- and post-survey instruments. Results from the study suggest the literature on the impact of teacher education programs may be more cynical than it need be. A well conceived pre-service teacher education program, one that considers student preconceptions about teaching, may hold promise for socializing technology teachers successfully into the classroom and the profession. The values, beliefs, and attitudes student teachers bring with them to teacher education, as Ginsburg and Clift (1989) found, can change when the dominant messages that teacher education programs send to students are critically examined and a program which addresses the broader needs of students instituted.

Probing the incongruent tendencies and aspirations of the candidates in the study proved equally revealing. Most technological education teachers leave one career to move into another [teaching]. What the data reveal are that the experiences they [student teachers] had prior to teacher preparation, to varying degrees, influence their thinking on and about teaching and learning. In his book "A Place Called School" Goodlad (1984), states that " . . . teachers teach the way they were taught." The statement is true for technological education teachers with one caveat. Many aspiring technological education teachers are set on teaching the way they work. Inferences by students about the value of training students to be more skilled at specific jobs, point to the presence of the business and industry ideology. In some cases, work experience had a powerful impact on the teacher candidates' thinking. In other cases, factors such as hobbies, family, and involvement with community groups had a stronger influence. The power of student predispositions is evidence of the need for students to critically analyze issues related to the place and role of technological education in schools.

From another perspective the teacher candidates studied brought rich and varied experiences to their new career- resources which are an asset in terms of curriculum relevance and interpersonal skills. To what extent do these assets offset any liabilities in terms of socializing into a professional culture that is, very often, so diametrically opposed to the world of work? George is the most salient case in point. Are George's preconceptions an asset or liability? There is no clear answer. The knowledge, skills, and values that candidates bring with them to the teacher preparation process were firmly embedded in the personalities and value systems of the students in the study. Those experiences and attributes make socialization into the profession, as it is experienced by technological education teachers, problematic.

The evidence from the UWO study suggests a flexible and well-delivered teacher education program can help teacher candidates examine their predispositions and, in some cases, change them. Also, by virtue of completing the teacher preparation process, they [teacher candidates] can become effective entry-level teachers and eventually learn how to become contributing members of a school staff. The fact that eleven out of thirteen students committed themselves to the project suggests student reflection, experimentation, risk, and self-renewal, is more than possible for candidates who are flexible and dedicated professionally.

Limitations of Teacher Socialization Research

Atkinson and Delamont (1985) remind us to be watchful of patterns in teacher socialization for particular sub-groups of teachers and of the social and political contexts within which the socialization process occurs. Zeichner and Gore's (1990) comments on methodological and research design innovation, in teacher socialization research, are enlightening.

> The socialization stories of teachers of a particular gender, and of those who represent certain social-class backgrounds, generations, races, and so on, and of teachers who teach in particular kinds of settings will have many things in common despite the unique aspects of each account. In our view [Zeichner and Gore], researchers need to pay attention to both uniqueness and commonality in the socialization of teachers. More attention to the collective aspects of socialization and to the kinds of structural issues raised by studies conducted in the critical tradition could help correct the imbalance that has developed in the literature from overemphasis on individual stories of socialization and the lack of attention to institutional and cultural contexts in which socialization occurs. More attention, in particular, needs to be devoted by researchers to the ways in which race, social class, and gender mediate the socialization process and establish socialization patterns for particular groups of individuals who teach in particular kinds of schools (p. 341).

Viewing teacher socialization as an interactive process, that is, how teachers are shaped by and in turn influence the structures into which they are socialized, requires further attention in socialization research (Zeichner and Gore, 1990). While the study undertaken at The University of Western Ontario did not set out to explore these larger social and political contexts, investigators were thankful that the teacher socialization literature to date had articulated the research design terrain. More helpful explanations of pre-service program impact concerns and the ultimate effectiveness of program adjustments would at least be possible.

Zeichner and Gore's (1990) warning about study results in teacher socialization research is most appropriate in the field of technological education. Using a lateral thinking process, one might well ask the question: Into what are technological education teachers being socialized? Perhaps the reason teacher socialization research is not as liberating as it could be is because schooling, as a system, is itself aslant. Experience in teacher education for technological education teachers suggests that socialization into the subject subculture is relatively smooth. Could it be that the disparity between the more conventional school subject subcultures, that is, mathematics, English, history, and the more applied technological specializations, makes socialization into the larger school culture problematic for technological education teachers?

The Need for Further Research

While much understanding and insight with respect to the socialization of technological education teachers was achieved in the teacher development project, there is much more to learn. The confusion some students experienced with respect to their "role" and the impact of dramatic changes in the world of technology, are important variables to be explored.

The intention in case study research is to increase insight and understanding. Subsequent research to explore other dimensions of technological teacher socialization, is now needed. The extent to which innovative and meaningful teacher education curricula, i.e., learning activities organized around teacher candidate preconceptions, make a difference, is also a rich area for further study. If learning to teach is a transformative process, as Feiman-Nemser (1990, p. 227) suggests, teacher educators need to remember that becoming a teacher is not just a matter of acquiring new knowledge and skills. Because prospective teachers are no strangers to classrooms, re-socialization is necessary, especially if new ways of teaching are to be fostered, and socialization into a new professional culture of education is to occur.

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Rousseau in the Heritage of Technology Education

John R. Pannabecker

In the June 1762 issue of his literary journal, Melchior Grimm, one of Jean-Jacques Rousseau's former friends, poked fun at Rousseau's interests in a flying machine.

> At the same time, he was busy with a machine with which he intended to learn to fly; he stopped after some attempts which did not succeed; but he was never sufficiently disillusioned with his project to calmly admit it to be fanciful. Thus his friends, with some faith, can expect to see him someday gliding in the air (Tourneux, 1878, pp. 102-103; all translations from the French in this essay are by the author).

Grimm's remarks remained something of a mystery until 1910, when Pierre-Paul Plan published a recently discovered essay by Rousseau on his investigation into human flight (Plan, 1910). Rousseau's machine was mechanical in design. He was influenced by bird-type models and Borelli's seventeenth-century mechanical explanation of the human body. Rousseau summarized the relatively low strength/weight ratio of the human body compared to that of birds and acknowledged this as a major difficulty (Plan, 1910, p. 594). He also compared flying to being suspended under water, a fluid with similar qualities to air.

According to Rousseau, two key problems would have to be resolved: first, finding a body lighter than an equal body of air; and second, once aloft, figuring out how to keep from going further up and how to become heavy enough to descend (Plan, 1910, p. 596). Rousseau's approach to the problem demonstrates a propensity to experiment and to solve technical problems in a rational fashion. In addition, he was sensitive to social attitudes and Grimm's mockery, noting that "it is always the destiny of truth to be mocked" (Plan, 1910, p. 591).

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Rousseau, Industrial Arts, and Technology Education

Jean-Jacques Rousseau (1712-1778) is best known for his ideas on education, religion, politics, and social issues–not for building a flying machine. He is considered one of the most important figures in the history of education, including industrial and practical arts education.[1] But just how does Rousseau fit into the heritage of technology education? Indeed, how is the heritage of technology education different from that of industrial arts education? Why is so little known about Rousseau's flying machine and why was it rarely, if ever, referred to in the history of industrial arts education?

Rousseau's text on a flying machine was not an exposition of his educational ideas but of a systematic approach to solving a complex problem. That problem might fit into certain technology education programs today, but not into traditional industrial arts programs. The problem of flying required experimentation and systematic knowledge, and prompted reflection on the relationships between society and what we now call "technology." This essay shows that Rousseau modeled these interests in a way that would not be incompatible with ideas in technology education today. But first, the work of Rousseau needs to be placed briefly in the context of the history of education.

Rousseau, Education, and Society

In the history of education, Rousseau has usually been viewed as a precursor of human development theory. Sometimes he has also been considered an advocate of non-authoritarian pedagogy, with children selecting and solving problems in a non-directive environment. But Carbone (1985) was critical of this "enduring myth," noting that "there is actually scant justification in the *Emile* for heavy reliance on the desires and interests of students in the establishment of educational ends and means" (p. 408).

Bennett (1926), a very influential American historian of industrial education, emphasized the importance of Rousseau's recognition of the manual arts as a means of mental training and noted his influence on educators such as Basedow, Salzmann, Pestalozzi, and others (pp. 81; 85; 108). But Bennett did not go much beyond a discussion of the mechanical arts and trades in Rousseau's *Emile.*[2] Subsequent writing in the history of industrial arts varied little from Bennett's interpretation.

[1]There is so much secondary literature on Rousseau that space allows only a few indications here. For example, see L'Aminot (1992) for different interpretations of Rousseau in the twentieth century. L'Aminot estimates about 15,000 books and articles on Rousseau since 1900. Rousseau's (1957) best known work on education was a sort of novel called *Emile*, published in 1762 during the period of his greatest literary productivity. For a broad interpretation of the genesis and writing of *Emile*, see Jimack (1960).

[2] Limiting this discussion to Rousseau's writing on teaching the mechanical arts might have resulted in a focus on *Emile* as did Bennett (1926). But Rousseau turned 50 years old in 1762 when *Emile* was published. Rousseau's interest in the mechanical arts, systematic knowledge, and experimentation long preceded the publication of *Emile* but there is less known about Rousseau's

Rousseau's belief that manipulative and perceptual skills are essential to mental development can still be controversial in education today, though not in technology education. But within technology education, there are unresolved issues related to the ideas of Rousseau. Some of these issues arise in controversies among different philosophies of curricular design. For example, Zuga (1993) acknowledged Rousseau's contribution to human development theories in her discussion of the tension between social efficiency, human development, and social meliorist tendencies in technology education. Rousseau's ideas have indeed been influential for human development theories, but taken as a whole his work does not fit neatly within the boundaries of contemporary categories. [48] To understand this requires some historical context.

Rousseau wrote during the Enlightenment period. [48] All kinds of issues in religion, philosophy, politics, and economics were being reexamined in light of "reason." Education became an especially popular topic following the work of Rousseau. French guilds (including guild education in the arts and crafts) were under intense scrutiny and were abolished during the French Revolution. The demise of the guilds was promoted through liberal economic ideas that favored

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early life. Boyd (1963) noted in 1911 that the "right method of approach to his [Rousseau's] theory of education is not through the *Emile* but through his whole social philosophy" (p. vi). Given the broader scope of technology education and its emphasis on understanding social context, Boyd's interpretative view now seems more appropriate than Bennett's more limited focus on the mechanical arts.

[3] Rousseau's work is often ambiguous and difficult to interpret. Scholars sometimes talk about different Rousseaus, for example, Rousseau before and after 1756 when he left Paris; Rousseau the writer; Rousseau the man; and Rousseau writing about himself. When Rousseau made his radical decision to leave the city life of Paris in 1756 and lead a simple life in the country, he claimed that this type of life also better suited his nature. Still, his departure was also a rejection of many of the aspects of the lifestyle he had experienced in the city, and his friends found this hard to accept. The isolation, his own poor health, and the incredulity of his friends all contributed to the notoriety of this break with high society.

In later life, Rousseau wrote his autobiography, the *Confessions*, in which many comments, dates, or recollections conflict with other historical evidence, such as his vast correspondence, that of his friends and acquaintances, and an important work of self-evaluation called *Rousseau Judge of Jean-Jacques* (Rousseau, 1959, Vol. 1). As a result, some critics claim that Rousseau was constructing a sort of myth of himself, often emphasizing his worst and best sides. Nevertheless, his book *Confessions* is still considered an important source for information about his experiences at a younger age.

[4] For a general overview of eighteenth-century Europe, see Woloch, 1982; for an overview of eighteenth-century French education, see Chartier, Julia, & Compère, 1976; for an overview of early technical education in France, see Artz, 1966; and for an assessment of the limits of Enlightenment reform, see Chisick, 1981. For the most part, classical education was scholastic in orientation and limited to the wealthy. Only a few schools even taught about such things as the "new" natural sciences. The mechanical arts were taught either in the urban regulated craft corporations through apprenticeship or in less regulated conditions in rural areas or small towns. In any case, in France, the mechanical arts were generally taught as vocational training.

freer trade and access to technical knowledge. France was already a world leader in systematic engineering and scientific education in schools, a trend that continued during and after the Revolution.

During the Enlightenment, Diderot (Diderot & d'Alembert, 1751-1772), the French Academy of Sciences, and others published extensive, systematic texts on science and the mechanical arts. These texts were conceptual precursors of modern texts that now serve as systematic knowledge bases for organizing "academic rationalist" and "technical" curriculum designs. Today curriculum designs based on such systematic organization of content are often considered representatives of "social efficiency" theory. But in the context of eighteenth-century France, these early technical texts could be considered "social meliorist" because many authors sought to change or improve existing society. (See Zuga, 1993 for a discussion of social efficiency and social meliorism in technology education.)

Early in his professional life, Rousseau contributed to one of these attempts to systematize knowledge, Diderot's *Encyclopédie*. Later he became an outspoken critic of high society and its arts and sciences to the extent that they contributed to a world of luxury and hypocrisy repulsive to him.[5] But Rousseau recognized that the mechanical arts included the techniques that people used to solve problems of practical importance to their basic well-being. As an advocate of simple living, Rousseau promoted teaching techniques to solve life's basic material problems, to become self-reliant, and to understand the common person.

This essay goes beyond Rousseau's writing on the mechanical arts and represents Rousseau in light of his broader interests as they relate to the heritage of technology education. These interests will be elaborated in the following three sections: (a) experimentation, (b) systematic knowledge, and (c) the relationships among education, mechanical arts, and society.

Rousseau and Experimentation

Jean-Jacques Rousseau was not French; he was a citizen of Geneva, a small independent city on the borders of eastern France and the center of Calvinism. He must have learned to read from his father because he wrote about the two of

[5]Today the term "technology," like the term "mechanical arts" in the eighteenth century, can be used to refer to either the collective technical forces in society or the small, incremental activities in which we as individuals engage in daily to construct or reconstruct our world. This distinction aids understanding of Rousseau's criticism of the arts, sciences, and social progress. The distinction is also important in the history and philosophy of technology today; people often feel a loss of control over technology considered collectively while they feel they have a sense of control over their own daily involvement in technological processes. See Schmidt and Miller (1980) for an essay on Rousseau and technology, where technology is considered primarily as a collective technical and economic force. See Galliani (1989) for a detailed discussion of Rousseau and luxury, a highly controversial subject of the time.

them reading novels left by his mother who died in childbirth (Rousseau, 1926, Vol. 1, pp. 12-13). These years of living and reading with his father came to an abrupt end due to his father's expulsion from Geneva after a brawl with an officer. Jean-Jacques was then supported by his uncle Bernard, an engineer.

For two years Rousseau lived with a cousin at the home of their tutor in a small village; these two years were to be the time of his only formal classical instruction. The young Jean-Jacques was a bit of a problem-solver, however. He enjoyed telling of his experience as a child civil engineer (Rousseau, 1926, Vol. 1, p. 31-35). The tutor, Mr. Lambercier, once planted a walnut tree to shade his terrace; in fun, Jean-Jacques and his cousin planted a willow and then proceeded to construct an underground conduit to water it from the other tree. The aqueduct was successful and Mr. Lambercier discovered and destroyed it, but later the two boys heard him roaring with laughter as he told his wife about the "aqueduct."

Later, he was exposed to drawing and the elements of Euclid during the lessons of his cousin who was being prepared for engineering. According to Jean-Jacques' *Confessions*, he and his cousin made cages, flutes, kites, drums, houses, popguns, crossbows, watches, and puppets (Rousseau, 1926, Vol. 1, p. 36). He remembers damaging his grandfather's tools trying to make imitations of his watches. Although Rousseau's unstructured childhood education is well known, it is sometimes forgotten that he built all kinds of devices which required experimentation and technical skills.

At age 13, his elders settled on his vocation; he would be an engraver, a trade that he did not really mind except for the brutality of his master (Rousseau, 1926, Vol. 1, p. 43). His "act of apprenticeship" (dated 26 April 1725) was to serve under Abel Ducommun, master engraver in Geneva. He served about three years out of his five-year apprenticeship contract; the official acknowledgment of his desertion was dated 30 March 1728 (Rousseau, 1959, Vol. 1, pp. 1209-1211). This was a period of turmoil, leading to his decision to leave Geneva. At age sixteen, Rousseau began his travels after his decision to remain locked out of the Geneva city walls during one of his nocturnal ramblings around the countryside with his friends. For a long time he moved around, at times working in paid positions, for example, as tutor and ambassador's assistant in Venice.

It was probably as a tutor that Rousseau first began to reflect seriously on pedagogy, because he left two brief manuscripts on the subject. They are significant in that they both suggest that some of Rousseau's ideas expressed in *Emile* about 25 years later were already in the process of formation. His emphasis on moral behavior was already present but he also stressed that learning should be amusing and fun. The environment should include "scraps of paper, a little drawing, music, instruments, a prism, a microscope, a magnifying glass, a barometer, a wind machine, a siphon, a fountain of Hero, a magnet, and a thousand other little curiosities" for teaching and learning (Rousseau, l959-1969, Vol. 4, p. 26). He also mentioned the importance of the "arts and crafts" as interesting subjects whereby children learn that people are useful and necessary to each other (Rousseau, 1959-1969, Vol. 4, p. 42).

Rousseau's enduring interest in the natural sciences was reflected in his discussions of experimental science. Already in the mid to late 1730s he became interested in physics and used to visit a professor of physics at Chambéry who performed amusing experiments. Rousseau experimented likewise and almost died from it. He filled a bottle with quicklime, orpiment, and water and sealed it with a stopper. The effervescence started almost immediately and he ran to pull out the stopper. Too late! It blew up in his face like a bomb and he was blind for six weeks afterwards (Rousseau, 1926, Vol 1, pp. 293-294). This adventure contributed to his poor health and was certainly a memorable way of learning about the resistance of materials.

Rousseau and Systematic Knowledge

The eighteenth century was in many ways an age of classifying and ordering knowledge. This process of structuring knowledge, as exemplified in Diderot's (1751-1772) *Encyclopédie*, also contributed to the systematization of the mechanical arts, a sort of "science of techniques" or technology (Pannabecker, 1992, 1994). Soon after Rousseau took up residence in Paris in the early 1740s, he encountered Denis Diderot whose intimate friendship he shared for about 15 years. When Diderot became editor of the *Encyclopédie*, Rousseau agreed to participate in the work and eventually wrote several hundred articles, mostly on music. According to Lough (1984), Rousseau's article on economics (moral and political) has been "the most closely studied political article in the whole of the *Encyclopédie*" (p. 509). (See e.g., Lough [1984] and Kafker & Kafker [1988] for more details on Rousseau's participation in the *Encyclopédie*.)

But in addition to his work with Diderot, there is a thread of systematizing knowledge throughout Rousseau's life. For example, he noted in his *Confessions* that around the age of 25, never having had much formal education, he attempted to organize knowledge with the help of an encyclopedia to facilitate his own education (Rousseau, 1926, Vol. 2, p. 17). In music he was largely self-taught, having acquired a copy of Rameau's *Treatise on Harmony* in the 1730s, a work that he devoured but criticized as long, diffused and poorly organized (Rousseau, 1926, Vol. 1, p. 248). He soon turned to making music, then composing music, and later developed a new system of musical notation that he eventually presented to the French Academy of Sciences in 1742. He labored for many years on his own dictionary of music.

Rousseau's interests in integrating systematic knowledge of the natural sciences and experimentation were particularly well illustrated in his text on a flying machine. There is some uncertainty about when Rousseau wrote this essay, but it may have been in the early 1740s around the time he presented his work on a new system of musical notation.[6] Rousseau also became very interested in chemistry and took some of the famous courses offered by Rouelle in Paris, a well-known chemist of the time (Rousseau, 1926, p. 159). Late in life, he maintained a strong interest in the sciences and in systematic knowledge in his study of the work and classifications of the botanist Linnaeus.

In 1750, Rousseau became famous almost overnight for his prize-winning essay submitted for competition on the topic of whether the arts and sciences had contributed to purify morals. In this systematic treatment of critical questions on the arts, sciences, and society, Rousseau stated that the arts and sciences ("arts" as used here included liberal arts, fine arts, and mechanical arts) had tended to corrupt society, a viewpoint that he acknowledged as contrary to general opinion (Rousseau, 1959-1969, Vol. 3, pp. 5-30). But he did not pretend to have idealistic views of going back in time. This essay marked a decisive point in his life and work–the beginning of a continual and systematic questioning of social issues. This questioning eventually led to his break with urban society in 1756 and the eventual production of the works for which he is most famous.

Rousseau, Education, Mechanical Arts, and Society

In 1762, Rousseau published two books which were immediately controversial: the *Social Contract* and *Emile.* The *Social Contract* challenged the despotic tendencies of the monarchy. *Emile* challenged traditional education and the values of French society of the time. Probably the most important immediate reason that *Emile* stimulated such controversy was its unorthodox treatment of religious faith in the "Confession of Faith of a Savoyard Vicar," not its advocacy of teaching mechanical arts.

Rousseau's questioning of traditional education and his inclusion of the mechanical arts in education were part of his broader critique of society, politics, and economics. Indeed, many critics consider *Emile* to be more of a social critique than an educational treatise. The fact that Emile's tutor required him to learn a trade was an indicator of Rousseau's social criticism and his unconventional approach to education.

[6] Plan (1910, p. 586) placed the date of the text in 1752 although its original publication claimed the manuscript as 1742. Guéhenno (1962, Vol. 1, pp. 126-128), where I first became aware of Rousseau's text on flying, suggested sometime in the 1740s.

Emile was divided into five books: (a) book I covers birth to about age 5 and focuses on early physical growth; (b) book II covers about age 5 to 12 and addresses the development of the child in the physical environment; (c) book III covers about age 12 to 15, early adolescence; (d) book IV covers puberty and later adolescence; and (e) book V covers feminine education.[7]

Rousseau's main discussion of the mechanical arts occurs in about 20 pages in book III. But since technology education is not limited to the mechanical arts, much of the preceding book (book II) on the importance of the physical environment is directly pertinent. Here, Emile's tutor stresses the development of the body, senses, memory, and reason–"a kind of experimental physics" (Rousseau, 1964, p. 128; further citations of *Emile* are from this edition). His emphasis is on developing in the child the means or "instrument" (p. 128) and interest (p. 192) of learning science in a way that the child understands as opposed to simply memorizing. This is why the tutor does not put much stock in books at this early age. For example, the tutor introduces drawing, not so much for the specific skill as to train the eye and the hand (p. 154). The tutor's concluding anecdote to the second book concerns a father, his son, and his tutor strolling in an area where children are flying kites. The father points to the shadow of a kite and asks his son where the kite is. Without hesitating or even looking up, the son responds correctly, thus indicating his awareness of his own position in the external, physical environment. This awareness of the natural world, according to the tutor, is in the natural order of learning and thus precedes the mechanical arts in book III.

Up until this point, the tutor considers Emile's environment to be governed by the law of necessity. At this point, he shifts to a discussion of that which is useful, the central topic of book III. The tutor's most important example for conceptualizing this new environment is Defoe's Robinson Crusoe and his island. Here Crusoe is faced with the critical issues of survival and the problems to be solved in living a simple life. Much of what precedes the discussion of the mechanical arts in book III is devoted to developing this notion of utility and thus justifying a pedagogy that is not based on book-learning but on how to teach what is useful in a relatively simple society. Emile is to construct his world with what is available, like Crusoe. Even if instruments and machines are required for learning, it is better to make them first. For example, in teaching statics, instead of buying scales, he recommends using a stick balanced on the back of a chair to which weights are added (p. 198).

This discussion of a rational method of teaching about the natural world and ways of solving problems to construct Emile's world sets the context for the discussion of the mechanical arts. To understand Rousseau's pedagogy, it is

[7] See L'Aminot (1992) for a review of feminist critiques of Rousseau.

imperative to keep in mind his assumption of a simple life and values consistent with a simple life. In introducing the mechanical arts into Emile's world, the tutor introduces a relatively simple, uncluttered society, similar to that discussed by Rousseau in his *Letter to d'Alembert* (Rousseau, 1927, pp. 222-225). In this famous essay published in 1758, Rousseau had already advocated the mechanical arts as found in a small, self-supporting Swiss village. The craftsmen were highly skilled, but not narrowly specialized as in the large city guilds, and so were capable of applying their general technical knowledge to any problem.

Emile is to practice some of the mechanical arts mainly for social reasons. The tutor's ideal society sets limitations on the selection and practice of the mechanical arts. One of the most important reasons for learning a trade is to conquer social prejudices against the trades and workers (p. 227). The reason for being an apprentice is not so much to learn the craft as to raise Emile and the tutor up to the craftsman's social status, to live as a craftsman, to become as one in the craftsman's family and lifestyle. Teaching the mechanical arts in the context of home and local society was central to moral education, and consistent with Rousseau's view of egalitarian society, at least among men, that runs throughout his major writings.

The tutor's emphasis on a simple lifestyle helps to explain his restrictions on the selection and practice of the mechanical arts. Emile's world is a sort of upside-down world in which social conventions are sometimes reversed. For example, value is not determined according to some mercantilist idea of exchange but by basic usefulness; hence, the tutor's preferred order of respectability for mechanical arts: agriculture, smithing, and carpentry (p. 216). This hierarchy is essentially the opposite of conventional value, which, according to the tutor, "is attached to the different arts in inverse proportion to their real utility." In conventional society, the most useful arts earn the least and are done by "artisans" and the least useful, performed by "artists" to make baubles for the wealthy, are paid the most (p. 213).

Nevertheless, the tutor's reasoning eventually breaks down into some inconsistency because he further restricts the choice of the arts. He distinguishes between arts according to gender, for example, noting that "the needle and sword could not be handled by the same hands" (p. 233). He excludes some of the metalworking arts such as basic ironworking and locksmithing. He also rules out masonry and shoemaking as well as arts that "require little skill and are automatic like weavers, stockingmakers, and stonecutters (p. 235)." Overall, the tutor prefers carpentry because it is clean, useful, and can be done at home. It keeps the body active and requires skill and craftsmanship. One alternative, if the student were really interested in the theoretical sciences, would be to make scientific instruments such as lenses and telescopes.

Turning the world upside-down as Rousseau does requires restructuring of values and concepts. But it is such a complicated task that inconsistencies are inevitable. For example, to base value on social utility in a simple society presents difficulties for the tutor in choosing a trade because many of the most useful are dirty and routine. The tutor's rejection of such trades weakens his emphasis on egalitarianism. Similarly, from a twentieth-century perspective, Rousseau's division according to gender and his relegation of women's education to the fifth book also undermine the emphasis on egalitarianism. But despite these limits, Rousseau set the stage for a tremendous surge of educational reflection in the eighteenth century and integrated the mechanical arts into his pedagogical approach as a means of reconstructing society, values, and social status.

Conclusion

Rousseau did not manage to solve the problem of flying, but the anecdote illustrates his approach to a complex problem. He was curious and more technically inclined than most of his peer philosophers. Faced with the problem of flying, he employed a rational approach to solve it. He analyzed the problem, read technical information, experimented, tinkered, and documented his work. He also became acutely aware of social biases against innovative ideas such as human flight.

Rousseau's life was one long, continuous experimentation in learning. His artisanal boyhood contributed to his learning about things and experimentation, an education that contrasted with that of his intellectual peers. He also embraced structured, systematic knowledge and study but did not reject his artisanal background as inferior. Nor did he reject the kinds of problem-solving activities so critical to constructing and reconstructing the material world. (See Pannabecker, 1991, for historical approaches to the social construction of technology.) But Rousseau did not stop at experimenting and organizing knowledge; he developed his own approach to life, critiqued social values, and promoted change in light of his chosen values.

When studying the heritage of technology education, the historical context needs to be left more open than in the history of industrial arts. For instance, it was probably the craft emphasis in industrial arts that influenced historians like Bennett to focus on the mechanical arts in Rousseau's work. Thus, since Rousseau's best known references to the mechanical arts in education occurred in *Emile*, interpretations of Rousseau's contributions were based primarily on that book. In contrast, Rousseau's importance to technology education can be grasped better by casting a larger net among his writings.

Rousseau's critique of the arts and sciences draws our attention to issues in technology and society. Technology education has made the study of technology and society part of its agenda. But how technology has been taught in the past also deserves study. Rousseau was not primarily interested in an "objective" view of experimenting, solving problems, or teaching the mechanical arts. Ultimately, his central concern was how to prepare better individuals to construct a better society, not how to teach or learn more effectively, how to solve problems more efficiently, or how to systematize knowledge more completely.

Rousseau became highly critical of materialistic values, social and economic disparities, and the ideology of progress. Beyond and through experimentation, systematic study, and the mechanical arts, Rousseau saw education as a means to change people and thereby reduce prejudices and inequalities among people. Teaching the mechanical arts was a means of bringing together persons of different social classes and to work towards eliminating cultural prejudices.

Teaching technology also has the potential of developing in students a more critical attitude towards issues in technology and society. Parallel to Rousseau's critical reflection, technology teachers and students need to reflect on choices of what technology is taught, how it is taught, and to whom and with whom it is taught. This reflective process will help students to critique the assumptions implicit in technological culture and thereby influence the direction of technology education.

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Case Studies of Multidisciplinary Approaches to Integrating Mathematics, Science and TechnologyEducation

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Traditionally, school curriculum has been largely based on the concept that instruction should be separated into distinct subjects for ease of understanding and then reassembled when complex applications are required. Although it is assumed that students readily re-connect their school knowledge and then use it in an applied context outside of the classroom, recent research does substantiate this belief (Crohn, 1983; Hawkins, 1982). Here in lies the crux of the matter, the school curricula is a segregated approach to instructional topics which does not adequately address the reassemblage of topics into a coherent body of knowledge to be used by students.

Senge (1990) addresses the fragmented way that we as a culture have been trained to solve problems. He writes:

> From a very early age, we are taught to break apart problems, to fragment the world. This apparently makes complex tasks and subjects more manageable, but we pay a hidden, enormous price. We can no longer see the consequences of our actions; we lose our intrinsic sense of connection to a larger whole. When we try to 'see the big picture,' we try to reassemble the fragments in out minds, to list and organize all the pieces. (p. 3)

The curricular concept of integrating or connecting school subject areas has gained significant attention in recent years as a plausible solution to developing a more relevant approach to teaching and learning (Adelman, 1989; Department of Labor, 1991; Cheek, 1992). Specific attention within the technology education field has been directed at integrating mathematics, science, and technology (LaPorte and Sanders, 1993; Scarborough, 1993). The

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integrative or multidisciplinary curricular approach related to technology education seeks to help students learn and appreciate the relevancy of how school subjects are tied together and how each subject builds on the other.

Although this is a noble task, the question of educational worth has not been determined with any degree of accuracy. The question remains, is the integration of mathematics, science, and technology education a step in the right curricular direction or are we again *"jumping on the band wagon of the most current education reform movement?"* There is a need to develop exploratory programs where evaluation can be conducted to determine the value of integrating curriculum. There is also a need to establish a knowledge base that will identify the most current findings related to this curriculum issue.

Therefore, the objectives of this research were to: (1) Review the literature reflecting the main fields of thought pertaining to integration of subject matter, (2) Present actual case studies of multidisciplinary approaches to curriculum planning and implementation at four high schools and draw conclusions regarding the development and implementation of multidisciplinary approaches from four pilot testing sites.

Review of the Related Literature

Recent professional literature in technology education has supported the idea of integrating traditional academic material with technology material (Gray, 1991; Wirt, 1991). However, relatively few authors have provided substantive philosophical and psychological reasons *why* integrating these materials would help modernize or improve education. Upon careful examination of the professional literature on the topic one finds that there are compelling reasons to implement and then evaluate these educational reforms. Germane to this topic are theories of advanced learning and thinking, situated learning (context), transfer of learned knowledge, the nature of problems to be solved, and working in cooperative teams.

Advanced Learning and Thinking

Spiro, Coulson, Feltovich, and Anderson (1988) have defined *advanced learning* as an intermediate stage on a continuum between the introduction of new material and practiced expertise. In this intermediate phase, students learn "what to do" with acquired information. Central to advanced learning is the concept of thinking. Resnick (1987) contends that thinking defies definition within the traditional paradigm of public education. However, she offers several key elements that are descriptive of higher-order thinking. According to her research, higher order thinking is nonalgorithmic, (meaning the path of action is not specified in advance), complex, and often yields multiple rather than simple solutions. Higher-order thinkers demonstrate nuanced judgment and the ability to use more than one criteria when solving complex problems. They also live well with uncertainty, are self-regulated, can impose meaning on apparent disorder, and demonstrate sufficient effort when elaboration and judgment are required.

Ill-structured Workplace Problems

Berryman and Bailey (1992) described an emerging workplace that is dependent on accelerated product and process innovation. Companies must respond to fast-changing markets by rapid delivery of products and services. These “quick response” capabilities are critical to successful international competition. Competitive workplaces require advanced learning and thinking on the part of employees at lower and lower organizational levels. These mental skills are particularly important in situations where complex problems must be solved under volatile conditions. Indeed, throughout their lives vocational graduates will encounter a diverse array of work and personal problems that are complex, ambiguous and cannot be solved using the same solutions every time (D’Ignazio, 1990). Spiro and Jehng (1990) refer to these as “ill-structured” situations or environments. To solve ill-structured problems, workers and learners must be able to adroitly use, or transfer, information often learned in other settings.

Learning Transfer

Educators have traditionally assumed that schooling directly enabled transfer to occupational or life settings. Yet, Berryman (1991) aggressively reports otherwise. She maintains that individuals *do not* predictably use knowledge learned in school in everyday practice, nor do they use everyday knowledge in school settings. Perhaps most importantly, learners do not predictably transfer learning across school subjects. Berryman (1991) writes that context is critical for understanding and thus for learning. “[T]he importance of context lies in the meaning that it gives to learning” (p. 11).

Wittgenstein (1953) postulated that the meaning of information is determined by its intended use. Bransford and Vye (1989) further believe that “students must have the opportunity to actively use this information themselves and to experience its effects on their own performance” (p. 188). If knowledge has no apparent application, it may not be perceived as meaningful nor readily transfer to other learning situations (Bransford, Sherwood, Hasselbring, Kinzer, and Williams, 1990). Brown, Collins, and Duguid (1989) believe that advanced concepts are learned and progressively developed when thought of as “mental tools” to be used in meaningful activities of a “particular culture.” However, these tools can only be fully understood through their use in a particular culture which involves changing the user’s “view of the world and adopting the belief systems of the culture in which they [the tools] are used" (p. 33). This approach rests on the assumption that there is more to using a tool (*i.e.,* developing an advanced cognitive skill) than mastering a list of explicit knowledge and rules.

Activating Potential Knowledge

To the extent that schooling is isolated from the community, too many concepts are learned in abstract ways. Theorists such as Berryman (1991), Resnick (1987), and Spiro, et al. (1988) believe that transfer of knowledge is inhibited by this condition which does little to activate knowledge for later use. Lave (1988) approaches this problem by advancing the concept of "authentic activity" which she defines as ordinary practices of "just plain folks" within a given culture. Rather than using the educational syntax of the classroom, they propose using everyday activities as a means of providing contextualized or situated learning. This places learners in a free and more relevant classroom shaped by a community of practitioners. Perkins and Salomon (1989) concluded that "to the extent that transfer does take place, it is highly specific and must be cued, primed, and guided; it seldom occurs spontaneously" (p. 19).

In summary, the research suggests several specific areas that must be considered by educators who wish to implement multidisciplinary teaching and learning. This is particularly important when the expectation of higher order thinking and problem solving is adopted as it has been in many suggestions for reform of technology education.

Case Studies of Multidisciplinary Demonstration Projects

To evaluate school programs where multidisciplinary curricula can be measured for effectiveness, it was determined that four (4) pilot high school demonstration sites would be established in four different states within the mid western section of the US. Each school established a multidisciplinary team comprised of teachers from three respective academic disciplines: technology education, science, and mathematics as well as a school administrator and a school counselor. In addition to the high school multidisciplinary team was a resource team to help support the local school integration activities. The resource team was comprised of teacher educators from the academic areas of technology education, science, and mathematics along with the state supervisor for technology education. Each demonstration site team was encouraged to develop a multidisciplinary curriculum that integrated mathematics, science, and technology education that they believed would be workable and effective within their unique educational environment. Although a limited number of curriculum integration criteria were encouraged (e.g., context based learning, learning transfer, working/learning teams, higher-order thinking skills), no effort was directed to specify curriculum models to be used.

To protect the confidentiality of the research participants, the demonstration schools are identified as Missouri, Nebraska, Colorado, and Oklahoma County School Districts (CSD's). These cases were studied and analyzed through three primary avenues of inquiry. The first inquiry was based on self-reported qualitative data from each of the demonstration sites. Each demonstration project team was required to explain in narrative form how they addressed or perceived each of the following project issues and concerns: *Goals of Their Project, Curriculum Approach Used in Their Project, Most Successful Aspect of Their Project, and Most Difficult Problem of Their Project*. The second method of inquiry was based on extensive personal interviews with students, teachers, and school administrators. Each project site was visited by a three (3) person team of researchers that conducted systematic interviews. The third inquiry effort was based on an analysis of three (3) open-ended questions that were part of a quantitative survey instrument administered to all student participants of the projects. The three questions provided opportunities for students to describe in their own words what they considered the most successful aspect of the project, the least successful aspect of the project, and how the project could be improved. Based on these three methods of investigation, the following cases are presented.

Missouri County School District

Overview. The mutidisciplinary instructional program at the Missouri CSD involved the use of technology in a Survey of Biology class with the support of the mathematics department. This course was distinct in that students received college level credit on a dual enrollment basis through a local community college. The teachers used a portfolio approach to evaluate the work of students in the class. As part of the portfolio, the students actively worked to supplement their learning through the use of instructional technology, problem solving approaches, and independent investigations. Problem-solving was particularly emphasized to establish, test and assist students to evaluate various hypotheses related to their research. In addition, the multidisciplinary approach was expanded into the agriculture department with the study of genetics and related horticultural areas.

Goals. The primary goal was for the teachers to understand that their particular instructional areas did not stand alone within the curricular offerings. The teachers worked well together in providing the students with an avenue by which they could properly use and discriminate data. It was also a goal that students realize that the realm of instruction is not confined to any constraints set forth by being in an isolated classroom. Students were permitted to move about the high school complex, accessing information, and using the facilities in other instructional areas. In addition to these primary goals, it was determined that an objective of the multidisciplinary project was to improve students ability to critically think and gather information that was pertinent to their research.

Curriculum. Since the *Survey of Biology* class was the focus of this project and was revised, in part, due to the experimentation with a multidisciplinary approach, the teachers in this project worked together to establish the objectives of the course with other instructional areas in mind. Students were instructed that this course would not be using a conventional education approach and that it would deviate from what they were accustomed to receiving in a classroom.

Objectives for the class were established based on a ill-structured problem-solving methodology with expectations that students would work independently and in small cooperative groups. Students were encouraged to access the faculty in the related instructional areas for support and instruction pertaining to their research. Conventional biological concepts were central to the course, however, they addressed these concepts through a research based problem-solving approach. The technology instructor provided students with guidance in the physical design and development of their research projects as well as providing opportunities to use technology laboratory facilities to construct and test their various research projects.

Most Successful Innovation. The most innovative success as described by the faculty was the relationship among the instructional areas. The coordinated efforts by the science and technology education instructors and to a lesser degree the mathematics instructor, created a learning atmosphere that provided students with a unique opportunity to learn in a much broader context. The principal at Missouri County program described this success in the following terms:

> In education, we have established artificial boundaries through Carnegie units and time blocks. These boundaries are inhibitive to learning in context and has established a paradigm of instruction of which these students have grown increasingly accustomed. By breaking down the autonomy among the disciplines, our students were able to realize that there was a relationship between the knowledge gained in one department versus the knowledge gained in another. By examining this relationship our students better understood the applicability of several subject areas in solving science problems. (Principal, Missouri CSD, personal communication, March 18, 1992)

Most Difficult Problem. The same pattern of instruction which is a constraint to teaching in most school programs existed in the program. Students had been trained to dismiss subject matter learned in one classroom as having little or no relevancy to another. This problem of artificial boundaries of school-based learning continued to exist during this project. Students tended to rely upon the immediate learning environment as their source of knowledge and then ceased to carry the learning beyond the classroom when the bell rang and the class ended. Although this problem abated to a degree during the school year, it continued to be a limiting factor for many students.

Nebraska County School District

Overview. The multidisciplinary program at the Nebraska CSD began by formulating a focus on a new method of instruction. The outcome of this development effort selected the *Principles of Technology* (PT) curriculum as the basis for integrating mathematics, science, and technology. The instructional staff worked together in developing a team teaching arrangement to present this curriculum. The three instructors supplemented the well established PT curriculum with additional material that helped place the learning in a more real world context for their targeted group of *"at-risk"* ninth grade students. These students were identified based on their past educational accomplishments and general attitude regarding education.

Goals. The primary goal was to increase the interest level of "at-risk" students in the instructional fields of mathematics, science, and technology. Through the application of an integrated "hands-on/minds-on" curriculum, students were encouraged to develop an interest in the practical uses of the three instructional areas. Efforts by the project team addressed the needs of these students to actively use the knowledge they were learning in class. By encouraging students to apply their learning outside of the classroom it was believed that greater meaning and retention could be attained.

Curriculum. The instructional sequence for the *Principles of Technology* (PT) course generally included a two hour block of time where the teacher team worked to address the major components of this curriculum. With this instructional design, students received both mathematics and science credit. Teacher-led discussions were followed with video presentations, math skills labs, student learning exercises, and laboratory experiments relating to the major components of the PT curriculum. Each segment of the curriculum was led by the teacher who was most skilled in that topic. This approach proved to be very successful, allowing the other two teachers to have opportunities to interact with individual students who needed additional help. Primarily, students worked in small groups to solve the various problems and experiments that were integral to the curriculum. Students were required to do library research, develop written technical reports, and develop special projects which applied an integrated approach to learning. In addition to the PT curriculum, the teachers provided supplemental instructional topics on solar collectors, barge building and testing, rocketry, and the creation of life sized moving mannequins. Each of these topics were highly motivational for the students.

Most Successful Innovation. The most successful aspect of the program was the improved motivation on the part of the students in this program to attend class and the reduction of discipline problems. This was measured through a comparison of school attendance records and disciplinary reports from the previous school year. In addition, students demonstrated an appreciation for the structured learning activities, an improvement in student self-esteem, and the development of a cooperative team mentality when addressing problems. The teacher team found that the joint teaching environment was both positive and conducive to professional growth. The understanding that no subject discipline exists in isolation was a realization for both the teachers and the students.

Most Difficult Problem. Although there was a perceived improvement in student attitude with regard to learning, several students in the program had difficulty in grasping the instructional content of this team taught course despite adjustments to accommodate their limitations. The teacher team encountered difficulty working together in the team teaching approach including difficulties in interpersonal communication, lack of commitment to the overall project goals, and orchestrating specific integration activities. It is important to note that there was a disparity of perceptions between the school administrator and the teachers regarding the teaching arrangements (i.e., 2 hour block-team teaching). The teachers presented a very positive view of this working arrangement while the administrator identified several negative aspects, primarily attitude and commitment that transpired during the course of the school year. The administrator suggested that the curriculum format was appropriate however, the teacher team was not working together to bring about suitable subject-matter integration.

Colorado County School District

Overview. At the Colorado CSD the integration of the mathematics, science, and technology curricula took on three distinct approaches. Each of the primary subject matter-teachers designed one of their courses to integrate the curriculum (*Algebra 1, Applied Physics*, and *Introduction to Engineering*). The instructional design strategy that the mathematics and science teachers followed was based on the concept of including new content and an alternate system of delivery (e.g., instructional topics from the other school subjects and unique instructional activities developed by the multidisciplinary teacher team) into existing courses. This may seem rather trivial at first glance but the teachers actually taught specific components within the three courses as well as shared ideas, media, and instructional activities. This was accomplished by allowing each of the teachers to rotate into and out of each others classroom.

Goals. The goals of the program were to:

- Provide a knowledge base of mathematics, science, and technology through instruction and application
- Interpret learning through the integration of subject areas
- Transfer learning to unique problems and solve for such problems
- Analyze a given learning situation and adapt to an individual learning style
- Evaluate solutions to problems in order to recognize and develop new problems

Curriculum. The curriculum design for the program followed three separate curricular strategies. The instructional sequence for the *Algebra 1* class was a modified sequence from the standard *Algebra* progression based on the Standards for School Mathematics objectives (National Council of Teachers of Mathematics (NCTM), 1989). Various learning activities were incorporated into the class to help students experience the scientific and technological applications of *Algebra*. The instruction sequence for the *Applied Physics* class was the *Principles of Technology* (PT) curriculum yet, it was modified substantially to fit perceived needs of the students and teachers. The primary modification of this curriculum was a self-paced modular format. The *Introduction to Engineering* course required the largest degree of development. As a new course designed to have integration of subject matter as a core element it required the design and development of an independent sequence of objectives. The objectives for the *Introduction to Engineering* course were to:

- Interpret mathematics and science principles
- Apply technology to solve for natural and man-made problems
- Synthesize mathematics, science, and technological techniques to aid in problem resolution
- Evaluate engineering solutions for appropriateness
- Appreciate the broad spectrum of knowledge and application required in engineering
- Accept responsibility for self-motivation and self-learning of mathematics, science, and technology in the realm of engineering

The use of computer-based-instruction using HyperCard stacks and interactive video provided unique learning experiences for students in both the *Applied Physics* and *Introduction to Engineering* courses.

Most Successful Innovation. The most successful innovation of the program was the development of the *Introduction to Engineering* course and the revision of the *Algebra 1* and *Applied Physics* courses. The coordinated efforts of the teachers to develop activities that supported the multidisciplinary approaches within each course was also viewed as a very positive outcome of this project. Faculty members worked together to collectively create, identify, and develop new instructional strategies for the integration of the curriculum. Positive change in the overall school curriculum was evidenced in that project members used cross-curricular activities in other classes they were teaching and faculty members who were not part of the project team began to consider multidisciplinary ideas for their classes as well. In addition, the use of teacher resources was greatly expanded. The principal remarked that, "In a small school, like [the Colorado CSD], the teacher is the primary resource, and by using the talents of different instructors the dynamics of classes and the instructional quality was greatly enhanced. All staff members recognized that they needed to be good educators, and great teachers in their specific subject area. This integrative approach to instruction aided the faculty to accomplish this goal." In addition to improving staff development, the project allowed students to experience activities that went beyond the traditional abstractness of learning school based concepts. Teachers within this project attempted to take the instructional content beyond the school grounds by allowing students to research, design, develop, and problem solve on topics that were of some avocational interest (i.e., kite design, development, and testing).

In addition to instructional advantages, many positive aspects of the integration project were noted by students. The greatest positive change for students came from those who were in the *Algebra* class. The mathematics instructor, commented that he rarely heard students complain "When are we ever going to use this stuff?" Student were able to see direct applications of *Algebra* in a variety of technology based activities.

Most Difficult Problem. A major concern was the perceived lack of student involvement in deep and meaningful discussion of the links among mathematics, science and technology subjects. This is primarily due to the over reliance on individualized curriculum and instruction and the mind-set of the teacher team (e.g., deep discussion was not high). In addition, access to the technology center laboratory was viewed as a limitation. This facility was used as the primary classroom for each of the teachers in this project and was stretched beyond its capability on several occasions. Many efforts were made to accommodate the student need for laboratory time during the year, both before and after school. Although these efforts were helpful, laboratory availability was viewed as a major limitation.

Oklahoma County School District

Overview. The *Principles of Technology* (PT) curriculum was the focus for the Oklahoma CSD project. The faculty team worked together to present a coordinated curriculum where each teacher took responsibility for the specific section of the curriculum that aligned with their particular field of study.

Goals. The goals for the program was to improve mathematics and science skills for students with below average abilities in these areas. In so doing, it was hoped that these same students would develop a greater interest in science and mathematics. A secondary goal was to incorporate other subject areas into the multidisciplinary instructional approach.

Curriculum. A unique approach to implementation was employed. Because the students in each of the three classes (mathematics, science, and technology) were *not* the same, the teachers designed a rotational schedule in which they moved to each of the classrooms to address a particular segment of the curriculum that pertained to their instructional field. In using this approach, specific instructional content could be delivered while maintaining a coordinated integration curriculum that students used to build on their knowledge of mathematics, science, and technology. In addition, student learning teams were created where each team was sub-divided into field experts. That is, each team had a student supervisor, a mathematics expert, a technologist, and two laboratory technicians. It was believed that this type of learning arrangement provided an ideal environment to address the various components in the PT curriculum as well as replicating "real world" strategies for working and solving problems. This approach to the team work concept allowed for excellent cooperative learning, peer teaching, and teamwork responsibilities. The friendly competition between teams within the classes also heightened the interest and learning that was taking place.

Most Successful Innovation. The most successful aspect was the creative use of the teaching staff. By allowing each of the teachers to rotate to the individual classrooms the students were introduced to a coordinated integrative curriculum without the obtrusive restructuring of existing class schedules. Although the coordination efforts were viewed by the instructional staff as a very positive product, it was also perceived as a significant logistical problem which periodically caused confusion for both teachers and students. In addition to the teacher rotation, the creation of the student learning teams was also a very positive experience for most students in this project. Students were able to perceive the importance of working together to solve a common problem as well as, exposure to occupational strategies of modern businesses and industries.

Most Difficult Problem. It was somewhat of a surprise to the teacher team that there were some students who resisted the multidisciplinary approach to the learning process. It was obvious that a number of students wished to be accountable to only one teacher. This resistance was manifested by the reluctance of some students to transfer knowledge from one subject area to another. The staff identified this hesitation to be based on limitations of students, specifically related to student reading ability and computational skills. Efforts are currently being formulated to address these concerns as the project team plans for future integration activities.

Findings

This research sought to develop and implement multidisciplinary approaches to the study of mathematics, science, and technology in the high school and to identify successful factors of those approaches (see Table 1).

After a careful examination of each of the pilot demonstration schools, three primary factors were identified that significantly affected the success or failure of the multidisciplinary curriculum: (1) teacher and administration commitment to the integration approach, (2) innovation and effort in curriculum re-design, (3) administration and teachers coordination of integration plan. Each of these factors are of paramount importance to creating the type of integrated curriculum that will help students learn, apply, and transfer learning beyond the classroom environment.

Commitment to Integration

Teacher and administrator commitment is critically important to a successful multidisciplinary program. Each teacher must understand that the sum of their collective efforts can be more than the simple addition of multiple school subjects. The effort that is needed in planning, coordinating activities, cross-training in other subject areas, making adjustments to teaching styles, making "mid-course" corrections during the school year, and re-designing and planning for future class activities are substantially more than what is experienced by a teacher working alone.

Interpersonal relationships become much more of an issue in the multidisciplinary curriculum environment. Teachers and administrators must be able to work together to accomplish their collective goals; their ability to communicate specific instructional ideas are essential for a smooth coordination of the multidisciplinary curriculum.

Table 1
Summary Comparison of Cases With Project Components

	Missouri County School District	Nebraska County School District	Colorado County School District	Oklahoma County School District
GOALS	1.Interdependency of subjects 2. Open access to learning 3. Improve critical thinking	1. Increase students (at-risk) interest in mathematics, science, & technology 2. Actively use knowledge & learning transfer	1. Evaluate problem solutions & develop new problems 2. Interpret learning through instruc tional integration 3. Transfer learning beyond classroom 4. Create new learning opportunities	1. Improve math & science skills of students w/ below average abilities 2. Incorporate other subject areas into multidisciplinary approach
CURRICULUM	1. Focus on Survey of Biology Course 2. Original experimentation & portfolio review	1. Focus on Principles of Technology Course 2. Team teaching in two hour block period	1. Focus on 3 courses - Algebra 1 - Applied Physics - Intro. to Engineering 2. Coordination & use of teacher expertise	1. Focus on Principles of Technology Course 2. Rotation of teachers to address specific instruc tional areas
SUCCESS	1. Teacher cooperation & relationships 2. Removal of artificial learning barriers	1. Improved student motivation based on class attendance 2. Team teaching was positive & conducive to professional growth	1. Development of new course of integration - Intro. to Engineering 2. Coordination efforts by teachers 3. Context based learning	1. Creative use of teacher's skills 2. Student learning teams - content experts, peer teaching
PROBLEM	1. Student reliance on specific subject instruction causing limitation of learning transfer	1. Inability of students to grasp instructional content 2. Teacher inter personal relation ships 3. Lack of commitment to project goals	1. Lack of student ability to discuss learning at deep levels 2. Limitations of physical facilities	1. Student resistance to multidisciplinary concept 2. Lack of teacher coordination of curricular content

There is an important link between the need for commitment to multidisciplinary instruction and the recent research on teacher empowerment. Empowerment can be defined as the opportunities a person has for power, choice, autonomy, and responsibility (Lightfoot, 1986). Maton and Rappaport (1984) found that a sense of community and commitment are strongly associated with the empowerment of community leaders. Further, empow- erment of teachers is mostly likely to occur in organizations where partici- pation, innovation, assess to information, and accountability are encouraged (Dobbs, 1993). In the Colorado CSD, we found that multidisciplinary teachers did have opportunities to develop expert organizational power. As a result, these teachers recognized as "experts" were empowered to positively influence their organization along horizontal and vertical axis (Hampton, Summer, and Webber, 1987). With the strong support of the administration, the Colorado County teachers had meaningful license to participate in fundamental curriculum changes. They had unlimited access to technical and pedagogical information which further added to their base of expert power. Perhaps most importantly, the organizational culture at the Colorado CSD were open to innovation and experimentation. Environments that encourage innovation are "hospitable to interesting people with innovative ideas–environments that encourage people to explore new paths and to take meaningful risks at reasonable costs, environments in which curiosity is highly regarded as is technical expertise" (Dobbs, 1993, p. 53).

Innovation and Effort in Curriculum Design

The second major factor effecting multidisciplinary curriculum efforts was the degree of innovation and effort teachers and administrators exercised in the design/re-design of the school subjects. Based on interviews and discussions with student participants, teachers, and administrators, the project sites that approached the goals of multidisciplinary education from a basis of significant curriculum change had more success overall than the project sites that addressed multidisciplinary education as a methodological adjustment to an existing curriculum. The Colorado CSD and to a lesser degree, the Missouri CSD were perceived by the researchers as developing the most extensive integration design/re-design of their curricula. In the Colorado County Program, two courses were re-designed to implement an integrated curriculum that would address aspects of each of the three subject areas. While the focus of each of these courses were aimed at fulfilling specific subject area requirements (i.e., *Algebra 1* and *Applied Physics*) the content of each course was adjusted in order for students to experience the integration of each of the three subject areas. The third course in the Colorado County program *(Introduction to Engineering)* was specifically designed to implement a multidisciplinary approach to teaching and learning. Students learned and applied mathematical formulas, science concepts, and technological applications on a regular basis in order to solve problems and fulfill course requirements. The efforts to innovate and create new and unique ways to teach students the interrelationships of mathematics, science, and technology were perceived by students to be the most rewarding activities in the project.

Teachers in the Nebraska County program and the Oklahoma County program used a pre-designed curriculum as the source of their multidisciplinary effort. In both cases the *Principles of Technology* (PT) course was the source of the curriculum. The PT curriculum provides by its design specific integration and application of mathematics, science, and technology principles. This curriculum however, did not motivate the student participants to be able to discuss technological issues at depth nor did it create an atmosphere where learning would be transferred beyond the classroom. This was a significant problem despite the fact that the teachers in these cases used a variation of the original curriculum design (i.e., team teaching, 2 hour block period, teacher rotation).

Innovation and effort in the design/re-design of the curriculum for multidisciplinary instruction proved to be highly significant in the overall success of this project. Teachers that made more effort and were more creative in their curriculum approaches were rewarded with higher levels of student learning and appreciation. Yet, these efforts alone were insufficient. Although the Missouri and the Colorado projects showed significant innovation in redesigning their curricula, neither appropriately considered the importance of the "learning context." Looking at the problem from a curriculum perspective, Caine and Caine, 1991) suggest that multidisciplinary curricula should be "infused." Perhaps an appropriate metaphor is "blending" a curriculum cake mix. To the extent possible, we believe that blended multidisciplinary learning should occur in realistic and applied settings where the student interacts as a member of a "community of practice" where "authentic" mathematics, science, and technology activities occur as one. We believe that technology and its cultural implications serves as an important curriculum theme where by mathematics and science can be co-investigated. However, curriculum designers should not only focus on integration of hard sciences. Liberal Arts subjects can also be effectively infused.

Coordination of Integration Plan

The third factor that had a notable influence on the overall success of this project was the coordination efforts between teachers and administrators. The pilot demonstration schools that had the most success with their multidisciplinary project were those that were allowed to develop and reorganize class scheduling. Although this factor had mixed results in the pilot schools, by in-large, moderate to substantial changes in teaching loads, class periods, and student scheduling were viewed as important considerations in the overall success of the project. The Colorado CSD allowed the most substantial degree of change to take place in scheduling and curriculum adjustment (e.g., creation of new course, re-design of existing courses, rescheduling of students and teachers) and met with the greatest degree of success based on teacher and student responses. The Nebraska CSD program also made significant adjustments in scheduling of teachers and students (e.g., team teaching, 2 hour block instruction period, rescheduling of students) however, only moderate success of this project was perceived by teachers, administrators, and students.

Experimental efforts made by administrators to allow for scheduling changes were viewed as extremely important to accomplishing meaningful multidisciplinary instruction. Once again, we are reminded of the importance of administrators and teachers who share governmental authority and power. Complex problems such as school scheduling and use of community locations, will only be solved by empowered teams of professionals. These are administrators and teachers who are willing to jointly refocus their organizations on student learning as the first priority, and the retention of tradition as a secondary consideration. In this research, we have found that the Missouri and Colorado County Districts have demonstrated a willingness to "break the traditional mold." We are reminded of the statement of the Colorado Principal. "In a small school [like ours], the teacher is the primary resource, and by using the talents of different instructors the dynamics of classes and the instructional quality was greatly enhanced." This is evidence of teacher empowerment that has resulted in effective multidisciplinary instruction.

Conclusions

Stepping back from our research, we believe that we can make the statement that these multidisciplinary projects have made a positive difference in both teachers and students. We have proven that where administrators are open to change and teachers are willing to empower themselves and take individual responsibility, increased student motivation and learning can be effected.

However, these demonstration projects have been subject to many limiting factors. Future research will focus on ways to "situate" integrated learning and teaching and on the importance of building more effective teams of administrators and teachers prior to and concomitant with curriculum reform.

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Book Reviews

Mitcham, Carl. (1994). *Thinking through Technology*. Chicago: The University of Chicago Press, $17.95, (paperback), 397 pp. (ISBN 0-664-25203-60)

Reviewed by Richard A. Deitrich

Thinking through Technology is designed ". . . to be a critical introduction to the philosophy of technology." The author is a past president of the Society for Philosophy and Tech- nology (l98l-l983), present general editor of the serial publication, Research in Philosophy and Technology, and Director of the Science, Technology and Society Program at Penn State University.

Thinking through Technology is more than an introduction, it is a compre- hensive resource for the philosophy of technology movement: to this end, it is nearly encyclopedic. Part One is a history of the philosophy of technology beginning about l850; Part Two is an exhaustive analysis of issues in the field; the Epilogue is a sweeping historical look at three ways of being with technology; and the Notes, References, and Index are a wealth of information about the Philosophy of Technol- ogy movement.

The title of this book is itself indicative of the syntactic "play" used by Mitcham concerning the subject of the book, "the philosophy of technology." The word "tech- nology" can be seen as a subjective or an objective genitive in both. The title is really a gerund, "thinking-through," followed by the genitive "of technology." Thus the book title is the "thinking-through of technology," and the book subject is "the phil- osophy of technology." Therefore, these two terms are nearly identical in meaning. Both the subjective and objective genitives are intended in both terms, as will be seen in Part One.

Part One. Historical Traditions in the Philosophy of Technology

The subtitle of *Thinking through Technology* is "The Path between Engineering and Philosophy." Actually, much of Part One describes a concourse between engi- neering and the humanities. The literary concourse for this history of the philosophy of technology field connects its two traditional discourses – the engineering phil- osophy of technology (EPT) and the humanities philosophy of technology (HPT).

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In Chapter One, Mitcham details the EPT (which uses "technology" as the subjective genitive) by beginning with the German philosopher Ernst Kapp (l808-l896) who coined the phrase "Philosophie der Technik." Next, the life and work of Russian engineer Peter Engelmeier (l855-ca. l94l) are examined; followed by that of German businessman/philosopher Friedrich Dessauer (l88l-l963). Then, Mitcham deals briefly with several non-German engineering-oriented philosophers of technology. His brevity is explained by this comment:

> Outside Germany, the term "philosophy of technology" has not until the l980s been widely used, although the positive intellectual attraction and power of the technical realm has not gone philosophically unrecognized.

Chapter Two explores the humanities philosophy of technology (HPT), which uses "technology" as the objective genitive. Mitcham details the life and work of four representatives--Lewis Mumford (l895-l988), Jose' Ortega y Gasset (l883-l955), Martin Heidegger (l889-l976), and Jacques Ellul (l9l2-l994).

There have been several attempts to reconcile EPT and HPT, and three such attempts are discussed in Chapter Three. The first occurred after World War II when the Society of German Engineers was refounded in l947. The second notable attempt is by the "pragmatic phenomenological approach" in America represented by John Dewey and Don Ihde. The third is the whole Marxist worldview, especially in its twentieth century neo-Marxist expression.

However, Mitcham forsakes reconciliation. With set-jaw determination, he builds "a brief for the primacy of humanities philosophy of technology" over its engineering counterpart.

This sets the stage for Chapters Four and Five which are, respectively, a philosophical questioning of technology, set in modernity; and, a philosophical questioning of techne, set in the classic Greek era. This de-linearization of history is somewhat problematic, but the correlation of modern technology and ancient techne are a preparation for the predominant work of the book– the thorough treatment of analytical issues in the philosophy of technology.

Part Two. Analytical Issues in the Philosophy of Technology

Chapters Six through Ten are an outstanding demonstration of the modus operandi of the humanities philosophy of technology. Having established its historical "primacy" over EPT in Part One, Mitcham establishes its effective hegemony in Chapter Six this way. He entertains engineering objectives to HPT, courts phil- osophical objections to HPT, weighs the arguments, then examines the extension of the word "technology" in modernity. The verdict: the term "technology" is so broad that only HPT can meaningfully engage it. In fact, scholars are, "techno-logists" when doing analytical, methodological, pragmatic, and technique-laden work in the philosophy of technology field.

Given this apologetic, the following four chapters analyze technology as object, as knowledge, as activity, and as volition. Here is water to swim in for conversant scholars, but deep for others. The notes and references, as was said, are nearly encyclopedic of the field. Also, the attempt to be thorough, even exhaustive, is evident.

For example, Chapter Seven (Types of Technology as Object) analyzes clothes and toys as technological objects, lists types of basic machines (lever, screw, wedge, etc.) and discusses biological artifacts (baked bread, engineered genes, cyborgs, etc.). We are faced with the question, "When does organic existence cross the line to artifact?" A thorough analysis of the phenomenology of artifacts follows.

Chapter Eight (Types of Technology as Knowledge) is an analytical epistemological scrutiny of technology. Piaget, Polanyi, and Kuhn are a few of the many scholars noted. The issue of scientific vis a' vis technological knowledge is explored.

Chapter Nine (Types of Technology as Activity) sets forth seven basic types of behavioral engagements of technology as activity. The Aristotelian notions of cultivation versus construction as "actions of making" are examined; and the terms "cobbling and badging" (patching and jerryrigging) are not ignored. The spectrum of activity from bricolage, to crafting, to engineering is analyzed. Also, "maintaining" (an intermediary activity between "engineering" and "using"), then "using," and lastly "work" are analyzed. "Work" is found to be both a making and a using activity.

Chapter Ten (Types of Technology as Volition) is an analytical feast of psychologies of technology. The human will to survive, to construct, to control, to freedom, to efficiency, to order, etc. speak of embracing technology as a tactic of living. Various philosophies of volition are examined as fleshed-out by Spengler, Ferre', Mumford, Jünger, Arendt, Ricoeur, and Heidegger et al.

The above final chapter is interestingly concluded by discussing the problem of technology and the weakness of the will – otherwise known as "technological incon- tinence." The eight-page conclusion is a very broad-brush recapitulation as well as a PR piece for the Society for Philosophy and Technology which was founded in l978. Eight pencil-drawn likenesses of former presidents of the Society appear on page 270, including Carl Mitcham who was president (l98l-l983).

A twenty-four page Epilogue (Three Ways of Being-with Technology) closes out the book. Although anticlimactic, it deals interestingly, though incompletely, with these three ways: ancient skepticism (Socrates, Plato, Aristotle), Enlightenment Optimism (Bacon, Kant, Hume), and Romantic Uneasiness (Wordsworth, Rousseau, Blake). Table 5 compares these three ways of being-with technology on the hori- zontal axis, while correlating them with technology as volition, as activity, as knowledge, and as objects on the vertical axis. The Epilogue is incomplete because it omits a fourth way of being-with technology—a well traveled way in modernity. This fourth way, beyond Romantic Uneasiness, might be termed "Post-modern Immersion."

Thinking through Technology succeeds in beckoning the reader to historically and analytically explore the philosophy of technology field. Part One is a clearly mapped, readable venture into its history. I heartily recommend venturing forth. However, Part Two is of difficult terrain. I caution you: it is a difficult and tedious venture, but it can successfully be a hardy and high adventure into issue-laden analysis. This work is, to my knowledge, the most comprehensive critical introduction to the emerging philosophy of technology field. For this reason, among others, it has earned a place on the working shelf of those with visage toward this field.

Dauch, Richard. (1993). *Passion for manufacturing.* Dearborn, MI: Society of Manufacturing Engineers, $29.00 (hardcover), 280 pp. (ISBN 0-87263-436-1)

Reviewed by Harvey Fred Walker

The automobile industry has employed many talented and capable individuals who have made noteworthy contributions to the field of manufacturing. One such individual is Richard Dauch, a former executive with Chrysler, Volkswagen, and General Motors. Mr. Dauch served in positions such as Executive Vice President of Diversified Operations; Executive Vice President of Stamping, Assembly, and Diversified Operations; Executive Vice President of Manufacturing; and Executive Vice President of Worldwide Manufacturing during his twenty year career.

Much of this book is devoted to discussing Mr. Dauch's attempts to revitilize his employers' competitiveness through productivity improvement. These discussions were focused on identifying productivity problems which hinder competitiveness in American manufacturing in general, and how these problems were eliminated or minimized at Chrysler.

A chronological review of manufacturing methods used in this industry from World War II to the present set the stage for a discussion of the current state of manufacturing technology. Lean production was identified as an em- erging technology which emphasizes efficiency and effectiveness of manu- facturing resources. Agile manufacturing was also identified as a tool to syn- thesize innovative methods and practices such as networking machine tools, implementing robotics, and accepting delivery of parts "just in time" to be used in manufacturing operations.

Mr. Dauch appeals to American leaders in industry and academia to work together to identify and provide educational experiences which will enable graduates to contribute to competitive revitalization. In fact, Dauch devoted an entire chapter to comparing and contrasting inadequacies in the American educational system to those abroad. Specifically compared were the amount of course work required in mathematics, physics, applied science, and advanced technology. Another comparison involved the relationships between educat-

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ional institutions and industry in areas such as sharing expertise, facilities, and financial support.

Realizing the potential benefits of improving team-work between academia and industry, Dauch and Chrysler took steps to form strategic partnerships with selected educational institutions. The steps taken were intended to strengthen the curricula Chrysler employees would be exposed to in applied mathematics, reading, and writing. Working for change in these "basic" areas, Dauch suggests, would enable technically-based curricula to address more advanced topics.

In addition to redefining the critical importance of academia/industry relationships and technically-relevant education, Mr. Dauch focused the reader's attention on the importance of remaining technological leaders in global manufacturing. Mr. Dauch made the point that many college graduates never even visit a factory until after graduation. Lack of exposure to operational manufacturing settings continues to delay many graduates from becoming productive members of the work force and significantly adds to corporate training and development costs. Further, too many college graduates continue to receive a formal education that is technically obsolete. Mr. Dauch considered formal education "out-of-date" because the types of knowledge, skills, and abilities possessed by newly-hired graduates often lags leading-edge technology by as much as five to ten years.

In response to the perception of obsolete technology in the academic setting, Mr. Dauch identified and discussed state-of-the-art technology, equipment, and management practices currently used in manufacturing facilities at Chrysler. These discussions would enable the technology educator and technology education student to review new types of technology, discover how these technologies have been put to use in industry, and understand how these technologies are combined into a synthesized and integrated system. The strategies outlined in this book reviewed current and emerging manufacturing practices. Primarily discussed were concurrent engineering, planning, control, supply, distribution, manufacturing, and management. Many of the concepts addressed are currently a part of technology-teacher preparation in educational programs emphasizing manufacturing.

In conclusion, *Passion for manufacturing* provided many useful insights into the current state of manufacturing technology and practices. Through many appropriate examples, technology educators may gain valuable insights into identifying curricula content that better serves the needs of students they are teaching. Similarly, technology education students can gain a unique perspective into current manufacturing practices which may help them be better prepared to enter the teaching profession.

Miscellany

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Virginia Polytechnic Institute and State University

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